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# AIR FORCE JOURNAL <sup>of</sup> LOGISTICS

*SPECIAL ISSUE: Military Logistics Faces the Future*

*"We are on the threshold of the greatest revolution in readily accessible management information since the advent of the telephone. We must be innovative in our thinking and devise new approaches to logistics data collection which fully exploit the capabilities of the technology that will be commonplace in the 1990s."*

Lawrence J. Korb  
Assistant Secretary of Defense  
(Manpower, Installations & Logistics)

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# AIR FORCE JOURNAL of LOGISTICS

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## The Way It Will Be

Colonel Leonard L. Clark, USAF

Director of Supply

8th Air Force

Barksdale AFB, Louisiana 71110

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*(The time was 0730, the day was 22 September, and the year was 2025.)*

Strategic Aerospace Command's Suborbital Bomber Olive one two was at 46,000 feet and 900 miles north of the 2d Bombardment Wing's (2BMW) stratoport and on the last leg of the only monthly training flight authorized the three aircraft assigned to the 2BMW. Suddenly, the ground maintenance debriefing terminals began to flash with "Status of Flight" readouts. The codes and numbers that appeared on the terminal screen had been burst transmitted in less than one second from the returning aircraft's Automated Built-in Test and Fault Isolation Test System (ABIT/FITS). Ground tracking computers had intercepted the transmission, selected the maintenance data, and then transferred it to four cathode ray tube (CRT) display units in the Logistics Recovery Center. "Ready for Flight Analysis" codes flashed on each screen and the four senior NCOs on the Logistics Recovery Team quickly terminated their discussions of tomorrow's maintenance schedule. All eyes turned to the soft green screen in the dimly lit debriefing room.

CMSgt Propulsion reached forward and touched the "Execute" key on his terminal. The on-board engine operating readouts and operating history data flashed across the screen and updated the data bank, then faded to green and flashed "Beginning Postflight Analysis." Engine module operating hours, temperature, and pressure data were displayed on the screen and automatically updated Olive one two's historical maintenance data file. All engine monitor lights were green, indicating fully mission capable (FMC) systems, and the preventive schedule maintenance blocks were blank for this postflight schedule. The Chief touched the "Execute" key twice and sub-module maintenance status arrays began to roll across the screen. Again all codes were FMC green, but module number four for the alpha engine was blinking to indicate a projected future flight problem. A touch of the "Isolate and Project Number Four Failure" keys called up the data base from the onboard spectrometric oil analysis sensors, and the screen flashed an amber work unit code for the number four widget bearing when the "What Part" key was activated. The amber code indicated a projected failure and a touch of the "When Fail" key called in the projected operating hours data base from the operations flight scheduling computer network. A trend line projection was superimposed on the screen to show that the number four module would not be in a remove and replace red condition for two more flights. The Chief punched the "Schedule Maintenance" key on his terminal and a number four engine module was placed on deferred order through supply; then the module replacement was entered in the preventive maintenance work load data file.

Chief Avionics was also busy at his debriefing station. On-board sensor readouts were all green except for the troublesome antisatellite electronic countermeasures (ASECM) system seven which was flashing "Out of Commission Red." Chief Avionics reflected a nanosecond on the trouble he had been having with the new ASECM system

and recalled that several recent failures had been caused by the scan microchip. He touched the "Activate Voice Input" key and the terminal replied in its slightly mechanical voice, "Ready for analytical input." The Chief eased back in his chair and said, "Status of scan microchip," and the computer voice replied, "It is not operating properly." The Chief smiled and said, "Analyze input and output circuits to scan microchip." A series of equations and numbers rapidly flashed across the screen and the computer voice replied, "Input circuits operational output circuits not operational beyond circuit processor 17." The Chief again reflected for a moment and said, "Replace scan microchip, replace circuit processor 17, and reanalyze operational status of ASECM system seven." The avionics screen flashed green and the computer voice replied, "Well done, Chief. The replaced parts will correct the malfunction. Do you wish to order the parts for postflight maintenance? I have scanned the supply data bank and the parts will be available when Olive one two begins postflight maintenance." The Chief answered in the affirmative and a microsecond later the terminals in both maintenance control and the avionics shop printed out work orders to replace the microchip and circuit processor during postflight maintenance.

On the other side of the stratoport, the minicomputer in Supply's Quick Response Room was printing out issue documents, delivery destinations, and required delivery time data to support the Avionics work orders. In the Supply Stock Control Center, the projected issue of two parts was decreasing on-hand storage and location records. The Aircraft Stock Controller noted the scan microchip was on the shelf ready for issue and the circuit processor already was on the daily resupply aircraft routinely scheduled to arrive 30 minutes before postflight maintenance would begin. She pushed the "Stock Control and Inventory Status Transfer" key on the remote terminal. Issue documents automatically printed out in the warehouse and central receiving sections.

