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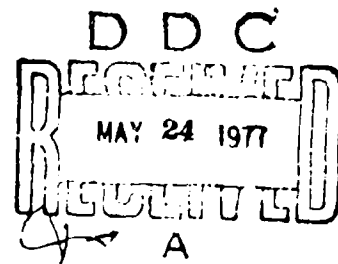
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R-1941/2-AF
March 1977

Strategic Mobility Alternatives for the 1980s: Vol. 2, Analysis and Conclusions (U)

W. E. Hoehn, Jr., R. L. Perry, J. R. Gebman
with A. A. Barbour, J. H. Hayes, J. W. Higgins,
W. R. Micks, and P. C. Paris

A Project AIR FORCE report
prepared for the
United States Air Force



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Nature of Privileged Information and Location in Publication:

Cost data, p. 61

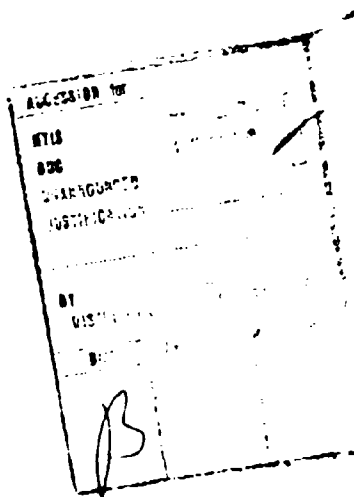
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER R-1941/2-AF	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Strategic Mobility Alternatives for the 1980s. 2. Analysis and Conclusions (U)		5. TYPE OF REPORT & PERIOD COVERED Interim <i>rept.</i>	
6. AUTHOR(s) W. E. Hoehn, Jr., R. J. Perry, J. R. Gebman, A. A. Barbour, J. H. Hayes, J. W. Higgins, W. R. Hicke, P. C. Paris		7. CONTRACT OR GRANT NUMBER(s) F49620-77-C-0023	
8. PERFORMING ORGANIZATION NAME AND ADDRESS The Rand Corporation 1700 Main Street Santa Monica, Ca. 90406		9. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS Project AIR FORCE Office (AF/RDQA) Directorate of Operational Requirements Hq USAF, Washington, D.C. 20330		12. REPORT DATE March 1977	
13. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 112	
		15. SECURITY CLASS. (of this report) Secret	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE xgds	
16. DISTRIBUTION STATEMENT (of this Report) Limited to Government Agencies Only - <i>Proprietary Inf.</i> 24 MAR 1977			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) No restrictions			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Air Transportation Cargo Aircraft Military Mobility Air Force Army			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) See R-1941/1-AF for abstract.			

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and other applicable guidance sources.**

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PREFACE

This report and its companion volumes¹ document research conducted under Project AIR FORCE (formerly Project RAND) on alternative strategic mobility forces and their contribution to the deterrence of nonnuclear conflicts involving NATO. The reports draw upon earlier research at The Rand Corporation on the importance of capabilities for early, rapid reinforcement of NATO's ground forces posture; on the role of tactical airpower, prepositioning, and sea lane defense in enhancing NATO's defensive capabilities; and on cost and capability tradeoffs to achieve the desired enhancement. Previous research emphasized rapid deployment to the NATO theater of U.S. ground forces as an indispensable element of enhanced defenses and demonstrated that only strategic airlift can provide the critical element of *timeliness* under many likely scenarios. These reports, accordingly, focus on the analysis of options for enhancing strategic airlift capabilities to greatly increase the rate at which Army units can be moved to the European theater by air following a mobilization decision.

Earlier publications on this subject examined in some detail the constitution and classification by size and weight of Army unit equipment to be moved and evaluated the cost effectiveness of various airlift enhancement options. Early in 1975, the project leader for the study effort left Rand, during the initial drafting of a summary report. The main author of the present report became the interim project leader. In his capacity (then) as Deputy Vice President for Project RAND, he had previously reviewed preliminary research results from two studies, in other areas of the Project RAND research program, that bore on airlift issues. One study evaluated a series of possible aerodynamic and engine modifications or retrofits to conserve aircraft fuels and reduce the annual Air Force fuel bill. Included in that evaluation were several modifications of the C-141A. The second study (undertaken at the request of the Air Force) evaluated the applicability of a Rand-conceived procurement technique--directed licensing--to

¹Executive Summary, R-1941/1-AF; Analysis and Conclusions, R-1941/2-AF (this volume); and Technical Appendixes, R-1941/3-AF.

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the prospective purchase of a new wing for the C-5A fleet. Neither issue has been treated earlier under the strategic mobility project.

Rand management unilaterally decided to undertake an intensive two-month exploration of some implications of the C-5A rewing and the C-141A stretch decisions for the long-term strategic mobility enhancement problem. The findings of that research, which went beyond the research program outlined for the Air Staff project monitor (OPR), were briefed to a selected set of Air Staff general officers in April 1975. Those findings were in many respects at variance with the Air Staff's position of that time on a program for airlift enhancement. Further, Rand's research had used unofficial or estimated values for several parameters in the analysis, and the briefing proposed measures of merit different from those underlying earlier Air Force studies. Therefore, the Air Force Airlift Enhancement Working Group was reconvened during May and June 1975 to review the Rand research methods, provide "official" inputs, and assess the major points of agreement and disagreement between Air Force positions and Rand views. After receiving new data inputs, but while clarification and definition of several points were pending, the Air Staff asked Rand to prepare a written report.

A preliminary draft was circulated within the Air Staff at the working level in the spring of 1976; comments received were reflected in a "for-comment" draft circulated in the late summer of 1976 to major Air Force commands and organizations with responsibilities for strategic airlift. A further series of technical discussions were held during the fall of 1976, leading to these final reports.

This work has been carried out under the original project, entitled "Strategic Mobility." Of necessity, the OPR has remained the same, but that office is in no sense responsible for the directions the study has taken during the past year. The reports represent the general state of knowledge as of late 1976. As effort has been made to footnote more recent information, changes of Air Force policy or emphasis, and new schedules.

The analysis of these sections has benefited from discussion and review of preliminary drafts with representatives of the C-5A Systems Project Office and the Aeronautical Systems Division of AFSC, as well as with Headquarters, Military Airlift Command. This should not be

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interpreted as suggesting endorsement by those organizations of the findings and conclusions herein.

Controversy has occasionally attended the research and interim reports of findings. Nevertheless, these reports should help the Air Force identify and assess alternative courses of action to evaluate options for enhancing strategic airlift capabilities over the next 25 years.

Recent Project RAND publications on airlift issues include:

Hayes, J. H., and L. Cutler, *The Army Deployment Simulator with a Data Base of Army Units and Equipment*, R-1893-PR, September 1976.

Hayes, J. H., *Future Army Deployment Requirements* (U), R-1673-PR, April 1975 (Confidential).

Carter, G. A., *Directed Licensing: An Evaluation of a Proposed Technique for Reducing the Procurement of Airlift*, R-1604-PR, December 1974.

Landi, D. M., and F. J. Morgan, *Airlift Augmentation Alternatives: Briefing for the Secretary of the Air Force* (U), December 1974 (Secret), unpublished working paper.

Morgan, F. J., J. W. Higgins, D. C. Gogerty, and A. A. Barbour, *Airlift Augmentation for NATO Reinforcement* (U), October 1974 (Secret), unpublished working paper.

Landi, D. M., J. H. Hayes, J. W. Higgins, and F. J. Morgan, *Augmenting Strategic Airlift: A First Look* (U), December 1973 (Secret), unpublished working paper.

Publications on NATO reinforcement, and tradeoffs among forces in being, prepositioning, airpower, and surface transport include:

Emerson, D. E., and L. E. Catlett, *Improving Future NATO Capabilities for Defending Against a Major Conventional Warsaw Pact Attack: A Total Force Posture Analysis* (U), R-1240-PR, July 1973 (Secret).

Emerson, D. E., *Comparison of Alternative 1980 NATO Land and Air Forces: Methods and Results* (U), R-1243-PR, June 1973 (Secret).

Emerson, D. E., *Performance of Alternative ASW Forces for Convoy Protection* (U), R-1244-PR, June 1973 (Secret).

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A partial listing of recent Rand research on tactical airpower contributions to the defense of NATO includes:

Ellis, J. W., D. V. Palmer, and A. H. Peterson, *Campaign Comparison of Equal-Cost Close Air Support Aircraft Systems: A-10A, A-7, Derivatives, and A-4M* (U), R-1546-PR, November 1974 (Secret).

Ellis, J. W., D. V. Palmer, and A. H. Peterson, *Comparing the Capability of Close Air Support Systems in Air/Ground Campaigns* (U), R-1547-PR, November 1974 (Secret).

Dadant, P. M., E. Dews, F. Kozaczka, J. K. Seavers, J. A. Wilson, and R. W. Wise, *Tactical Airpower in a Mid-Seventies NATO Defensive Contingency (NATO Alpha)* (U), R-1192-PR, October 1974 (Secret).

Dadant, P. M., *Findings from Rand Studies of General Purpose Forces: A Briefing* (U), R-1460-PR, June 1974 (Secret).

Dadant, P. M., E. Dews, J. W. Higgins, F. Kozaczka, J. K. Seavers, and R. A. Wise, *Tactical Airpower in Two Mid-Seventies NATO Contingencies: Summary Report* (U), R-1191-PR, June 1974 (Secret).

Harris, K., and L. W. Wegner, *Tactical Airpower in NATO Contingencies: A Joint Air-Battle/Ground-Battle Model (TALLY/TOTEM)*, R-1194-PR, May 1974.

Dadant, P. M., E. Dews, T. E. Greene, J. W. Higgins, F. Kozaczka, A. H. Peterson, and R. A. Wise, *Tactical Airpower in a Mid-Seventies NATO Offensive Contingency (NATO Beta)* (U), R-1193-PR, May 1974 (Secret).

Huschke, R. E., *Tactical Airpower in NATO Contingencies--Modeling Weather Constraints on Air Operations: Weather and Warplanes IV* (U), R-1195-PR, January 1974 (Confidential).

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SUMMARY



This report addresses an interconnected set of issues affecting strategic mobility: the capacity of the United States to move substantial combat ready forces quickly to distant parts of the world in time of crisis. Although a great many demanding scenarios have been and can be constructed that strain that capacity in various ways, the timely reinforcement of NATO by Army and Air Force combat units is generally considered to be a baseline requirement. If it can be satir it will provide a capability adequate to serve most other combat needs. For that reason, and because the NATO-reinforcement scenario has most often been used by analysts to test the effectiveness of different modes of strategic mobility, it has also been used here. It is assumed, therefore, that a capacity to ensure early reinforcement of U.S. forces on the NATO Central Front in time of crisis will be critical to deterrence of an attack by the Warsaw Pact and, should deterrence fail, to NATO's ability to repel any such attack.

The vast bulk of U.S. personnel and materiel that would be called upon to support U.S. forces in Europe ordinarily remain in the Continental United States. Moving troops and support personnel presents no special problem; the passenger capacity of the U.S. civil airline fleet is sufficient to ensure that people, their personal equipment, and many of their immediately needed supplies can be delivered to Europe quickly enough to satisfy mobilization plans. Materiel is quite another problem. Between 500,000 and 750,000 tons of major equipment (exclusive of "bulk," which can be accommodated in the holds of civil air transports) must either accompany the troops, be awaiting their arrival, or reach them shortly after. Without combat equipment, neither deterrent effect nor combat effectiveness survives.

Matching up reinforcement troops and equipment can conceivably be assured solely by prepositioning, solely by sealift, or solely by airlift of the essential combat and support equipment. In practice, some combination of those three modes will be used. Timeliness, however, dictates a heavy reliance on strategic airlift, which as currently composed

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cannot fully satisfy the requirements likely to be levied on it. This study explores the reasons for that reliance and examines the costs and benefits of several options for enhancing the present and future capability of strategic airlift forces.

(U) A major thesis underlying all the analysis of airlift enhancement in this report is that DoD should plan to move early reinforcements entirely by air, with sealift initially supporting only the (substantial) resupply requirements of the deployed combat forces. The rationale for this view includes the secular decline in numbers and suitability of available U.S. and NATO shipping, the time-consuming nature of convoy assembly and crossing, and the anti-shipping threat to early convoying posed by Soviet forces. These factors argue for initially deploying both men and equipment by air, limiting the early sealift role to resupply. As convoying becomes less risky over a period of weeks to months, additional equipment can be sent by sea.

(S) Prepositioning of equipment in the theater is one way of reducing the burden of both airlift and sealift. Much of the unit combat equipment for 2-2/3 U.S. divisions is nominally prepositioned¹ in NATO, but there are serious shortages of critical items. Prepositioning has its limits: It is inflexible; buying duplicate division sets, one for U.S. training and use and one for prepositioning, is expensive; concentrations of equipment in storage may be subject to preemptive attack; for some items, airlift (by suitably modified jets in the U.S. Civil Reserve Airlift Fleet--CRAF) is a more cost-effective deployment technique than prepositioning; and the effectiveness of prepositioning in the past has been degraded by storage and maintainability difficulties and the extensive work required to break out the prepositioned equipment and make it ready. Nevertheless, some additional prepositioning is likely in the long term, although its scope remains uncertain.

(U) Future airlift requirements planning must include the premise that early reliable sealift and additional large-scale prepositioning may not be feasible. Should that premise be in error, the consequence

¹(S) But much of the divisional support equipment, which includes such indispensable combat elements as tank companies and non-divisional artillery, is not.

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would be the enhancement of strategic mobility and the prospect of more rapid deployment. But airlift forces sized only to support sealift could be inadequate to NATO needs if sealift were not reliably available. A similar shortfall could occur if the capacity of the airlift force were to be tailored to augment prepositioning plans that had not been fully carried out.

(U) In terms of transportability by air, Army equipment can be categorized as *bulk* (707 class), *oversize* (C-141A class),¹ or *outside* (C-5A class).² Each type of Army division (armored, mechanized, infantry, etc.) has its own special mix of equipment; thus, a different mix of C-5As, C-141As, and civil aircraft is needed to minimize deployment times for each division type, subject to Army constraints (called *unit integrity*) on the *order* in which unit equipment is moved. An airlift force planned as an adjunct to sealift will emphasize oversize capability. Sealift can carry outside as readily as oversize, and the aircraft capable of carrying oversize are cheaper and more widely available than those that can handle outside. But if sealift were unavailable, that airlift force would have insufficient outside capacity, and either unit integrity could not be maintained or much of the oversize capacity would become redundant. Deployment times would suffer in either case. No "excess" of outside can occur because outside-capable aircraft can, by definition, carry oversize equipment, insuring unit integrity.

GROUND RULES AND ASSUMPTIONS

(U) Section II reviews a number of study assumptions and ground rules used in the analysis of deployment rates. They include:

- o The Army to be moved entirely by air consists of eight Army division equivalent maneuver units,³ including initial support increments (ISI) for the divisions.

¹(U) E.g., trucks, trailers, vans, armored personnel carriers, jeeps.

²(U) E.g., medium and heavy tanks, self-propelled artillery, some helicopters, combat engineer equipment, and large trucks and semi-trailers.

³(S) This does not include the 2-2/3 divisions whose combat equipment (but not ISI equipment) is largely prepositioned; existing

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- o The equipment to be moved is a Rand-developed projection of elements of the 16-division "Abrams Army" as planned for FY 1982.
- o In addition to the Army equipment, equipment to support 54 Tac Air squadrons scheduled for deployment to NATO must be moved by air.
- o No additional prepositioning is assumed except as noted in special excursions.
- o Aerial refueling of C-5As and use of C-130s to augment strategic airlift are not considered in basic scenarios (but a brief evaluation of the effect of assuming aerial refueling is provided).
- o Unit integrity is maintained only at the division or brigade level, as appropriate to the unit being moved.
- o Movements assumed to be feasible and timely in studies done elsewhere (and therefore not modeled here) include: troops and bulk cargo (by the present CRAF fleet); resupply (by sealift and by the current narrow-body CRAF); and Army sustaining support increments (by sealift).
- o No terminal handling problems or enroute traffic problems are considered.
- o No adverse weather constraints and no airlift attrition (accidental or hostile) are considered.
- o Army and Military Airlift Command (MAC) readiness and performance parameters are assumed to conform to established planning factors, and all support and ancillary requirements to meet those planning factors are assumed to be available (e.g., maintenance personnel, fuel, spares).

(U) A fundamental question for planning increases in airlift forces is, how rapidly must ground forces be capable of deployment? Guidance by the Secretary of Defense reveals only a notional criterion of a division a week;¹ war-gaming combat outcomes and military judgments suggest this is more nearly a minimum than a maximum requirement. Therefore, in Sec. III, a method is developed for evaluating closure

shortfalls in prepositioned equipment are scheduled to be eliminated by FY 1982.

¹(U) The criterion is loosely defined, since divisions differ markedly in both total weight and percentage of outsize equipment.

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rates for the specified eight division equivalent force. The contribution to more rapid closure of *each* aircraft enhancement option and of the cumulative effect of combinations of the options is analyzed. A cost-effectiveness measure of merit--the incremental cost for each day of decreased closure--is then applied to each airlift enhancement option considered.

(S) The base case considers the capability of the current organic airlift force--the 70 unit equipment (UE) C-5As and 234 UE C-141As--operating at present planning factor rates of ten hours per day for the first 45 days and eight hours per day thereafter. This airlift force can move the eight division equivalents plus ISIs (plus Tac Air equipment) from present widely dispersed CONUS locations to NATO in 121 days, roughly a division every 15 days.

ENHANCEMENT OPTIONS

(U) Three basic enhancement options (and their approximate costs) being considered by the Air Force as of late 1976 are:

1. Modification of up to 110 wide-body commercial aircraft for CRAF to make them capable of carrying oversize equipment (\$850 million).
2. Building plugs into the fuselages of existing C-141A aircraft, increasing their volume by one-third, resulting in a 25 to 30 percent increase in the effective throughput of oversize equipment (\$550 million).¹
3. Increasing spares, maintenance resources, and crew ratios sufficiently to support a 25 percent increase in the utilization rate of both C-141A (oversize) and C-5A (outsized) aircraft (\$1,250 million ten-year cost).²

(U) In addition to these three basic enhancement options, the Air Force is planning to acquire at least 41 UE advanced tanker cargo

¹(U) The program costs of \$676 million are reduced here by \$126 million, representing our estimate of the cost for refueling and aerodynamic cleanup portions of the program.

²(U) A shorthand designation, the *increased UTE rate*, is used hereafter; it could be carried out separately on either the C-141A (\$780 million) or C-5A (\$470 million).

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aircraft (ATCA, modified 747 or DC-10 aircraft) at a cost of \$3.1 billion. They would operate chiefly as tankers but optionally as transports with a limited oversize cargo capability. Another \$1.3 billion program has been used for wing rebuilding to extend the service life of the C-5A. Although, strictly defined, that is not an airlift enhancement measure, it is generally considered to be an element of the composite program and will, in all, cost more than \$6 billion.

(U) Table S-1 presents values of the measure of merit for the three basic enhancement options (the Air Force's requested program, except for increased C-5A utilization rates), each considered *individually* as an add-on to the base capability and then summed to show their collective effect.

(S) Table S-1

INDIVIDUAL CONTRIBUTION OF EACH ENHANCEMENT OPTION TO DEPLOYMENT OF FY 1982 ARMY (U)

Case Description	Closure Days	Closure Decrease (Δ)	Cost (\$ million)	Cost (\$ million/ Δ day)
Base case: organic force	121	--	--	--
Add CRAF (38 required)	93	28	425 ^a	15.2
(or)				
Add C-141 stretch	107	14	550	39.3
(or)				
Add increased UTE rate on C-141A	107	14	780	55.7
Add all three options (13 CRAF required)	93	28	1,755 ^a	62.7

^aOnly 1/2 of CRAF program costs included because of limited numbers required.

(S) Several points are clarified by the table. First, deployment of the FY 1982 Army is heavily outsize-constrained; only 38

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oversize-capable CRAF mods¹ need to be added to the existing C-141As (oversize) to balance the outsize capacity of the C-5As, which thereafter constrains the time of deployment to a minimum of 93 days. Using more than 38 CRAF would not contribute to more rapid deployment, given Army unit integrity constraints; at best they would provide additional capacity to move the Air Force equipment somewhat more rapidly, enhance resupply capacity, or provide more flexibility to airlift schedulers. Second, of the several oversize enhancements available, CRAF mods are clearly the cost-effective choice. They produce more rapid closure than either C-141A enhancement option, and they do so more cheaply by a factor of 3 to 4. Third, the last line of the table shows that exercising the less cost-effective C-141A options does not promote more rapid closure, it merely results in the displacement of CRAF mods. If the C-141A enhancements are undertaken, only 13 (rather than 38) CRAF mods are required to maintain unit integrity. Finally, although not displayed in the table, an ATCA used in a cargo-carrying mode would add additional, redundant, oversize capacity. Should the chosen ATCA be a 747 (rather than a DC-10), its capability would essentially equate to that of the CRAF mods, so that the 41-UE planned ATCA buy, if used in the cargo mode, would itself provide more than enough oversize capacity to balance available outsize capacity. Given its estimated costs, the acquisition of ATCA as an oversize cargo carrier would be less cost-effective than any of the other options.

(S) Table S-2 displays the outcome for two cases in which it is assumed that the UTE rate increase has been effective for the C-5A (the only planned outsize capacity augmentation), uncreasing capacity by some 25 percent. Closure of the force is now more rapid than for any of the cases in Table S-1 because outsize equipment is always the constraining factor. The CRAF mods program alone can still provide all the needed oversize to balance the enhanced outsize lift and still represent the cost-effective solution, again by a substantial margin. The net effect of buying 110 CRAF mods, the C-141A stretch and UTE rate

¹(U) Notional CRAF mods containing both the "mini-mod" nose door and the "full-mod" strengthened floor are assumed. In this report, they are called "maxi-mods."

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increase, and a cargo-mode ATCA would be to create a grossly redundant oversize capability for deployments by air, given the limited capacity of the present C-5A force even with the UTE-rate increment.

(S) Table S-2

CONTRIBUTION OF ENHANCEMENTS INCLUDING INCREASED C-5A UTE RATE TO DEPLOYMENT OF FY 1982 ARMY (U)

Case Description	Closure Days	Closure Decrease (Δ)	Cost (\$ million)	Cost (\$ million/ Δ day)
Base case	121			
70 UE C-5A with Δ UTE; 234 UE C-141 with stretch and Δ UTE; CRAF (33 required)	72	49	2,225 ^a	45.4
70 UE C-5A with Δ UTE; 234 UE C-141A; CRAF (60 required)	72	49	1,320 ^b	26.9

^aIncludes 1/2 of CRAF program (42 aircraft) costs.

^bIncludes full CRAF program (85 aircraft) costs.

ARE CLOSURE RATES ADEQUATE?

(S) None of the combinations of options thus far considered can close the eight division force at a rate anywhere near a division a week. Moreover, since the 1982 Army modeled here is a not unreasonable representation of those forces to be stationed in the United States (without prepositioned equipment in theater) and designed for early reinforcement of NATO's fighting strength, it is likely that the desired closure time for those forces would be within 30 days of the outbreak of hostilities (D+30, in military terminology). Conventional scenarios assume that actual conflict will be preceded by a period of warning and mobilization and that U.S. and NATO mobilization will begin about a week after mobilization by Warsaw Pact forces begins. However, if the 93 (or 72) day minimum closure times shown in the preceding tables are taken at face value, closure by D+30 would imply that 63 (or 42) days will

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be available for U.S. mobilization in advance of hostilities. The arithmetic thus implies that Pact mobilization will continue for seven to ten weeks before an attack. These implied scenarios are somewhat less than credible; mobilization as extensive as that would imply a massive Warsaw Pact buildup, including substantial reinforcement from the Western Military District of the Soviet Union. In that case, U.S. mobilization and reinforcement aims would no doubt be much larger than the eight divisions analyzed here. Moreover, such long periods of mobilization would provide reasonably adequate time for sealift to be organized and functioning, so that neither the size nor the mix of airlift capabilities need be of great concern.

(S) Closure times for the 1982 Army--without reliance on sealift--can be decreased only through some combination of stationing more forces in NATO, prepositioning more unit equipment, and adding airlift capacity (especially outsize capacity). Increasing the number of U.S. units in Europe runs against the grain of many current trends: Mutual Balanced Force Reduction talks aimed at reducing stationed forces, the costs and foreign exchange drain of stationed forces, and the current Congressional and general public attitudes (to mention only three). Additional prepositioning of complete combat unit equipment sets in quantities greater than are currently programmed for the 1982 Army is probably infeasible before 1982. There are significant shortfalls of major combat items of equipment in the present prepositioned stocks and, in the interim, realization of the "1982 Army" by 1982 implies the production of divisional equipment to outfit the three new Abrams Army divisions, to upgrade two divisions from infantry to mechanized status, and to preposition the full unit equipment for one more mechanized division--in addition to making up the current shortfalls of prepositioned stocks.

(S) The production task is so large that it may not be possible even as planned. An earlier phase of this study indicated that replenishing currently prepositioned equipment from stocks in this country would completely occupy the present airlift force for some 30-40 days. Closure times for the Army would be correspondingly lengthened if such shortfalls still existed in 1982.

(S) A further problem for reduced deployment times is in 1982

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the Air Force plans to being the serial modification of C-5As to correct the wing fatigue problem. At any time from 1983 through 1986, 12 C-5A aircraft will be in modification, which implies a maximum available UE of 58 C-5As. If the planned 25 percent increase in C-5A capacity provided by an increased UTE rate affects only the *then-available* C-5As, the aggregate capability will be about that of 70 UE C-5As operating without the increased UTE rate. At least for the 1983-86 time period, deployment of the 1982 Army by air is more likely to require 93 than 72 days, *if* prepositioning shortages are eliminated.

MORE RAPID DEPLOYMENT BY AIR

(U) There is increasing concern about a class of NATO-Warsaw Pact confrontations involving short mobilization times and initial conflict using largely in-place forces. "Sudden attack" and "short warning attack" are two widely used generic descriptors of this scenario. "Short warning" attack cases obviously impose stringent requirements on deployment rates and strategic airlift capabilities. For such cases, the *prompt* availability of substantial sealift is doubtful, whatever sealift is immediately available would hardly be able to make a successful transit before hostilities begin, and few convoys are likely to arrive during the first 30 days after fighting begins. Clearly, this scenario puts a premium on capabilities for rapid, balanced deployment by air.

(U) Only a substantial augmentation of airlift capabilities, both outsize and oversize, can offer the prospect of meeting the stringent closure requirements inherent in "short warning" scenarios. Table S-3 summarizes the outcomes for forces containing nominally twice the current outsize capacity plus substantial CRAF modification programs, in conjunction with the current C-141A force.

(S) The various airlift forces identified in the table could in principle close the eight division force by D+30, given mobilization times no longer than 11-21 days prior to the outbreak of hostilities. In addition, given only 3-10 days of mobilization, by D+30 they can close all but the last two divisions (an airmobile and an airborne division) and their two collocated reserve brigades. Since those units

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(S) Table S-3

DEPLOYMENT OUTCOMES FOR "DOUBLE THE OUTSIZE" PLUS CRAF--1982 ARMY AS PLANNED (U)

Description	Days to Closure	
	Without Δ UTE on C-5s	With Δ UTE on C-5s
140 C-5; 234 C-141A; 85 CRAF	51	46
140 C-5; 234 C-141A; 100 CRAF ¹	48	43
140 C-5; 234 C-141A; 115 CRAF	45	41

are less suited than others to deal with heavily armored Warsaw Pact forces, this slippage of closure may be tolerable. In any event, initial dependence on sealift would be significantly lessened.

(U) The more rapid closure times require a large number of CRAF mods;¹ thus far U.S. airlines have offered only 85 of their 747s; the original program objective was to enroll 100. Acquiring as many as 115 CRAF mods would probably require participation in the modification program by our NATO allies, whose civil air fleets include more than enough 747s to make up the difference. Alternatively, if the ATCA is procured in its currently envisioned oversize-only configuration, some part of the deficit could be made up by using it in the cargo rather than the tanker mode.

(U) In the near term, the only way to obtain additional oversize capacity equivalent to 70 more C-5As is to purchase some major modification derivative of the 747 or the C-5. Either represents a one-for-one C-5 equivalent.² If the oversize-capable derivative also had a refueling capability, the tanker part of the ATCA role could be

¹(U) All assumed in the analysis to be Boeing 747 maxi-mods; there are currently about 16 747s in service with U.S. airlines that are freighter or cargo-capable modifications.

²(U) The Air Force has estimated the cost of an oversize-capacity ATCA at \$65 million apiece (in then-year dollars).

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partially satisfied, and the resulting equal-cost force would more nearly approximate the balance of outsize and oversize capabilities necessary for deployment without sealift than would the Air Force's requested force.

(U) Both 747 and C-5 derivatives have advantages and disadvantages. The 747 has better range, payload, spares availability, and maintainability characteristics than the C-5, but its low-wing design makes it less flexible in loading and unloading. The cockpit would have to be raised to accommodate an outsize-capable door and increased vertical clearance near the nose, and even then the loading "cube" would be less flexible than that of the C-5A.

(S) Although the rapid modification and introduction of either a 747 or C-5 derivative conceivably provides a near-term solution to the outsize problem, without a risky concurrent development and production program additional capacity enhancement before about 1984 is doubtful. "Double the outsize" could be available by about 1987 if the program began by 1979, if aircraft were produced at a rate of two per month, and if no major problems developed. In view of the scheduled drawdown of available C-5A aircraft between 1982 and 1986, a critical shortfall of airlift deployment capacity seems likely during that period.

(U) An alternative to modifying a 1960s technology aircraft is to design a new, larger, and more efficient transport that would offer lower life-cycle costs and major improvements in engines, structures, and aerodynamics. A civil development that could also be used for military airlift is unlikely to be economically feasible before the 1990s unless heavily subsidized by the federal government. But if a new outsize aircraft with both civil and military uses should be developed, it might be available as a replacement for the C-5As when they begin to reach the end of their economically useful life toward the end of this century.

(U) The 1982-86 outsize shortfall and the prospective emergence in the 1990s of a new-technology cargo aircraft together raise questions about the remaining life of the C-5A and options for extending that life

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and their costs. The service life limit for the C-5A aircraft is set by the Air Force at 8,000 fatigue equivalent flight hours (based on 1974 aircraft configuration and 1973 operational use). As of 1976, the fleet average accumulation was about 4,000 hours, or nearly halfway to the limit in only about five calendar years of operation. The original design goal was 30,000 flight hours of more severe operational use than that of 1973, which reflected some limits on current operations to conserve remaining life. The structural deficiencies of the wing and the development of the original Option H plan (requiring the replacement of the lower surface panels in some of the wing boxes), which was approved by the Secretary of the Air Force in 1973. Option H has evolved to include the full replacement of all of the wing boxes, an expedient intended to ensure that the wing would be capable of sustaining 30,000 flying hours in severe use. The 1973 Middle East war, the subsequent oil embargo, and the eventual quadrupling of the price of aviation fuel brought on reductions in peacetime use of all Air Force aircraft, especially of large aircraft. Although the original plan for the C-5A envisioned flying each aircraft about 1,800 hours per year on the average (the 30,000-hour design life corresponds to about 17 calendar years of service), MAC's current peacetime operating plans envision about 700 hours per year on the average¹ to maintain 4.0 flight crews per UE. Thus, if Option H restores no more than 22,000 additional flying hours (to bring total use to 30,000 hours), MAC's planned UTE rate implies retention of the C-5A in the active inventory at least until the decade 2010-2020 (assuming no extra utilization for contingencies). If, as expected based on current use, the wing will provide more than 30,000 equivalent additional hours, the notional retention date would be further extended.² Such a long period of use might be reasonable if the C-5A were economical to operate and maintain and not

¹After the wing modification, MAC expects an average UTE rate of 2.13 hr/day (360 day year) for each of the 70 UE aircraft. This is equivalent to 697 hr/yr/aircraft based on all 77 aircraft.

²However, at some point, a high-cost modification/maintenance program would presumably be required to control corrosion and fatigue in other structural areas.

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subject to technological obsolescence. If that is not the case, the Air Force could usefully review the 1973 decision that a service life of 30,000 hours should remain the design goal for fixes to the C-5A wing. Option H represents a high-confidence but expensive way to meet this design goal. Lesser options involving more modest structural modifications and extending present constraints on operational use conceivably could extend the service life of the C-5A through the balance of this century for significantly less than Option H will cost, and could avoid the critical reduction of outsize capacity during 1983-86.

Assessments of airframe fatigue problems of the C-5A and other Air Force aircraft are currently being performed using crack growth calculations based on the scientific theories of fracture mechanics. Until recently, service use limitations had been established by the wholly empirical correlations that underlie the classical fatigue methods. The advantage of the fracture mechanics approach is that, in addition to estimates of time to failure, it provides a rational theoretical basis for the assessment of the critical crack length at which an element will fail. Both approaches rely on test data to assess the validity of the assumptions and procedures that are followed in any given application. However, it is agreed that the calculated 8000-hour safe service life is as yet subject to considerable uncertainty and that empirical evidence accumulated to date is insufficient to confirm or refute the precision of that calculation.¹ Nor are data available to support confident estimates of the benefits and costs of lesser modifications.

Increases of several thousand hours in the service limit can extend the average service life of the C-5A force at least into the 1990s. The effects of various service life extensions are shown in Fig. 3.1, which relates utilization rates and peacetime operational limitations of differing stringencies to the calendar time to which the forcewide average service life could be extended (without further

¹One question about the forthcoming fatigue problems with the current C-5A wing is whether it is possible to wait for the appearance of cracks in service aircraft (e.g., reinstitute higher UTE rates for the lead-the-force aircraft) before making the final commitment to modification.

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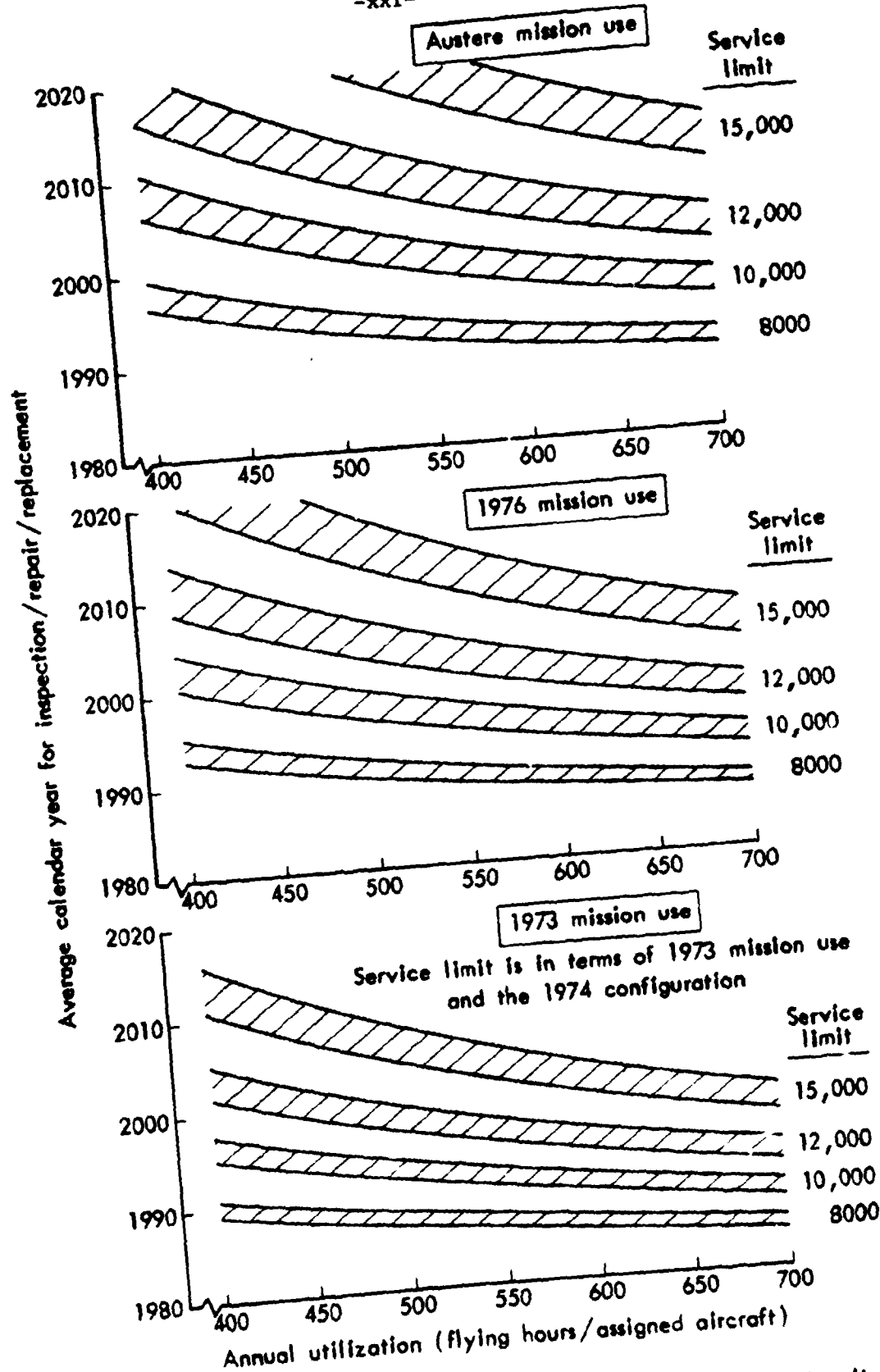


Fig. S.1 — Sensitivity of calendar year service to mission use, service limit, ALDCS life extension effectiveness (shaded area) and annual utilization

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modification). Because the C-5A could become technically or economically obsolete by the turn of the century, an immediate effort is warranted to determine how it might be made to last that long without the expense of Option H modifications. Technical activities and empirical testing to that end can and should be undertaken over the next year or two. The results would permit more confident assessment of service life limits and lesser cost modification alternatives. Promising initiatives encompass (1) resolution of the effectiveness of the active lift distribution control system (ALDCS) in reducing stress at critical locations, (2) tests to determine the initial flaw distributions, (3) reassessment of the onset of general area cracking and verification of the operational stress experience, (4) adjacent panel residual strength tests, and (5) evaluation of the need for additional full-scale fatigue testing. A desirable first step is the formation of a new high-level review group to develop detailed test plans, evaluate new information, and provide alternative sources of action to top-level Air Force decisionmakers.

Two alternatives--no modification and Option H--represent the end points of a spectrum of service life management actions for the C-5A. If some greater life extension were required than might be obtained through austere use of the remaining service life in the current C-5A force, or if an extended period of such austere use were deemed infeasible, at least two other options might provide lesser service life extensions than Option H but at much lower cost. A modest fastener change program might provide several thousand more hours at one-fourth to one-fifth the cost of Option H (if disassembly of the wing boxes can be avoided), and a rework of the current configuration of the wing could more than double the present service life estimate at a cost lower than that of Option H. Both modifications would extend service life into the next century, even with 1973 operational use and an increased UTE rate, with a margin for contingency or wartime use. Evaluation of the fastener change option is urgent; to be effective it may have to be undertaken before the 8000-hour point occurs.

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OPTIONS, STRATEGIES, AND HARD CHOICES

Section VI compares the Air Force's current programs with a sequential decisionmaking strategy designed to minimize the cost of moving to a future balanced capability. The most serious problems with the current enhancement program are:

- o The major commitment to oversize capacity expansion of airlift forces will leave deployment capabilities strongly dependent on the timely availability of reliable sealift for the foreseeable future;
- o A severe future shortfall of outside capacity will develop, relative to available oversize, under *any* scenario that requires rapid deployment of ground forces entirely by air;
- o The earliest expenditures are invested in the least cost-effective oversize enhancement options--the C-141A stretch and increased UTE rate;
- o The prospective near-term expenditure of some \$6 billion for the C-141A stretch, the UTE rate increase, CRAP mods, ATCA, and the C-5A Option H may limit or foreclose additional funding to acquire the needed outside capacity increase;
- o A commitment to Option H mod for either part or all of the C-5A force may not be necessary if additional test and analysis confirm that:
 1. The C-5A's service life can be made to extend to the 1990s at minimal cost, or
 2. Other, lower-cost options could lead to further extension if necessary.

THE INCREMENTAL DECISION STRATEGY

The objectives of an incremental approach are to trade time for money, proceeding only with clearly indispensable programs, to use some of the withheld money to resolve crucial uncertainties, and to commit additional funds later to those programs that then appear most likely to provide enduring airlift enhancement.

There are few clearly indispensable programs at this point:

- o A CRAP modification program, with renewed emphasis on the maxi-mod;

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- o Continued, even accelerated, acquisition of the spares necessary to support at least the currently planned utilization rates of ten hr/day for the first 45 days and eight hr/day thereafter;
- o Early design of a fastener change modification along with increased technical analysis of the severity of the C-5A wing problem;
- o Continuation of the design, fabrication, and testing of Option H as planned, with no commitment to production;
- o A prompt start on a design competition, possibly including prototyping, to demonstrate the feasibility and technical capabilities of an outsize ATCA.

Table S-4 displays the principal cost implications of the two approaches. The upper portion of the table recapitulates the cost of the enhancements (other than the CRAF mod program) currently requested by the Air Force. The balance of the table sums up generously estimated notional allocations for the near-term actions and items identified as elements of the incremental decisionmaking process suggested above. It includes two potential follow-on programs, an outsize ATCA buy and a range of prospective C-5A fixes.

The base cost of CRAF mod programs remains uncertain. But as they are an element of both the Air Force request and the incremental strategy, Table S-4 includes an estimate of the incremental cost that might be incurred if only maxi-mods were ordered, rather than the mix of mini-mod and full-mod aircraft now contemplated. The estimated incremental cost is \$1 million per aircraft for a total of \$85 million. Similarly, the incremental strategy provides an allocation of \$100 million from the planned FY 1980-81 spares buy to support currently authorized utilization rates. The design of outsize ATCAs based on C-5A and 747 derivations is estimated to cost no more than \$500 million, adequate to provide for prototyping should that be judged necessary.

The lack of precision in such estimates and the incompleteness of the cost analysis limit the uses to which the table may be put. Nevertheless, it suggests that the incremental strategy does not necessarily lead to significantly higher outlays than the Air Force's currently requested programs, even with generous estimates of the costs of

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Table S-4

COST COMPARISONS OF AIR FORCE AND INCREMENTAL STRATEGIES

Program Description		Costs, \$ Millions			
<u>Air Force Requested Programs</u>					
C-141 stretch		550			
C-141 increased UTE rate		780			
C-5A increased UTE rate		470			
Option H kit production and installation		1,126			
ATCA	(41 UE)	<u>3,100</u>	(91 UE)	<u>5,900</u>	
Total:		6,026		8,826	
<u>Illustrative Incremental Strategy</u>					
CRAF maxi-mods incremental		85			
C-5A testing and option enhancement		100			
Spares to support 10/8 UTE		100			
Prototype outsize ATCA derivatives		500			
Acquisition 80 outsize ATCA (\$65 million per aircraft)		5,200			
Possible C-5A repairs (no mod)		0	(fastener change)	300	(Option H) 1,126
Total:		<u>5,985</u>		<u>6,285</u>	<u>7,111</u>

information enhancements to be undertaken in the interim. Proceeding with Air Force programs first and then embarking on a program to restore balanced airlift capabilities (by acquiring double the present outsize capacity) could nearly double the costs of either strategy.

In the NATO scenario, the principal role of the outsize ATCA would be to carry outsize equipment, not to refuel other airlifters. An outsize ATCA refueling a C-5A would produce some modest increase in C-5A utilization and in payload carried (preliminary calculations by the Air Force suggest an 8 to 24 percent improvement), but an outsize ATCA carrying outsize equipment accompanied by an unrefueled C-5A produces some two C-5 equivalents of throughput. The tanker capability of the ATCA is certain to have a high value for non-NATO contingencies

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that involve deployments of extended ranges with few (or no) enroute bases.

FUTURE CONSIDERATIONS AND FURTHER ANALYSES

Although uncertainties about the remaining life of the C-5A are of major importance in planning future airlift enhancements, they are by no means the only critical uncertainties that must be resolved. Other important points that could influence decisions about long-term airlift enhancement include:

- o Obtaining clearer OSD guidance on the primacy of airlift for early NATO reinforcement, on desired airlift capabilities, and on closure rates;
- o Evaluating the feasibility of an outsize version of ATCA and the interrelationships of tanker and airlift requirements in the post-1980 period;
- o Conducting detailed feasibility studies of potential capabilities, costs, and availabilities of both new and derivative outsize aircraft;
- o Undertaking more refined airlift enhancement studies over an extended time horizon, using appropriate assumptions about escalation, and discounting and comparing "balanced" capabilities over time;
- o Exploring with the Army ways to reduce both outsize and oversize equipment lists, thus moderating NATO contingency airlift requirements;
- o Evaluating with the Army the feasibility of *partial prepositioning*--prepositioning high-weight but low-cost items--duplicating only less-expensive items but reducing the initial demands on airlift.

Several issues that can influence CRAF mod program decisions could be resolved in the next two years or so:

- o Completion of the prototype mods and tests of their compatibility in loading Army oversize items to better understand loading, unloading, and handling problems;

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- o A more concerted Air Force effort to upgrade some of the airlines' offers of 747s from mini-mod to maxi-mod;
- o Efforts by DoD to insure participation of our NATO partners in the CRAF mod program;
- o Consideration of a legislative mandate to incorporate maxi-mod CRAF capabilities in all new Boeing 747 aircraft at the time of manufacture.

In the same time frame, several uncertainties about the C-141A stretch program should be resolved:

- o Clarification of uncertainties about the remaining service life of the stretched aircraft;
- o More careful assessment of the benefits foreclosed by the stretch;
- o Operation of the prototype to discover the effect of the stretch on aircraft performance.

A number of conditions precedent to future higher crew ratios can also be satisfied in the interim:

- o Congressional authorization for the acquisition of the additional spares needed to support higher surge rates is needed before more crews can be utilized;
- o A detailed analysis of what factors first constrain the C-5A surge capability can be conducted;
- o Allowable and probable maximum wartime flying hours for transport crews can be reviewed.

In conjunction with the resolution of uncertainties about the C-5A, the initiatives enumerated above would place the Air Force in a position to present to Congress a coherent program for the acquisition of balanced airlift forces. The dominant question remains: What mix of organic transport aircraft as additions to an indispensable widebody CRAF mod program must the Air Force have by the late 1980s to achieve the objective of early, rapid reinforcement of NATO? The key factor is that outsize-capable aircraft can always help move an excess of oversize

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equipment, but oversize-capable aircraft cannot transport an excess of outsize equipment.

THE FUNDAMENTAL ISSUE FOR STRATEGIC MOBILITY DECISIONMAKING

The above array of unanswered technical and operational questions is impressive; but for most, their resolution would only refine program decisions. The issue for policymakers is: Should the United States reduce the long-term critical dependence on sealift to deploy the Army, or should efforts be concentrated on making larger amounts of more capable sealift available much earlier than at present?

Current defense guidance and proposed programs do not address this issue; rather, they are a patchwork of improvements at the margin in both sealift and airlift. Moreover, the lack of policy focus leads to a lack of funding authorizations adequate to carry out either approach effectively. An emphasis on sealift would require many more vessels, better suited to rapid loading and transport of Army cargo, on immediate standby availability; more robust defense of both convoys and ports would also have to be provided. Airlift enhancements would be of low priority, given more reliable and timely sealift in quantity. Alternatively, a policy emphasis on airlift would require somewhat more oversize, for which redundant programs are proposed, and a lot more outsize capacity, for which no efforts are under way. Sealift would require little augmentation effort, since it is adequate to handle resupply tasks and contribute to later stages of extensive deployments.

Given that much of the problem of conventional defense of NATO is attributable to insufficient prior investment in combat equipment, the need for rapid and timely reinforcement is not likely to vanish, and the costs of stiffening NATO defenses will be substantial. It is doubtful that, in addition to those expenditures, the United States can afford to pursue adequate and timely reinforcement capabilities both by air and by sea. That course runs the risk of achieving only partial success in both areas, the sum of which would not enhance our confidence in our ability to conduct timely reinforcement.

The direction of the Air Force's current program implies a decision to rely on sealift. Oversize enhancements alone do little to

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reduce the current critical U.S. dependence on timely availability of sealift. At the logical extreme, even if *all* of the Army's oversize equipment could be deployed by air, the Army's oversize equipment--much of which constitutes the heavy firepower of maneuver units--could only be deployed slowly, at first limited by the available oversize airlift, and in larger quantities only after several weeks have elapsed, as sealift begins to arrive. But is "several weeks" timely enough?

No compelling case can be made for exercising all the oversize enhancement options while reserving judgment on how much and what kind of oversize aircraft to acquire when. The CRAF mod program alone provides more than sufficient oversize capacity to balance the available C-5A lift. More oversize than that simply runs up the ultimate airlift enhancement bill without mitigating all-airlift deployment problems, even in the short run.

A prompt start on oversize aircraft augmentation can set in motion the development of a future deployment capability that at least can significantly reduce the dependence on sealift for deployment of Army equipment and may substantially increase the rate of deployment of combat units in the critical early weeks of an unfolding crisis. If the objective is to reduce U.S. dependence on the timeliness of sealift, a lot more oversize airlift capacity is needed, even though the total increment cannot yet be defined precisely. Before making the current program decisions, the Department of Defense should decide whether to continue reliance on sealift or to begin an oversize aircraft augmentation.

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ACKNOWLEDGMENTS

The preparation of a report of this complexity and length inevitably involves the support of many more individuals than the listed authors. D. M. Landi and F. J. Morgan assisted in updating and integrating the results of earlier Rand airlift analysis; W. L. Stanley, P. K. Dey, K. Bloomberg, G. M. Burkholz, and D. Dreyfuss performed many of the technical calculations and prepared many of the figures, tables, and graphs in the appendixes. Helpful comments on portions of the analysis and earlier partial drafts were provided by W. T. Mikolowsky, J. R. Rice, B. Lambeth, D. Palmer, and L. Kaechele. Of course, errors of fact and interpretation are the responsibility of the authors.

Many support people at Rand have had a hand in the preparation of this report and earlier drafts; those whose tireless contributions cannot go unremarked are S. M. Birch, J. Houston, L. L. Moorhous, J. Pederson, and H. B. Turin.

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I. BACKGROUND: THE ELEMENTS OF THE PROBLEM

In the late months of 1973, motivated by the need to improve the responsiveness of general purpose forces, the Department of Defense undertook a review of the adequacy of U.S. strategic mobility forces.¹ At issue was the ability of the United States to transport war materiel and, if necessary, combat units quickly and on short notice from the United States to Europe or other areas of the world where vital U.S. interests might be at stake. For several years the defense community and the Congress have reviewed and debated extensively whether to enhance military airlift capabilities and if so, how.

Recent proposals for acquiring additional airlift capability have been addressed during periods of rapid inflation and deepening world recession that together have generated intense budgetary pressures on the United States and its allies. During much of that time, large and complex issues and events independent of the abstract requirements for strategic mobility have tended to both stimulate and obscure consideration of airlift enhancement policies. Political and economic considerations, as well as military requirements, have influenced arguments for and against additional airlift capabilities of various kinds. Some of the issues are of immediate concern, others may not influence events until the mid-1980s. Several involve highly technical matters or have large budgetary implications. Many are tied to major uncertainties of U.S. foreign policy. Studies, testimony, and related literature are so voluminous that it is not feasible to attempt a complete review here. Instead, this report focuses on those strategic mobility factors and decisions that are most directly under the control or influence of the Air Force.

ORGANIZATION OF THIS REPORT

Airlift enhancement is a complex subject, and those complexities

¹"Strategic" mobility forces are those assets designed for inter-theater (intercontinental) movement of forces, as distinct from "tactical" mobility forces for use within a theater, and in or near the combat zone.

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are increased by the number of options potentially available, by the necessity to look at the effect of short-run decisions on long-term capabilities, and by the extent of the uncertainty that surrounds a number of key parameters.

This report proceeds from simple analysis in which uncertainties are modest, to more complex analysis in which it is necessary to consider the effects of decisions that may later turn out to be wrong. The first section addresses the role of strategic mobility in defense planning and the role of airlift in strategic mobility. The discussion also considers certain simplifying assumptions and caveats in the context of national security planning.¹

Section II considers the question, "How much airlift is enough?" It describes, without supporting rationale, those explicit assumptions on which the capability and cost-effectiveness calculations presented in Sec. III are based. One result of these calculations is to highlight the critical deficiency of aircraft capable of hauling the largest and heaviest ("outsize") items of Army unit equipment, a deficiency made the more pressing by the well-known service-life problems of the C-5A, the only aircraft currently able to handle outsize equipment. Section IV briefly evaluates the options for increasing the numbers of aircraft capable of hauling outsize equipment, since that capacity may be the bottleneck in terms of smooth deployment of the Army by air.

Section V is devoted to the question of how much longer the present C-5A can be expected to last, what can be done to husband that remaining life, and what kinds of fixes are available to extend the life of this unique asset. The emphasis is mostly on the uncertainties in what is known about the problems, and on steps that could be taken to reduce these uncertainties, thereby increasing confidence in program decisions.

These findings and a number of other constraints limiting airlift capabilities are then combined in Sec. VI to construct alternative strategies for improving airlift capabilities over time, with emphasis

¹One of the most important assumptions--supported by earlier Rand studies--is that a sealift alternative to reliance on airlift for *early reinforcement of NATO* may not be wholly credible. That rationale and its implications are extensively considered hereafter.

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on the development of enhancement options that have enduring value and with regard for the uncertainties that cannot be resolved in the short run.

Quantitative assessments of the adequacy of strategic mobility ultimately depend on assumptions about scenarios, relationships between inventories and capabilities, and basic requirements. Differing assumptions about the availability and effectiveness of sealift, or about prepositioning equipment, for example, can lead to completely different conclusions about the requirements for, adequacy of, and costs of strategic mobility. The use of a NATO crisis as a proxy for a "most demanding" set of requirements, the use of a per-day cost of closure improvement as a cost-effectiveness measure, and total reliance on airlift for transport of ready forces (as have been done here) provide means for adjusting to changes in assumptions that may result from an evaluation of other scenarios. In the end, all analyses of strategic mobility capabilities, requirements, and costs hinge critically on *how much of what equipment goes by air, and on how quickly it must arrive.*

Finally, the flexibility of scenario assumptions and the considerable sensitivity of analyses of these kinds to changes in data or premises make necessary specification of a firm baseline for substantive evaluations. This report reflects the state of the world--particularly in terms of program plans, decisions, and cost estimates--as of late 1976. Subsequent changes during the preparation of the report have been noted mostly by way of footnotes.

THE ROLE OF STRATEGIC MOBILITY IN NATIONAL SECURITY

U.S. military forces, acting in conjunction with the forces of our allies, are designed, procured, and postured so as to deter a broad spectrum of hostile actions by other powers. The range extends from massive strategic nuclear attack to small-scale military actions by proxy forces and third powers. But no other contingency in which U.S. nonnuclear forces might be expected to play a major role so dominates force requirements and reaction times as the case of massive conventional warfare in the Central Front region of Europe.

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Although this is by no means the only important contingency, or in all respects the most demanding,¹ it is the scenario addressed here. Analysts recognize that "once we have established our baseline requirements, we should test their adequacy against a number of 'off-design' cases to see whether what can lick the cat can also lick the kitten."² We do not address that here; our focus is on NATO reinforcement throughout.

The near-term eruption of a Central Front crisis may seem unlikely, but that assessment stems partly from the outcomes of earlier efforts to enhance the strength and credibility of NATO's conventional deterrent. There have been continuing efforts to improve the responsiveness of U.S. and NATO forces for several years. The United States is upgrading readiness and force support potential to increase the early combat effectiveness of the 300,000 troops now stationed in the Central Front region of NATO.³

The ready forces likely to be committed by both sides in the critical Central Front region of NATO are currently judged to be pretty well in balance.⁴ Defense planners are confident that NATO would be capable of a stout initial defense against a major attack by mobilized Warsaw Pact forces. Such judgments raise questions about the ability of the Warsaw Pact to more quickly concentrate the forces needed to launch and sustain an attack without massive early mobilization. Warsaw Pact forces enjoy the advantage of multiple and redundant interior land lines of supply, and the Soviets can mass ready armies and assemble reserves quickly; comparable U.S. augmentation forces must cross an ocean before concentrating to support European NATO members charged with buttressing their own segments of the front. These realities, which apply to most other conceivable contingencies involving U.S. conventional forces,

¹The 1973 Middle East war reemphasized the difficulties of deployment at extended ranges without the use of intermediate bases; as a result, however, plans and actions are now under way to improve the in-flight refueling capability of strategic airlift aircraft.

²Annual Defense Department Report, FY 1975, p. 85.

³In response to the Jackson-Nunn Amendment of 1975.

⁴Annual Defense Department Report, FY 1978, p. 86.

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generate a significant U.S. requirement for strategic mobility in general, and airlift in particular.

(U) If U.S. planning contingencies did not have to take into account a major crisis in the Pacific area, some of the Central Front deficiencies could be overcome by stationing more of the existing U.S. forces in Europe. However, this ignores the difficulties NATO faces in attempting to meet possible Soviet confrontations on either the North or South flank of NATO, the economic effect of U.S. forces stationed abroad, and the potential constraints of Mutual Balanced Force Reductions (MBFR) negotiations. Given such constraints, American defense plans call for rapid mobilization and deployment of active U.S. forces and selected reserve elements in time of crisis. If the crisis or war were to last sufficiently long, mobilization would include virtually all reserve and guard units and, following reinstitution of the draft, would ultimately extend to the formation of completely new units. However, in terms of early fighting strength, only existing forces in a high degree of readiness are likely to be able to contribute to crisis resolution, and then only if units and their equipment can be rapidly transported to the scene of the crisis.

(C) The state of readiness of active Army units and selected high readiness reserve components will not be examined in detail in this study, but it is generally acknowledged that there are serious shortages in both equipment and munitions stockpiles.¹ Current production rates can rectify these shortages only over a period of years. Of related importance is the current DoD proposal, now being reviewed by Congress, to increase the authorized division strength of the Army from approximately 13 divisions to approximately 16 divisions.² That enlargement is to be provided without increasing authorized Army manning levels, by trading headquarters and support jobs for combat jobs, as is now being done with U.S. forces in NATO. These new units will have to be equipped,

¹(U) See, e.g., GAO Report LCD-76-441, *Continuing Problems with U.S. Military Equipment Prepositioned in Europe* (U), July 12, 1976 (Secret).

²(U) See Annual Defense Department Report, FY 1976 and 77, pp. III-14, 16, III-39, 43.

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an upgrading phase that will extend at least through the remainder of this decade.

NATO: THE REQUIREMENT

(S) Because NATO is principally oriented toward defense, it follows that mobilization and efforts to augment emplaced forces would commence only upon receipt of unambiguous information that Warsaw Pact forces were mobilizing or concentrating, which would imply preparations for attack. The underlying presumption is that NATO governments would receive credible information about the nature and extent of Pact mobilization a few days after the start of preparations but well in advance of an actual attack. A political decision to mobilize NATO resources would presumably follow as a matter of course. NATO defense planning assumptions traditionally have assumed a time lag of about a week following the beginning of Pact mobilization before NATO mobilization efforts would be started and that NATO's mobilization period before hostilities would last for 23 days.¹

(U) NATO's strategy (in brief) is to avoid major losses of territory in the early days of a war. That is a particularly challenging mode of defense, compared with the classic defensive strategy of trading territory for time while wearing down advancing forces and mobilizing and deploying additional forces for later counterattack and recapture of lost territory. An effective forward defense strategy severely tests the ability of the defending forces to mobilize at rates roughly equal to those of the attackers. It is largely because of the desire of NATO governments *not* to trade territory for time that mobilization and deployment of forces has become so critical. The forward-defense strategy also drives the requirement that combat-ready U.S. forces stationed at home be capable of reaching the European theater on extremely short notice.²

¹(S) A JCS study recently performed at the request of the Congress reportedly examined a 14/7 scenario, rather than this traditional 30/23. There is also much concern for and analysis of lesser-warning cases within the defense establishment--"sudden attack" scenarios, as they are known--that focus on warning times of only a few days.

²(U) Recent negotiations on MBFR have highlighted these deficiencies. Reducing forces in place will unavoidably result in a

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Given such assumptions, airlift must serve as the principal mode of reinforcement for NATO, although sealift would be called up in any extended conflict or crisis to transport most of the replacement equipment, munitions, stocks, and other resources that modern armies consume in such great quantities.

THE ROLE OF STRATEGIC AIRLIFT

In the event of a major war or confrontation in Europe, the greatest demands on strategic airlift would occur during the first six to eight weeks, particularly if only a brief period were available to NATO for mobilization. Deploying available U.S. forces to Europe entirely by air would be a massive operation of unprecedented scope; deploying U.S. forces by sea would expose them to a substantial Soviet submarine threat in the Atlantic, which may involve unacceptable risks. Although it is clear that the earliest U.S. reinforcements must be deployed by air, airlift alone could not support a major, continuing European conflict. Within weeks, the amount of supplies and ammunition needed to sustain U.S. forces would cause a significant portion of the airlift force to be diverted from deployment to resupply. Therefore, U.S. strategic mobility must rely on a combination of preconflict stockpiling of equipment and consumables on the European continent, airlift, and sealift. During the time-consuming process of assembling the first convoys, initial deployments would have to be carried out by air, and both theater forces and those deployed by air would have to draw on prepositioned stockpiles of supplies and ammunition. Once secure sea lines of communication are established, the principal role of airlift would change largely to resupplying high-value items and satisfying emergency needs. Sealift assumes the vast task of sustaining forces in the theater, deploying follow-on reinforcements (reserve divisions) and rebuilding emergency stockpiles on the continent.¹ Two main factors, then,

situation where the course of the conflict is dependent on the rates at which the two sides are able to reinforce.

¹Indeed, preliminary analysis of the resupply problem reinforces the crucial role of early sealift once combat begins; the much larger and more rapidly delivered ground forces generate much higher early resupply requirements than envisioned in older plans tied to 90 to 180 day deployments.

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determine the overall military requirement for strategic airlift: the minimum acceptable deployment rate for U.S. ground forces, especially during the important early period of mobilization, and the length of time required to begin effective deliveries by sea.

SEALIFT

During the past ten years, U.S. sealift assets have dwindled markedly, both in quantity and in suitability for transporting the unit equipment of deploying ground forces. Although some steps have been taken in recent years to improve sealift capability, the general decline is likely to continue into the early 1980s.¹ Moreover, the nature of the decline has had and will continue to have its greatest effect on the appropriateness and availability of shipping during the earliest phase of mobilization, when deployment of combat forces is of paramount concern.

The only immediate sealift capability available to the Department of Defense is in the Military Sealift Command's "nucleus fleet" consisting of ships that are either owned by or under direct charter to the government. Its capabilities have been depicted in these terms:

In the late 1970s the Military Sealift Command Force is expected to consist of only two Roll On/Roll Off cargo ships and eight tankers, plus three cargo ships and ten tankers on controlled fleet charter.... Since the capability of the DoD controlled sealift will probably be insufficient to support even a minor contingency in a timely fashion some years hence, heavy reliance will have to be placed on the U.S. Merchant Marine and, in the case of a NATO conflict, on the commercial fleets of our NATO allies as well.²

¹The FY 1977 Annual Defense Department Report, pp. 206-207, proposed a sealift augmentation plan that would offset, to some extent, the worst aspects of the shipping shortage. The plan is aimed at making available by the early 1980s (on 10 days' notice) 30 ships from the National Defense Reserve Fleet (the "mothballed" fleet).

²Annual Defense Department Report, FY 1975, p. 165.

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Since 1965, the total number of ships in the U.S. Merchant Marine has shrunk by over 40 percent and, owing to the prospect of block obsolescence during the 1970s, is expected to continue to shrink. By 1980, the combined inventory of government-owned ships and the U.S. Merchant Marine will be able to carry less than half the material required by full mobilization for a NATO-Warsaw Pact conflict. Present U.S. plans include provision for use of as many as 300 NATO flag ships, but their early availability during mobilization remains uncertain.

Even given modernization of the U.S. Merchant Marine, the suitability of the fleet for accommodating the type of cargo involved in a military deployment will decline. To compete effectively in the open market, cargo vessels must be large, fast, automated, and for the most part designed for specialized cargos. In terms of dry cargo capability, modernization has involved the replacement of older, slower, general-purpose break-bulk ships by newer, faster container ships. During 1976, the U.S. flag fleet is expected to consist of about 300 dry cargo ships. Of these, some 40 percent are container ships, the majority of which require special berth facilities. Only about one-third of the ports serviced by noncontainerized vessels can accommodate the new, large, deep-draft ships.

Military equipment for deployment has never been designed for containerization, and as of 1975 there were no plans or preparations for enhancing containerization compatibility even for those items and cargos potentially able to fit into containers. Approximately 90 percent (by weight) of Army unit equipment is made up of tanks, other tracked and wheeled vehicles, and aircraft that are not self-deployable (mostly helicopters);¹ less than 25 percent of Army unit equipment is readily subject to containerization. In the near term then, only 60 percent of U.S. merchant ships would be capable of assisting with the deployment of ground forces, and most of those are from the older, smaller, and slower elements of the U.S. flag fleet. As modernization of the merchant fleet proceeds and as more of the older break-bulk ships are

¹ See J. H. Hayes, *Future Army Deployment Requirements* (U), The Rand Corporation, R-1673-PR, April 1975 (Confidential), which explores the makeup of the Army in considerable detail.

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replaced by container ships, the mismatch between military deployment requirements and the suitability of shipping assets for deployment will become more pronounced.

(U) Although the amount of material required to deploy and sustain U.S. forces in Europe is enormous, *total* sealift capacity is not a problem. Given sufficient time to assemble the ships, the U.S. Merchant Marine augmented by 200 to 300 NATO flag ships could provide more than enough sealift to meet the most demanding long-term NATO contingency. The question, however, is on what time scale suitable ships will become available in sufficient numbers to support an acceptable deployment rate.