Almost simultaneously at the Central Support Air Logistics Center, 2,000 miles away, the projected issue of the two parts for Olive one two was updating wholesale logistics data files, acquisition schedules, cost projections, and consumption trend files. The wholesale computerized projections indicated that the 2BMW would immediately require another microchip because of its high usage trend. The requisition was automatically established, and the delivery mode and time were flashed back to the stock control computer at the 2BMW. Analytical projections indicated that the next circuit processor failure at the 2BMW would not occur for two months, but the acquisition data file counter was updated for future procurement action and a back order signal for future delivery was transmitted to the 2BMW.

Back in the Ground Maintenance Debriefing Room at the 2BMW, the other System Maintenance Specialists had completed their analysis of Olive one two's flight. All looked

good for the returning aircraft. Only routine consumable servicing would be required to "recock" the bomber on alert in the required time. The Post Flight Servicing Hangar Chief had been alerted that Olive one two would arrive at 0830. As he scanned his control terminal, he was pleased to see that all servicing devices behind the silver panels that lined the hangar walls were operational and ready for action—fuel hydrant pressure and quantity in the green, liquid oxygen level near optimum, air condition packs, collapsible stairs, and access stand and power units all ready to roll out and attach their mechanical arms to the returning aircraft. The Avionics work orders to replace the microchip and circuit processor had printed out on the Chief's terminal, along with the names of the two technicians who would perform the work. The Chief noted that two parts would be required and that both would be available. He was pleased because nothing frustrated him more than to see Supply's automated delivery train pull up to his hangar without all the parts his technicians needed to put a bomber back on alert. He punched the "Aircraft Records" key and the long series of technical data which told the life story of Olive one two began to unfold across his CRT.

*As he routinely reviewed the data, he reflected on his many years of experience in maintenance and recalled the illegible volumes of data he used to review for aircraft after aircraft as they entered postflight maintenance. He remembered the long hours of aircraft records checks when the status of needed parts was always questionable and the days when a 65% parts availability rate was considered good. He also remembered the days when the Chief of Maintenance and the "Line Supers" spent 18-hour days running from shop to shop and from aircraft to aircraft in vain attempts to keep track of maintenance status, to keep generation flows on time, and to keep tired people motivated to do more with less.*

***"On-board troubleshooting systems constantly isolate maintenance problems and forecast future failures with incredible accuracy."***

Today the senior staff seldom leave their stations. Computer networks provide instantaneous status at a touch of a CRT key. On-board troubleshooting systems constantly isolate maintenance problems and forecast future failures with incredible accuracy. The maintenance persons' millstones, stubby pencils and inaccurate paperwork, are virtually eliminated by interactive computer networks. Historical data, parts ordering, work orders, accounting forms, aircraft forms, etc., are all automatically accomplished by unseen electrons as they pass from one small computer net to another. What a

change, thought the Chief! Gone are the days when 20 to 70 aircraft had to be maintained at each base to have half that number fully mission capable. Today the average strategic offensive wing only possesses three super aircraft and they very seldom are ever out of commission for more than an hour or two. If extensive maintenance is required, the aircraft is flown to the central depot and an operational replacement is temporarily reassigned from the depot pool. There is no need for a huge logistics support organization at each base because only remove and replace maintenance is performed. All the malfunctioning "black boxes" are returned to "regionalized" central repair facilities. Huge stocks of spare parts are no longer required because system reliability was given super high priority when the aircraft was designed, and the art and science of malfunction forecasting allows a push parts pipeline system to do the same thing with three or four serviceable parts that required hundreds in past pipelines.

The Chief touched the final key on his terminal to indicate that Olive one two's postflight maintenance would begin on time. One more preparatory action was required—activate the cost and accounting system. A single touch of a terminal key accomplished the task. Man-hour accounting, parts cost, accounting and finance records, budgeting projections, and other cost based data files for real time update were established to track what was about to happen to Olive one two.

*Once again the Chief's thoughts marched back in time and he remembered when his Chief of Maintenance used to worry about using \$5 bolts, \$1,000 windows, and \$30,000 electron tubes. Today his throwaway microchip would cost over \$10,000 and circuit processor 17 had a \$200,000 price tag. The Chief remembered the great price debates of the past when the high reliability advocates finally won the battle over those who thought it was more cost effective to buy thousands of cheap quick failing parts, stock them all over the world, and maintain the huge logistics infrastructure needed to keep replacing those same cheap parts. He chuckled to himself and thought that it should not have taken much analytical ability to recognize the efficiency associated with a 60% smaller work force, maintaining about 10% of the plant and equipment, and less than 10% of the aircraft fleet. But even more importantly, how much smarter it is to maintain an aircraft that is several hundred percent more reliable than those in the past.*

A loud buzzer sounded and snapped the Chief back to the present. The postflight hangar door was sliding open to allow Olive one two to taxi into the postflight recovery position. As the sleek nose of Olive one two inched forward and the silver panels along the hangar began to divulge their mechanical servicing arms, the Chief remembered an old advertising slogan that said it all for the new logistics system: "We've come a long way," and the Chief added, "and it's about time." LE

### *Most Significant Article Award*

The Editorial Advisory Board has selected "Reliability and Maintainability in the Air Force" by Major Gordon M. Hodgson, USAF, as the most significant article in the Summer issue of the *Air Force Journal of Logistics*.