(S) A second major factor compounding the uncertainties associated with early deployment by sea is the considerable Soviet threat to Atlantic sea lines of communication. By the early 1980s, the Soviets will have a formidable force of attack and cruise-missile submarines and long-range aircraft. Studies by the Navy and others have concluded that if the Soviets devote a large portion of their attack submarine force to interdiction, allied shipping losses would be substantial.¹ The cumulative attrition on convoys sailing during the first 15 days after D-Day is expected to be between 30 and 60 percent. For convoys departing later, the attrition will be reduced but still will be heavy. By 30 days after hostilities begin, the cumulative losses are expected to be between 20 and 45 percent; after 45 days, from 10 to 30 percent.² The spread in these attrition estimates results largely from differing assumptions about the number of Soviet submarines committed to interdiction, Soviet rules of engagement, and the estimated effectiveness of revised U.S. antisubmarine warfare (ASW) tactics.³ Finally, sealift may be exposed to a severe mine threat in coastal waters and approaches to ports of debarkation.

¹(U) D. E. Emerson, *Performance of Alternative ASW Forces for Convoy Protection* (U), The Rand Corporation, R-1244-PR, June 1973 (Secret).

²(U) Ibid.; *Navy Accelerated Sealift Study Project Sea Express* (U), Office of the Chief of Naval Operations, July 1974 (Secret).

³(U) In general, the lower estimates assume that fewer Soviet submarines are deployed in the Atlantic before D-Day, that Soviet cruise-missile submarines will target only U.S. and allied surface naval ships

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(U) The effect of heavy ship losses on allied capabilities would depend on the amount of time available for mobilization before D-Day. If pre-attack mobilization lasted four to six weeks, the first convoys carrying combat equipment could load, assemble, sail, and dock without being attacked. Post D-Day attrition would largely affect convoys carrying resupply items of lesser importance than primary combat equipment. Although the loss of ships would be heavy, such loss rates could be tolerated for a short time. If, however, the period of U.S. mobilization lasted only one to three weeks before the outbreak of hostilities, heavy attrition of the enroute convoys would cause the loss of Army combat equipment that could not soon be replaced.

(C) The Army does not stock unit equipment on the European continent to offset losses incurred during deployment by air or sea. War reserve stocks (WRS) are maintained in Europe to replace equipment lost as a result of ground combat.¹ Levels of WRS are calculated, item-by-item, on the basis of historical combat experience. Therefore, items that receive high combat exposure, such as tanks, are stocked in greater quantities than items of equipment used in rear areas, such as artillery. It is thus not clear to what extent WRS could be used to reconstitute combat units that incurred large equipment losses at sea, or what effect that practice might have on the ability of U.S. forces to maintain an adequate fighting capability during the first weeks of combat.

(U) Even modest attrition levels at sea during the first 15 days of combat could disrupt mobilization plans. If Soviet attack submarines were able to distinguish container ships from break-bulk ships carrying Army combat equipment cargos, an "average" loss rate might mask a much greater loss rate among those ships carrying heavy unit equipment. The long lead times involved in the production of new heavy equipment (e.g., tanks) insure that large enroute losses would lead to

(not cargo ships), and that a wider spacing of the convoy formation will allow protecting antisubmarine forces to pursue and kill Soviet submarines that have successfully penetrated the convoy's perimeter defenses.

¹(C) Currently, WRS stocks on hand are well below target levels for many combat items.

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a severe impairment of early fighting strength of U.S. forces. For planning purposes, therefore, surface-ship transport of Army combat equipment in the early stages of a NATO crisis cannot be uncritically assumed.

PREPOSITIONING

(S) In addition to the five division equivalents now stationed in Europe, the Army now has notionally prepositioned in Europe¹ duplicate heavy equipment sets for three Army divisions (one brigade of each is deployed in Europe) stationed in the Continental United States but committed to Europe. One armored cavalry regiment also has its equipment largely prepositioned. In the event of a NATO mobilization, those divisions would be the first to deploy. Combat personnel are to be carried to Germany by commercial passenger aircraft from the current Civil Reserve Air Fleet (CRAF). Unit equipment is to be withdrawn from theater storage sites and field-tested; within two weeks (according to current planning documents), these units should be deployed forward, ready for combat.

(U) During the past few years, several factors have reduced the desirability of additional prepositioning as a method of accelerating deployment. First, additional prepositioning in Europe incurs obvious opportunity costs for assisting allies in other potential theaters of conflict. Second, even when the analysis is limited to Europe, prepositioning no longer dominates all alternatives in a classical cost-effectiveness analysis. Modifying commercial wide-body passenger aircraft to give them a cargo-convertibility feature results in a faster, more flexible, and less expensive means of accelerating deployment of some types of equipment in support of NATO. Third, improved Soviet and Warsaw Pact capabilities for extended-range precision air attack are likely, over the next decade, to increase the vulnerability of prepositioned equipment.² Finally, Army experience with maintaining stored

¹(S) But a significant amount of that equipment was sent to the Middle East in 1973, and as of mid-1976 had not been replaced. See GAO Report LCD-76-441.

²(U) The vulnerability of airlift, in terms of both bases and en-route aircraft, may also increase if Soviet capabilities improve.

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equipment over long periods of time suggests that prepositioning does not work as well in practice as on paper. Nonetheless, the Army has scheduled the prepositioning of one additional division set (mechanized) by 1982, and partial prepositioning (selected outsize equipment) may represent one of the few feasible short-term mobilization increments.¹

(S) The 1973 Middle East war led to a major drawdown of U.S. stocks of equipment prepositioned in Europe, exacerbating existing shortages; these shortages are not to be fully rectified until 1982.²

ARMY WEIGHTS AND MEASURES

(U) The Army has several types of divisions: Infantry, Armored, Mechanized, Airborne, and Airmobile. All of the Army divisions have about the same manning (about 17,000 men, except for the slightly smaller Airborne division), but they vary greatly in weight of equipment assigned--about a factor of five between the lightest (Airborne) and the heaviest (Armored). Given this substantial variation in weight of assigned equipment, it becomes evident that the airlift capacity necessary to meet any "quantitative" criterion such as "a division a week to NATO" is strongly dependent on the types and numbers of divisions being considered.

(U) At the division level Army units are composed of several discrete entities. The maneuver battalions and brigades, and the division artillery that constitute the bulk of the division's fighting power, represent one element. Those maneuver units are supported by other units found only at the division level. The divisions in turn are supported by a variety of units, such as engineer companies, mobile hospital first aid units, maintenance battalions, and some combat units, etc., which collectively were (formerly) called the Initial Support Increments (ISI), and more recently designated as Non-Divisional Combat Increments (NDCI).³

¹(U) See pages 105-107, below.

²(U) GAO Report LCD-76-441.

³(U) For long-term continued combat, additional augmentation of divisions in the form of what were formerly called Sustaining Support Increments (SSI) and are now called Non-Divisional Theater Support Increments (NDTSI) provide autonomous combat operations of unlimited duration. The terms ISI and SSI fell into disuse while this report was being prepared, but for reasons of convenience and consistency they have been continued in use here.

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The combat units in the ISI (such as non-divisional artillery and some tank companies) provide autonomous firepower additional to that in the maneuver units. The ISIs contain the support equipment that permits sustained autonomous operations for a number of weeks. These ISIs are made up of combat support units located on a large number of posts, camps, and stations throughout the Continental United States and Hawaii. Such units are generally not collocated with the divisions to which they will be assigned in war, making another matching-up problem to be considered in the deployment of divisions and their supporting increments. In addition, a number of units listed on "notional" Army ISI requirements simply did not exist or were not equipped in 1975.¹ Therefore, the ISI complements for the various divisions vary somewhat by division type.²

The size and weight of Army equipment present yet another complication for airlift. Each item is categorized as non-air-transportable, outsize, oversize, or bulk. *Non-air-transportable* equipment is too heavy or bulky or both to be carried by any existing aircraft. It must be delivered by ship. (Only a few items fall into that category.) *Outsize* designates equipment too large or heavy to be carried by any USAF aircraft except the C-5A. *Oversize* equipment will fit into C-141s and, of course, C-5As. (Oversize items can also be carried by C-130s, but only for short distances.) All other items scheduled to be airlifted that fit the dimensions of military pallets are classified as *bulk* and can be carried in any cargo-configured aircraft or, for that matter, in the cargo hold of such passenger aircraft as the 707, DC-8, DC-10, L-1011, and 747. Suitably modified by the addition of side or nose cargo doors, most current wide-body commercial aircraft could carry many items of oversize equipment; in addition, one modification

¹Hayes, *Future Army Deployment Requirements*.

²The Rand studies have *not* addressed the issue of validating Army ISI requirements--whether all of the units and equipments programmed for deployment by the Army are truly indispensable. If the weight of ISI could be reduced (e.g., by reliance on NATO allies for adequate trucks to provide rear-area transport), the airlift job could be reduced correspondingly.

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of the 747 proposed by Boeing could carry many items now classified as outsize.

The value ordering of different kinds of divisions (for NATO purposes) specifies that the larger the quantity of armor in a division, the more urgent its availability. In the context of probable Pact strategies and tactics, this urgency argues for placing first priority on delivering (or prepositioning) armored divisions, then mechanized divisions, then infantry divisions (which include one mechanized and one armored battalion), followed at the end by airmobile and airborne¹ forces. (This ordering conceivably might change if the "lighter" units developed notably effective anti-armor capabilities.) In the absence of assured sealift during the first couple of weeks following a mobilization order, it will be incumbent on airlift to satisfy the urgent need for reinforcing NATO's armored contingent. Because armor implies outsize, that imposes immediate and demanding requirements for effective use of all outsize-capable airlift resources.

A recent Rand study has surveyed the locations of all active and reserve Army units in the United States and the Pacific, identifying by weight and airlift categorization all those that might be deployed to Europe by air during the early period of major contingency.² The survey set included the active divisions based in the Continental United States and Hawaii, reserve affiliate battalions and brigades programmed to deploy with those divisions, and the aggregate of active and reserve combat support units that constitute the ISI for each division. Estimates covered both the earlier 13-division Army as it was equipped in early 1975 and the "Abrams Army," the programmed 16-division Army to be fully equipped during FY 1978-1982. During 1975, the nominal equipage of the projected 1980 Army was substantially increased; when fully put into operation, the projected Army will have

¹Notwithstanding that the 82nd Airborne Division is maintained in a state of high readiness for deployment.

²Hayes, *Future Army Deployment Requirements*, devoted particular attention to the reduction of outsize requirements through simple dimensional reductions to military equipment (e.g., removing bows from trucks).

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some 40 percent more outsize equipment to be moved than was assigned the same units in 1974.

OTHER DEPLOYMENT TASKS

The traditional NATO scenario specifies three principal tasks in addition to the deployment of Army equipment: the deployment of tactical Air Force units and their supporting equipment to bases in NATO to augment NATO's tactical air power; the deployment of Army and Air Force personnel and bulk cargo; and resupply, a broad term covering not only the provision of spare parts, replacement equipment, munitions, and consumables, but also the provision of SSI described earlier.

The Air Force units to be deployed can be identified and their airlift requirements defined (60,000 oversize tons to support 54 squadrons). The necessity for early massive reinforcement of NATO's tactical air power, to provide additional confidence in NATO's ability to contain massive armored thrusts by the Warsaw Pact, has been addressed elsewhere.¹ The thesis is nowhere seriously contested.

The present availability of narrow-body and passenger-only wide-body commercial aircraft is sufficient to transport personnel at rates well in excess of those required to match equipment lift, and is believed to be adequate for bulk transport. The resupply mission as portrayed in planning documents is so extensive that it can only be met by sealift,² hence the long-term importance of secure sea lines of communication. As noted earlier, losses of resupply shipments should be somewhat more tolerable than losses of combat unit equipment, an argument favoring air transport of division items and sealift of most consumables. Of course, such a division of labor assumes that there are adequate stockpiles of consumables and spares in Europe and that high volume production of such items begins quickly in the United States.

¹See, for example, D. E. Emerson, *Comparison of Alternative 1980 NATO Land and Air Forces: Methods and Results*, The Rand Corporation, R-1243-PR, July 1973; and P. M. Dadant et al., *Tactical Airpower in Two Mid-Seventies NATO Contingencies: Summary Report (U)*, The Rand Corporation, R-1191-PR, June 1974 (Secret).

²Annual Defense Department Report, FY 1975, p. 165.

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CURRENT AIRLIFT RESOURCES AND ASSUMPTIONS

Present MAC airlift resources include 77 C-5As, organized into four squadrons totaling 70 unit equipment (UE) aircraft; 273 C-141s, organized into 13 squadrons possessing 234 UE aircraft; and the current CRAF fleet, which as of January 1976 consisted of 91 passenger-only and 153 cargo-capable jet civil aircraft. Many of the passenger-only CRAF aircraft are wide-bodied jets, but most of the cargo and convertible types are narrow-body civil aircraft. Because of this imbalance, the current CRAF fleet is assumed in our analysis to be devoted exclusively to troop movement and the early resupply mission, which we do not explicitly model.¹ Also not used in the subsequent analysis is the fleet of over 400 C-130 aircraft of all types possessed by active, reserve, and Air National Guard units. The C-130E and H variants have enough range to haul some military cargo from CONUS to NATO, refueling at intermediate bases. But that use ignores both substantial European intratheater airlift requirements and the airlift requirements likely to be associated with the assembly of the many widely dispersed combat support units at a limited number of convenient U.S. aerial ports of embarkation (APOEs). This discussion and subsequent analysis assume that no C-130 aircraft contribute to the airlift of Army unit equipment.¹

THE ANALYSIS OF AIRLIFT REQUIREMENTS AND AIRLIFT ENHANCEMENT OPTIONS

Most elements required for an analysis of airlift requirements were identified above. The process of identifying Army units and their location, and classifying their equipment by type (as bulk, oversize, outsize, or non-air-transportable), has established sets of equipment weights (and sizes) and locations at one end of the move spectrum. It remains, then, to identify a set of APOEs in proximity to each of the units (preferably within one day's march), at which points unit equipment can be loaded on strategic airlift aircraft. Given a set of aerial

¹The same assumption would apply to the case of the Advanced Medium STOL Transport (AMST) under development as a possible replacement for the C-130s, beginning in the early 1980s.

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ports of debarkation (APOD) in the NATO theater, the tonnages and distances for each of the categories of equipment can be defined. Current airlift assets have been identified, and enhancement options will be discussed shortly. The payload capability, dimensions, and block times for each of the types of airlift aircraft are similarly well known. A set of standard Air Force planning factors provides assumptions about the daily use of the aircraft as well as turnaround times and other aircraft down-time requirements. Thus, in principle, one can construct a model that systematically addresses the sequential movement of categories of equipment by the classes of airlift aircraft available.

The synopsis above obscures a number of intermediate difficulties and issues. First, the loading of Army unit equipment on transport aircraft is not constrained merely by tonnage. Many items--helicopters, for example--are large but not very dense. Therefore, one must address the question of loading of individual aircraft so as to use both the volume of its cargo hold and its weight carrying capability effectively, given the range of the mission to be flown. This subsidiary analytic problem introduces additional constraints into the model formulation.

Second, any model inevitably abstracts from a number of real-life issues: the availability of Army units at the right time in the right locations with the right kinds of equipment to load available airlift aircraft efficiently without undue dead-time on the ground; congestion at APOEs and APODs, as well as enroute traffic management; the routine availability of fuel, spares, and appropriately skilled personnel to keep the aircraft working as planned; and unscheduled maintenance needs. Other gross uncertainties remain--the survivability of airlift aircraft once hostilities have begun and the effects of such exogenous constraints as bad weather. Finally, there are organizational side-constraints, principal among them being the Army's detailed move plans that establish a specified sequence for moving units and equipment so that units can be formed and moved to the front lines expeditiously. This so-called "unit integrity" requirement is specified *in detail* by the Army in master movement plans that are updated from time to time. Most models

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of deployment (including Rand's)¹ preserve unit integrity only at the division level. That is, all of the items of one particular division are assumed to be equally accessible for loading and are moved according to an "efficient" sequencing, using all available airlift aircraft, until the unit movement has been completed. *The model* then directs airlift resources to the next *designated division*.

The advantage of using a sequential move model stems largely from its value in analyzing the effect of changes in assumptions and policies, or in airlift capabilities, or in the number and kind of airlift aircraft, or in Army unit equipment. In conjunction with the costs of various changes, such a model can be a useful tool for analyzing the cost effectiveness of a wide variety of options for enhancing airlift capabilities.

The influence of aerial refueling on airlift scenarios has not been examined quantitatively in this study.² Several circumstances influenced Rand's decision on that point: (1) Although tentatively

¹A more detailed discussion of the several models used by Rand in its analyses is contained in J. H. Hayes and L. Cutler, *The Army Deployment Simulator, with a Data Base of Army Units and Equipment*, The Rand Corporation, R-1893-PR, September 1976.

²The Air Force Studies and Analysis airlift group has calculated that aerial refueling capability in C-5As adds about 8 percent (5,800 tons in 30 days) to the productivity of the airlift as a whole and that refueling capability added to C-141s would increase its delivery potential by about 4 percent (3,100 tons in 30 days) at maximum utilization rates. (Briefing, "Airlift Enhancement," ACS/SA, November 1975, Secret.) The Rand scenario assumed that C-5A would be refueled on the ground, at a northeastern CONUS base, before departing for Europe, if range-payload factors ruled out unrefueled nonstop flights from departure fields to NATO.

Recent internal studies performed by the Military Airlift Command have shown somewhat larger benefits to aerial refueling, although a significant portion of that improvement derives from reducing congestion at a planned refueling base (RAF Mildenhall) which has insufficient refueling capacity to handle the assumed aircraft flows.

Aerial refueling may have an important role to play in supporting planned higher aircraft utilization rates, by eliminating refueling stops; the benefit here may derive less from better utilization than from avoiding the possibility of malfunctions occurring during layovers for refueling. It may also permit slightly higher utilization rates for a given crew ratio by reducing the amount of crew staging required. (See also the Addendum at the end of Sec. VI.)

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planned for the C-141A fleet, it is not yet approved; (2) at the start of the study too few trained crews were available to support the use of aerial refueling for the entire C-5A fleet; (3) training additional C-5A crews and maintaining their proficiency for aerial refueling operations is likely to accelerate the exhaustion of residual fleet life (measured in calendar years) if those training missions are conducted in advance of any life extension modification; (4) trans-Atlantic scheduling and enroute weather problems (not considered in the deployment model) are critical to realistic modeling of refueling modes; (5) the need for tankers to refuel MAC aircraft in a period of intense crisis may well occur just when SAC requirements would presumably be increased, as would the need for tankers to deploy tactical aircraft to bases in Europe; and (6) perfect-schedule, weather-free models necessarily *overstate* real deployment capability for the real airlift fleet, so the slight improvement in deployment times that would have resulted from exploiting refueling capabilities is one of the few elements of conservatism in the otherwise optimistic estimates of capabilities from exercising deployment models.

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II. GROUND RULES, ASSUMPTIONS, AND METHODS OF ANALYSIS

(U) This study analyzes the deployment of equipment for early reinforcements to NATO by airlift, and airlift enhancements designed to speed the rate of deployment. The clear focus of the analysis is on capabilities in the early phase of crisis:

Strategic airlift plays a particularly important role in our commitment to the conventional defense of Europe. Our ability to deploy forces rapidly could do much to offset the Soviet Union's geographic advantage, particularly in the early weeks of confrontation in Europe. Sealift also plays a crucial role and, over the long term, would account for the bulk of material movements. However, only airlift insures the delivery of combat forces in the opening weeks of deployment. In addition, airlift has the advantage of providing a visible, growing buildup starting with the first few days. Our capability to deploy forces in the first few weeks by air may well be crucial to the success of a NATO defense and, indeed, it may deter an attack in the first place.¹

HOW MUCH OF THE ARMY TO MOVE BY AIR?

(S) The subsequent analysis will focus on the deployment to NATO by air of most of the active Army and a few selected reserve roundout units.² The basic forces to be moved and the weights of outsize and oversize equipment to be airlifted are given in Table 1; this represents all but three active Army divisions--one in Korea, one in Hawaii, and one on the Pacific coast. The table also includes the equipment for the Air Force units (54 squadrons) to be deployed and a Rand estimate of the makeup tonnages of equipment required to support the authorized levels for the divisions (and their ISIs) prepositioned in theater; it amounts to some 55,000 tons of outsize and 84,000 tons of oversize equipment. The deficiencies are planned to be rectified by FY 1982. Also planned by FY 1982 is the upgrading of two present

¹(U) Annual Defense Department Report, FY 1976, p. III-123.

²(U) Deployment by air of U.S. Marine Expeditionary Forces have not been considered.

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(S) Table 1

1977 FORCES TO BE DEPLOYED--LOCATIONS AND UNIT TONNAGES (U)

Unit	Location	Weights, in Thousands of Tons		
		Outsize	Oversize	Total
Air Force (54 Sq.)	Various	0.0	61.6	61.6
ISI and Combat Equipment for Prepositioned Divisions	Various	55.4	84.1	139.5
1st. Cav. Armor Div.	Ft. Hood	41.6	51.9	93.5
5th Mech. Div.	Ft. Polk	36.5	51.3	87.8
9th Inf. Div.	Ft. Lewis	24.0	46.0	70.0
24th Inf. Div.	Ft. Stewart	24.0	46.0	70.0
194th Armor Brig.	Ft. Knox	7.7	8.0	15.7
197th Mech. Brig.	Ft. Benning	6.0	7.8	13.8
6th Air Cav. Combat Brig.	Ft. Hood	2.0	0.3	2.3
32nd Mech. Brig. ^a	Ft. Riley	6.0	7.8	13.8
67th Mech. Brig. ^a	Ft. Carson	6.0	7.8	13.8
81st Mech. Brig. ^a	Ft. Lewis	6.0	7.8	13.8
116th Arm. Cav. Regt. ^a	Boise	4.7	2.5	7.2
101st Airmobile Div.	Ft. Campbell	16.9 ^b	27.7	44.6
39th Inf. Brig. ^a	Ft. Campbell	2.5	6.3	8.8
82nd Airborne Div.	Ft. Bragg	18.8 ^b	32.9	51.7
30th Mech. Brig. ^a	Ft. Bragg	<u>6.0</u>	<u>7.8</u>	<u>13.8</u>
Total tonnage:		264.3	457.3	721.6

^a Reserve Unit.

^b Includes oversize as filler in outsize loads.

NOTES: "Div" tonnage includes divisions plus ISI.

5th Mech. Div. includes 48th Mech. Brigade (Reserve) as roundout.

24th Inf. Div. includes 256th Mech. Brigade (Reserve) as roundout.

39th Inf. Brigade is deployed as part of 101st Airmobile Div.

30th Mech. Brigade is deployed as part of 82nd Airborne Div.

Tonnage totals do not add because of rounding.

Bulk tonnage is not included.

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infantry divisions to mechanized division status, and the prepositioning of one additional unit set of equipment in NATO for one of those new mechanized divisions.¹

(S) The importance of the assumption that all combat units and their ISI are airlifted cannot be overstated. For instance, earlier Air Force analyses keyed to DoD-directed "balanced-mode" deployment schemes postulated delivery by *sealift* of three heavy divisions plus three heavy brigades plus the ISIs for all committed forces. Airlifted forces included only CONUS-based equipment for the prepositioned divisions, three infantry divisions, an airmobile and airborne division,² and eight independent brigades. Sealift was assumed to be immediately available and early sealifted forces arrived by M+20, before hostilities were assumed to begin.³ In this Air Force/DoD construct, airlift forces moved 77,000 outsize tons and 115,000 oversize tons.⁴ By contrast, the nine division equivalent forces outlined in Table 1 total some 721,000 tons, 264,000 tons of outsize, and 457,000 tons of oversize.

HOW RAPIDLY MUST AIRLIFT MOVE THE FORCES?

(U) An appropriate source of guidance for the planning of strategic airlift enhancement should be the annual posture statements prepared by various elements of the Department of Defense. Unfortunately,

¹(S) The study recently conducted by the JCS for the Congress reportedly considered prepositioning two additional division sets, one armored and one mechanized; however, that is not a part of the approved defense program.

²(U) The ISIs for these divisions were assumed to be sent by sealift.

³(U) The rationale for such a prompt marshalling of sealift forces is that a NATO crisis would have been preceded by crises or low-level hostilities in either the Middle East or along the southern flank of NATO-Europe, and that both airlift and sealift forces would have been assembled in response, in advance of NATO or Pact mobilization on the Central Front.

⁴(U) Those numbers, rounded, represented Air Force/JCS calculations as of December 1975. The tonnage to be airlifted in 30 days was assumed to total 388,000 tons (including 116,000 tons of bulk, which Rand studies assumed would go in the cargo holds of narrow-body commercial jets pressed into service from the current Civil Reserve Air Fleet).

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neither those statements nor more detailed defense studies and reports establish precise, quantitative limits on the desired capabilities of strategic mobility forces. Perhaps the clearest statement occurred in the FY 1975 Annual Defense Department Report, in which the Secretary of Defense said:

Hence, a dependable U.S. capability to deliver large-scale reinforcements to Europe quickly in an emergency could not only be decisive in preventing a NATO defeat, it could also be decisive in deterring the attack in the first place. Indeed, I can think of no more impressive a deterrent to a Warsaw Pact attack on NATO than a clearly demonstrable U.S. capability to put down in Europe a fully equipped combat-ready division (including its supporting forces) every few days.¹

After reviewing several possible methods of augmenting existing capabilities, the Secretary concluded:

This strategic airlift force--the C-5As, the C-141s, existing CRAF, plus about 110 convertible 747s--could airlift the planned force (including the Initial Support Increments) to Europe at an average rate of about seven days per division.²

Subsequent efforts have resulted in measures of tonnages deliverable in 30 days and, more recently, in terms of the shortfall of fighting strength as measured in armored-division-equivalent days (ADE-days). Ideally one would wish to determine from campaign analysis the force necessary over time to provide a robust conventional defense and base the mobility requirements on that outcome. However, campaign analyses have come to significantly different conclusions based on modeling differences, different threat and scenario assumptions, and the like; and there is no generally accepted analytic criterion of requirements over time.

¹Annual Defense Department Report, FY 1975, p. 168.

²Ibid., p. 162. Unfortunately, the growth of assigned Army equipment noted in the previous section makes that analysis correct only for the 1974 Army, not the current or future Armies.

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For given, fixed equipment lists, the analytic results to be presented in the next section will show the range of closure times achievable for the current airlift force and for alternative improvements in airlift capabilities. Subsequent analysis will focus on the options--and their costs--needed to provide capabilities of at least a division a week, with particular attention to the marginal capabilities and costs of additional enhancement options in the vicinity of division-a-week capabilities. First, we specify a set of caveats and constraints used in this analysis.

REVIEW OF ASSUMPTIONS AND CAVEATS

Various assumptions that apply to the quantitative analysis of airlift enhancement options have been scattered through the previous sections. Minus their supporting rationale, they are summarized in the following statements:

- This study examines only NATO reinforcement scenarios, involving the Air Force and Army units identified in Table 1 and subsets of those units.
- All Army maneuver units considered in this analysis and their ISIs are to be deployed by air (except for explicitly defined excursions clearly noted).
- Unit integrity is to be preserved down to the division or brigade level as appropriate.
- Airlifted cargo is assumed to be predominantly outsize and oversize; bulk equipment is moved only incidentally, as filler or when it is part of the loaded weight of a truck or other vehicle.¹
- C-130s are not used to augment intercontinental lift of outsize or oversize equipment.
- Troops and SSI and resupply items (predominantly bulk cargo) are assumed to be shipped by a combination of Stage III CRAF, C-130s, and sealift, and are not modeled herein.
- Additional prepositioning of Army equipment is considered only as explicit excursions, clearly identified.

¹The small amount of bulk cargo that is part of Army equipment lists can go into cargo compartments of unit trucks and trailers, supplemented if necessary by movement on pallets by Stage III CRAF.

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- Move lists include the support equipment for 54 squadrons of tactical air from U.S. bases to NATO.¹
- No aerial refueling of C-5As and C-141As is assumed; East Coast ground refueling is provided where necessary; no constraints on the availability of fuel are considered.
- Equipment will be shipped in reduced configuration.²
- Army and MAC readiness and performance are assumed to conform to standard planning factor estimates.
- Adequate fuel, maintenance, crews, spares, etc., as needed to maintain planning factor performance, are assumed (e.g., ten hours per day for 45 days, and eight hours per day thereafter).
- No traffic handling, availability, etc. constraints at APOEs, APODs, or enroute are assumed.
- No constraints due to adverse weather are considered.
- No attrition of airlift assets, whether by accident or hostile action, is calculated.

DEPLOYMENT OUTCOME FOR CURRENT FORCES

(S) Given the assumptions and caveats stated earlier, one must begin by considering the movement of the previously identified unit equipment (for the listed divisions, their ISIs, and 54 TAC squadrons) from CONUS to NATO, using only the currently available airlift assets.³ Figure 1 shows a time history of that deployment. The final closure date of the Army units transported by air (including ISIs), as well as of the equipment of the 54 tactical Air Force units, occurs on the 173d day after beginning of the airlift. This corresponds to a deployment rate of about 19 days per division. For analytic convenience, the Air Force equipment was "moved" first, followed by the non-prepositioned unit equipment for the 2-2/3 prepositioned divisions, much of whose

¹(U) The TAC aircraft are usually ferried across separately.

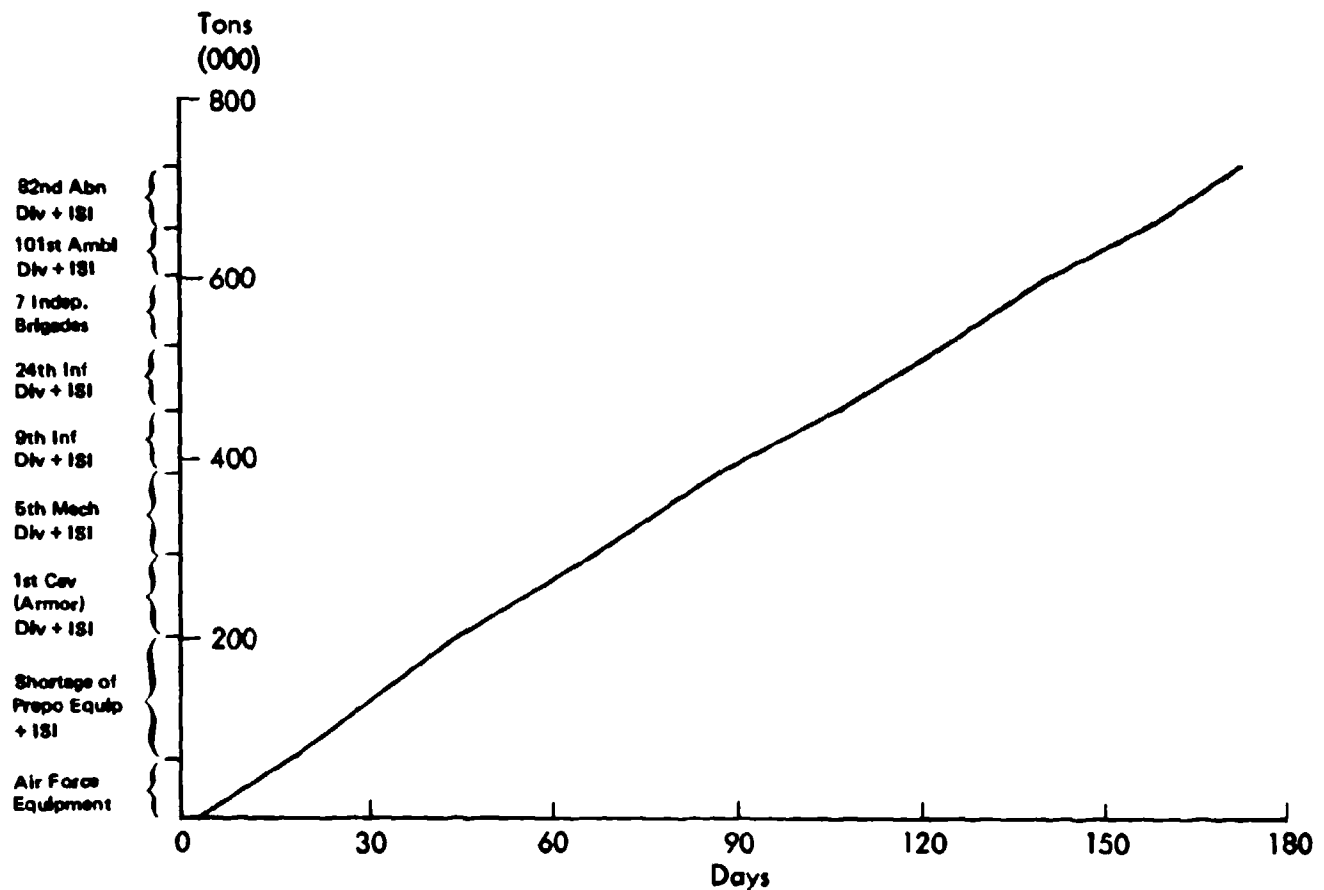
²(U) E.g., removing bows from trucks to convert them from out-size to oversize where possible. See Hayes, *Future Army Deployment Requirements*, for a more comprehensive discussion.

³(S) That is, the Air Force equipment, the equipment and ISI not currently available in Europe for the prepositioned forces, and the equipment for the nine equivalent divisions designated in Table 1--the 1977 Army, using 1977 airlift force of 70 UE C-5A and 234 UE C-141A at 10 hr/day for the first 45 days and 8 hr/day thereafter, assuming emergency overload conditions apply to aircraft loadings, if necessary.

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(S) Fig.1—Rate of deployment of 1977 Army by air, using only organic airlift assets (U)

equipment is already prepositioned in NATO. Thereafter the model moves each division and then its ISI in turn. Obviously, the *order* of move could be changed, and certain of the tasks could be overlapped or performed in parallel at reduced rates (e.g., moving two divisions).¹

¹(S) The movement of the tactical air forces involves very little outsize equipment, and the use of C-5As to move them is inefficient. It might well be better to use the C-5A's outsize capability early on, first moving those Army units with the largest outsize equipment. In some cases to be presented below, all C-5A assets were applied to the task of moving Army units from day one onward. In those cases, closure times are controlled by the amount of outsize equipment that must be moved, and movement of the Air Force is commingled with movement of the first Army unit, which, since it is an armored division, is heavily outsize.

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From this curve, it is possible to read off closure dates for intermediate numbers of divisions and, given the tonnage scales on the abscissa, to read off the weight of material closed at a particular time.

(U) By applying such a methodology for alternative airlift forces, it is possible to evaluate the contribution of any candidate airlift enhancement option *individually*, in terms of its reduction in the number of days to closure compared with a base case result. Similarly, one can compare the *aggregate* effect of combinations and permutations of the candidate airlift improvements in terms of decreased closure times. This establishes as one measure of merit the *reduction in closure days* for each of these various combinations. Given the cost of each of the programmed improvements, it becomes possible to rank each of the options using as a second measure of merit the *cost per day of decreased closure*, a cost-effectiveness measure. With this process, then, for any enhancement option or combination of options one can evaluate both the *absolute reduction in closure time* that results (and thus the extent to which the various enhancement options move the total airlift capability toward a division a week or other criterion) and the *rank order of their relative cost effectiveness* in reducing closure times.

(S) Any deployment model is at best an abstraction of the real world, and all models are sensitive to both assumptions and inner workings. The absolute closure date calculations (173 days for the 1977 example above) need to be viewed as approximate values, which, given real-world constraints and practices, could easily be in error by a margin of 10 percent.¹ Less credence should be attached to the absolute closure dates calculated than to the *differences in closure* of different airlift combinations. Biases in methodology and in assumptions remain fairly constant between such runs.

¹(U) Even before the sensitivity of outcomes to variations in the more important assumptions about readiness, no attrition to airlifters, no APOD and APOE congestion, and no weather constraints are considered.

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III. PROGRAMMED IMPROVEMENTS AND COST-EFFECTIVENESS CONSIDERATIONS

This section considers the merits of several Air Force proposals for the enhancement of the present U.S. strategic mobility capability. The focus of concern throughout is on the length of time for each specified mix of aircraft types to deliver the equipment for the specified force to European debarkation points--the closure time--and on the incremental cost of that option. This approach permits the evaluation of options against two separate metrics: *closure interval*, the measure of how nearly a given airlift mix approaches a division a week or other capability objective and, for each augmentation option (individually as well as in combination), the *incremental cost* of each reduction in closure time. This array allows decisionmakers to perceive, from a cost and capability perspective, which of several capability enhancement options is most cost effective and the effects of additional improvements on deployment rates.

THE ENHANCEMENT PROPOSALS

The several proposed airlift options are well known within defense circles. The four principal near-term augmentation proposals are:

- Modifying CRAF-eligible commercial wide-body jet aircraft to enable them to carry much of the Army's oversize equipment;
- Increasing the crew ratios (and maintenance manning and spares) associated with aircraft now in the inventory to increase the (wartime) utilization rate and thereby the capacity of the C-141A and C-5A fleet by 25 percent;
- Putting fuselage plugs into the C-141A aircraft to increase their volume (but not maximum payload) by approximately one-third, permitting more efficient use of the aircraft when they carry less dense cargos;¹
- Acquiring the capability to carry some oversize equipment in the Advanced Tanker/Cargo Aircraft (ATCA).

¹"Less dense" since the maximum payload is slightly reduced by the weight of the mods. The C-141A modification program also envisions the incorporation of certain aerodynamic modifications to offset to some extent the effects of adding the fuselage plugs. An aerial refueling capability would also be added.

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In addition to such enhancement options, another major program is relevant--indeed, *central*--to the analysis of strategic airlift: the development and installation of a number of structural components in the wing sections of the C-5A aircraft to alleviate fatigue problems with the current wing design. This program, the C-5A Option H mod as it is known, is not so much an *enhancement* of strategic airlift capability as it is a means of *preserving the only current outsize capability* the United States now has.

CRAF MODIFICATIONS

The CRAF modification program over time has involved at least six different proposed modification configurations of the Boeing 747 and two for the DC-10.¹ The two current configurations proposed are designated as either *full-mod* or *mini-mod*, a designation principally relating to the degree of floor strengthening. The 747 mini-mod, as the name implies, has a minimally strengthened flooring that restricts upper deck loading to about 50 tons and requires a staggered loading pattern for vehicles as large as the standard 2-1/2 ton truck, the mainstay of Army units.² The mini-mod has a standard B-747 200-F nose door. The 747 full-mod variant currently contemplated has a strengthened floor so that floor-loading constraints are much reduced relative to the mini-mod, but it suffers the handicap of a side rather than a nose door, which greatly reduces the loading flexibility. The mini-mod adds some 2,600 lb to the aircraft operating empty weight of a 747; the full-mod adds some 9,700 lb. This 7,100 lb difference, of course, is one measure of lost revenue payload in peacetime, and for a few long stage-lengths on commercial routes, it can be critical. Most of the difference is attributable to the floor strengthening.

How many mini-mod and maxi-mod aircraft might ultimately emerge from the program, and in what ratios, remains uncertain. The original

¹Only three DC-10s have been offered for modification by the airlines, and neither the DC-10 nor the L-1011 is more than marginally useful in deploying Army equipment. The focus of this discussion is on modifications to the B-747 series aircraft.

²In addition, the trucks must be empty of any bulk cargo and that bulk palletized for shipment.

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Air Force proposals in various forms were twice rejected by the Congress. They called for a program objective of 100 "747 equivalents," which could be made up of a mix of mini-mods and full-mods. The FY 1978 program contains only a four-aircraft demonstration program.¹ The program currently being drafted for possible inclusion in next year's budget calls for 87 modifications, of which 84 are for 747s; of these, 27 are full-mod and 57 are mini-mod.² The original Air Force funding proposal calls for a payment package to the civil airlines that involved cost of modification, reimbursement for lost revenues during the modification period, reimbursement over a finite period for the costs of carrying the added modification weight in regular service, and an incentive payment. To prevent disruption of the civil air cargo market, severe restrictions were to be imposed on peacetime use of the cargo-carrying capability of the modified aircraft. It is contemplated, however, that next year's submission will include another option, "cost sharing," under which the airlines would waive incentive and reimbursement payments and repay the government one-half of the modification cost in return for the freedom to exploit the cargo-carrying capability of the modified aircraft in peacetime. To date, the airlines have informally committed 19 of the 27 aircraft scheduled for the full-mod to the cost-sharing option, while all of the 57 mini-mod variants are committed to the (not fully defined) reimbursement incentive program.

The cost of modification of the aircraft is expected to range from \$5.5 million (FY 78 dollars) for the mini-mod to \$7.1 million for the full-mod (and, hence, about \$3.5 million for the cost-share option). Annual reimbursement costs for other than cost-shared aircraft are expected to amount to \$50-100 thousand per year per aircraft.³

¹On 22 February 1977, Secretary of Defense Harold Brown announced that an additional four modifications would be proposed in the FY 1978 budget.

²U.S. flag airlines also currently operate some 16 747 main-deck-cargo aircraft, which should be used for deployment of Army oversize rather than movement of bulk under Stage III CRAF. Ten more 747 cargo aircraft are in operation by NATO flag airlines.

³Data provided by Air Force Directorate of Transportation, February 1977.

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Thus, the 84 747s as now committed would incur a total modification cost of \$436.8 million (FY 78 dollars), plus a ten-year operating payment of perhaps \$32-65 million (FY 78 dollars) for those not committed to cost-sharing. Modifications would be carried out during FY 1979-82, if the Congress approves.

The basic 747 airframe is better suited to a contingency airlift role of deploying Army oversize equipment if the positive features of the full-mod and mini-mod are combined in what we might call a *maxi-mod*--the greatly strengthened floor of the full-mod with the nose-door flexibility of the mini-mod for the greatest flexibility in loading. In this configuration the 747 can carry almost any item of oversize equipment that the C-141A can, and its maximum payload is significantly higher than that of the C-141A. It is unfortunate that this configuration, formerly designated the M-3 modification option, is no longer a candidate. The added cost over the full-mod is only about \$700,000.

Since the current program is far from settled and does not emphasize the most useful combination of features, for the purpose of the subsequent analysis we "define" an *improved* CRAF program consisting of *all maxi-mods* (our terminology for nose-door, strengthened floor) and will assume that the objective is up to 100 such modifications at a per-unit cost (in FY 78 dollars) of \$8.5 million and annual payment of \$150,000 (somewhat higher than current plans) to overcome resistance to the extra weight penalty of the full-mod. Thus, each such mod has a ten-year cost of \$10 million in FY 78 dollars.¹

THE INCREASED UTE RATE

The principal incentive for the increase in the manning levels and spares for organic airlift assets is to provide, in crisis or war-time, increased aircraft utilization (the *increased UTE rate*) and thus more efficient use of organic airlift assets. The objective of this proposal is a 25 percent increase in the planning factors for average use of the C-5A and C-141A aircraft--an increase from ten hours per

¹ Although this may seem less than a precise reckoning, the subsequent analysis of CRAF mod capabilities will make clear that this option so dominates all other oversize augmentation options that even gross misestimates of program costs would not reverse that preference.

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day to 12.5 hours per day for the first 45 days (the surge capability), and from eight hours per day to ten hours per day after the 45th day (the sustained capability).¹ The ambitious nature of the increased UTE rate proposal is best grasped by comparing it to the Lufthansa "Red Baron" 747 air cargo operation between New York and Frankfurt, West Germany, which since 1974 has operated six days a week, about 15 hours per day of flying (an average of 12-8 hours per day for the year). Although the feasibility of a 12.5 hour-per-day operating schedule has thus been demonstrated, the Lufthansa operation has some marked advantages over crisis deployment of the Army in operating only between two specially constructed freight terminals and largely carrying roll-on, roll-off intermodal containers.

In 1975 the Air Force estimated the increased UTE rate proposal to have a ten-year cost of \$854 million, based on significant increases in crew ratios and a minimal spares buy. Congress, however, refused to approve the program. Partial information available in January 1977 indicates that the present program provides for \$358.4 million to be expended in FY 81 and 82 for only the war readiness spares (WRS) necessary to support the higher UTE rates.² No costs are given for additional crews assumed in the earlier submission, additional peacetime proficiency flying, additional maintenance personnel, additional crew qualification training, and (for the C-141A) additional qualifications and maintenance of proficiency in aerial refueling.³

Previous Rand analysis of the earlier increased UTE rate proposal, based on the use of reserve associate augmentation for the full 0.75 crew ratio increase then deemed necessary to achieve the 12.5/10

¹The short notations 12.5/10 and 10/8 will be used hereafter.

²Some part of this spares expenditure represents a "get-well" spares buy intended to support the *currently* planned utilization rate of 10/8 hr/day.

³As discussed on pp. 107-110, below, to achieve the expected benefits of the UTE-rate increase, it may be necessary to provide aerial refueling for all C-5 flights, both eastbound and westbound. The costs of that capability have not been included in the foregoing reckoning.

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utilization rate, and applying standard Air Force costing techniques and cost factors from AFM 173-10,¹ derived an operating and support cost for the increased UTE rate proposal of \$84.0 million per year in constant 1976 dollars. The required increases in crew ratios to 4.0 crews per UE were derived from studies by the Aerospace Medicine School of crew performance factors and the effects of crew rest and flying limitations on the number of crews required to sustain various aircraft utilization rates.

Unless some method has been found to achieve a 12.5/10 utilization rate with the existing 3.25 per UE crew ratio, the ten-year cost of the increased UTE rate should approximate \$940 million (FY 78 dollars), plus the programmed investment in spares, for a ten-year total of about \$1,250 million in FY 78 dollars. Smaller crew ratio increases, of course, would incur lesser costs; some use of active duty crews rather than reservists as assumed above would increase costs. Of this total, we estimate the increased UTE rate for the C-5A at about 3/8 of the total, or about \$470 million in FY 78 dollars.

THE C-141A STRETCH

The C-141A stretch program was proposed largely because of the observation that on many missions the cargo compartment of the C-141A fills ("cubes-out") well before the design payload limit is reached.² Therefore, lengthening the fuselage by 280 inches is intended to permit the aircraft to approach its design payload more closely on many sorties. As with the increased UTE rate, the objective is more efficient use of currently owned assets. In addition to the fuselage lengthening, the addition of an aerial refueling capability has been proposed as has an aerodynamic modification that will offset some of the negative effects of lengthening the fuselage. The aerodynamic modification envisioned as part of this program is a compromise between an earlier, inexpensive proposal intended solely to reduce drag and the need to

¹USAF Cost and Planning Factors, Department of the Air Force, 6 February 1975; an abstract of Rand's cost analysis is contained in Appendix A in Vol. 3 of this report.

²A significant class of exceptions is the transport of munitions, which are dense.

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reduce stresses at the wing root after aircraft modification. The proposed aerodynamic fillet associated with the stretch program is more expensive and less effective in drag reduction than the fillet proposed earlier for the unstretched aircraft.

The Air Force's 1977 estimate of total program costs for the C-141A modification package is \$676.6 million in then-year dollars;¹ the official estimate for the increase in C-141A deployment payload capability attributable to the program is 27.9 percent. Modification of one aircraft has been approved and rollout occurred early in 1977. Several program options under consideration range from considerable concurrency of testing and serial modification (procurement of kits in volume early in the fall of 1977 and program completion in about FY 1981) to various stretchouts for additional testing of the modified aircraft (which implies considerable overlap between this and the C-5A program, discussed below). For cost-effectiveness analysis, we will use an adjusted program cost intended to capture *only* that part of the modification cost attributable to the increased cargo space. This estimate, \$550 million, reflects reductions to the programmed cost (\$676.6 million) of \$55.9 million for the cost of the aerial refueling option (which could be separately installed if additional study showed that to be useful)² and \$70.7 million for the cost of the earlier-proposed simple aerodynamic fairing, which previous Rand research has shown to be cost effective.³

THE ATCA PROGRAM

The ATCA program has been justified to date on its use as a tanker,

¹Of which \$41.5 million were expended in FY 77 and previous years; the balance is equivalent to \$583.8 million in FY 78 dollars.

²The contribution of aerial refueling has not been quantitatively analyzed. It is clearly most useful in non-NATO contingencies where routes may be long and overseas bases limited; however, the aerial refueling capabilities of the ATCA and the C-5A may be adequate to handle those lesser contingencies.

³J. R. Gebman et al., *The Potential Role of Technological Modifications and Alternative Fuels in Alleviating Air Force Energy Problems*, The Rand Corporation, R-1829-PR, December 1976. See Appendix A (Vol. 3 of this report) for a benefit-cost assessment of this program.

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principally for deployment of tactical fighter and airlift aircraft, a role now handled only by KC-135s. Since it is likely that any scenario involving major reinforcement of NATO would be accompanied by increased levels of alert and generation of strategic forces, the competing demands for tankers would be at a maximum. It is this implied scarcity of resources that drives the planning for a new tanker. However, on the basis of analyses done by others to which we have had access, we are not convinced that aerial refueling of airlift aircraft *in the NATO scenario* is cost effective. Some limited aerial refueling may help selected C-5A flights to carry out large payload missions without intermediate stops, but the effect is quite modest given the *planned* aircraft utilization numbers. Aerial refueling may contribute to the *actual attainment* of high utilization rates by minimizing ground time and the unscheduled maintenance requirements often generated as a consequence of an aircraft stopover. However, the increased UTE rate proposal was not initially judged by the Air Force to be dependent on aerial refueling, nor have the planned higher utilization numbers been changed at all in contemplation (more recently) of the effect of aerial refueling. If aerial refueling is *required* to meet higher planned utilization rates, then the cost of the tanker support should be charged to the increased UTE rate proposal (see Appendix A in Vol. 3).

The importance of these issues arises because of the size and cost of the ATCA program--last year's program objective of 41 UE was expected to cost some \$3.1 billion; the objective force was reported to have been increased in recent internal DoD planning to 91 UE, estimated to cost some \$5.9 billion.¹

During the early phases of this study, it seemed possible that an ATCA might be procured in an outsize-capable configuration, thus contributing to the resolution of both outsize and tanker capacity shortages. Either a C-5 derivative with removable tanker capability or a 747 derivative with both an outsize cargo capability on the main deck and a refueling capability on the lower deck would satisfy such a

¹On 22 February 1977, Defense Secretary Brown announced that the planned initial procurement of aircraft would be deferred one year.

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requirement. However, by mid-1975 the Air Force had concluded that the ATCA should be primarily a tanker and that it need have no more than bulk (or a limited oversize) capability.

THE C-5A WING MODIFICATION

The C-5A modification, which will be discussed in more detail later, arises from a shortfall in expected service life. Although the original design specification called for a 30,000-hour lifetime in high-stress operations, the C-5A structure was lightened during development to meet contractually required operating weight specifications. It subsequently became apparent that the aircraft could not satisfy that design goal. The initial assessment of the fatigue test results indicated that the service life would be 3,500 hours based on the original design mission profiles. A number of measures were carried out to extend this initial estimate of service life to 17,000-20,000 hours. Subsequent analysis has led to reductions in the expected benefit from these measures. Those reductions have led to revisions in the service life estimates (between 1973 and 1975) from 17,000-20,000 hours to 9,500-13,000 hours, to 8,000-10,000 hours, and, in 1975, to the current official estimate of 8,000 hours. At this point, assuming the continuation of historical patterns of mission use and aircraft utilization of 1,000 hr/year, the Air Force calculated that the first aircraft would require corrective action in 1979 and the 77th in 1985. When probable lead times were taken into account, the imminence of such events drove the Air Force to propose a concurrent program leading to the design and installation of a "new wing"¹ on the old static test article to serve as a new fatigue test article, with production of kits to begin prior to the beginning of fatigue testing to validate the new design. The first aircraft was slated to enter modification in July 1979. Subsequent to the formulation of this initial schedule, the results of the Military Airlift Command's

¹The leading and trailing edges of the present wings are to be saved, but the proposed "Option H" modification now extends to complete replacement of the primary structure.

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actual annual utilization (550-650 hr/year) were considered and the continuation of this restricted use has provided several years of additional margin. Thus, the current program calls for the first aircraft (following the flight test article) to enter into modification in February 1982. The fatigue test will be completed in June 1982, and the modification program will be completed in July 1987. The Air Force's official program cost in early 1977 was \$1,267.5 million in then-year dollars, of which \$1,163.3 will be expended after FY 1978.

FY 1982 ARMY DEPLOYMENTS

(S) The capability of the current airlift force shown at the end of Sec. II displayed the dimensions of the problem of deploying a sizable portion of the Army entirely by air. It also suggests the present strong dependence of our NATO defense posture on substantial warning time to mobilize, timely availability of a considerable amount of sea-lift, and adequate control of both air and sea lines of communication (LOCs). No airlift enhancement options are available by the end of 1977, so the effects of enhancement options can be observed only in later years.

(S) The end of FY 1982 is a convenient benchmark for several reasons: It is the end-point of the current FYDP, so programs to that point are well defined; if the present airlift enhancement program is approved by Congress and fully carried out, the C-141 stretch program and the CRAF mod program would be concluded, and the spares to support the increased C-5A and C-141 utilization rates would be bought. In addition, whatever increased crews are necessary to support the higher utilization¹ can be acquired and trained, and crews could have completed aerial refueling training (if included on the C-141A). An important event scheduled to occur at this time is the beginning of serial modification of C-5As under the H-mod program; 12 C-5A aircraft will be out of service at any given point during the period 1983 through 1986, resulting in only 58 UE C-5As available during that

¹(U) We have assumed 0.75 per UE for both C-5A and C-141A.

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period.¹ Finally, by the end of FY 1982, the present deficiencies of the prepositioned stocks of equipment in NATO are scheduled to be rectified, and full ISI for the prepositioned divisions is to be available in the theater. Moreover, by then the full equipment set for one additional mechanized division is to be prepositioned, and two present infantry divisions are to be reequipped as mechanized divisions. We assume for the purposes of the subsequent analysis that the two divisions to be converted to mechanized are the 9th Infantry at Ft. Lewis and the 24th Infantry at Ft. Stewart, and that the 9th Infantry (Mechanized) will be the division whose equipment set is prepositioned. The end-FY 1982 Army to be moved is as shown in Table 2. This Army now contains only eight division equivalents to be moved, thanks to the added prepositioning, and now totals only 529,800 tons to be airlifted,² rather than the 721,600 tons in the 1977 Army of nine division equivalents plus prepositioning shortfalls.

(U) For the analysis of the deployment of this Army, the base case is the capability of the current organic force of 70 C-5As and 234 C-141As; to be examined are the effects on deployment of the several possible enhancement options described above. Table 3 presents the measures of merit for the base case and a number of enhancement alternatives. Line 1 presents the results of the base case, the current organic force, in deploying the 1982 Army. Lines 2, 3, and 4 portray the consequences of adding to the base, individually and in turn, CRAF modifications, the C-141 stretch, and the increased UTE rate on the C-141A only (keeping the utilization rate of the C-5A fixed at 10/8 throughout). The first column gives the closure date and the second column the reduction in closure compared with the base case. The third column gives program costs, and the fourth column, the cost-effectiveness metric, dollars per day of decreased closure.

¹(S) For the 77 in-service aircraft, one has suffered extensive fire damage to a wing, seven are reserved for special missions during a NATO deployment, and the remainder constitute the UE force (even 70 UE may thus be an optimistic assessment); during the H-mod program, therefore, at most 58 UE are available for deployment.

²(U) 197,400 outsize tons and 332,300 oversize tons.

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(S) Table 2

1982 FORCES TO BE DEPLOYED--LOCATIONS AND UNIT TONNAGES (U)

Unit	Location	Weights, in Thousands of Tons		
		Outsize	Oversize	Total
Air Force (54 sq.)	Various	0.0	61.6	61.6
1st Cav., Armor Div.	Ft. Hood	41.6	51.9	93.5
5th Mech. Div.	Ft. Polk	36.5	51.3	87.8
24th Mech. Div.	Ft. Stewart	36.5	51.3	87.8
194th Armor Brigade	Ft. Knox	7.7	8.0	15.7
197th Mech. Brigade	Ft. Benning	6.0	7.8	13.8
6th Air Cav. Combat Bgd.	Ft. Hood	2.0	0.3	2.3
32nd Mech. Brigade ^a	Ft. Riley	6.0	7.8	13.8
67th Mech. Brigade ^a	Ft. Carson	6.0	7.8	13.8
81st Mech. Brigade ^a	Ft. Lewis	6.0	7.8	13.8
116th Arm. Cav. Regt. ^a	Boise	4.7	2.5	7.2
101st Airmobile Div.	Ft. Campbell	16.9 ^b	27.7	44.6
39th Inf. Brigade ^a	Ft. Campbell	2.5	6.3	8.8
82nd Airborne Div.	Ft. Bragg	18.8 ^b	32.9	51.7
30th Mech. Brigade ^a	Ft. Bragg	6.0	7.8	13.8
Total tonnage:		197.4	332.3	529.8

^aDenotes reserve unit.

^bIncludes oversize as filler in outsize loads.

NOTES: "Div." tonnage includes division plus ISI.

5th Mech Div. includes 48th Mech. Brigade (Reserve) as roundout.

24th Mech. Div. includes 256th Mech. Brigade (Reserve) as roundout.

39th Inf. Brigade is deployed as part of 101st Airmobile Div.

30th Mech. Brigade is deployed as part of 82d Airborne Div.

Tonnage totals do not add because of rounding.

Bulk tonnage is not included.

(U) Line 2 shows the effect of adding CRAF modifications to the organic force and illustrates several points. First, the deployment of the Army is constrained by the amount of outsize equipment to be delivered (that is, by C-5A capacity). Only about 38 CRAF mods¹ are required to provide balanced closing of the outsize and oversize complements of equipment, maintaining unit integrity to the division

¹(U) Assumed in our deployment modeling to be strengthened-floor, nose-loading "maxi-mods."

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(S) Table 3

CAPABILITIES AND COSTS OF OVERSIZE AIRLIFT IMPROVEMENTS--1982 ARMY (U)

Description	Days to Closure	Δ Days from Base	Estimated Costs, FY 78 \$M	\$M per Δ Day
Base case: 70 C-5A, 234 C-141A	121			
To base, add (38) CRAF mods ^b	93	28	425 ^a	15.2
To base, add C-141 stretch	107	14	550	39.3
To base, add Δ UTE to C-141A	107	14	780	55.7
To base, add all three (13 CRAF) ^b	93	28	1,755 ^a	62.7

^aDenotes cost for 1/2 of planned CRAF program (42 UE) included.

^bDenotes deployment time is constrained by outsize capacity; number of maxi-mod CRAF mods to provide balanced deployment force is in parentheses.

or brigade level. That is, additional CRAF mods beyond 38 would only provide a hedge for schedulers, or additional capacity to handle re-supply or other missions; they would not contribute to *balanced* deployment of the Army equipment and do not produce more rapid closure. Since the currently envisioned CRAF force will be a mix of mini-mod and full-mod versions, neither of which is likely to be as capable as the version modeled here, let us assume that half of the (generously estimated) program costs for the full 85 UE "maxi-mod" program objective are attributed to this mission (equivalent to 10 percent more capacity in terms of maxi-modes).¹ Given this estimated cost (\$425 million in FY 78 dollars), we can establish the first of our cost-effectiveness numbers, measured in terms of millions of FY 78 dollars

¹(U) Given this deployment task and the organic airlift assets available, a buy of as many as 85 CRAF, whether mini, full, or maxi, would not be economically rational.

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per day of decreased closure. This number, \$15.2 million per day, is meaningful only in comparison with alternative enhancements, to be considered next.

Line 3 displays the consequences of acquiring the stretched C-141 rather than CRAF mods. The decrease in closure time is only half that for the (partially underutilized) CRAF program; this case is *not* constrained by the availability of outsize capacity. The modification cost (adjusted downward to remove the cost of aerial refueling and the simple aerodynamic fairing) of \$550 million produces a cost per day of decreased closure of \$39.3 million. The C-141 stretch is less preferred than the CRAF program on two grounds: it produces a smaller absolute decrease in closure time, and it is more than 2-1/2 times as expensive per day of decreased closure.

Line 4 displays the effects of adding only the increased UTE rate for the C-141A (unstretched) to the base case; this is done to assess the effectiveness of enhanced utilization of oversize assets and to retain comparability with the two preceding cases.¹ The increased UTE rate on the C-141A produces the same decrease in closure time as would the C-141 stretch. Since the ten-year cost of the increased UTE rate on the C-141A² is higher than the cost of the stretch, its cost effectiveness is lower than that of the stretch (which is in turn lower than that of the CRAF modification program).

The CRAF program is clearly preferred to the stretch and the increased UTE rate, in terms of both absolute reduction in closure time and cost per day of decreased closure; of the remainder, the stretch is more cost effective than the increased UTE rate. Indeed, the margin favoring CRAF is such that, even substituting the cost of the *full* program buy of 85 mods (although fewer than half could be utilized for a balanced deployment capability), it would remain the preferred choice.

¹If the C-5A UTE rate were also increased, this would enhance outsize capacity and give a false view of the C-141 contribution; increased C-5A UTE rates are discussed below.

²As described earlier, this is based on the use of reserve crews in the ratio of 0.75 per UE; unlike the stretch and CRAF, the costs of the UTE rate are dominated by annual recurring costs.

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(S) Line 5 displays the results of acquiring the stretch and increased UTE rate on the C-141A (but not on the C-5A) and the CRAF program. This combination is no faster in closing the Army than the CRAF mod program alone (see line 2); 93 days is the *outsized deployment limit* for that Army, and no mix of different *oversize* enhancements can reduce that. Indeed, all that happens is that the added oversize capacity contained in the stretch and higher UTE rate on the C-141 *displace* CRAF mods; instead of 38 CRAF needed for balanced closure as in line 2, the added C-141A capability displaces all but 13 CRAF mods.

The cost column of line 5 simply sums the costs on the three preceding lines (2-4), again using half of the total CRAF costs as a proxy for the limited number of CRAF mods (13) that are actually needed.¹ The combined program in line 5 does no better than the CRAF mod program alone but is more costly to acquire. It is less cost effective than the straight CRAF option--by a factor of four.

The situation portrayed in line 5 is very nearly what would result from the Air Force's airlift enhancement program for which legislative approval was sought in the FY 1976 and 1977 budget cycles. The only element missing is the increased UTE rate on the C-5A. Table 4 reproduces the first five lines from Table 3 and adds two new cases involving a 25 percent increase in utilization of the C-5A.² Line 6 provides the outcome for the case in which the higher C-5A UTE rate is accompanied by the set of airlift enhancements of the previous discussion: the stretch and increased UTE rate on the C-141 and CRAF. The closure dates are decreased by three weeks as a result, reflecting the more rapid movement of the Army *outsized*--the constraining factor. Since the *oversize* capacity of the C-141 is the same in both lines 5 and 6, additional CRAF mods are needed to balance the "new" C-5A

¹Substituting 13/85 of the CRAF program costs does not alter the cost-effectiveness rankings. Even if the 13 were *free*, CRAF alone (line 2) is still three times more cost effective than the case in line 5. (The 13 might be free since U.S. airlines operate 16 747 freighters today.)

²From a currently planned 10 hr/day for the first 45 days and 8 hr/day thereafter to 12.5 hr/day for the first 45 days and 10 hr/day thereafter.

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(S) Table 4

CAPABILITIES AND COSTS OF OVERSIZE AND OUTSIZE AIRLIFT IMPROVEMENTS--1982 ARMY (U)

Description	Days to Closure	Δ Days from Base	Estimated Costs, FY 78 \$M	\$M per Δ Day
Base case: 70 C-5As, 234 C-141s	121			
To base, add (38) CRAF mods ^a	93	28	425 ^b	15.2
To base, add C-141 stretch	107	14	550	39.3
To base, add Δ UTE to C-141A	107	14	780	55.7
To base, add all three (13 CRAF) ^a	93	28	1,755 ^b	62.7
To base, add all three (33 CRAF) ^a plus Δ UTE to C-5A	72	49	2,225 ^b	45.4
To base, add Δ UTE to C-5A plus (60) CRAF ^a	72	49	1,320 ^c	26.9

^aDenotes deployment time is constrained by outsize capacity; number of maxi-mod CRAF mods to provide balanced deployment force is in parentheses.

^bDenotes cost for 1/2 of planned CRAF program (42 UE) included.

^cDenotes full CRAF program costs (\$850 M).

capacity produced by the higher UTE rate--33 maxi-mods rather than 13. This case reflects the Air Force's full enhancement program.

(U) Since the CRAF mods have already been shown to be significantly more cost effective than the C-141 stretch or increased UTE rate, we need to examine whether substituting CRAF for enhanced C-141 capabilities would be more cost effective than the Air Force's enhancement program. These results are displayed in line 7, in which we assume the increased UTE rate for the C-5A and the CRAF mod program, but neither the stretch nor the increased UTE rate for the C-141A. Again, because the outsize equipment complement is still constraining deployment time, the CRAF mod program alone (60 maxi-mods in this case) can still

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provide all the oversize capacity additions necessary to match the C-5A outsize capacity when its utilization rate is increased. The "costs" column of line 7 includes the full CRAF program cost estimate of \$850 million, since the 60 maxi-mods represent a significant fraction of the total program objective; and whatever mix of mini-mod and full-mod aircraft might emerge from the directions the program is currently taking will have lesser capability than an equal number of the maxi-mods used in this deployment analysis. Nonetheless, the CRAF option (line 7) clearly dominates the option to increase the capabilities of the C-141A (line 6)--the CRAF mod program is nearly twice as cost effective.

(U) To sum up the principal findings of the analyses thus far presented:

- Both the 1977 and 1982 Armies evaluated for deployment to NATO by air become outsize-equipment constrained upon the addition of modest CRAF mod acquisitions to the current airlift force.
- In terms of deployment by air, the three principal enhancement options advocated--the C-141 stretch, the increased utilization of the C-141A, and the CRAF mod program--together provide much too much oversize capacity to balance available outsize capacity, even if the increased UTE rate can be carried out for the C-5A.
- By a wide margin, the CRAF mod program is the most cost-effective oversize capacity enhancement, and it *alone* can balance the outsize capacity of the C-5A, whether or not the C-5A UTE rate is increased.

OTHER DEPLOYMENT CONSIDERATIONS

(S) Several additional issues not addressed in the preceding analyses need to be explored next. They include such topics as:

- How realistic are the outcomes portraying the effects of the increased UTE rate for the C-5A?
- What are the implications of the closure times shown for warning and mobilization times, if we assume that the Army must be delivered by a specified date, such as D+30? How many divisions have we moved at those points?

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- How persistent over time is the outsize constraint likely to be?
- What options are there for improving closure times by what future date, and what can be said about their cost effectiveness?