## Building a Logistics Roadmap for the Future

Lieutenant Colonel Ray P. Linville, USAF  
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### Introduction

In 1979, the Deputy Chief of Staff, Logistics and Engineering, HQ USAF, initiated the logistics long-range planning process to provide broad planning guidance for developing future Air Force capabilities and to ensure that near-term planning and programming actions support long-term goals.

The process has been developed and is now formally established. It includes two planning groups, an annual Air Force-wide conference, a planning guide, and the active participation of the major commands and the Air Staff.

The development of logistics long-range planning was an outgrowth of the emphasis by senior leaders to include a long-term view in Air Force planning and programming. In 1978, John C. Stetson, Secretary of the Air Force, chartered an ad hoc study group to study the benefits of formally establishing a systematic process of formulating objectives for the future and developing the strategies to achieve them. Before that year had ended, the Air Staff was reorganized with a permanent organization charged with long-range planning.

### Logistics Long-Range Planning Process

After the importance of having logistics long-range planning to complement the new Air Force long-range planning process was acknowledged, the first logistics long-range planning seminar was held in 1980. The seminar, which was chaired by Lieutenant General George Rhodes, USAF, Retired, concluded with the unanimous agreement by the 47 senior logisticians who attended "on the need for long-range planning and a commitment to support long-range planning efforts" (3:11).

This early effort led to the creation of a planning group that developed the first Air Force logistics long-range planning documents. During the last four years, the process has been refined to its present state.

#### Phases

The logistics long-range planning process consists of two phases: the formulation phase and the implementation phase.

#### Formulation Phase

The formulation phase provides the long-term view and broad planning guidance to meet future threats and opportunities. It involves actions to establish goals, objectives, and strategies.

Goals are broad statements of desired logistics capability. An objective describes a general direction that Air Force

logistics should take to address future conditions and is generally enduring in nature. Strategies indicate how an objective might be accomplished.

This first phase includes studying the anticipated environment and assessing long-range trends, evolving concepts, and projected conditions, including the long-range planning guidance disseminated by the Deputy Chief of Staff, Plans and Operations, HQ USAF. These factors are analyzed as to how they will affect Air Force logistics. The Logistics Long-Range Planning Team develops proposed goals, objectives, and strategies based on this analysis and presents them to the Logistics Long-Range Planning Steering Group for review and approval.

The Planning Team is a task force of representatives from Air Staff divisions involved in logistics planning and programming actions and from each major command (MAJCOM), the Air National Guard, and the Air Force Reserve. The Steering Group is an executive group chaired by the Deputy Chief of Staff, Logistics and Engineering, HQ USAF. Its membership includes the Deputy Assistant Secretary of the Air Force, Logistics and Communications; Air Staff directors, MAJCOM DCSs/Logistics, and equivalents responsible for logistics planning and programming actions; and other senior officials invited by the chairperson.

*"... HQ USAF publishes a logistics long-range planning guide."*

#### Implementation Phase

The implementation phase sets into motion the near-term actions needed to implement the strategies and objectives. To reflect the approved long-term direction for logistics, HQ USAF publishes a logistics long-range planning guide.

Near- and mid-term planning to accomplish the logistics long-range planning objectives may result in new policies, procedures, and programs. Actions in this phase are accomplished by the responsible staff offices and agencies who must also identify and program any funding requirement. Implementation planning and programming actions are also presented to the Logistics Long-Range Planning Steering Group for review, modification, and approval (5).

#### Future Look Conference

The Steering Group meets at an annual conference, "Future Look," which serves as a forum to focus on long-range planning issues; review logistics long-range goals, objectives, and strategies; examine implementing actions; and develop a

planning strategy for logistics initiatives in the Air Force program objective memorandum (POM).

Future Look 84 was the fifth conference since the first one was held in 1980. The format has been changed from that of a seminar to a "board of directors" meeting. Participation has been expanded to include senior personnel, representing Air Force operations, personnel, technical training, operational requirements, research and development, and other scientific areas, because of their critical role in implementing logistics objectives. Future Look 84 was attended by 21 general officers and senior executive service members.

*"Several commands have established a logistics long-range planning structure and are developing logistics long-range plans."*

The theme of the conference was "The Role of the Major Commands in Logistics Long-Range Planning." Several commands have established a logistics long-range planning structure and are developing logistics long-range plans. The conference agenda was dedicated to discussion of their long-range issues:

(1) Strategic Air Command briefed on its plans to support future strategic systems.

(2) Tactical Air Command discussed the logistics requirements for the new advanced tactical fighter.

(3) Air Force Logistics Command outlined its overseas logistics strategy to meet wartime surge and survivability requirements and its efforts to relate logistics resource decisions to future combat effectiveness.

(4) Air Force Systems Command discussed plans to automate technical information and the impact of warranty requirements on supportability.

Other topics included improvements in acquiring support equipment, technical training, logistics career development, and logistics research and studies programs. Based on the discussions at the conference, long-range goals and objectives are then refined and new strategies and actions are proposed and undertaken by the Air Force logistics community.

At Future Look 84, attendees identified the need to concentrate long-range planning efforts in four areas: weapon system design, personnel, logistics systems/infrastructure, and programming. To ensure specific progress would be made in five discrete elements of these areas, Lieutenant General Leo Marquez, who chaired the conference, formed "tiger teams." These teams were formed primarily with representatives of the MAJCOMs to propose actions to make improvements in: (1) logistics information systems, (2) preferred spares, (3) fault isolation and diagnostics, (4) logistics specialty structure, and (5) statements of need and program management directives.

Setting up these special teams has put more emphasis on the implementation phase and has given the logistics long-range planning process an action orientation. Breaking up problems into manageable pieces to encourage action has been described as the "theory of chunks" in *In Search of Excellence*. That book, which is a study of successful management practices, cited effective efforts by US corporations in creating similar ad hoc teams to get their "arms around almost any practical problem and knocking it off—now" (2:126).

The long-term direction for Air Force logistics established at the Future Look conference also serves as the basis for

developing logistics guidance in Air Force mid-term planning documents, such as the USAF Planning Input for Programming Development, and provides the starting point for MAJCOMs to propose logistics initiatives for their POM submissions. These initiatives are reviewed each fall by the MAJCOMs and the Air Staff at the Worldwide Logistics Planners Conference (Cross Talk). This conference is chaired by the Director of Logistics Plans and Programs, HQ USAF, and is held to focus on near- and mid-term logistics planning and programming issues.

## U.S. Air Force Logistics Long-Range Planning Guide

The long-range goals, objectives, and strategies that are accepted by the Steering Group at the Future Look conference are published in the U.S. Air Force Logistics Long-Range Planning Guide. It outlines long-range issues that must be considered by logistics planning and programming activities.

### Air Force Direction

The guide reflects the long-term direction for Air Force logistics based on the assessments and guidance established by the Air Force long-range planning process. Two primary documents provided by this process are the USAF Global Assessment and the Secretary and Chief of Staff of the Air Force Planning Guidance Memorandum.

The Global Assessment gives a long-term view of the environment in which the Air Force is expected to operate and provides the background data and supporting analyses for the Guidance Memorandum. This second document provides broad executive guidance and the long-term perspective for the Air Force. Since the Guidance Memorandum is signed by both the Secretary and Chief of Staff, it reflects the direction of senior Air Force leadership.

### Logistics Planning Goals

Based on the planning foundation established by these two documents, five broad planning goals have been developed to shape the Air Force logistics posture of the future and are outlined in the Air Force Logistics Long-Range Planning Guide. These five goals are to:

(1) Organize for wartime operations and conduct peacetime activities within that framework.

(2) Develop a logistics capability postured to support US forces engaged in varying levels of conflict, either independently or in concert with other friendly nations.

(3) Include logistics at the forefront of all Air Force contingency planning and weapon system design.

(4) Develop a means to better identify and assess logistics requirements and capabilities, especially those that relate to the execution of US contingency plans.

(5) Effectively manage or influence the management of scarce logistics resources to maintain Air Force combat capability (6:3).

### Objectives

The guide also identifies the logistics long-range objectives. They range from acquisition logistics to space logistics and cover most of the principal functions and processes of logistics. Their subjects are listed in Figure 1.

Each objective describes a desirable characteristic for the future and identifies the office having primary responsibility at HQ USAF. For example, the acquisition logistics goal is to "make logistics supportability an acquisition criterion equal in importance to cost, schedule, and performance." The Directorate of Maintenance and Supply is the responsible office (6:12).

Each long-range objective is supported by several interrelated strategies that provide potential methods for achieving the objective. The acquisition logistics objective has six strategies that are concerned with product performance agreements and incentives, program development documents, and methods to quantify supportability. The long-range objectives provide the basis for more detailed logistics long-range planning and implementing actions by the Air Staff and the major commands. They also serve to guide logistics-oriented research and study programs.