(S) The well-known C-5A wing problem and the dilemma that problem poses for the Air Force will be explored in greater depth in a subsequent section. Here we treat only the question of the feasibility of increasing the C-5A UTE rate through FY 1982 and beyond. At present, the utilization rate achievable by the C-5A force (for any period measured in weeks or months) is constrained by a serious shortage of spares. This is widely recognized and is the rationale for the planned major buy of spares (for the C-141 as well as the C-5A) now programmed for FY 1980 and 1981. In the interim, the increased utilization rates are infeasible. Second, the present authorized crew ratio of 3.25 crew per UE is not sufficient to provide the planned higher utilization rates; that could be rectified between now and FY 1982, although the added C-5A flying time required to train and maintain proficiency of new crews would further exacerbate the C-5A wing life problem. Third, the calculations presented in Table 4 assumed that the increased UTE rate applied to all 70 UE C-5As; however, as noted earlier, by the last quarter of FY 1982, the planned Option H wing replacement will begin to remove aircraft from service for modification on a regular schedule. For the four years 1983-1986, the equivalent of 12 UE will be unavailable. This leads to the following simple calculation: 58 UE available at 25 percent greater productivity due to the increased UTE rate are equivalent to 72.5 UE at standard utilization. Thus, if the UTE rate could be carried out during 1982-1986,¹ its only effect would be to keep the capability to move outsize fairly constant during that time.

¹(S) The current crew ratio of 3.25 per UE is nearly sufficient to provide four crews for the 58 UE available during the modification period. Thus, more crews are not needed until the H-mod is completed. Also, the spares buy could be stretched in part into the 1983-86 time period.

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(S) The relevant planning basis for that period, assuming Option H, is likely to be more nearly the case depicted in line 2 of Table 4 (93 days to closure) than that in line 7 (72 days to closure). Indeed, with only 58 UE and no increased UTE rate, the deployment time increases to 114 days.

(S) A longstanding planning objective has been that the forces designed for immediate reinforcement in the line (whose equipment is prepositioned) should be in place by the beginning of combat and those designed for augmenting the strategic reserve (not committed to forward defense and to be deployed with their equipment) should be in theater by D+30 days. *No combination of planned airlift enhancements can deploy the Army evaluated here by air by D+30 unless the period of warning and mobilization (M to D) is prolonged.* Closure in 93 days, the outcome when C-5A utilization is held at 10/8 (or is increased but offset by withdrawals of UE for H-mod), implies that for the objective to be met, D-Day occurs at M+63, and, assuming the customary seven-day lag for U.S. mobilization to begin after initial warning of Pact mobilization, that the Warsaw Pact mobilizes for 70 days (ten weeks) prior to launching an attack. Only slightly less preposterous is the implicit scenario for the cases in which C-5A utilization can be increased across the full 70 UE force. Closure in 72 days in that case is only consistent with 42 days of mobilization; that implies Warsaw Pact mobilization extending over seven weeks prior to attack.

(S) Whether there are seven or ten weeks of mobilization, the implied scenario would be much more consistent with massive Pact buildup and substantial reinforcement of the front from the Western Military Districts of the Soviet Union than the "unreinforced attack" scenarios to which the Army deployments envisioned here are deemed an adequate response. Moreover, the implied warning and mobilization times are wholly at variance with the growing concern for "sudden attack" with only a brief period of warning and little overt evidence of mobilization. Finally, given seven to ten weeks of mobilization, sealift alternatives may well be entirely feasible and are clearly capable of solving the outsize equipment problem that airlift cannot handle. But in that event, the rationale for very large *oversize* airlift enhancements also

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largely vanishes. If sealift is really available on such a timely basis, that must assume full NATO shipping mobilization, and the shipping capacity is there to move oversize equipment as well. Even if one assumes sealift availability, airlift forces should be tailored to *balanced* deployment of Army units, which would not be the case for a greatly expanded *oversize* capability.

Figure 2 illustrates the closure rates of the 1982 Army for three representative airlift cases considered earlier; the base case (curve A) and the fastest achievable closure rates without (curve B) and with (curve C) an increased UTE rate on the C-5A, with oversize capacity sufficient to balance the closure of outsize equipment.¹ From these curves, one can read off the times required to close various elements of the 1982 Army, by what deployment date intermediate numbers of divisions can be closed, and related questions.

(U) For those contingencies in which the timely availability and reliability of sealift would be questionable and closure by D+30 is a valid requirement, the 1982 Army clearly must close in about half the time that the programmed 1982 airlift force could accomplish. Before turning to that issue, however, we briefly consider whether even the lengthy deployment pattern portrayed above is not overly optimistic.

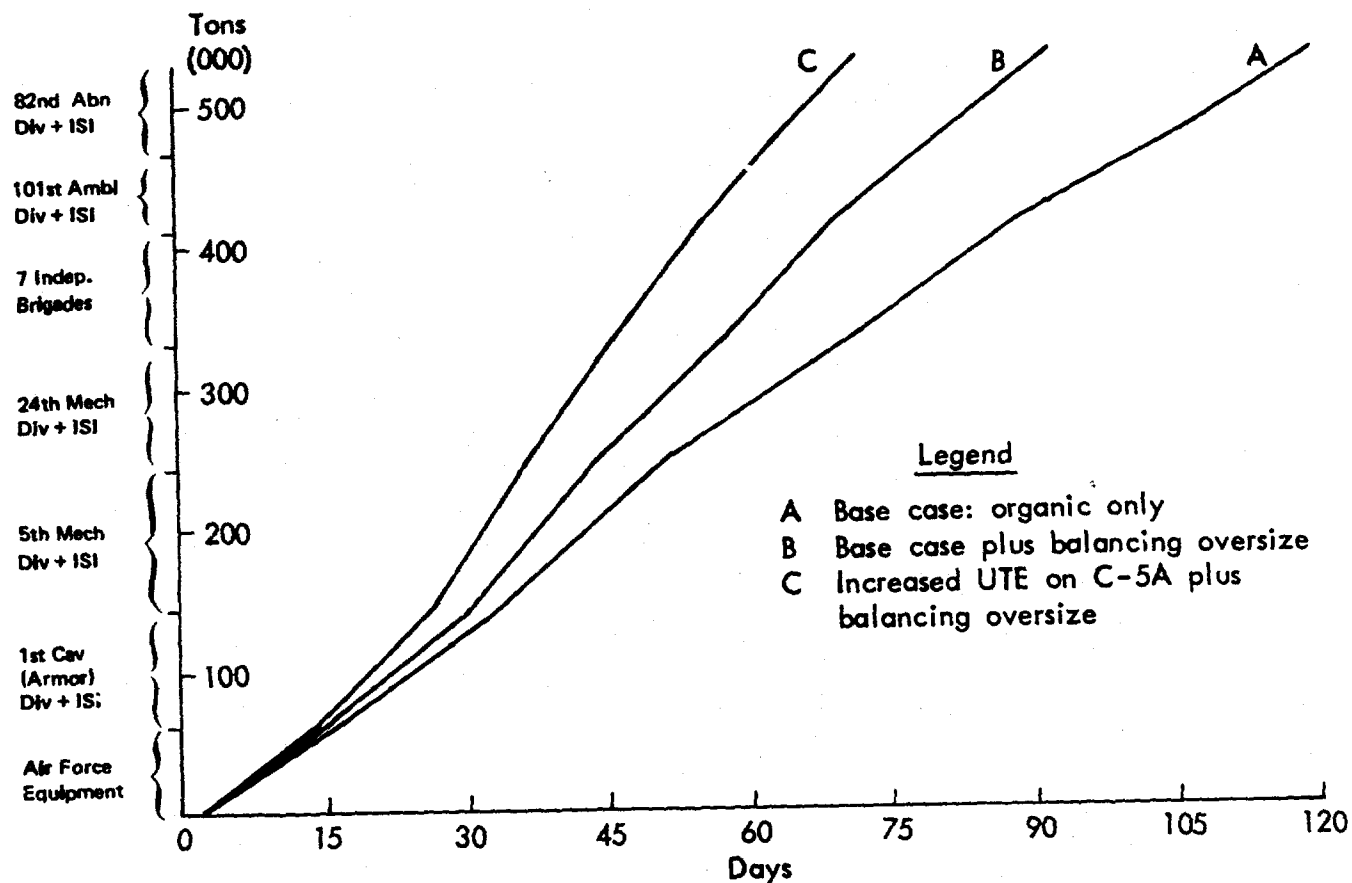
(S) We have assumed that airlift aircraft are not directly attacked, and that the smooth flow into NATO airfields is unimpeded; both are optimistic assumptions. To repeat, problems of defending APODs and air LOCs are not analyzed here; but they are obvious areas of concern, once the necessary resources to carry out a deployment by air are better defined. The effect of attrition to airlift assets could be modeled, given a set of assumptions about attrition rates over time. There are fairly large numbers of airlifters (including the Stage III narrow-body CRAF fleet), and they tend to be distributed rather than concentrated. Therefore, modest levels of attrition occurring over time would somewhat extend deployment times and would have greatest effect in the later stages of deployment, when deploying units tend to be somewhat less capable additions to forces and when sealift

¹(U) These curves cover cases displayed in lines 1, 2, 4, 5, and 7 of Table 4.

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(S) Fig. 2—Rates of deployment of 1982 Army by air, various airlift enhancements (U)

might begin to play a larger role. However, the effects of harassment might be more profound. The strategic airlifters are, by and large, tied to a limited set of potential APODs, and repeated runway-closing attacks, for example, could considerably affect the timeliness and orderliness of deployment.¹ The greater the reliance on airlift for deployment, the more tempting such tactics would become. To our knowledge, the magnitude of the potential problem has not yet been adequately addressed. It should be.

(S) Apart from these obvious but unanalyzed difficulties, the question remains of whether the 1982 Army portrayed here is likely to be realized in fact by the end of FY 1982. Recall that there are four differences in assumptions between the 1977 and projected 1982 Armies:

¹(S) Analogous to laying sea mines in the coastal waters near major ports, as mentioned in Sec. I.

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- The outfitting of the Abrams Army, to include one new mechanized and two new infantry divisions will be completed (7th and 24th Inf. and 5th Mech.).
- A duplicate equipment set for one additional mechanized division will be procured and prepositioned in NATO (9th Mech.-- currently Inf.).
- Two infantry divisions will be converted to mechanized divisions (9th and 24th Inf.).
- The present shortfalls of both unit equipment and ISI equipment in both the prepositioned stocks (POMCUS) and the combat replacement stocks (WRS) in the NATO theater will be rectified.

(S) Such information as is available to us in current guidance and planning documents strongly suggests that these points are also arrayed in terms of priority. If so, the United States will have to produce the heavy combat equipment for no less than four mechanized divisions before making up the significant deficiencies in the prepositioned and theater WRS stocks.¹ We have not attempted to estimate potential shortfalls in equipment stocks, to examine the production rates necessary to make up the shortfall, nor to examine the effects of shortfalls on deployment times; however, we can estimate the effects of completing only the first three of the tasks by adding back into the 1982 Army previously analyzed the estimated shortfall of prepositioned equipment for combat units and ISI identified in earlier Rand analyses (see Table 1).

(U) Table 5 compares the results of deploying by air this heavier 1982 Army with uncorrected prepositioning shortfalls, with the results of the cases analyzed earlier and presented in Table 4. Calculations of cost effectiveness for these new cases are omitted only because the preference ordering is unchanged. Outsize-limited cases remain outsize-limited, and CRAF is still the dominant choice for oversize augmentation. What is different is that the alternative Army is somewhat more outsize-constrained than before, as indicated by the uniformly smaller numbers of CRAF mods required to balance the outsize capability of the C-5A.

¹(S) Both the 1976 GAO report previously cited and the study recently completed by the JCS for the Congress identify the magnitude of the shortages for selected items of heavy unit equipment.

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(S) Table 5

COMPARISON OF DEPLOYMENT TIMES AND CRAF MODS REQUIRED FOR BALANCED DEPLOYMENT OF TWO POSSIBLE FY 1982 ARMIES (U)

Description	1982 Army Without Prepositioning Shortages		1982 Army with Current Prepositioning Shortages	
	Days to Closure	Number of CRAF Mods	Days to Closure	Number of CRAF Mods
Base case: 70 C-5A, 234 C-141A	121	NA	156	NA
To base, add CRAF mods	93	38	131	29
To base, add C-141 stretch	107	NA	137	NA
To base, add Δ UTE to C-141A	107	NA	138	NA
To base, add all three	93	13	131	5
To base, add all three plus Δ UTE to C-5A	72	33	103	21
To base, add Δ UTE to C-5A plus CRAF mods	72	60	103	46

That is, the present prepositioning shortfall contains a higher proportion of outsize tonnage than does the basic Army to be moved, so that less oversize augmentation is needed to balance the available capacity of the C-5As if prepositioned equipment shortfalls are *not* corrected.

(S) The other major difference is that deployment times for all the cases are lengthened by an additional 30-40 days, a good proxy for the magnitude of the airlift effort required if the deficiencies are not corrected. Such a large effort means that in the first month to six weeks of a crisis, no more than the equipment to support the deploying tactical air squadrons and the equipment for the nominally "prepositioned" forces could be deployed by air. That is, *any short-warning (short M to D) scenario implies that almost none of the Army*

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*forces in the United States designed for reinforcement by D+30 would be delivered by that date.*¹

(S) In view of the magnitude of the problem and the serious consequences these deficiencies have for deployment capabilities, a detailed study of current shortages and the options and the timing for rectifying the problem is urgently needed. It may well be necessary to give higher priority to rectifying deficiencies of stocks in theater than to converting current infantry divisions to mechanized divisions, since at least up to the end of FY 1982 the means for promptly transporting those divisions are lacking.

(U) Various possibilities for coping with the problem of more rapid deployment of these eight division forces in the near term will be discussed at greater length in the concluding section. Section IV briefly assesses one possibility suggested by the analysis to date-- more outsize capacity.

(S) As discussed in somewhat greater detail below,² prepositioning some outsize-dominant portions of Army division sets could appreciably reduce the outsize problem. Equipment match-up problems are an unavoidable byproduct, but the concept seems otherwise acceptable. Indeed, it may represent one of the few currently feasible means of lessening the time needed to deliver combat-effective forces to the NATO front.

¹(U) As noted earlier, sealift probably cannot contribute significantly during the first month or so of a contingency.

²(U) See pp. 105-107.

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IV. TOWARD MORE RAPID DEPLOYMENT OF THE ARMY BY AIR

(U) The analyses in the preceding section demonstrated that, in deploying by air the several Armies examined, the principal airlift shortcoming is the inability to deal with the outsize complement. In all cases considered, the CRAF program *alone* could provide more than enough outsize capacity to match the outsize capacity of the C-5A force, to achieve balanced (albeit slow) deployment of the 1982 Armies. The CRAF mod program is demonstrably more cost effective than either of the outsize enhancement options involving the C-141A. Thus the major enhancement issue for more rapid deployment is the addition of more outsize capacity. For CRAF programs of at least the size envisioned in Air Force planning, how much additional outsize capacity (beyond that of the present C-5A force) could be acquired while still providing balanced capabilities, and what effect on closure times results? We explore those limits by adding more notional C-5A equivalents to the 70 UE initially modeled.

(U) Table 6 displays how many C-5A equivalents would be needed, with and without an increased C-5A utilization rate, to just balance

(S) Table 6

C-5A EQUIVALENTS NEEDED FOR BALANCED DEPLOYMENT OF
THE 1982 ARMY WITH NO PREPOSITIONING SHORTFALL (U)

Description	Days to Closure	C-5A Equivalents Required for Balanced Deployment	
		Without Δ UTE Rate	With Δ UTE Rate
85 CRAF	58	107	86
100 CRAF	52	118	94
115 CRAF	47	128	102

NOTE: All cases include 234 UE C-141A, without stretch or increased UTE rate, and all cases assume CRAF maxi-mods.

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the oversize capacity of the basic C-141A plus CRAF programs of various sizes: 85, 100, and 115 maxi-mods. The Army to be moved is the 1982 Army with prepositioning shortfalls assumed to be corrected.

(U) For a CRAF program of 85 modifications (the number of 747s currently offered by U.S. civil airlines), 86 C-5 equivalents provide a balanced outsize capability if the increased UTE rate can be achieved across that force; if not, 107 provide a balanced mix. That is, depending on the assumption about increasing the UTE rate, between 16 and 37 more C-5 equivalents than the present 70 UE would be needed to balance 85 CRAF mods. Indeed, closure is only two days short of meeting a criterion of a division a week for the eight division force deployed here.

(S) As the number of CRAF mods available increases, to 100 or 115, the numbers of C-5 equivalents needed to provide outsize balance increases, and the time required to close the 1982 Army decreases. For 100 CRAF mods, closure of the Army could be achieved in 52 days, given some 24-48 more C-5 equivalents; that would be just sufficient to close the Army by D+30 under the "standard" planning assumptions of 30 days' warning/23 days' mobilization.¹ The outcome for 115 CRAF mods and still more C-5 equivalents, it is evident, would produce even more rapid closure, so that shorter warning/mobilization periods could be accommodated (24/17 days in this case).

(U) Although 100 CRAF mods were the original Air Force program objective, that number exceeds the present offering by U.S. airlines; whether and when additional 747s might become available are open to question, as is the mechanism for increasing their effectiveness to the levels assumed by our maxi-mod configuration. A number as large as 115 might be achievable only by including 747s belonging to the flag airlines of our NATO allies in the modification program. The 747 holdings of those airlines total significantly more than the 30 needed to achieve a program size of 115, and there is good reason why NATO members' aircraft should participate equally in the program--after all,

¹(U) Both modeling abstractions and real-world constraints are likely to limit the accuracy and precision of absolute closure-time estimates, so that the reductions in closure indicated by analysis should be viewed only as "reasonable approximations."

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the purpose of the CRAF mod program most clearly pertains to reinforcing NATO's defenses.

OUTSIZE EQUIPMENT TRENDS

Acquiring only enough additional outsize capacity to balance planned oversize capacity results in the least-cost aircraft mix for a fixed Army. However, this ignores the issue of flexibility, given that the outsize-oversize mix is not static. That mix can change for any of a number of reasons: different mixes of divisions in an assumed Army, different assigned equipment within units, modernization with new equipment that falls into a different air-transportability category, etc. Outsize-capable aircraft can always carry oversize equipment; by definition, oversize-capable aircraft can never carry outsize equipment. Thus, the penalty for acquiring "too much" outsize capacity is small--a modest misallocation of dollars;¹ the penalty for acquiring too little outsize is an imbalanced force, part of which is redundant to deployment needs.

The conversion of two infantry divisions to mechanized status is already in process, significantly increasing the ratio of outsize to oversize for those divisions. We noted earlier the growth of outsize that has occurred in the support increments for the divisions as more tanks, artillery, and helicopters were added to the lists of authorized unit equipment. In terms of future equipment, both the XM-1 main battle tank and the new mechanized infantry combat vehicle (MICV) may shift the outsize-oversize balance. The weight of the XM-1 is already perilously close to the limit that would prevent carriage of two tanks in a C-5A even after the wing modification is completed and under emergency overload conditions; if so, that would complicate deployments involving large numbers of new tanks. Similarly, the MICV has now become an outsize vehicle, although the original design specification was for it to be air transportable in the C-141A.² Of course, current plans call

¹On the reasonable assumption that outsize capacity costs somewhat more than an equal tonnage oversize force.

²Addition of armor plated skirts outside the vehicle treads increased the width of the vehicle to beyond the C-141 door width. Although the skirts are classed as "removable," it takes a crew some

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for initial production of both the XM-1 and the MICV to be allocated first to units in the NATO theater, so these vehicles will not have an immediate effect on the mix of outsize and oversize transport capacity.

Finally, many critics of Army deployment plans have made their voices heard recently, pointing to a variety of equipment in support units (pianos, bands, etc.) that in some sense is not indispensable to combat operations. However, most such items would be classed as bulk or oversize rather than outsize. Of course, the examples mentioned are seldom consequential, either in terms of Army planning to move them initially or in terms of the prospective tonnages involved. Some analysts, however, have suggested more sweeping changes, largely focused on the amount of rear-area truck transport that is currently allocated to a division's support units. They have questioned whether, in a NATO scenario, sufficient civil transport could not be requisitioned to provide most of the necessary rear-echelon, on-road transportation. Of course, sufficient organic off-road-mobile transport must be provided to support combat units in their dispersed combat posture, but, nonetheless, significant reductions might be possible in the number of Army trucks required. This equipment category, of course, makes up a sizable fraction by weight of the oversize complement of a division/ISI combination; reductions in the numbers required (or even delayed shipment by sealift as part of the SSI complement) could both reduce the total deployment task and markedly increase the proportion of outsize equipment remaining to be transported by air.

In sum, we conclude that the proportion of outsize equipment to be moved has increased in the past, is programmed to increase within the current planning horizon (FYDP), and is more likely to be further increased than decreased by future events. This needs to be reflected in planning flexibility into the future mix of outsize and oversize airlift capabilities.

3.5 hours per vehicle (for uncorroded equipment) to make the MICV oversize, and the skirts must be reinstalled at the terminus for the vehicle to be combat-ready.

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"DOUBLE THE OUTSIZE" CASES

(U) To accommodate possible CRAF mod programs that might ultimately provide the oversize capacity equivalent to 115 maxi-mods and to leave available a margin for potential future increases in the proportion of outsize equipment, we consider the effect of a notional outsize capacity that is double the current C-5A capacity (some 10 percent more capacity than the largest outsize entry in Table 6). Table 7 shows the capabilities of this 140 C-5 equivalent force to close the 1982 Army for several CRAF programs and for different UTE rate assumptions. None of these outcomes are outsize-constrained.

(S) Table 7

CLOSURE RATES FOR "DOUBLE THE OUTSIZE" IN C-5
EQUIVALENTS PLUS VARIOUS CRAF MOD PROGRAMS (U)

Description	Days to Closure	
	Without Δ UTE Rate on C-5A	With Δ UTE Rate on C-5A
140 UE C-5 equivalents; 85 CRAF mods	51	46
140 UE C-5 equivalents; 100 CRAF mods	48	43
140 UE C-5 equivalents; 115 CRAF mods	45	41

NOTE: All cases include 234 UE C-141A without stretch or increased UTE rate, and all cases assume CRAF maxi-mods.

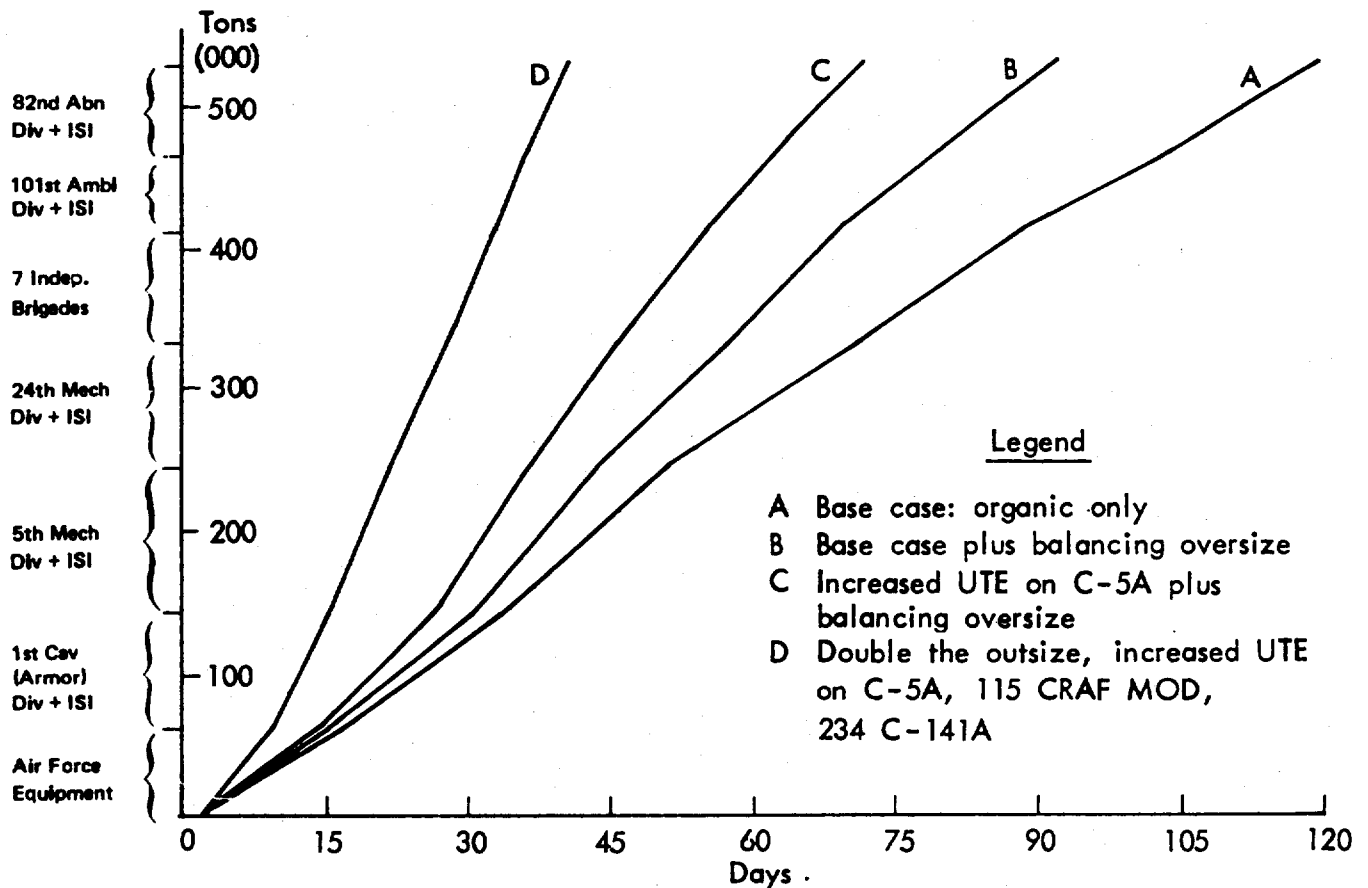
(S) Closure rates for this larger force are even more rapid; closure of the 1982 Army by D+30 is now possible given warning/mobilization periods ranging from 28/21 down to 18/11 days.¹ In Fig. 3, this most rapid closure case is added to the set of curves displayed earlier in Fig. 2. Although closure of the 1982 Army by day 41 would not meet the criterion of eight divisions transported by D+30 for very

¹(U) The reader is again reminded of the caveats on absolute closure times; also, as deployment time is compressed, the real-world problems of base congestion, fuel availability, and Army readiness become more severe.

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(S) Fig. 3—Rates of deployment of 1982 Army by air, various airlift enhancements (U)

short warning scenarios, by day 33 all of the Army save the Airborne and Airmobile divisions, their ISIs, and the collocated reserve brigades are closed. The Air Force, one armored and two mechanized divisions and their ISIs, and seven independent brigades¹ have closed.

(U) This 140 C-5 equivalent force contains a "cushion" of outsize capacity potentially available to accommodate to modest upward changes in the outsize proportion of future Armies to be moved, or to close even more rapidly a future Army that has been pared of some of its current oversize equipment complement. This would not be the case for any of the C-5 equivalent forces displayed in Table 6, which are

¹(U) The seven "brigades" are one armor, four mechanized, and one air cavalry combat brigade, and one armored cavalry regiment (see Table 2).

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sized to be in perfect balance with prospective oversize capacity for the 1982 Army as defined. For the forces given in Table 6, increases in the proportion of outsize equipment would render some of the oversize capacity excess, and reductions in the oversize complement would not produce decreased closure times.

Unless the several arguments against relying heavily on sealift (timeliness, vulnerability, availability) or prepositioning (readiness, Army disenchantment, inflexibility) can be effectively neutralized, or the Army can be compelled to cut back on the size and composition of outsize equipment, *a requirement for additional outsize capability in the airlift fleet becomes the dominant consideration in strategic mobility planning.* The preceding analyses have indicated the amount of additional outsize capacity necessary to produce closure of the 1982 Army on a time-scale roughly consistent with deployment completion by D+30, given only two to three weeks of mobilization time after warning. The issue now to be addressed is at what cost and on what time-scale could additional outsize capacity be obtained.

OUTSIZE AUGMENTATION

In the short term, only modifications of an existing aircraft could be produced and incorporated into the inventory. The only candidates are a modified version of the Boeing 747 freighter or an updated version of the C-5. In a slightly longer-term perspective, an enlarged or growth version of the prototype Advanced Medium STOL Transport (AMST) might possibly be obtainable toward the late 1980s. It would, as a minimum, have to satisfy requirements for carrying 60 tons unrefueled over a range of about 3,000 n mi.¹

A totally new transport, unless very largely derived from one now in being, presumably would take at least ten years of planning and development before initial production, which suggests the early 1990s as a realistic full operational capability date.

The cost and capabilities of an advanced technology large airlifter (with a gross weight in excess of one million pounds) have

¹ A next-generation Army tank from the Atlantic Coast to Europe.

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recently been investigated.¹ Preliminary estimates suggest that the development costs of such an airplane could range from \$2.8 to \$4.5 billion (1975 dollars); unit procurement costs are expected to be in the range of \$80 to \$115 million (in a lot of 100). Each of these new aircraft would provide twice the capability of the C-5A. A "stretch" AMST with tank-carrying capabilities might cost appreciably less, but it probably would be suboptimal for strategic airlift use. NATO deployments and similar operations are better served by smaller numbers of large-capacity aircraft than by larger numbers of smaller-capacity carriers. The annual recurring costs for crews and peacetime flying diminish the cost effectiveness of smaller aircraft in competition with fewer but larger aircraft, in any sizable airlift deployment. Thus, in the broad, a large, multimission aircraft with outsize capability would be a more attractive augmentation option than a tank-capable AMST. In any case, because neither a "stretched" AMST nor a new advanced technology airlifter could contribute to resolution of the outsize bottleneck problem much before 1990, and both have speculative aspects, they will not be considered further. Either or both could, however, be candidates for replacement of the C-5A force sometime in the 1990s, which, as will be discussed in Sec. V, may be of some interest.

The only outsize-augmentation candidates available in the near future are C-5 or 747 derivatives. Lockheed has proposed the production of a new version of the C-5, either a modest variation of the C-5A that would incorporate structural improvements and simplifications and various minor changes in configuration, or an "austere" C-5D (for Derivative) that would dispense with some of the features of the C-5A (all tactical airlift features, for instance) in the interests of production economy and weight saving. (Deletion of the rear cargo door, the upper-level troop compartment, and a few other items distinguish the "austere" C-5D from the "standard" C-5B proposal.) In

¹W. T. Mikolowsky and L. W. Noggle, *An Evaluation of Very Large Airplanes and Alternative Fuels*, The Rand Corporation, R-1889-AF, December 1976.

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a lot of 50, a C-5B would cost (by Lockheed estimates)¹ about \$55 million (1975 dollars). The estimated cost of the "austere" version would be about \$2 million less.²

Boeing's proposed outsize-capable aircraft is essentially a 747-200 freighter with a floor strength similar to that of the C-5A, an enlarged forward cargo door, a raised crew compartment (repositioned to allow taking in articles 12.3 feet high), an aerial refueling receptacle, and a more powerful version of one of the three current 747 engines.³ Boeing's estimate of unit acquisition costs for a 50-aircraft production program was on the order of \$43.5 million.⁴ At comparable

¹ Contractor costs are used here only to permit order-of-magnitude comparison of program cost estimates.

² Those estimates do not include as nonrecurring costs the expenses of designing and testing the "new" wing for the C-5. Lockheed assumed, for the purposes of costing the two C-5 model improvements, that the Option H wing would be used but that costs would have been absorbed entirely by the Option H wing modification program. If the nonrecurring costs of the wing improvement program were charged to a 50-aircraft C-5B program, the additional per-aircraft cost would approximate \$2.8 to \$3.2 million (1975 dollars). See "C-5B and Austere C-5 Data Package," ORWP 74-9.1, Lockheed-Georgia Company, 27 September 1974.

³ At various times, Boeing has proposed slightly different 747 outsize modifications. They all share an ability to carry most Army outsize equipment. (According to Boeing, five items that fit into the C-5 will not fit the "outsize" 747: a U-21 airplane, two cranes, a rock-crushing machine, and a ditching machine. A total of about 15 to 25 such pieces is in each divisional ISI. Some additional items--an armored vehicle bridge launcher, for instance--must be "broken down" for loading. But the total inventory of such items in a division is small, and scheduling those few items and others that may be marginal for transport by C-5A should not present insurmountable difficulties.)

⁴ Estimates provided by Boeing Aerospace Company in August 1975 are based on the configuration defined in Boeing Report DC-33552-032, 15 April 1975. Range and payload figures were derived from applications of MIL-C-5011A rules, as were C-5A and C-5B data. Boeing costs have been expressed in 1975 dollars to make them comparable to Lockheed estimates for C-5B costs. Additional specialized ground handling equipment would presumably be required for loading and unloading the 747; its main deck is some 16 feet above ground level. Costs of modified 747 and C-5 derivatives have not been independently estimated by Rand and are provided for illustrative value only. More refined capability and cost analysis should be a first order of business if additional outsize capacity is sought.

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ranges, the 747 variant would have slightly greater payload capability than the C-5A, and with similar payloads it would have modestly better range and speed. However, the potential payload advantage might not be uniformly realized in operational use because the 747 has less head room and a slightly narrower cargo compartment than the C-5A, with still narrower areas at nose and tail. In addition, owing to its low-wing design, the main deck of a 747 is significantly higher above the ground than that of a C-5A. The differences pose questions of capacity for the variant sizes and weights of the outsize equipment; a more detailed loading simulation than current models provide is needed to establish accurate capabilities, or perhaps a prototype.

Buying additional outsize capacity before the end of FY 1982 is likely to be impossible. Boeing has estimated that a development program for an "outsize 747" (including two flight test "prototypes") would take 40 months, after which aircraft would be delivered at a maximum of two per month. Procurement of 70 aircraft could not be completed before the end of FY 1985, assuming a go-ahead early in FY 1979. More outsize capacity by the end of FY 1982 would require a high-risk, highly concurrent "crash" program. Lockheed assumes that wing redesign will precede any C-5B procurement decision, in which case the first operational aircraft would be available 36 months after program approval but without any "prototype." (An additional 5.5 months would be required if the wing design were not completed earlier and tested.)

Since the additional capabilities of both a C-5B and an outsize 747 added to the current C-5A force appear to be comparable, and since neither proposal is in any sense *definitive*, it can safely be assumed for present purposes that either could constitute a C-5A equivalent on a one-for-one basis. If the two contractors' cost estimates are taken at face value, the additive acquisition program costs for double the present outsize capacity would be on the order of \$3-\$4 billion in 1975 dollars.¹

¹Through 30 June 1975, the Congress had appropriated \$4.158 billion for the C-5A development and production of a total buy of 81 aircraft. See GAO Report, "Correction of Defects and Modifications--C-5A Aircraft," Comptroller General of the United States, 2 December 1975.

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AN OUTSIZE ATCA?

During the early phases of this study, it seemed possible that an ATCA might be procured in an outsize-capable configuration, thus contributing to the partial resolution of both outsize and tanker capacity shortages. Either a C-5D with partially removable tanker capability or a 747 with both outsize cargo capability on the main deck and a refueling capability permanently incorporated in the lower deck would satisfy such a requirement. However, by mid-1975 the Air Force had concluded that the ATCA should be primarily a tanker and that it need have no more than bulk (or a limited oversize) capability. In January 1976, the Secretary of Defense explained that the main contribution of ATCA to strategic airlift would be "to expand the range/payload capability of cargo-carrying C-5As and C-141s and to support the inter-theater deployment of tactical aircraft."¹

It is difficult to fault the concept of acquiring an outsize-capable, tanker-adaptable aircraft. The costs would be somewhat larger, of course, but that increment of cost conceivably could provide hedges against a variety of contingencies--a gradual rundown of the C-5A fleet during the late 1980s, continued growth of Army outsize, or misspecification of the outsize-oversize mix. The estimated unit acquisition cost of an outsize-capable Boeing 747 with aerial tanker capability would appear to be only a few million dollars more than for a cargo-only version (which has a program unit cost of about \$43.5 million in fiscal 1975 dollars). Lockheed's incremental acquisition costs for a tanker capability in a C-5B (or C-5D) would presumably be similar. (The estimates for the C-5B and C-5D in a cargo-only configuration were about \$55 and \$53 million in 1975 dollars.) The Air Force has estimated the then-year costs of a Boeing outsize ATCA at about \$65 million each.²

¹Annual Defense Department Report, FY 1977, p. 205.

²See Lockheed-Georgia Report NMR 75-5, "C-5 Advanced Tanker/Cargo Aircraft Configuration, Description and Data," 24 March 1975; and Boeing Aerospace Company Report D180-18657-3R1, "An Advanced 747 Tanker/Outsize Cargo Aircraft," September 1976. Cost estimates for the 747 variants were provided by Boeing, and those for the C-5B by Lockheed. The Air Force then-year cost estimates were obtained from the Air Force Directorate of Transportation in August 1975.

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If an ATCA had outsize capability, its best application for NATO deployments would appear to be hauling outsize equipment, *not refueling airlifters*. Since either a 747 or C-5 derivative outsize ATCA would approximate a C-5 equivalent, each outsize ATCA carrying equipment is a *direct* alleviation of the critical bottleneck. Tables 6 and 7 (above) displayed the reductions in closure time achievable for larger numbers of C-5 equivalents in airlift forces that *require no refueling of aircraft for balanced deployment*. If, instead, all outsize-capable ATCA's were used for in-flight refueling of the present organic force, closure times would be decreased at best only marginally from the 72 days shown in Table 5. Given the increased UTE rate, the 70 UE C-5As are *already* credited with average utilization of 12.5/10 hours per day, and even the proponents of aerial refueling would be reluctant to assume utilization rates, however briefly, in excess of 14 hr/day.¹ But that coupled with somewhat higher average payloads for aerial refueled C-5As still would not approach any of the closure times presented in Tables 6 and 7. Since the incremental acquisition cost of the *outsize* capability (development costs aside) is not likely to be more than a few million dollars per aircraft, the cost-effective solution appears to be to use the outsize capability in preference to the refueling capability. Moreover, preservation of the *tanker* option in an outsize ATCA provides a substantial inherent capability for deployments at extended ranges without reliance on intermediate bases--a relevant point for scenarios other than the NATO deployments analyzed here.

POST-FY 1982 DEPLOYMENT PROBLEMS

The preceding analyses have shown that the problems of rapid deployment of the Army² at any point up to 1982 are substantial, indeed even largely intractable. Few airlift augmentation options can be completed before about the end of 1981, and they are all oversize

¹And across a C-5A fleet for which unscheduled maintenance requirements have been both *frequent* and *time-consuming* to rectify.

²Whether the 1977 Army displayed in Table 1 or the 1982 Army in Table 2.

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augmentations, of which only the CRAF mod program is both necessary and sufficient for balanced deployments. By the end of 1981, the provision of sufficient spares and crews would eliminate at least some of the obstacles to increased C-5A utilization, which would directly affect potential closure rates. Given customary DoD planning processes, Congressional approvals, and a cautious prototyping approach to the development of any derivative outsize airlift aircraft, additional outsize capability is unlikely to be available in consequential numbers before 1985. Only an urgent program could offer some prospect for earlier service, and that would involve unattractive technical and financial risks.

Since the C-5A is scheduled to be undergoing the Option H wing replacement modification during 1982-1986, and the resulting capacity shortfall can barely be made up even if the increased UTE rate is fully achievable across the C-5A force not in modification, 1982-1986 clearly will be a very critical period for U.S. capability to provide rapid reinforcement to NATO. Apart from the CRAF program and possibly a crash program to acquire more outsize, the only other consequential variable affecting deployment times under the Air Force's direct control is the timing of the wing modifications to the C-5A force.

In view of the critical nature of the 1982-1986 time period, we turn next to an examination of the feasibility and technical risks inherent in the present Option H program and schedule and in alternative programs and schedules that might defer the loss of outsize capacity during that period. We will also explore questions pertaining to desired C-5A service life extensions and their costs. We then can consider, in the concluding section, the combined effects of all of these issues on long-term airlift enhancement options and on short-term measures that, although suboptimal, may help to tide us over the critical period of the early and mid-1980s.

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V. SERVICE LIFE OF THE C-5A: PROBLEMS AND STRATEGIES¹

The C-5A is the only U.S. aircraft capable of carrying outsize equipment over transoceanic ranges. Eight to ten years would be needed to procure a fleet of supplemental--or substitute--aircraft. In the near term there appears to be no reasonable alternative to doing whatever is necessary to ensure that the C-5A remains a useful element of the airlift force.²

Choosing the most appropriate strategy for preserving C-5A capability is potentially of great significance because: (1) the \$1.267 billion wing repair program is the largest single item of cost (except for ATCA) in the current strategic airlift program; (2) the critical problem for rapid Army deployments by air is the shortfall of outsize capacity; (3) there could be as much as 17 percent reduction in outsize airlift capacity during the four years required for serial modification; (4) the cost burden of replacing the C-5A wing may hinder future efforts to procure additional outsize airlifters; and (5) the C-5A continues to draw the attention of Congress. A basic issue is, how urgent is the C-5A wing problem?

The Air Force's assessment of the current service life limit, means to extend the years of service, and wing modification options have been based on analyses prompted by the fatigue test results (summarized in Appendix C in Vol. 3), which constitute the only empirical evidence that the C-5A may develop serious fatigue problems with the current configuration of the wing. In response to these concerns, fracture

¹This section has benefited from personal communication and discussions with C. F. Tiffany of the Aeronautical Systems Division, members of the Division Advisory Group, the former C-5A System Program Office (Col. W. A. Newsome, Jr., G. F. Purkey, L. Smythers), and the Lockheed-Georgia Company (A. P. Shewmaker and R. L. Circle). This support is gratefully acknowledged; however, the interpretations presented are those of the authors, who are wholly responsible for any errors of fact or interpretation. Additional technical detail is contained in Vol. 3 of this study, Appendixes B-H.

²See Appendix B, Vol. 3, for a brief discussion of the background on the C-5A service life problems and a summary of previous evaluations and resulting actions.

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mechanics methods have been used to make a calculation of what is thought to be a prudent safe service limit for the present wing. An analysis of the uncertainties implicit in this calculation is contained in Appendix D, Vol. 3. Appendix E, Vol. 3, presents an evaluation of the uncertainties that are implicit in the empirical evidence (Appendix C, Vol. 3). The combination of these technical uncertainties raises three important questions:

1. How accurate are the estimates of the remaining life of the present wing?
2. What is the minimum remaining life requirement for the C-5A?
3. What are the alternatives for meeting this minimum remaining life requirement?

The first and third questions are addressed here in terms of the sensitivity of the answers to the major technical uncertainties.

An answer to the second question ultimately involves a value judgment that must be based on a wide spectrum of inputs including, perhaps, a refined analysis of the other questions. In 1965, the answer to the second question was 30,000 flying hours based on a planned utilization rate of 1,800 hours per year (implying a 17-year *calendar service life*). However, the underlying assumptions for this answer have changed:

(1) through the first five years of its service life, utilization of the C-5A has only been about one-third of the originally planned rate; (2) the C-5A has thus far been plagued by more than the usual share of problems for a new aircraft; and (3) even with the present problems resolved, the utilization rate for the C-5A is not likely to exceed 700 to 750 hours per year.¹ Thus, a reconsideration of the second question, in conjunction with a narrowing of the technical uncertainties (see Appendix F, Vol. 3, for some possible information enhancement initiatives), may ultimately avoid a 17 percent drawdown in outsize airlift capacity in the mid-1980s, as well as yield a less costly

¹After the wing repair and the UTE rate increase, MAC plans for a utilization rate of 2.13 hours per day for 70 aircraft based on a 360-day year. Spread over the entire force of 77 aircraft, the average annual utilization would be 697 hours per aircraft ($2.13 \times 360 \times 70/77$).

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approach,¹ which would release funds for a more timely acquisition of additional outsize airlift capability.

BACKGROUND

For planning purposes, the Air Force has set the safe service life for the C-5A at 8,000 fatigue equivalent flight hours (based on the 1974 configuration and the 1973 mission use). Since some aircraft have already exceeded 6,000 equivalent hours of service, the repair decision has been viewed as a matter of some urgency.

In addition to curtailing peacetime operations and applying a near-term load-alleviation modification to the C-5A aircraft,² the Air Force decided in 1973 that it would be prudent to proceed with the Plan d modification (Option H) rather than lesser modifications, because of the lower risk involved in a wing that would not restrict the design mission use of the aircraft up to the original service life goal of 30,000 operating hours. However, since 1973, the C-5A force has averaged less than 700 flying hours per plane per year,³ and future operations may only slightly exceed that average even if the UTE rate increase were to become effective. Thus, if Option H provides only an additional 22,000 hours of flying potential for each C-5A, operations averaging 600 to 750 hours a year imply retention of the C-5A in the force until about 2010-2020 (assuming no major contingencies).⁴ Such

¹Potentially less costly wing repair options are discussed subsequently and described in more detail in Appendix G, Vol. 3.

²The Active Lift Distribution Control System (ALDCS). For a description of this modification, see Appendix B, Vol. 3.

³The difference between the originally planned utilization rate of 1,800 hours per year and the current rates of less than 700 hours per year is probably attributable to: (1) overly optimistic estimates of peacetime requirements for military airlift services, (2) reduction in the demand for peacetime military airlift services due to the rising cost of shipping by air (higher fuel and personnel costs), and (3) efforts to preserve the service life of the current wing configuration.

⁴Several airlift operations, each equivalent to the 1973 Middle East Airlift, would not have a significant influence on this projection. However, a major deployment to Europe, such as was considered earlier in this report, could take one to two years off the projection.

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a possibility stimulates questions about whether the costs for other repairs (e.g., for corrosion) or replacement of other components will limit the economic life of the aircraft to less than the safe service life of the wing. Furthermore, technological obsolescence may overtake the C-5A long before such extended calendar service is realized. The Air Force has seldom retained aircraft in service for more than 30 calendar years, yet the initial C-5A deliveries occurred in the late 1960s.

Two questions underlie the consideration of lesser modifications than Option H. Is the extent of the Option H repair necessary? Would the long-term benefit from a new wing be fully realized?

THE TECHNICAL UNCERTAINTIES

Following extensive technical discussions, personnel from Rand and the Air Force's Aeronautical Systems Division (ASD) have agreed that the uncertainties implicit in the service limit calculation and the interpretation of the available empirical evidence may be summarized as follows:

1. The current requirement imposed on ASD is that they modify the wings on the present force of C-5A aircraft to make them capable of meeting the 30,000-hour service life requirement. If the 30,000-hour requirement is still a reasonable objective, then it is likely that no reasonable alternative would be more cost effective than replacing major structural elements in the wing boxes.
2. The 8,000-hour service limit set for the current C-5A wing configuration has been established for programming and planning purposes and is, therefore, based on a number of considerations in addition to the technical evaluation of the structural integrity of the present configuration of the wing structure beyond the 8,000-hour plateau. One of the considerations was that the 30,000-hour requirement imposed on ASD means that the current wing boxes (or substantial portions thereof) eventually will have to be replaced. Given this reality, it was felt that the wing boxes might as well be replaced sooner (e.g., at the 8,000-hour plateau) rather than later. The 8,000-hour plateau should not be viewed as the point at which widespread fatigue cracking is expected; indeed, that is not expected to happen until some time beyond 8,000 hours.

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3. Alternative measures to Option H may be more cost effective given an alternative requirement, somewhere less than 30,000 hours and greater than 8,000 hours.
4. More information is required with respect to the structural integrity of the current configuration of the C-5A wing beyond the 8,000-hour plateau. Efforts to obtain some information are already planned. For example, as soon as the first aircraft reaches the 8,000-hour plateau, there may be a detailed inspection of the wing on that aircraft. This could be followed by a reappraisal of the minimum actions required to safely extend the service life of the current configuration of the wing beyond 8,000 hours.
5. The 30,000-hour requirement, the future requirement for out-size capacity, and the alternatives for meeting that capacity all need to be reassessed.

Much of the foregoing uncertainty stems from the fact that the current service limit is not directly supported by either the time at which cracks were observed during the fatigue tests or the experience of the service aircraft to date (see Appendix E, Vol. 3). Rather, the service limit is based on the *possibility* that initial manufacturing damage (equivalent to a propagating quarter circle crack with a .05 inch radius) located at a corner of a fastener hole could have been introduced along a critical spanwise splice in the highly stressed region of the wing lower surface.¹ The initial damage could have been introduced into both overlapping panels² at a tapered fastener hole. The fastener that was installed in this dual-flawed hole could have failed to achieve even a partially effective interference fit, (which, if achieved, would retard crack growth); and the propagating cracks in both panels could have developed at rates equivalent to those observed under conditions of 95 percent relative humidity.³ With these assumptions, the Lockheed-Georgia Company has used state-of-the-art fracture

¹Not all lower surface spanwise splice fastener holes are in the highly stressed region; defects in other regions will not lead to failure as rapidly. See Appendix E, Vol. 3, for additional discussion.

²"Panels" is the technical term for the pieces of aluminum that are spliced together to form the wing surface; the initial damage in the second panel may be less extensive (i.e., equivalent to a corner crack with a radius less than .05 inch).

³Although crack growth intervals decrease with increases in relative humidity, Lockheed judges that it is appropriate to use the 95

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mechanics methods to calculate that after 8,000 hours (1974 configuration and 1973 operational use), an initial .05 inch corner radius crack will have grown to a limit load "critical length" of 0.8 inch. The critical crack length is such that, if the aircraft encountered a "limit load" condition, both panels would fail.¹ It is assumed that this would lead to wing failure and loss of the aircraft because the C-5A was not designed to withstand a double panel failure. Thus, 8,000 hours has been designated as the safe service limit for the current configuration of this aircraft. Relaxation of these analysis assumptions would lead to a higher service life limit. More conservative ground rules (e.g., larger initial damage or the application of a safety factor) would yield a lower service limit.

The technical uncertainty attendant on the 8,000-hour service limit and the limited empirical evidence available to support or refute it make it important to examine increases in service life even as small as 2,000 hours. That increment may open a number of interesting options for preserving the C-5A's wartime capabilities into the 1990s without a major modification of the wing.

THE POSSIBILITIES OF POSTPONING A MAJOR WING MODIFICATION

In his FY 1976 posture statement, the Secretary of Defense said, "At the rate the C-5 aircraft are incurring fatigue damage, the force will begin to reach a damage accumulation point in 1979 at which time some of the aircraft will have to be grounded." ASD made a similar projection in January 1975 in the "Competition Feasibility Study for C-5A Plan 'H' Wing Modification." The ASD projection assumed that high-time aircraft would be flown from 900 to 1,000 hours a year under

percent relative humidity data to offset "other aspects" of the calculation that would result in an overestimate of the crack growth interval. However, technical documentation of these "other aspects" could not be provided to Rand for the present review.

¹The stress level for the limit load condition is 50 percent greater than the maximum stress expected in one service lifetime (30,000 hours); it traditionally has been the maximum load (consistent with the operational use limitations imposed on the aircraft's gross weight, payload, speed, and maneuver conditions) that will not permanently deform the structure.

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conditions similar to those existing in mid-1973.¹ However, peacetime use of the C-5A has changed since 1973 (e.g., average payloads have been reduced). Figure 4 shows that at the FY 76 utilization rate, the difference between 1973 and 1976 mission use represents a potential 2.5-year extension of the average time at which the 8,000-hour plateau would be encountered.

Illustration of the Useful Service Calculation

The procedure used to construct the curves in Fig. 4 can be illustrated as follows:

1. A per plane average of 3,856 fatigue equivalent flight hours (1974 configuration, 1973 use) had been accumulated by the C-5A force as of December 31, 1975,² 4,144 hours then remained to the 8,000-hour limit.
2. The average installation date for the ALDCS was approximately April 1976, so the C-5A SPO's life extension factor of 1.25 for this modification pertains to about 4,000 remaining hours. Thus, there were about 5,000 hours of 1973 mission use remaining (as of about April 1976)³ in terms of the 1977 configuration (with ALDCS).
3. At 500 hours of 1973 mission use per year, there would be ten years of service available (not accounting for any contingency use).
4. However, data from the first nine months of 1976, a period of reduced cargo use,⁴ indicates that nearly 1.3 flying hours (without the ALDCS) were equivalent to one hour of 1973 mission use. Thus, there would be 13 years (1.3×10) remaining based on 1976 mission use.
5. Similarly, a more austere use (discussed in Appendix H, Vol. 3) may yield 1.6 flying hours per 1973 mission use hour, in which case there would be 16 years remaining (1.6×10) as of April 1976.

¹An explicit allowance for contingencies was not included in this projection.

²This was the most recent individual aircraft data provided by the C-5A SPO as of early 1977. See Appendix H, Vol. 3, for additional data's.

³Calculations of remaining life in this example will refer to April 1976.

⁴Because of a misunderstanding during the Congressional appropriations process, this reduced cargo use program was suspended in late 1976. However, it is planned to be reinstated in late 1977.

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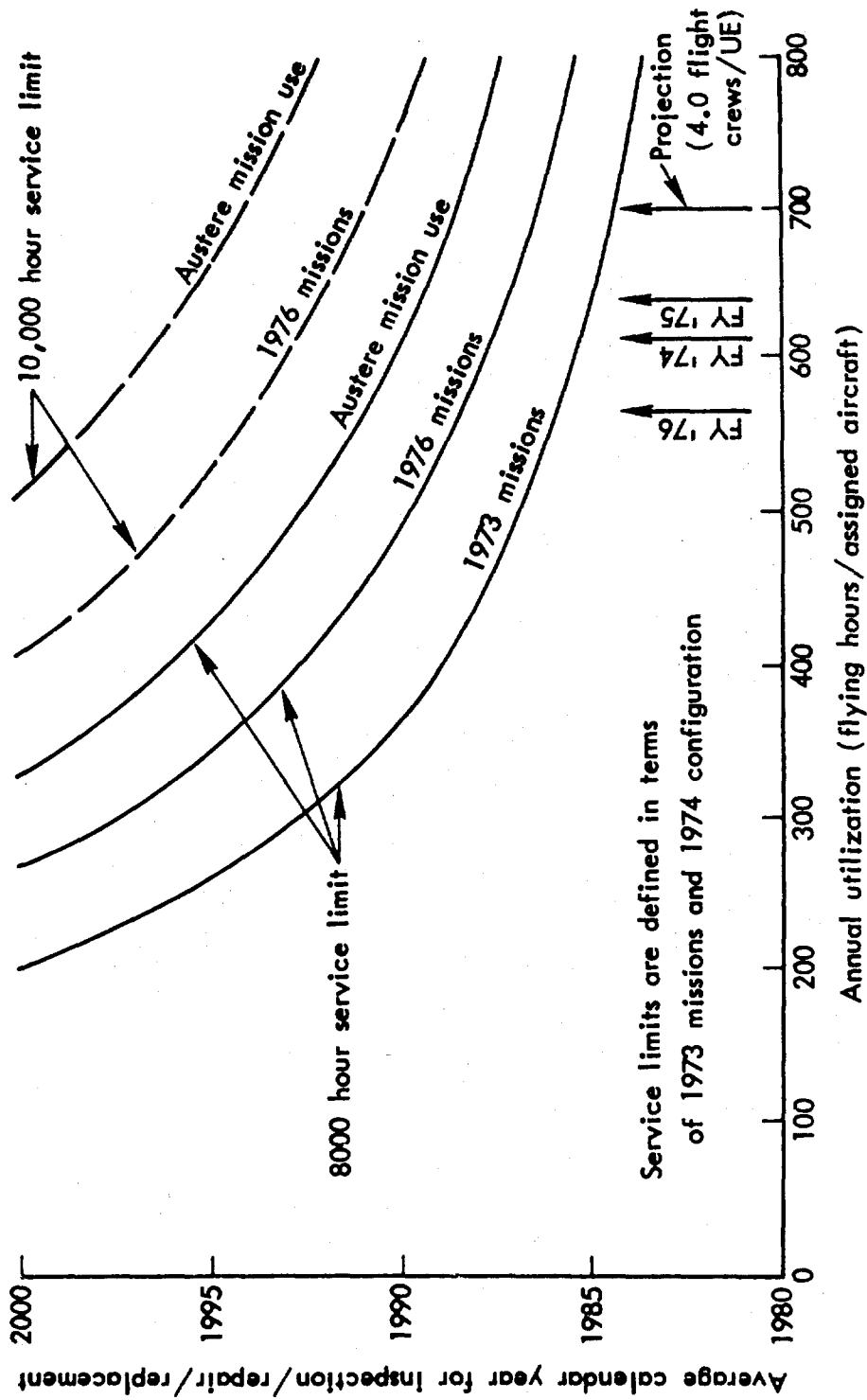


Fig. 4—Time for special inspection/major repair action/replacement for the aircraft in the C-5A force

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6. If the service limit were extended by 2,000 hours (1974 configuration, 1973 mission use), this would be equivalent to 4,000 ($2,000 \times 1.25 \times 1.6 = 4,000$) additional hours based on the ALDCS configuration and austere mission use. Thus, at 500 hours per year, this would add an additional eight years for a total of 24 years remaining as of April 1976. Therefore, with a 2,000-hour service limit extension, utilization of 500 hours per year, austere mission use (assumed to yield 1.6 flying hours per 1973 mission equivalent flying hour), a 1.25 life extension factor for the ALDCS, and no allowance for contingencies, the service life of the C-5A wing could be extended 24 years beyond April 1976. If the use rate is changed to 700 hours per year, the total extension would be 17 years (to 1993). In addition, if the mission use is changed to that of 1976, the total extension would be 14 years (to 1990).

Discussion of Results

The austere mission use¹ curve in Fig. 4 is based on a previous MAC assessment of an austere use of the aircraft that would be consistent with maintenance of wartime capability (see Appendix H, Vol. 3). At a 3.25 crew ratio, the required annual use would be about 550 flying hours per force aircraft² and the "inspect or repair or replace" threshold (the 8,000-hour limit) would be the year 1988 for the "average aircraft" in the fleet, based on 1976 mission use. Although that would obligate MAC to operate some 15 to 25 high-time C-5As at a much lower annual rate, enough low-time aircraft now in the inventory could be flown at a higher than average rate to make up the difference. The two dashed curves in Fig. 4 show that if the safe service limit were

¹Although the austere mission use, with a ratio of 1.6 flying hours to one 1973 mission use hour, is viewed by MAC and ASD as being possibly overly optimistic at the present time (see Appendix H, Vol. 3), there is reason to believe that the 1.25 life extension factor for ALDCS is low (see Appendix H, Vol. 3). In our view, satisfactory resolution of these uncertainties, as well as whether a service limit extension may be practical, will require better information than currently available (see Appendix F, Vol. 3).

²About 600 hours per year on a 70 aircraft unit equipment basis.

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10,000 hours, the useful life might be extended to the 1990s without a major modification, and with no operational change more drastic than careful management of peacetime flying. The sensitivity of this finding to contingency use is considered next.

The 8,000-hour service limit is based on the provision that "as individual aircraft attain their safety limit, they must be placed in flyable storage for wartime contingency use."¹ However, the extent of wartime service so reserved (at an implicitly higher risk) is not specified. Figure 5 illustrates the effects of *additional* emergency operations on the residual life of the aircraft. Transporting the outsize equipment for eight division equivalents plus 54 TAC squadrons to NATO (the notional contingency examined earlier in this report) represents about 56,500 C-5A flight hours. The effect of providing for a one-contingency reserve (in addition to that available at 8,000 hours) is to shorten the useful life of a C-5A force by one to two years depending upon peacetime mission use (for utilization rates from 500 to 700 hours per year).

Assuming 1976 utilization and mission use and one such notional deployment, the average threshold for inspect or repair or replace would be mid-1986 (corresponding to a modification start date of 1984). Thus, *even given the current Air Force assessment of the safe service life of the aircraft*, the proposed wing replacement program does not appear to be as time-urgent as was previously thought. Moreover, the Air Force's former projection for the 1979 starting date for modification did not include an allowance for a contingency reserve. Even a deferral of modification startup to 1984 may provide some opportunity for additional outsize capacity to offset the loss of C-5As during modification.

The preceding discussion suggests that it may be possible, with austere mission use, to extend the C-5A's safe service life--including at all times a reserve for wartime operations--to the 1990s without a major wing modification. This sets a *lower* bound on options, if Option H is considered as an upper bound. Intermediate options with service

¹C. F. Tiffany, *C-5A Wing Structure*, Aeronautical Systems Division, Briefing, January 1975. It is MAC's position that actually placing the C-5A in flyable storage is unacceptable.

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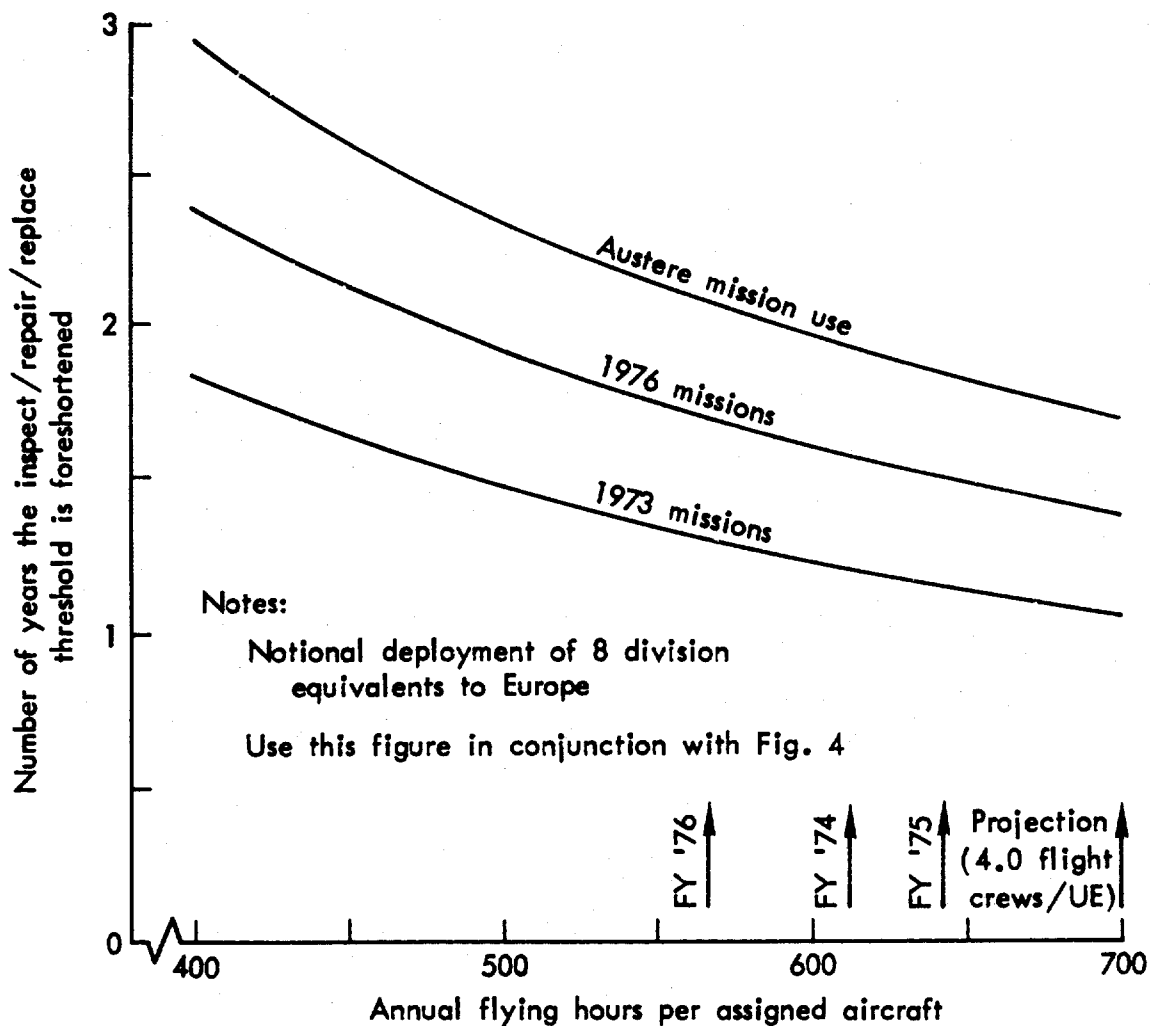


Fig. 5—Effect of a notional contingency on the special inspection/repair action/replacement threshold

life objectives of less than 30,000 hours may also be technically feasible. Figure 6 displays the same kind of results as Fig. 4 for a range of service limits (up to 15,000 hours) that might be achieved by modifications to the wing structure less extensive than Option H.