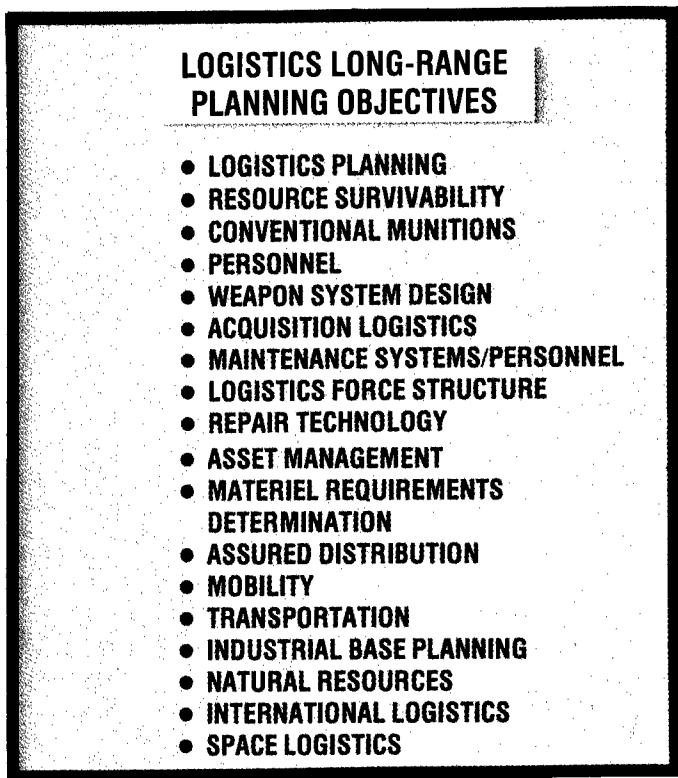


Figure 1.

### Department of Defense (DOD) Long-Range Logistics Plan

The Air Force Logistics Long-Range Planning Guide is the Air Force document that supports the long-range planning framework established by the DOD Long-Range Logistics Plan. This plan was prepared by the Deputy Assistant Secretary of Defense (Logistics and Materiel Management), Office of the Assistant Secretary of Defense (Manpower, Installations and Logistics), and was published in October 1983.

Its purpose is to establish a framework for logistics planning, involving improvement efforts, weapons support, and logistics research and development, to provide effective logistics support in 1990-2010. It states that "long-range logistics planning must exist at every management level of the Defense establishment and should encompass every applicable

aspect of the military/industrial complex concerned with logistics support to the U.S. and allied military forces" (4:1).

The plan sets two priorities for the DOD logistics community:

- (1) *Plan for surge and wartime requirements.*
- (2) *Plan for the most affordable peacetime operation.*

### DOD Logistics Goals

The DOD plan also outlines key elements of logistics guidance for wartime planning, peacetime operations, and acquisition logistics. It identifies several logistics planning challenges and sets six goals concerning the logistics system, energy usage, the industrial base, acquisition logistics, logistics personnel, and international logistics. These goals are to:

- (1) Possess a logistics infrastructure and logistics practices which achieve the tenets of a logistics system.
- (2) Achieve energy self-sufficiency in time of crisis or war.
- (3) Possess assurance of adequate national industrial base responsiveness capability to meet national security needs.
- (4) Achieve assured, affordable supportability for future weapons systems.
- (5) Possess adequate numbers of highly qualified logistics personnel to provide responsive, effective logistics support in peace and war.
- (6) Possess logistics support plans and agreements which ensure that maximum, reliable support will be provided in peacetime, crisis, or wartime to deployed US forces by host nations, and for US-origin equipment employed by friends and allies (4:46-51).

The DOD goals are also listed in the Air Force Logistics Long-Range Planning Guide and are cross-referenced with the Air Force logistics objectives that support them.

### Conclusion

The Air Force logistics long-range planning process has been built based on the lessons from private industry and the efforts to integrate the long-term view into Air Force planning. It begins with the unique perspective provided by the Air Force long-range planning process and focuses on logistics issues. The process does not involve extensive manning. It has been kept simple to keep it responsive and to avoid a complexity that would only cause lethargy and inertia. The Logistics Long-Range Planning Guide has also been kept brief (approximately 30 pages).

*"The Future Look conference is held annually to provide feedback necessary to permit . . . meaningful direction."*

Review of the various implementing actions is accomplished at the Future Look conference. Massive status reports that would have to be massaged by various staffs—which would only drive out creativity and block action—are not required.

Senior logisticians in the Air Force are involved in providing "top-down" direction and set aside a week each year to refine the goals and objectives. The Future Look

conference is held annually to provide feedback necessary to permit iterative, meaningful direction. The long-term direction established at Future Look is continued as the MAJCOMs develop the logistics initiatives for their POM submissions which are reviewed at the annual Cross Talk conference. At Cross Talk the mid- and long-range planning activities are linked, and logistics long-range planning direction is translated into a programming strategy.

*"... the process is more important than the product."*

The long-range planning process is important since it forces Air Force logisticians—who are driven by their in-basket to focus on current problems—to consider the future implications of their decisions. "The long-range planning process ensures that the future intrudes on the present" (1:54).

In fact, the process is more important than the product. Plans themselves become obsolete after they have been prepared. However, the process which created them fosters

attitudes to recognize changes in future threats and opportunities and to make adjustments (7:25).

The success of the long-range planning process is still being measured. Goals and objectives have been set, and actions are underway to achieve them. Results of the process have showed that near- and mid-term planning and programming efforts can be linked to future goals. The challenge remains to shape the logistics structure needed for the future.