ASSESSMENT OF WING STRUCTURE MODIFICATION OPTIONS

The 1972 Independent Review Team (IRT) defined a large number of alternative airframe modification strategies for extending the C-5A

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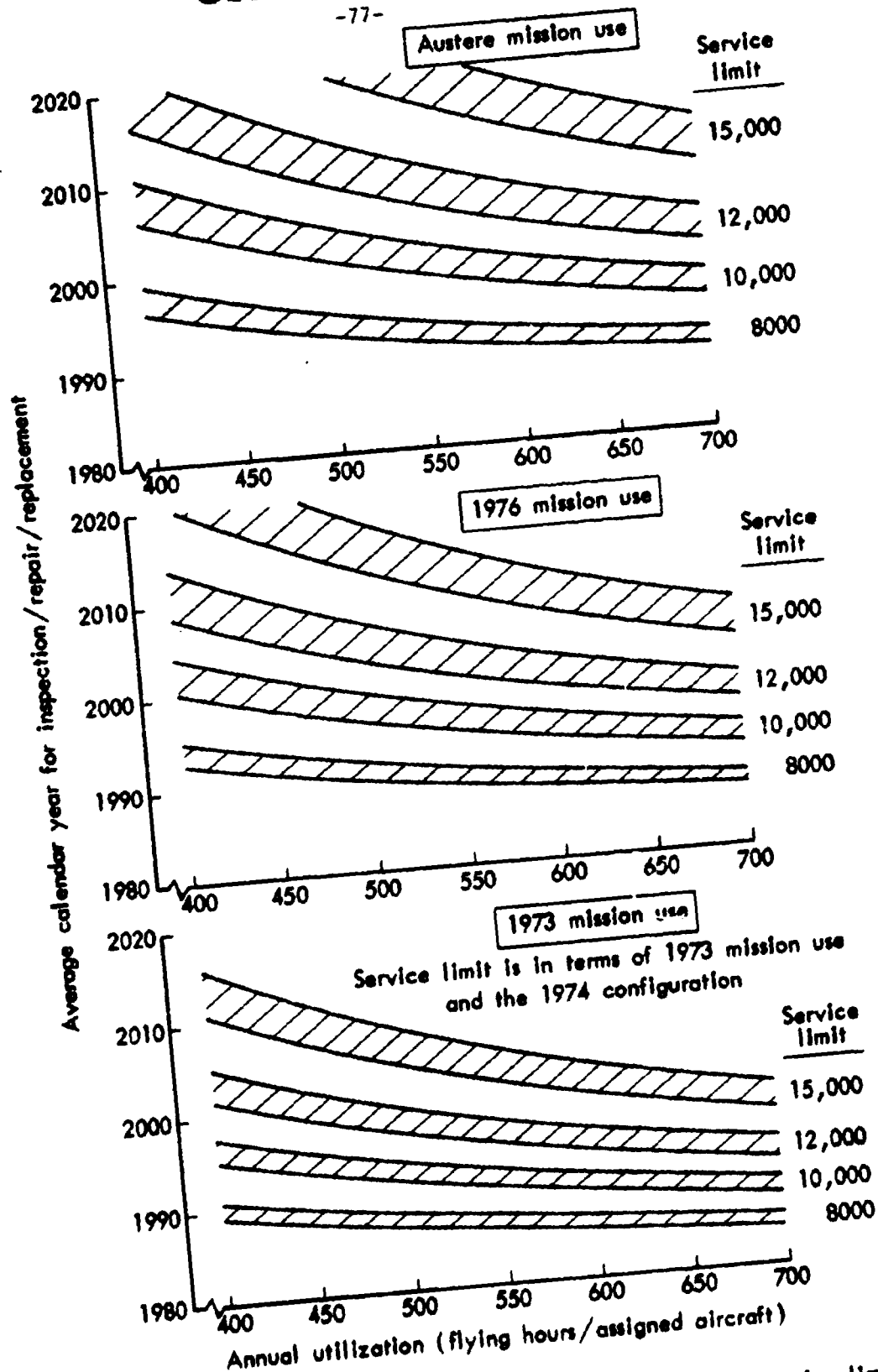


Fig. 6—Sensitivity of calendar year service to mission use, service limit, ALDCS life extension effectiveness (shaded area) and annual utilization

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wing life. From these strategies, nine options were developed to provide various degrees of life extension.¹ The Secretary of the Air Force approved the adoption of ALDCS (Plan D) as a near-term means of extending the life of the current wing while development of a longer-term solution (Plan H) proceeded.

The IRT projected that the incorporation of the ALDCS would extend the wing's service life limit to 11,300 to 16,700 hours (depending on the hours already accumulated). The projection assumed mission use slightly different than that of 1973. The difference between this IRT assessment and the present 8,000-hour limit is attributable to the IRT's use of a higher estimate of the life extension effectiveness of the ALDCS, a different procedure to construct the stress spectrum, different crack growth rate data, and the neglect of shear load transfer. The IRT also used a smaller initial crack length (of .03 inch rather than .05 inch); however, this was more than offset by the IRT's use of a safety factor of two because an explicit safety factor has not been used in the 8,000-hour calculation.

The original long-term plan (Plan H) was to satisfy the 30,000-hour life objective through a *rework* of all of the wing boxes (incorporating a change in fasteners and the replacement of some surface panels). An intermediate plan (Plan E) was projected to be capable of providing 22,600 hours by means of a fastener change similar to that performed on the fatigue test article. (The IRT life extension estimates need to be reappraised in the light of new data and analysis procedures.)

By the fall of 1976, the ASD Division Advisory Group had approved a series of modifications to the original Plan H, the cumulative effect of which is the *replacement* of the center, inner, and outer wing boxes with boxes of improved design in order to assure that the wing would not preclude the fulfillment of the original design mission use and 30,000-hour service life goal.

If the 30,000-hour service life goal continues to be a constraint, then there appears to be no overwhelming technical evidence (see

¹For a more thorough discussion of these options, see Appendix B, Vol. 3.

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Appendixes E and G in Vol. 3) that would foreclose consideration of any one of a number of alternatives--for example: (1) a variation of the IRT Plan E fastener change, (2) a variation of the original Plan H rework, or (3) the current wing repair program (Option H). The fastener change¹ alternative might be applicable only to the low-damage aircraft (for the purpose of illustration it is assumed here that 62 aircraft would fall in this category). Reworking wing boxes, with some surface panel replacements, might be required only for the remaining high-damage aircraft (15 aircraft in this illustration). A mixed modification concept (rework on high damage and fastener change on low-damage aircraft) would minimize the C-5A downtime for modification. Moreover, it would avoid the weight penalty associated with the Option H modified wing. The Option H configuration of the C-5A has an empty weight 26,000 lb greater than the current configuration (22,000 lb of additional structure to the wing, 3,500 additional pounds for the engine installation, and 500 more pounds of unusable fuel). This must reduce either the range or the maximum payload for unrefueled missions with a range greater than about 1,900 n mi.²

Table 8 provides preliminary life extension and cost estimates for the purpose of illustrating the potential relative costs and benefits associated with alternative structural modification options.³ The modification start dates are also described in the table. The threshold for inspection, repair, or replacement of the wing⁴ is expressed as an average year for the entire force. The results in Table 8 are presented for utilization rates of 500 to 700 hours per year per aircraft (sufficient to support 3.0 to 4.0 crews per UE). The principal assumptions

¹New fasteners might provide 8,000 hours of post-installation service life, but other factors may limit a C-5A wing to as little as 12,000 hours; the service life expectancy of the C-5As modified by fastener changes is assumed to be 12,000 hours.

²See Appendix A, Vol. 3, for a more thorough discussion.

³The tentative nature of these cost estimates must be emphasized; they are for comparative purposes probably accurate only to about ± 20 percent. (See Appendix I for the assumptions used in the cost analysis.)

⁴Repair work or replacement action must begin about 2.5 years before this "average date" occurs. To that must be added time for planning, programming, budgeting, engineering design, testing, and mod-kit production.

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Table 8
AN OVERVIEW OF OPTIONS FOR EXTENDING THE SAFE SERVICE LIFE OF THE C-5A WING
(Assumes 25 percent life extension for the ALDCS)

Description of Structural Modification Options	Cost in Millions of 1975 \$	8,000-Hour Safe Service Limit		With 2,000-Hour Service Limit Extension		With Austere Use ^a		Austere Use ^a Plus 2,000-Hour Extension	
		700 ^b	500 ^b	700 ^b	500 ^b	700	500	700	500
Hours/Year Annual Utilization		700 ^b	500 ^b	700 ^b	500 ^b	700	500	700	500
1. Do nothing									
2. Fastener change on 62 low damage aircraft	267	1983 - 1986 ^c		1987 - 1991		1987 - 1992		1993 - 2000	
3. Rework current wing boxes on 15 high damage aircraft	239	1989 - 1994 (1979 - 1981) ^d		1992 - 1999 (1980 - 1982)		1997 - 2005 (1982 - 1985)		2002 - 2013 (1983 - 1986)	
4. Retrofit with Option H design on 15 high damage aircraft	480	1986 - 1990 (1980 - 1982)		1990 - 1996 (1984 - 1987)		1992 - 1998 (1983 - 1985)		1999 - 2008 (1988 - 1993)	
5. Rework current wing boxes on all 77 aircraft	610	1989 - 1995 (1980 - 1981)		1993 - 2000 (1983 - 1986)		1997 - 2006 (1982 - 1984)		2003 - 2014 (1988 - 1992)	
6. Retrofit with Option H design on all 77 aircraft	910	1997 - 2006 (1979 - 1981)		2004 - 2016 (1983 - 1986)		2010 - 2024 (1982 - 1985)		2022 - 2040 (1988 - 1993)	
		2014 - 2030 (1979 - 1981)		2018 - 2035 (1983 - 1986)		2038 - 2063 (1982 - 1985)		2043 - 2071 (1988 - 1993)	

^a Subtract two years for the equivalent life reducing effect of each NATO deployment of eight division equivalents.

^b Based on 1976 mission use. Subtract 1.5 to 2.0 years for the equivalent life reducing effect of each NATO deployment of eight division equivalents.

^c Average year for inspection or repair or replacement.

^d Dates in parentheses are start dates for modification.

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are a 25 percent extension of remaining wing service life due to the ALDCS modification, a 1,000-hour cushion between scheduled start of modification and lapse of safe service life limit, operation of each aircraft for at least 100 hours per year, and life extension benefits of an additional 4,000 hours for the fastener change and 8,000 hours for the rework (1974 configuration, 1973 mission use). (See Appendix G, Vol. 3, for the rationale for these assumptions.)

Table 8 indicates that not all 77 aircraft need be modified to extend the C-5A force service life to the end of the century, even if the increased UTE rate is carried out at about 700 hours per year per aircraft. No more than the high-damage aircraft (about 15 in the present analysis) would need a wing box rework to extend the C-5A force service life to the 1990s (nearly 30 calendar years of service from the C-5A). Changing the fasteners on the 62 low-damage aircraft might produce the same effect. Table 8 suggests that it may be possible to extend the availability of the C-5A to the year 2000 at a cost of one-fourth to one-half of the current wing repair program.¹

Even with no structural modification, the 62 least damaged aircraft might remain in service to the 1990s (with no allowance for contingencies) if they could be operated less than 600 hours per year according to the postulated austere mission use. (See Fig. 7.) However, the 15 most damaged aircraft used in the present analysis would require either modification or some restrictions on use to remain in service into the 1990s. Merely imposing payload and maneuver restrictions might allow the high-time aircraft, unmodified, to fly perhaps

¹The cost estimate in Table 8 for the Option H modification (\$910 million in 1975 dollars) was derived by means of a cost analysis methodology that was consistently applied to each of the modification options. The estimate may not be completely consistent with the official Air Force estimate (\$1.267 million in then-year dollars) used in Sec. III, because the Rand estimate was originally calculated for an earlier version of the Option H modification, which would have involved the rework of the outer wing boxes instead of the current plan to replace them. A revised Rand estimate for the current Option H modification would be somewhat higher than the \$480 million (Option 4) and the \$910 million (Option 6) indicated in Table 8. The estimates for the other options would not be affected because the outer wing box does not become a problem within the service life extension goals of the other options.

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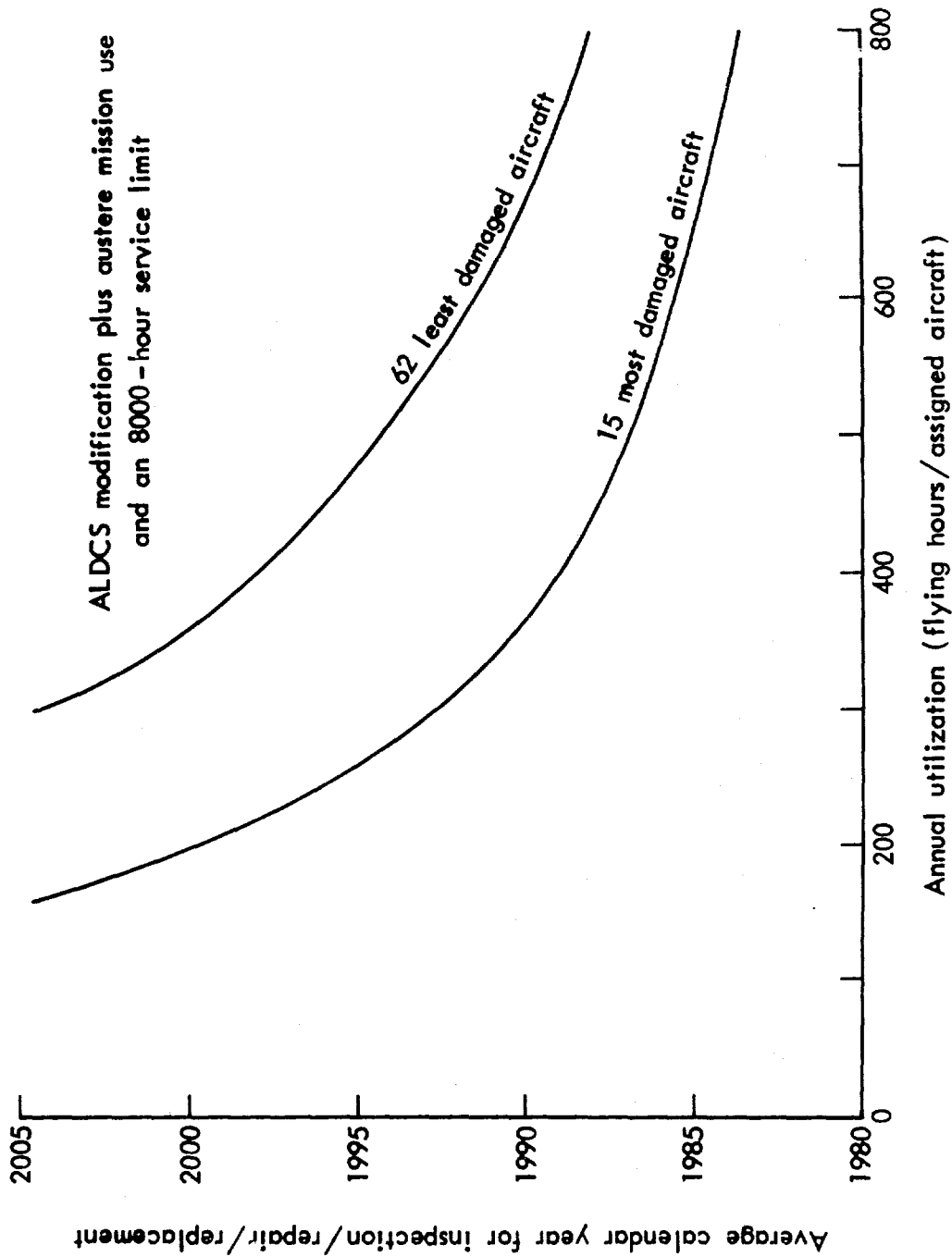


Fig. 7 — Effect of fleet composition on the time for special inspection/repair/replacement

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4,000 or more hours beyond the current service limit. During peacetime, they might be used for training and proficiency flying without incurring any more risk than is accepted in current operations;¹ in contingency operations, they might deploy bulky but not heavy equipment (helicopters, for example); ultimately, they might be available for cannibalization to provide ready sources of spares at strategic points in the airlift network.²

The foregoing preliminary feasibility analysis of alternatives to the present Option H program, together with the agreed-upon uncertainty that is attendant on both the calculation of the 8,000-hour service limit and the present understanding of expected fatigue problems with the current configuration of the C-5A wing, raises the question: *What actions might be undertaken to more clearly define the problem and the alternatives for dealing with it?*

INFORMATION ENHANCEMENT INITIATIVES

Because time may be running out on some of the potentially less costly modification options, it may be desirable to pursue two sets of initiatives simultaneously to develop a refined assessment of the problem and formulate (and selectively prototype) engineering proposals for a series of wing modifications that could provide for progressively larger increments of service life extension (presumably at increasing costs). The two sets of initiatives would have to be closely coordinated to assure that the first set provides meaningful information on when the alternative modifications in the second set would have to be installed.

Refined Assessment of Prospective Fatigue Problems

Some of the objectives for this set of initiatives (see Appendix F, Vol. 3, for details) would be to refine the assessments of:

¹See Appendix F, Vol. 3.

²About 2,000 items were cannibalized during October and November 1973 according to *Airlift Operations of the Military Airlift Command during the 1973 Middle East War*, GAO Report LCD-75-204, 16 April 1975, p. 14; MAC Headquarters (DOQA) reports that 2,571 sorties were flown during that period.

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1. The point at which the onset of general cracking is expected;
2. The number of austere mission use hours that are equivalent to one hour of 1973 mission use (1974 configuration);
3. The life extension effectiveness of the ALDCS;
4. The procedures that would have to be carried out beyond the current service limit to protect the C-5A from the rogue flaw upon which the current service limit is based;
5. The ability of the adjacent structure to carry the load that is released from the failure of a panel (or two adjacent panels).

Formulation of Modification Alternatives

Engineering proposals should be prepared for a series of modification alternatives at each of several repair levels: The first level modifications could be installed without requiring the removal of the wing; at the second level the wing would have to be removed, but the wing boxes would not be disassembled; and at the third level one or more wing boxes would have to be disassembled. The repair methods considered in the formulation of the alternatives should include: inspection plus on-condition repair, fastener changes in critical areas, and the replacement of surface panels in critical areas. The most cost-effective modification alternatives should be considered for early prototyping.

For each modification alternative (defined here as a specific combination of repair method and repair level), a tradeoff should be prepared that relates the extent of the modification (e.g., number of fasteners to be replaced) and the service life extension. The maximum benefit potential for most modifications will eventually be limited by a "new" fatigue problem other than the ones addressed by the modification. The sensitivity of the maximum benefit to the "new" or benefit limiting fatigue problem should be explored and the basis for determining when the benefit limiting problem is expected to arise should be documented.

If initiatives are to be undertaken, it is recommended that a broadly based and unbiased group of senior members of the aerospace community be convened to organize, monitor, and evaluate the efforts. It is also recommended that a second unbiased panel of experts be constituted to define and carry out the program of initiatives.

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MANAGEMENT STRATEGIES FOR COPING WITH UNCERTAINTIES

Commitment to the Option H modification for the entire force of C-5A aircraft is a minimum risk strategy for dealing with the uncertainties about the current wing's structural integrity and the repair options for extending service life. Starting from the opposite end of the risk spectrum, one might consider a strategy where the present service limit is arbitrarily extended by several thousand hours, the benefits of austere mission use are presumed to pertain necessarily to future operations, and the Option H modification program is canceled. If "rogue" manufacturing damage to the current wing should be prevalent across the force, it is conceivable that one or more aircraft may be lost. (However, the evidence suggests that this is not the case.)¹

If frequent widespread cracking of the wing should suddenly materialize (e.g., after a period of particularly severe operation--perhaps after a NATO deployment),² or if widespread "rogue" flawing is discovered, many aircraft could be in imminent danger of catastrophic structural failure if continued in operation. Special inspections and minor repairs might result in the release of some of the aircraft to continued operation; however, a sizable number of aircraft might be grounded pending major repair actions. A major interim repair might take a number of years to complete and require the replacement of numerous structural elements. A "final" repair, such as replacement of the wing boxes, might then be required only shortly thereafter. Even if the present wing box design³ were to be used for such a final repair, it could take a number of years to carry out. The net outcome could be that a considerable portion of the force would be in inspection or modification status for upward of even a decade in the worst case scenario, where an "interim" plus a "final" modification would be required. The total dollar cost could easily exceed that now planned for the Option H modification. Moreover, the reduction in outsize airlift capacity could easily exceed 17 percent (the reduction due to

¹See Appendix E, Vol. 3.

²The history of the wing fatigue problems with the B-52D force is a particularly unsettling historical precedent in this regard.

³With various pending engineering change proposals incorporated.

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the Option modification) and could conceivably persist for many more years than the Option H modification program.

The foregoing catastrophe scenario, although unlikely, is sufficiently ominous that it deserves careful attention in the evaluation of any life management strategy entailing less than the planned incorporation of the Option H modification as *the* final solution. From the standpoint of outsize airlift capacity, the most threatening aspect of the catastrophe scenario is the possibility that two modifications ("interim" plus "final") might be needed. This might occur as the result of some surprise problem for which no "final" solution was available. This aspect of the scenario can be dealt with by continuing with the Option H wing redesign program, along with a modest commitment to incorporate the modification on a few aircraft.

An alternative strategy for coping with the most threatening aspects of the catastrophe scenario would be to: press for immediate determination of a lesser service life objective (e.g., 15,000 hours), develop an engineering definition for a fastener change/rework that may meet that life objective, and prototype the modification on the highest time aircraft to establish modification feasibility. Once feasibility had been established, the Option H design effort might be cut back to a sustaining level of effort. The aforementioned information enhancement initiatives would determine whether the fastener change/rework was going to meet the service life objective and modification incorporation dates for the force. Pending the outcome, the Option H program might be terminated.

A compromise strategy would be to make the Option H modification on several of the high-time aircraft while proceeding with the fastener change/rework on the low-time aircraft. The final decision on the modification mix (high versus low) would not need to be made for a number of years. Meanwhile, either modification program could be canceled if new, compelling information were to become available. However, immediate action would be needed on the fastener change/rework modification because it may prove to be most cost effective if done early. Programming the modification funds now does not necessarily mean a commitment to the modification; it merely preserves the option.

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SUMMARY

This section has raised the prospect that technical uncertainties about the service life of the current configuration of the C-5A wing and alternative life extension measures may be sufficiently broad that wing fatigue problems might be coped with to the end of this century at a significantly lower cost than that for the current wing repair program.¹ It is our view that an aggressive, near-term pursuit of additional information, which could better define the C-5A wing fatigue problems and alternatives for dealing with them, may yield a long-term savings in wing repair costs that could be invested in acquisition of additional outsize airlift capability, which may be very important to a strategic deployment of U.S. forces in the crucial early days of a major conflict in Europe.

¹Both in dollars and in reduced outsize airlift capacity.

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VI. STRATEGIC MOBILITY: OBSERVATIONS, FINDINGS, STRATEGIES, AND THE HARD CHOICES

The earlier sections of this report were an effort to deal objectively both with uncertainties having quantifiable dimensions and with factors that resist quantification. How and by how much some of the uncertainties might be reduced have been briefly suggested in the text and supplemented in the appendixes.¹ Where possible, we have identified short-run and long-run issues and explored their linkages. Most of the ingredients for shaping alternative airlift enhancement strategies are on hand, yet the analysis of alternatives still hinges on three fundamental questions that lack firm answers: How much by air? How soon? What is a reasonable price for each of the enhancement increments, and in what sequence should they be carried out? In the absence of precise high-level guidance, no final optimization is possible. Analysts can only construct alternatives, describe the relative strengths and weaknesses of each, and dissect capabilities and costs.

Sections I through IV considered the rationale for and the cost effectiveness of airlift deployment capabilities that rely on sealift only for the substantial resupply mission. The DoD and Air Force have jointly and separately explored "balanced mode" scenarios and capabilities that hinge on the substantial early use of sealift for transporting combat equipment, principally outsize equipment. In the abstract, those are equally sound bases for analysis. If sealift is available and can be effectively used on short notice, or if an assumption of extended warning can be justified, and if the prospective attrition rates of ships carrying combat equipment are acceptable, sealift could move Army unit equipment as well as perform resupply assignments. However, without using carefully chosen assumptions, we have not been able to generate comprehensive strategic mobility enhancement programs that require only very large increments of oversize airlift capacity for rapid balanced deployment. If sealift is generally available, it can

¹The appendixes are contained in Volume 3 of of this report.

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carry both outsize and oversize; the supplemental airlift forces required for more rapid closure still need a broadly balanced mix of both outsize and oversize capability.

Contingency deployment plans incorporating sealift in varying quantities, on various schedules, and for different missions can and should be prepared. The issue is whether timely, reliable sealift is sufficiently assured to permit DoD to *plan* for its use in *all* NATO contingency scenarios.

The earlier Air Force studies have concluded that the major airlift problem is a shortfall of oversize capacity. That result stems in part from the assumption that most outsize unit equipment can go to Europe by sea. The Rand analysis indicates that if matched delivery and unit integrity are to be maintained and if sealift is not used to move combat equipment, there is indeed a modest shortfall of oversize capacity. However, balanced deployment times are much too slow; when as few as 30 to 40 wide-body CRAF modifications are available together with the existing unmodified C-141A force, the mix is in balance. Thereafter, more CRAF or other oversize augmentation leads directly to a shortfall of outsize. That outcome arises from the Rand assumption of no reliance on sealift to transport combat equipment during the initial deployment of the eight division equivalents of the 1982 Army scheduled for early movement. The most cost-effective force for balanced deployment by air would emphasize only CRAF and new outsize capability.

We do not imply that Rand's premises are "correct" or that the JCS/Air Force premises are "erroneous." It is enough to note that they differ and to inquire into the consequences of error in those disparate planning assumptions.

If sealift were reliably available on short warning, contrary to Rand's assumptions, the combination of sealift and Rand's proposed airlift force would accelerate the deployment rate once convoys began to arrive (after a few weeks), resulting in decreased closure time for large deployments--provided, of course, that Army readiness will support still more rapid deployment. That earlier arrival would further enhance NATO's early fighting strength and thereby contribute to

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deterrence. The closure decrease would be proportional to the contribution of sealift.

(S) *If reliable sealift were not available, contrary to the DoD/Air Force assumptions, grave deployment problems would arise for the planned airlift force, as the closure rate analysis of Sec. III makes clear. Deployment could well become piecemeal at best. Reinforcement would become much lengthier, as the last of the outsize equipment would be closed two to three months after the start of the deployment.*

(S) The continuing growth in the size and quantity of large Army vehicles and the Army's plans to convert more infantry divisions into mechanized (even armored?) divisions means that future outsize requirements are unlikely to shrink, either absolutely or relative to oversize requirements. *In the absence of outsize airlift capability additional to that provided by the C-5A, the U.S. dependence on timely, survivable sealift for NATO reinforcement will constitute the critical vulnerability of strategic mobility throughout the 1980s.*

(U) When decisions must be structured under conditions of uncertainty about both ends and means, planners are driven to search for strategies that foreclose the fewest options, provide the most flexibility of movement from one decision path to another, and require the fewest irrevocable commitments of scarce resources. The usual, and most desirable, product is a decision structure built about incremental decisionmaking and a willingness to expend fairly small sums as hedges against program foreclosures or on efforts to resolve critical uncertainties. To be evaluated in such terms, from both near-term and long-term perspectives, are the Air Force's present enhancement programs, including the C-5A wing modification project and the ATCA program, and a strategy that incorporates sequential decisionmaking and accommodates the present uncertainties by undertaking specific measures to reduce uncertainty while carefully husbanding the remaining life of existing assets until enhancement decisions can be taken with greater confidence.

THE AIR FORCE ENHANCEMENT PROPOSALS

(U) The Air Force's proposed program was treated in detail in Sec. III. The timing of the elements was also defined, although some

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residual uncertainty arises because various Air Force options are still more or less open.¹ The costs of these various airlift enhancements in terms of post-FY 1977 expenditures spread over the next ten years or so is estimated to total more than \$6 billion, not including CRAP modifications, as is shown in Table 10.² If the notionally planned 91 UE ATCA buy is substituted (at \$5.9 billion) for the current 41 UE program, the total then-year dollar outlay comes to nearly \$9 billion.

Table 10

FIRST-ORDER COST OF AIR FORCE ENHANCEMENTS (U)
(\$ millions)

C-141 stretch	550		
C-141A Δ UTE	780		
C-5A Δ UTE	470		
Option H kit production and installation	1,126		
ATCA (41 UE)	3,100	(91 UE)	5,900
	\$6,026		\$8,826

NOTE: Table contains both constant and then-year dollar estimates; for derivation see Sec. III.

(S) The Air Force program, as a whole, chiefly addresses the existing shortfall in oversize lift capability, a near-term problem. Concern for near-term actions to redress that oversize shortage has inhibited long-term planning to address the outsize capacity shortage that will inevitably develop if timely and secure sealift is not reliably available and if even a modest wide-body CRAP program is undertaken. Several points bearing on that issue require careful consideration:

¹(U) Indeed, testimony before Congress during 1976 tended to emphasize the incremental nature of Air Force decisions and the number of options available that influence program start dates and rates of completion.

²(U) The Option H costs shown are for FY 1980 and beyond, reflecting continuation of the design, fabrication, and testing of the prototype H-mod wing.

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- The outsize shortfall will be accentuated during the period 1982-86, when about 12 of the 70 UE C-5A airframes will be out of service continuously during wing modification. The effect will be to increase Army deployment times proportionately, because they are all outsize constrained.
- The crew ratio increase implicit in the UTE rate increase proposal becomes redundant if Option H is carried out as scheduled, again because of the airframes that will be out of service between 1982 and 1986.
- The UTE rate increase for the C-5A cannot be realized until spares are acquired, and that is now planned to occur in 1981, just before the planned wing modifications begin. Moreover, the UTE rate increase may not be fully achievable because of the magnitude of essential unscheduled maintenance actions in periods of intense flying. It may also be dependent on the simultaneous use of aerial refueling.
- Even if both the cost and the capability restoration assumed for the C-5A wing replacement program fall within predicted boundaries, and even if the payload-reducing effect of the added structural weight of the strengthened wing can be offset by operating the aircraft with maneuver limitations, *the Option H modification does little to increase outsize capacity.* It merely preserves well into the next century the outsize capacity now embodied in a 1960s technology aircraft.
- Other than a conceptual plan to begin development of a new-technology transport--the C-XX--at some future time, the Air Force has no program on its planning horizon that will result in the addition of an outsize-capable aircraft.

(U) In the present Air Force program, the small option set that will lead to enlarged outsize capability (essentially only a UTE-rate increase for C-5A aircraft) is overwhelmed by the richness and redundancy of oversize augmentation options (CRAF modifications, the C-141A stretch, the increased UTE rate for the C-141A fleet, and an organic ATCA with at least some oversize potential). Of these, the clearly dominant solution for NATO deployment, in terms of closure decrease and on cost-effectiveness grounds, remains the CRAF mod program.

(U) The Air Force's requested program has few fallback options and provides limited flexibility for adapting to new information or coping with major uncertainties. The schedule for the C-141A modification allows little time between the completion of test and evaluation phases and the start of serial modification, and answers to such basic

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questions as how much life remains in the C-141 force are not yet at hand. Of all the options considered, the C-141 enhancement options are the least cost effective. Concurrent acquisition of the C-141A stretch, the CRAF mod program, and the UTE rate increase on the C-141A diminishes the cargo-carrying value of an oversize-capable ATCA. If the ATCA is only oversize capable, its addition to the force further exacerbates the major imbalance in NATO deployment capability; used as a tanker to refuel C-5As, its contribution to more rapid closure, given achievement of the higher C-5A UTE rate, would be marginal. Either ATCA must have an outsize capability, or another organic outsize aircraft must be acquired in substantial numbers to balance the prospective enhancement of oversize lift. *A consideration in all such tradeoff calculations is that an outsize-capable aircraft automatically accommodates oversize, but an oversize aircraft cannot carry outsize cargo.* If future requirements are uncertain, it would be better to err in the direction of "too much" outsize lift relative to oversize, rather than the other way around.

In the case of the Option H mod, and considering the frustrations the C-5A has generated since its introduction, the Air Force program can be viewed as the lowest risk solution to the troublesome wing fatigue problem. But the option selected is the most expensive of those previously identified and may provide a calendar life extension that could prove to be longer than the Air Force will want. More important, the fatigue problem may be as serious and time urgent as previously portrayed by the GPO and review groups, but, as is indicated in Sec. V, that is not a confident pronouncement. Reducing uncertainties is essential. If residual service life is greater than currently estimated,¹ the Air Force risks discarding a significant element of future service life and creates an unfortunate mixture of short-run and long-term risks. Discarding that remaining life by proceeding with Option H as planned may reduce the already outsize-constrained deployment capability to NATO by air by 10-20 percent from 1982 through 1986.

¹It is generally agreed that the 8,000-hour service limit is a prudent planning number in that the safe service limit is unlikely to be less than 8,000 hours.

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Utilizing the remaining life to defer (or eliminate) Option H while also acquiring new outsize capability may prevent that slump, but it runs some risks.

(U) In sum, the present directions of the Air Force program may well lead to an investment of more than \$6 billion in what may become an unbalanced airlift force; to redress this imbalance could require the subsequent investment of another \$5 to \$6 billion in new organic outsize aircraft. The proposed timing of individual actions is such that the earliest expenditures are planned for the stretch and the UTE rate increase on the C-141A, the least cost-effective programs in the short term.

(S) That might be acceptable if the resulting Air Force program, whatever its possible long-term deficiencies, were a significant contributor to balanced deployment capabilities during the critical interim years. Given that the spares buy for the C-5A is not to be completed until the year of the planned start-up of the H-mod serial modifications, the prospects for capability increases in *outsize* capacity before 1986 are quite limited. The current shortages of major outsize equipment in both POMCUS and WRS stocks are so great and the outsize equipment needs of the several mechanized divisions required for the FY 1982 Army are so large that additional production, which would permit additional prepositioning of outsize combat equipment (beyond that already planned), seems unlikely. The oversize capacity needed to match existing outsize capacity can be obtained from even a modest CRAF program, and as rapidly as the C-141 stretch or increased UTE could be carried out. Therefore, increases in stationed forces and reliance on sealift become the only feasible options for more rapid deployment during that period. But given the extent of reliance on sealift that would be required, the additional oversize capacity additions (beyond CRAF) programmed in the Air Force's plans cannot be judged to be of great utility. Since for some years the United States will be critically dependent on sealift to move the outsize equipment, alternatives that lessen dependence on sealift *only* for moving oversize equipment are of questionable value.

(U) None of the above is intended as an indictment of Air Force rationality and foresight. In both the Air Staff and other elements

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of the Air Force there has been a growing realization that the various proposals do not fit together well, partly because the package was initially assembled in some haste. Appendix B traces the events surrounding the C-5A wing problem and conveys some feeling of the compelling sense of urgency that underlay the deliberations of the earlier review groups and the decisions taken by Air Force military and civilian decisionmakers. Previous assessments of the severity of the problem, the highly technical nature of the analysis, the controversy attendant on the C-5A itself, and the uniqueness of the capabilities of that aircraft make it scarcely surprising that an element of conservatism was applied to analyses and decisions at every level. The critical issue is whether the conclusions are not, in the end, more conservative than warranted by the sum of their parts.

Much the same is true of the other elements of the Air Force program. The impetus for airlift enhancement stemmed in large part from the perception--in the aftermath of the October 1973 Middle East War--that airlift was invaluable in the early stages of crisis or conflict, and the logical inference was that for NATO contingencies *more airlift* was needed. Reasoning from those observations, the then Secretary of Defense charged the Air Force to identify major near-term airlift enhancement opportunities; from that, the present set of options emerged. The imposing growth of Army outsize tonnage was not widely acknowledged until recently. Proposing more intensive use of existing organic airlift (the C-141 stretch and the increased UTE rate) was a natural response, made still more attractive by ever-present budget constraints. Although the Air Force's advocacy of CRAF has sometimes seemed to be less than forceful (particularly in proposing many modification options, some of limited utility in deploying Army equipment, and embedded in an enhancement program also containing many options), a *careful* reading of submissions and testimony reveals that the CRAF modification program was consistently represented to be the most cost-effective augmentation measure available. Continuing evaluation of the costs and benefits of the various near-term enhancement options has led the Air Force to reconsider aspects of their utility, either for early implementation or in toto. As noted in this study, that reevaluation is continuing.

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Although recent Air Force statements to Congress have emphasized the sequential character of the several funding requests and program decisions on which airlift enhancement depends, major uncertainties persist. Unfortunately, time gained by undoing concurrency and relaxing planned schedules does not necessarily translate, unaided, into the resolution of uncertainties. In the absence of positive measures (involving some added expenditures) to reduce critical uncertainties, tomorrow's choices among competing options will not necessarily be any easier, or more confidently taken, than today's.

AN UNCERTAINTY RESOLUTION AND SEQUENTIAL DECISION STRATEGY

The objectives of this approach are to trade time for money, proceeding only with clearly indispensable programs, to use some of the money to attempt to resolve crucial uncertainties, and later to commit additional funds to programs with greater assurance that improved long-term capability will result.

There are few clearly indispensable programs at this point:

- A CRAF modification program, with renewed emphasis on the maxi-mod;
- Continued (even accelerated) acquisition of the spares needed to support *at least* the current 10/8 hr/day utilization rates for the C-141A and C-5A;
- Increased technical analysis aimed at reducing uncertainties concerning the severity of the C-5A wing problem, with early emphasis on a more confident assessment of the safe service limit and of the effectiveness of such lesser modifications as a fastener change;
- Continuation of the design, fabrication, and test of Option ¹H on the current schedule, with no commitment to production;
- A prompt start on a program to demonstrate the feasibility and technical merits of an outsize-capable ATCA.

The cost implications of such a program are shown in Table 11, which depicts (in the upper portion of the table) the expected

¹As a continuing hedge against the failure of information enhancement actions to reveal more attractive life-extension possibilities than Option H.

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Table 11

COST COMPARISONS: AIR FORCE PROGRAMS VS. INCREMENTAL APPROACH

<u>Air Force Programs</u>		<u>Costs, \$ Millions</u>	
C-141 stretch		550	
C-141A Δ UTE		780	
C-5A Δ UTE		470	
Option H kit production and installation		1,126	
ATCA	(41 UE)	<u>3,100</u>	(91 UE) <u>5,900</u>
		\$6,026	\$8,826
<u>Incremental Strategy</u>			
CRAF incremental cost for maxi-mods		85	
Spares to support 10/8 UTE		100	
C-5A testing and option enhancement		100	
Prototype outsize ATCA derivatives		500	
Acquisition 80 A/C outsize ATCA		5,200	
C-5A repairs	(no mod)	<u>0</u>	(fastener change) <u>300</u>
		5,985	(Option H) <u>1,126</u>
			6,285
			7,111

NOTE: Table contains both constant and then-year dollar estimates; see Secs. III and IV for derivations.

expenditures of the Air Force's current programs, as given in Table 10. The first four items in the lower part of the table represent generously estimated near-term commitments in line with the above approach. The first entry (\$85 million) assumes that an all-maxi-mod CRAF program might incur *additional* ten-year costs averaging as much as \$1 million per aircraft more than the costs now in prospect for the planned CRAF mod program (for which the costs are not well defined). The spares scheduled to be acquired in FY 1980-81 and needed to support the current 10/8 hours/day UTE rate should cost significantly less than \$100 million. A generous outlay of \$100 million is included to provide greater understanding over the next two to three years of the

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costs and benefits of alternatives to Option H, without foreclosing the decision to begin Option H modifications in 1982 as planned.¹ The \$500 million for prototyping represents a generous estimate of the cost of design of competing versions of C-5 and 747 derivatives with tanker capability and the prototype development of at least one candidate (perhaps both) prior to a decision on serial production.² In our judgment, the prototyping step is prudent in view of the extent of modifications necessary to either variant, notwithstanding the critical prospective shortfall of outsize capacity looming well into the 1980s. A prompt start and urgent competition are badly needed.

The last two entries in Table 11 reflect one possible set of outcomes of the first three activities--procurement of 80 outsize aircraft with tanker capability at an average then-year cost of \$65 million,³ and a notional range of actions that might subsequently be deemed necessary to extend the service life of the C-5A, ranging from careful management of remaining service life without explicit modification to carrying out Option H as planned. Given the inherent lack of precision both in anticipating outcomes and in estimating the potential costs of modifications, prototype programs, and future outsize-capable aircraft, only two points need be emphasized. First, the incremental decision strategy does not necessarily incur greater costs than the planned Air Force program (even though it leads to a more *effective* force). The second is to suggest that proceeding with all of the Air Force programs *first* and *then* having to acquire additional outsize capability can rather easily double the prospective costs of either the Air Force's program or the direct incremental approach.

The analysis covered in Secs. III and IV demonstrates that, for balanced deployment by air to NATO, CRAF is the critical investment.

¹Design and testing costs through FY 1979 have been removed from the H-mod costs in Tables 10 and 11.

²Still lower costs could result if the prototyping were confined to essential new features and existing aircraft were modified for test purposes.

³Consistent with Air Force estimates for the cost of an outsize-capable ATCA.

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Congress has regularly rejected the various Air Force CRAF proposals, and the rejection is attributable to a complex set of underlying factors. We believe that any approved program must be sold on its military merits; that requires some simplification and reorientation. Elements of that reorientation, we believe, should include:

- Prompt renegotiation of all U.S. civil airline CRAF commitments¹ to upgrade mini-mods to maxi-mod configuration and to try to persuade full-mod (including "cost-shared") commitments to provide a nose door (as a replacement for an addition to the side door).
- If at least one maxi-mod commitment can be obtained, a prompt prototyping effort should be undertaken to demonstrate its advantages.²
- A proposal to the Congress for a legislative mandate that the maxi-mod modifications be incorporated during manufacture of all future Boeing 747-series aircraft to be sold to U.S. civil airlines; full reimbursement of added costs should be included.³
- A proposal to our NATO partners that 747s from their flag airlines be modified to maxi-mod configuration at their expense as part of our common defense effort.
- A proposal that all future Boeing 747 sales to flag airlines of our NATO partners also have maxi-mod provisions incorporated during manufacture.
- Explicit explanation and justification of the dominant cost effectiveness of the CRAF program for balanced NATO deployments (in conjunction with explicit discussion of the prospective outsize shortfall and its implications).

It is our belief that this straightforward approach will help to allay some Congressional concerns: The scope of both the program

¹ Except for those few in the current FY 1977-78 budget as a demonstration program.

² An effort should be made to try to convert one of the modifications scheduled for FY 1977-78 to maxi-mod configuration.

³ The cost of installing the nose door and strengthened floor during production is about half that of retrofiting--\$4 million rather than \$8 million.

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(including its foreign cooperation aspects) and the individual aircraft modifications that would result goes far beyond what would be necessary or cost effective if the program were merely a subterfuge to "promote civil air cargo competition" or "subsidize the airlines," to mention but two of the objections to earlier CRAF proposals. Indeed, the scope of individual aircraft modifications will require skilled Air Force negotiations with the domestic airlines, and a strong Congressional endorsement and other efforts may be necessary to enhance acceptance by the airlines. However, we are confident that some mutually acceptable level of reimbursement can both provide adequate compensation to the airlines and preserve the cost effectiveness of the program.

The C-5A wing modification issue is complex, as previous sections have shown. Here the Air Force runs different kinds of risks: First, schedule and cost slippage are not inconceivable; second, in undertaking Option H as currently scheduled, the Air Force may be discarding a significant amount of remaining useful service life in the old wing; and finally, the early exercise of Option H will foreclose the prospect of other fixes that may be distinctly less costly and may provide enough long-term extension of the service life of the C-5A to phase in an orderly outsize augmentation program. Of critical importance in view of the impending shortfall of outsize capacity is to select a strategy that delays the effects of Option H modifications on deployment capabilities at least until additional outsize capacity is entering the inventory in some numbers.

As noted, the only outsize aircraft that can be obtained in the near-term are 747 and C-5 derivatives, and the choice between them is not easy. A C-5 derivative might be preferred on several grounds. It would basically use the same airframe as the C-5A, easing the worldwide maintenance and support problem. Given a C-5 derivative (C-5D), the Air Force could forgo the Option H mod on the C-5A, place all the C-5As in a minimal operation standby mode, and rely on the C-5D to provide almost all peacetime proficiency flying and training for both C-5A and C-5D crews. In that case, the "service years" of the C-5A might be extended indefinitely. Starting production of a C-5D would also reactivate subcontractor production lines for some critically short

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spares, thereby somewhat simplifying the production problems and lowering costs. In a deployment contingency, high-hour C-5As might be scheduled to haul equipment classified outsize because of bulk rather than weight--helicopters, for instance--thereby reducing stresses. On the negative side, a C-5 derivative would be less flexible as a tanker. Moreover, it is highly likely that a C-5 derivative program would elicit unfavorable Congressional reactions, given the history of the C-5A.

Selecting the 747 for production as an ATCA invokes different arguments. A mix of 747s, some modified for outsize and some for over-size,¹ might have support cost commonality and cross-training implications as attractive as those for the C-5A and its derivatives. Worldwide support would be available from the commercial sources at major airports, commercial support of the fleet could be encouraged, and commercial 747 airlines crews might be effectively drawn into a true wartime surge capability that required no peacetime flying training yet was available in a major crisis.²

Section V considered a set of information enhancement options³ that promise, in principle, to moderate the present risks and uncertainties associated with Option H. Information so developed could suggest the advisability of not modifying some or all C-5A aircraft, or making lesser changes. Those options provide the foundations for a broad range of potential strategies, outcomes, and service life extension dates; their comparative attractiveness would depend on the outcomes of various information enhancement initiatives. The critical issue is to make a start, soon, on activities aimed at answering specific questions related to the efficacy of some of the lesser options--for instance, the fastener change option. The cost would not be large, and the program need impinge on no ongoing activities.

A second key step is a high-level Air Force review of desired C-5A service life, given the crucial need for outsize in the short run and

¹If a persuasive rationale for ATCA tankers in a NATO deployment can be generated; otherwise, in our view, *all* should be outsize.

²Civil airlines average about six crews/747.

³Developed in greater detail in Appendixes F and G, in Vol. 3 of this study.

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the potential availability of wholly new and more capable outsize aircraft by the 1990s. In the short run, the problem can be met only by derivatives of existing aircraft, a solution that from an operational standpoint is less than perfect but is the only available option. Deferral of Option H for at least several years would prevent a loss of capacity during 1982-86. If those derivative aircraft also have tanker capability, the resulting flexibility for future force planning may be valuable. In the longer term, somewhere in the 1990s, the growth of civil air cargo markets may offer attractive possibilities for a new-design transport, such as the C-XX, that would support both civil and military airlift needs. This would allow the Air Force to make the transition toward a much more efficient strategic mobility force by the end of the century, a force that contained a limited number of organic airlifters and was augmentable in crisis by aircraft of the same type drawn from the civil fleet (through CRAF). The prospective pace and timing of these developments suggest the attractiveness of a strategy of extending the C-5A life into the 1990s as inexpensively as possible, relying on acquisition of a derivative outsize-capable aircraft with tanker capability to provide a balanced interim airlift force. Acquiring a new outsize-capable aircraft would somewhat mitigate the risks inherent in trying to extend C-5A service life at minimal cost.

If action is prompt and positive, we believe that the program strategy outlined above can satisfactorily preserve all present options with respect to the C-5A and by the mid-to-late 1980s can lead to an airlift force that is efficiently designed to enhance the deterrence of conventional attack in Europe. Such a force could better cope with shorter warning times than would the product of present Air Force airlift enhancement programs, is prospectively attainable for the same order-of-magnitude costs,¹ and is no more critically dependent in the intervening years on sealift or on improved warning and mobilization times than are the programs the Air Force is currently requesting.

¹O&S costs might be somewhat higher, depending on differences between the numbers of outsize ATCAs in the "incremental program" and of oversize ATCAs in the Air Force program.

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FUTURE CHOICES AND FURTHER ANALYSES

For reasons that by this time are abundantly obvious, a decision on what to do about the problems of the C-5A impinges heavily on decisions on airlift augmentation options. The cost is prospectively large, the uncertainties are considerable, available information is insufficient for confident planning, and the technical and political consequences of error are non-trivial. But concern for the engineering uncertainties of fatigue analysis, fracture mechanics, stress, operational uncertainties of mission profiles, and potential future use of the C-5A, however important, must not divert attention from the larger and potentially much more critical issues of long-term airlift capacity and adequacy. Modest and timely investments in a variety of information enhancement opportunities can provide a better understanding of the magnitude of the C-5A wing problem than is currently available. Urgency may be as great as was previously believed, once the returns are in; or it may not. In the interim, many other questions must also be addressed promptly and in parallel. The urgency of the shortfall in the 1980s leaves scant time for debate.

With regard to long-term airlift enhancement, a number of issues require further timely consideration:

1. The USAF must obtain clearer OSD guidance on the primacy of airlift for early NATO reinforcement, on desired airlift capabilities, and on desired closure rates.
2. The feasibility of acquiring, at reasonable cost, an outsize version of ATCA, and the interrelationships of tanker and airlift requirements in the post-1980 period must be addressed, both for NATO and non-NATO contingencies.
3. Feasibility studies of potential capabilities, costs, and availabilities of alternative outsize aircraft should be accelerated.
4. The opportunity to conduct more refined airlift enhancement studies over a prolonged future time horizon, using appropriate assumptions about escalation and discounting and comparing "balanced" capabilities over time, should be exploited.
5. The Air Force should continue to work with the JCS and the Army to reduce both outsize and oversize equipment lists and thus to moderate assumptions about NATO contingency airlift requirements.

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6. Other Dod components need to address in detail the shortages of in-theater stocks and reconsider the priority of rectifying those relative to reequipping divisions in the United States.
7. The problems of protecting air LOCs and especially APODs from attack and harassment must be analyzed and enhanced protective measures defined. More attention to reducing congestion at airlift APODs and recovery bases is also urgently required.

With regard to the CRAF mod program, four other matters beg attention:

1. Completion of the prototype mods is essential so that tests of the compatibility of the prototypes with Army oversize items can be undertaken, leading to better understanding of loading, unloading, and handling problems.
2. The Air Force should make a positive effort to upgrade some of the airlines' offers of 747s from mini-mod to maxi-mod and to convince the Congress of the dominant requirement for CRAF.
3. The DoD should urge our NATO allies to participate in a NATO CRAF mod program that will bolster the available oversize capacity for NATO deployments.
4. The Congress should consider mandating convertibility in all future wide-body civil transports.

With regard to the C-141 stretch issue, three questions require better answers than are yet available:

1. Uncertainties about the remaining service life of the stretched aircraft must be resolved.
2. The benefits foreclosed by the stretch must be more carefully assessed (see Appendix A in Vol. 3 of this study).
3. Test operations of the prototype should be completed rapidly to validate estimates of the influence of the stretch on aircraft performance and service life.

With regard to the increased crew ratio proposal, there are three major uncertainties:

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1. Can Congressional authorization be obtained for the additional spares that are needed before higher surge rates become feasible?
2. To what extent do factors other than spares and crews constrain the C-5A surge capability, and how is serial refueling inter-related with higher UTE rates?
3. What are the allowable and probable maximum wartime flying hours for transport crews, and how do they affect the required crew ratios for both the C-141A and C-5A to sustain higher UTE rates?

And, in the end, one dominant question recurs: *What mix of organic transport aircraft, as additions to essential wide-body aircraft in the Civil Reserve Air Fleet, should the USAF have in its airlift force by the late 1980s?* An important factor is that outsize-capable aircraft can absorb an excess of oversize equipment, but oversize-capable aircraft can do nothing to move an excess of outsize equipment.

THE FUNDAMENTAL ISSUE FOR STRATEGIC MOBILITY DECISIONMAKING

The above array of unanswered technical and operational questions is impressive; but for most, their resolution would only refine program decisions. The issue for policymakers is: Should the United States move to reduce the long-term critical dependence on sealift to deploy the Army, or should efforts be concentrated on making larger amounts of more capable sealift available much earlier than at present?

Current defense guidance and proposed programs do not address this issue; rather, they are a patchwork of improvements at the margin in both sealift and airlift. Moreover, the lack of policy focus leads to a lack of funding authorizations adequate to carry out either approach effectively. An emphasis on sealift would require many more vessels, better suited to rapid loading and transport of Army cargo, on immediate standby availability; more robust defense efforts of both convoys and ports would also have to be provided. Airlift enhancements would be of low priority, given more reliable and timely sealift in quantity. Alternatively, a policy emphasis on airlift would require somewhat more oversize, for which redundant programs are proposed, and a lot more outsize capacity, for which no efforts are under way. Sealift would

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require little augmentation effort, since it is adequate to handle re-supply tasks and contribute to later stages of extensive deployments.

Given that much of the problem of conventional defense of NATO is attributable to insufficient prior investment in combat equipment, the need for rapid and timely reinforcement is not likely to vanish, and the costs of stiffening NATO defenses will be substantial. It is doubtful that, in addition to those expenditures, the United States can afford to pursue adequate and timely reinforcement capabilities *both* by air *and* by sea. That course runs the risk of achieving only partial success in both areas, the sum of which would not enhance our confidence in our ability to conduct timely reinforcement.

The direction of the Air Force's current program implies a decision to rely on sealift. Oversize enhancements alone do little to reduce the current critical U.S. dependence on timely availability of sealift. At the logical extreme, even if *all* of the Army's oversize equipment could be deployed by air, the Army's outsize equipment--much of which constitutes the heavy firepower of maneuver units--could only be deployed slowly, at first limited by the available outsize airlift, and in larger quantities only after several weeks have elapsed, as sealift begins to arrive. But is "several weeks" timely enough?

No compelling case can be made for exercising all the oversize enhancement options while reserving judgment on how much and what kind of outsize aircraft to acquire when. The CRAF mod program alone provides more than sufficient oversize capacity to balance the available C-5A lift. More oversize than that simply runs up the ultimate airlift enhancement bill without mitigating all-airlift deployment problems, even in the short run.

A prompt start on outsize aircraft augmentation can set in motion the development of a future deployment capability that at least can significantly reduce the dependence on sealift for deployment of Army equipment and may substantially increase the rate of deployment of combat units in the critical early weeks of an unfolding crisis. If the objective is to reduce U.S. dependence on the timeliness of sealift, a lot more outsize airlift capacity is needed, even though the total increment cannot yet be defined precisely. Before making most of the

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current program decisions, the Department of Defense should decide whether to continue reliance on sealift or to begin an outsize aircraft augmentation.

POTENTIAL ALLEVIATION MEASURES IN THE NEAR TERM

(S) This report has addressed the problems of augmenting strategic airlift capabilities for rapid deployment of the Army and has noted in passing a series of problems related to shortages of prepositioned equipment, limited rates of production of major combat items that inhibit further prepositioning, and a shortfall of outsize that will not be rectified for a number of years. The combined effect is to heighten dependence on sealift while those problems are being addressed. We have not explored this matter in detail, but on the basis of earlier Rand work we believe that in the short run some alleviation measures may be feasible. An earlier Rand report¹ proposed prepositioning only portions of Army division sets--locating in theater major items that have fairly low unit costs per unit of weight (and thus that could be replicated cheaply) while planning to transport from CONUS only the high-cost per unit weight items in time of crisis.

(U) Although such measures would further complicate the Army's equipment match-up problems, as a short-term expedient this may represent one of the few *feasible* enhancements. We have attempted only a cursory examination of major categories of outsize equipment in armored and mechanized divisions and ISIs. The shortfalls of most major items of combat equipment that will prevail during that period make those items poor candidates for additional prepositioning. Hence we have focused on the areas (designated by the arrows at the axes of Fig. 8) containing mostly combat support equipment that *might* be procured in sufficient additional numbers to permit their prepositioning. Since the 1982 Army has one armored and two mechanized divisions for deployment, the tonnages indicated, if prepositionable, could reduce the outsize equipment complement to be transported by nearly 25 percent.

¹(U) D. E. Emerson and L. E. Catlett, *Improving Future NATO Capabilities for Defending Against a Major Conventional Warsaw Pact Attack: Total Force Posture Analysis* (U), R-1240-PR, July 1973 (Secret).

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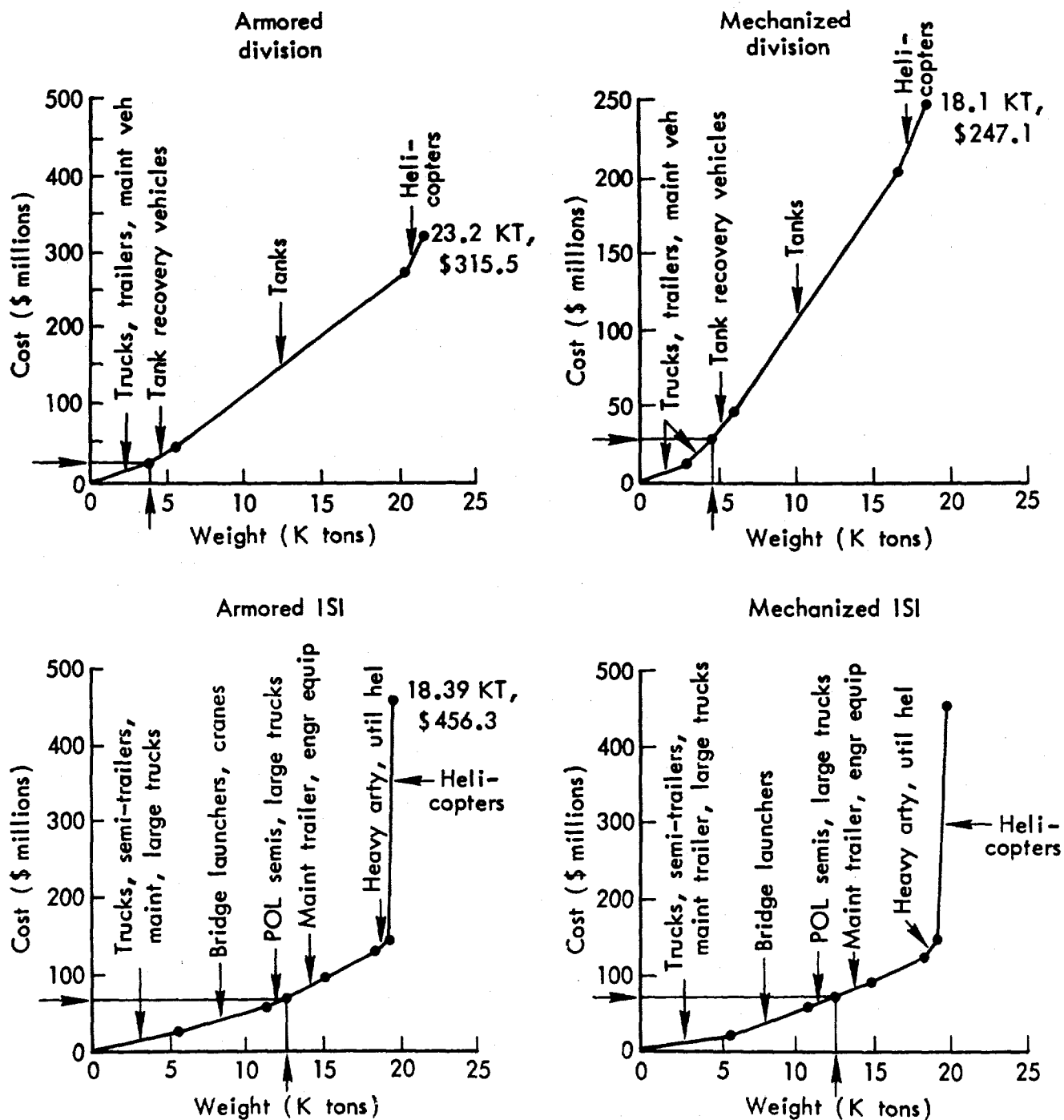


Fig. 8—Outsize cargo in selected army units
(cost vs weight)

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at an added acquisition cost of some \$265 million (plus the cost of storage in theater).¹

(S) If that were entirely feasible, then our rough calculations suggest that deployment times for a force of 70 UE C-5As with the increased UTE rate, the existing C-141A force (unstretched, current UTE), and very nearly the full CRAF mod program (some 109 aircraft) could reduce the closure time for the 1982 Army from its present (outsize constrained) limit of 72 days to about 50 days; without the C-5A UTE rate (or assuming H-mod drawdown of UE), closure would require some 63 days and about 74 CRAF mods.

(U) Further reductions to outsize lift requirements might be made if some of the large transport helicopters now scheduled to be airlifted as part of ISIs were either prepositioned (probably expensive in terms of storage and maintenance) or else self-deployed using the northern island-hopping route (clearly subject to higher risks of attrition due to weather, etc.). The magnitude of the deployment problem in the early 1980s is such that these less than optimal solutions may be the only ones available.

(S) A third expedient not considered in view of the present shortages is to draw upon WRS stocks of major weapons systems stored in theater to equip units whose personnel could rapidly be deployed by air, rebuilding the reserve stocks gradually during the course of the airlift (and, later, sealift). This concept deserves further evaluation and analysis both as to its feasibility and for its influence on the required mix of oversize and outsize capabilities, once the current shortages are eliminated. A fourth issue to be explored pertains to Army deployment requirements, both in total and in terms of urgency for deployment. In a crisis, combat capabilities may count for a great deal more than support capabilities, however important they may be to longer-term function, and some innovative analysis should be done of the extent to which more teeth and less tail can be moved in the *early* phases of any airlift deployment. Combinations of these concepts could

¹(U) To reiterate, these are tentative estimates based on preliminary analysis; we believe the *method* outlined should be further explored.

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increase the rate at which forces in NATO can be augmented. These and related issues warrant serious follow-on analysis.

ADDENDUM ON THE EFFECT OF AERIAL REFUELING

(U) As noted earlier, aerial refueling of C-141s and C-5As was not modeled in our analysis; thus its potential contribution to more rapid closure was not quantified. Our qualitative assessment was that, given the increased UTE rates, the added effect of aerial refueling would be small. During the final preparation of this report, we were provided some preliminary results of analysis being performed by the Military Airlift Command to explore the effect of aerial refueling on closure times and other factors. Their deployment simulated closure of a force of eight division equivalents, but they were lighter divisions (with less total weight of equipment and substantially less outsize equipment)¹ than the 1982 Army used in the analysis in Secs. III and IV.

(U) MAC's preliminary analyses examined the effects of four enhancement options on to their base case, which was the organic force without aerial refueling. Those four cases are: refueling on the eastbound leg only, refueling both eastbound and westbound, for the C-5A only, and for both the C-5A and the C-141 (stretched). Since the Army deployments analyzed by MAC are *not* outsize constrained (because of the divisional mix chosen), the cases in which MAC used aerial refueling for both C-5As and C-141s cannot be compared to the results here (and much of the 24 percent decrease in closure time from their base case is attributable to elimination of congestion and delayed fuel onload at UK bases).² The cases involving only refueling of

¹(U) One airmobile, an airborne and three infantry divisions, three infantry brigades, three mechanized brigades, an armored cavalry regiment, an air cavalry combat brigade, and an armored brigade.

²(U) The simulation gave priority in fuel onload to C-5As over C-141s, and the numbers of aircraft to be refueled saturated the fuel tank truck fleets assumed available. The result was decreased C-141 utilization in the base case, alleviated through aerial refueling. Although congestion may be an important real-world constraint, it was ruled out in our analysis by assumption. We suspect that there are likely to be cheaper solutions to such problems than using aerial refueling.

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the C-5A are somewhat more comparable. Aerial refueling of the C-5As in both directions reduced closure times by 11 days, which was about 18 percent (although again a major portion of the closure decrease was due to elimination of C-141A queueing for fuel at recovery bases) and required the use of 15 ATCA tankers continuously (somewhat more than one-third of the planned ATCA buy of 41 UE).

A related analysis by MAC examined the relationship between closure rates, required C-5A crew ratios, and C-5A aircraft utilization rates for cases with and without C-5A aerial refueling, thus providing some insight into those issues raised earlier in both Sec. III and Appendix A (in Vol. 3 of this report).

The results, presented for selected combinations of those variables, are instructive: Closure times were decreased by a week with C-5A aerial refueling on both outbound and return legs (relative to no aerial refueling). For a crew ratio of 4.0 per UE, a utilization rate of 12.3 hr/day was *achievable with refueling* and 10.1 hr/day *without refueling*. For a crew ratio of 3.4 (slightly above the currently authorized 3.25 ratio), a utilization rate of 8.3 hr/day was achievable without aerial refueling. For a crew ratio of 3.3, and using aerial refueling on the C-5A, a utilization rate of 10.1 hr/day was achieved. These utilization rates can be taken to be reasonable approximations of surge capability (the rate during the first 45 days of deployment), since the closure times for these four cases ranged from 49 to 71 days.

If these outcomes are broadly representative of real-world operational considerations, the following modest reinterpretations must be made to the closure rate analysis presented in Sec. III:

- Those cases that assumed the increased UTE rate on the C-5A (12.5/10 hr/day) would require aerial refueling of the C-5A in addition to the 4.0 crew ratio to achieve the deployment outcomes indicated.
- Those cases that assumed the current planning factor UTE rates for the C-5A (10/8 hr/day) would require either a 4.0 crew ratio (rather than the 3.25 currently authorized) or aerial refueling of the C-5As.
- Without either crew ratio increases or aerial refueling, the eight hr/day utilization rate estimated by MAC for the C-5A

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would produce an outcome roughly comparable to the excursion run with 58 UE C-5As (nearly a 20 percent reduction in UE and presumably comparable in effect to the 20 percent reduction in utilization rate from ten to eight hr/day).

Aerial refueling of C-5As in both directions required the continuous commitment of 15 ATCAs during deployment, representing more than one-third of the planned 41 UE fleet. Therefore, the cost of ATCA procurement to provide the refueling capability would be more than \$1 billion;¹ the ten-year cost of increasing the crew ratio to 4.0 (plus acquiring the spares to support that rate) was estimated to be \$470 million. These incremental costs should be added as indicated to the cost-effectiveness analyses, although the major messages will not be changed. Indeed, if these preliminary results are broadly representative, the major message about the shortfall of outsize capacity is highlighted--aerial refueling may be necessary *even* to achieve the relatively slow closure rates displayed earlier, rather than representing a potential margin of enhancement that might be invoked to speed deployment.

Of considerable concern is the implication of these findings for the cases emphasizing additional outsize capacity and presuming an increased UTE rate. Here, the costs above would be doubled. One clear objective of any competition undertaken between 747 and C-5 derivatives for an outsize ATCA role should be to minimize the costs of high utilization rates. If the chosen vehicle is also to be the new tanker, it cannot be used *both* for refueling *and* carrying outsize cargo. In this context, the possibility of augmenting crew ratios through the use of reservists who are 747-qualified civil airline employees may merit careful study.

¹For the MAC case of seven days' reduction in closure time, this would lead to a cost per day of decreased closure of at least \$150 million, significantly higher than for any of the cases analyzed here.

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29 May 2003

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Rand
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Santa Monica, CA 90407-2138

Dear Mr. Bancroft

Reference your letter, 18 February 2003 requesting a Mandatory Declassification Review for public release of the following documents:

Strategic Mobility Alternatives for the 1980s: Vol. 1, Executive Summary,
R-1941/1-AF, March 1977

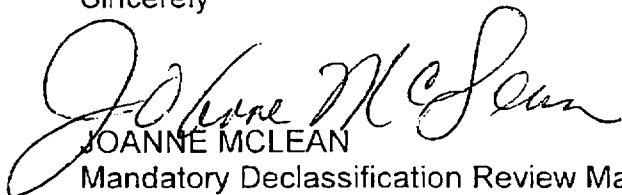
Strategic Mobility Alternatives for the 1980s: Vol. 2, Analysis and
Conclusions, R-1941/2-AF, March 1977

The appropriate Air Force activity reviewed the subject documents in accordance with DOD 5200.1-R and Executive Order (EO) 12958 and recommend declassification of entire documents.

One copy of each document was retained in this office for future reference concerning this case.

Any questions regarding this review may be addressed by contacting the undersigned at (703) 696-7265, DSN: 426-7265 or e-mail joanne.mclean@bolling.af.mil. Please reference Air Force case # 03-MDR-025.

Sincerely



JOANNE MCLEAN

Mandatory Declassification Review Manager

1 Attachment

Records for Review, Documents
R-1941/1-AF and R-1941/2-AF,
dated March 1977