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#### Excerpts From General Mullins' Farewell to AFLC

"... a few years ago, we logisticians came to the conclusion that, given the paramount importance of logistics in modern warfare. . . . We vowed to accept our solemn responsibility to inject logistics into the mainstream of the Air Force operations.

"In recent years, technology created a far greater need for the goods and services we provide—a need which has, in many cases, exceeded the resources available. Yet technology also recently gave us the opportunity to deal with the problem by finding innovative ways of producing more with less. . . .

"Not all that long ago, the members of this command began coming to grips with the logistics challenge as it really is—not as everyone pretended it to be—when they recognized that logistics was an *a priori* consideration, one which, in fact, determined what strategies and tactics would be feasible. And they began to think of what they were doing as a vital and necessary activity directly related to the outcome of modern warfare, whether that activity be in requirements, acquisition, distribution, or maintenance.

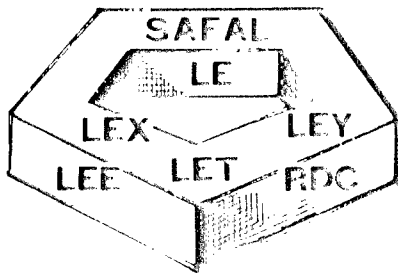
"Then something else very important happened: Air Force Logistics Command, a command many believe represented the most intransigent bureaucracy of the United States Air Force, suddenly jumped out in front. AFLC broke free of old, outdated mind-sets, took advantage of the latest technology, and started building the finest logistics system anywhere on the face of the earth. . . .

"Now what exactly have we done? We've reordered our priorities to support weapon systems and war plan taskings, not to maximize fill rates and minimize backorders, although they're important too. We've modernized our telecommunications and automatic data processing—we've built state-of-the-art weapon system analytical models to help us deal with future uncertainties—and we've adopted a management philosophy and built a management system which coherently and effectively allocates scarce resources, by the bottom-line of combat capability. . . .

"In terms of the paramount importance of logistics, the die has been cast. Technology has seen to that, the declining resources base has seen to that, and our enemies have seen to that. Your challenge, then, will be to continue living up to the responsibilities that being a logistician now entails. And that means demanding, incessantly if necessary, the proper consideration for those logistics imperatives which are so much a part of modern military reality."

#### *Best Article Written by a Junior Officer*

The Executive Board of the Society of Logistics Engineers (SOLE) Chapter, Montgomery, Alabama, has selected "Air Force Retention Policy for Consumable Items—A Logistician's Problem" (Fall 1984 issue), written by Captain Martha P. Ham, USAF, in collaboration with Major Douglas J. Blazer, USAF, as the best AFJL article written by a junior officer for FY84.



# USAF LOGISTICS POLICY INSIGHT

## Planning Guide Published

The Deputy Chief of Staff, Logistics and Engineering (HQ USAF/LE) has published the *US Air Force Logistics Long-Range Planning Guide, FY 1987-2001*, which identifies logistics long-range goals, objectives, and strategies that serve as broad guidance for today's planning. The guide was prepared by the Air Force Logistics Long-Range Planning Team and was approved at FUTURE LOOK 84, the USAF Logistics Long-Range Planning Conference. This document supports the broad goals outlined in the DOD Long-Range Logistics Plan and is the latest edition in a series of guides which focus on logistics planning and programming actions.

## Contracting Reorganized

The Directorate of Contracting and Manufacturing, HQ USAF, has reorganized to provide more focus on logistics contracting issues. The new Systems and Logistics Contracting Division (AF/RDCS) has primary responsibility for formulating logistics contracting policy on source selection, business strategy panels, spare parts acquisition, data, modification/overhaul programs, support equipment, and other related areas. This division is also responsible for the overall coordination of Air Staff contracting actions to implement the OSD and AFMAG spare parts acquisition reforms.

## Shelters Moved

Within the next five years, the Air Force expects to have an inventory of 1,700 tactical shelters while DOD will have nearly 10,000. The shelter itself solves many facility related problems, but its size creates several challenges to the Defense Transportation System. For example, each user must identify the transportation system which moves the shelter from the ground at the home base, through the airlift or sealift system, and onto the ground at the deployment location. If the user is not knowledgeable about the part he plays in the movement, he should study the shelter deployment scheme. The Military Airlift Command, Military Traffic Management Command, Military Sealift Command, and overseas commanders share the remaining responsibility, but they CANNOT do their job unless each participant identifies his movement requirements to them.

## Life Support Equipment Tested

The Air Force is planning a major field test of newly developed chemical protection life support equipment during FY85 (Survivable Collective Protective System (SCPS-2)). Initial operational testing demonstrated successful dry decontamination and extended operational protection. The SCPS-2 systems are completely self-contained, concrete-reinforced shelters, with decontamination, sleeping, water, latrine, environmental, generator, and communication equipment. The systems are designed to accommodate from 72-90 personnel for decontamination and protection from chemical and conventional warfare attack, and enable sustained operations in a wartime environment. The collective protection with SCPS-2 overcomes the critical time limitations inherent with individual suit-type chemical protection. Full deployment of the systems is planned for follow-on fiscal years.

## Courses Revised

The supply training programs are undergoing significant changes. The basic airman courses have been revised to place emphasis on the "core" subjects associated with inventory management and supply support (to be implemented by December 1984). In addition, the supply officer courses are being revised to concentrate more on concepts and theory, management practices, and customer support principles (to be implemented by October 1985).

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## Future World Systems—The Calamity of Logistics

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### Introduction

Future world systems—the calamity of logistics. Why make such an issue of it? Don't we have problems with logistics right now? Aren't a lot of people working hard to fix them? Yes. But the future systems hold the promise of much more. There is a multiplier effect. Logistics support of our future world systems will be much more critical and difficult. But it could also be much more manageable if we do the right things along the way.

The operational environment is going to get tougher, and technology is going to breed more and more complexity. But this same technology offers the logistics process some very powerful ways to catch up, keep up, and gain ground through a variety of methods. So it is important that we move into the future with our eyes wide open and improve on our innovation and creativity. Opening this paper by focusing on the calamity of logistics was actually a way of backing into a discussion of interesting challenges and unbelievable opportunity.

### Future USAF Military Systems

We need to look at some of the types of systems we may see in our future to set the stage for a discussion of logistics. Obviously, the future is impossible to predict with any great amount of accuracy because of the rapidly accelerating rate of change. Even so, some forecasts can be based on what we now know.

#### TransAtmospheric Vehicle

All of us are familiar with the space shuttle—launches like a rocket, performs a space mission, and lands like an airplane. One likely future system, a TransAtmospheric Vehicle (TAV), could be a spin-off of the shuttle, but with some very expanded capabilities.

#### Description

A TAV is a craft that can conduct military missions either in space or in the atmosphere. It not only lands like an airplane but also takes off like one and is capable of controlled aerodynamic flight as well as space flight. This vehicle could operate in the suborbital regime with a terrestrial or space mission capability; that is, it could shoot up or down or sideways in these arenas of operations.

#### Capabilities

A TAV can conduct missions which include space-to-space conflict or classical strategic and tactical tasks, or it may even function as an emergency communication system. It could reach any point on the globe in an hour or two, thereby denying sanctuaries and circumventing the problem of penetrating defenses. Furthermore, a single vehicle could

interdict an entire battlefield. The TAV could also be used as a transporter for either humans or cargo, in space and in the atmosphere.

#### Modes of Operation

To accomplish the missions in an effective and survivable manner, the TAV may require flexible basing (possibly ground and space) and autonomous operation. On the ground the TAV should be capable of operating from main operating bases (MOBs) or from dispersed bases. In the space arena, the TAV could be parked (alone) in orbit, or it could be based on a carrier in orbit (which could have maneuvering capability), or even eventually based on the moon. Another alternative is combined basing where the TAV could be launched from the ground up on warning of hostilities and parked in space orbit. Regardless of the basing approach, the problems of life support, rearming, refueling, and maintenance must be solved. Also, these bases must be equipped to support "aircraft type" operations—high sortie rate and quick turnaround.

#### Issues

Some interesting questions are:

- Can a TAV fit into the classical aircraft logistics process (on the ground)?
- Can a space logistics system survive and be supported in orbit? on an orbit-parked carrier? on the moon?
- What is the logistics/human factors interface (life support and maintenance requirements, physiological environment, and medical needs)?
- What is the TAV's operational concept? If it (properly) needs to operate autonomously (independent of ground stations for navigation), it may need to operate independently of any single main base—ground or space. Thus, a number of fueling/rearming stations may need to be dispersed in a number of orbits.

### High Energy Laser Aircraft

A second type of future system could use high energy laser technology. We are all familiar with the science fiction weaponry of "Star Wars." As we move towards the last decade of the twentieth century, science fiction may be turning into science *fact* in bringing us laser weaponry for airborne applications.

#### Description

The high energy laser (HEL) aircraft is a concept which can combine the cruising platform efficiency and range of the modern aircraft with the speed, power, and range of lasers. It could potentially dominate military operations on the ground, in the air, and in near space.

## Capabilities

Postulated HEL weapons could damage or destroy aircraft, missiles, space vehicles, and sensors. Integrated into a military aircraft, the HEL weapon system can provide dramatic increases in the effectiveness and survivability of current missions and permit ventures into mission opportunities not now possible.

## Unique Operational Features

Being liquid-fueled, the HEL can potentially be rearmed with in-flight refueling just as aircraft are refueled. Under war conditions, sorties could be rapidly restaged from aerial refueling points, rather than from vulnerable airfields (subject only to tanker availability, aircrew fatigue, and engine limitations). Laser weapons are thus "dynamically retargetable" against a great range of targets because they do not require the aircraft's return to base to change the ordnance mix. Once the laser system weight is "paid for," a very large laser shot magazine is available at low weight and cost per (laser) shot compared to other weapons. Laser engagements can occur nearly instantaneously over hemispheric fields of view, negating target maneuvers.

## Applications

Strategic and tactical missions have been examined for HEL application. As high energy laser technologies continue to mature, laser devices of greater power per unit of system weight, shorter wavelengths, longer range, and broader military mission applicability are being developed. The question increasingly becomes one of selecting the point in the HEL development process at which to make the cost leap to full-scale laser weapon system development, directed towards the most profitable mission application.

Once this choice is made, the financial investment in developing core weapon system technology in airborne devices, sensors, fire control, and aircraft weapon system integration will proceed. When these technology thresholds are crossed, a torrent of future HEL applications can be expected to develop quickly. Offensive and defensive "laser shield" applications of HEL will multiply, both as independent systems and as integrated elements of complementary HEL/missile and hybrid HEL/ECM (electronic countermeasures) systems. This could open up a dramatic era of highly survivable, flexible-response aircraft weapon systems. The pace of combat will quicken as agile speed-of-light weapons shrink engagement times, permit operation in threat-rich environments, or engage targets at long range. Human operators will become the slowest response element in the system and could evolve into executors, controlling the time and place, but not the dynamics, of the increasingly automated attack.

## Logistics Implications

High energy laser aircraft weapon systems will require a high degree of system integration of the laser device, high-power optical elements, fuels/fluids supply, beam control, sensors, fire control/battle management, pointing/tracking telescope systems, and computer/control technology. System reliability and maintainability will be paramount concerns of mission readiness. Consequently, flight line versus depot

maintenance functions will have to be clearly defined. Support facilities will become more sophisticated and technically specialized (optics clean rooms; exotic, sometimes toxic laser fuels). Yet, these facilities must also be capable of total system ground checkout. Technical and educational qualifications of the support personnel will grow and perhaps exceed even those that are the most demanding.

## Artificial Intelligence

A third future system, actually more of a pervasive, across-the-board capability than a discrete system, is "artificial intelligence." In concept, this idea has been proven but its military capability and future applications fall into the category of predictions.

## Description

Artificial intelligence (AI) is a field of specialization within computer science that specifically is concerned with the translation of information into knowledge and vice versa. Artificial intelligence also encompasses the processes of representation and manipulation of knowledge.

## Capabilities

Artificial intelligence provides a capability to assist in decision making or actually make decisions in situations where human inference or heuristics are successful in the face of uncertainty. Some examples of currently successful AI applications are in air traffic control, medical diagnosis, and chemical analysis. It also has application in world models, knowledge bases, and robotics, and works best in a limited domain.

## Future System Applications

Artificial intelligence is predicted to have highly effective application in the following types of areas:

- a. Multisensor data fusion and track correlation.
- b. Cybernetic, stand-alone software which manages flight and fire control functions of a penetrating bomber.
- c. Target detection, recognition, and identification.
- d. Robot-controlled fighters and cruise missiles.
- e. Cockpit decision aids.
- f. TAV and space applications.

These are basic, typical examples of future applications. But, the potential for application of AI in future systems is virtually unlimited.

Artificial intelligence makes the concept of robot-controlled aircraft a strong possibility. Some advantages that can be predicted for robot-controlled aircraft in both air-to-ground (AG) and air-to-air (AA) roles are:

- a. High-G performance is facilitated.
- b. No life support systems are required.
- c. No loss of life will occur, even in dense air defense environments.
- d. Systems are autonomous to a great extent.

## Logistics Implications

Some of the logistics problems related to use of AI are:

- a. Greater complexity of software programs.

- b. Basing support, trained personnel requirements.
- c. Support of AI-augmented space maintenance platforms.
- d. Adaptability of software to changing sensor, political, and policy decisions.
- e. High-skilled support personnel.
- f. Data base development and management.
- g. Testability of software.

### Hardware Parity

In spite of almost unbelievable increases in avionics hardware capacity and capability, which beyond the year 2000 may far exceed the expectations of the most optimistic of today's futurists, a physical limit of hardware capacity and capability may be reached in military applications of electronic and photonic technologies. Besides, potential adversaries will be trying to match our hardware capability step by step (in other words, we may not have technological superiority) because of the way hardware technology is developed. To describe this point:

(1) Industrial and commercial users (typified by today's electronic entertainment industry and the exploding field of home computers) will be the drivers in hardware development. Military users will be only a small percent of the market and consequently not a driver.

(2) Developments will be controlled by multinational corporate conglomerates and, consequently, will be available to all customers worldwide.

### Software Leverage

Therefore, software rather than hardware will be the area where an advantage can be gained—from three perspectives:

(1) First is in the increased sophistication of higher order languages (HOL). We would envision layer after layer of nested HOLs which would both decrease the cost of software development and shorten development time.

(2) Second is in the increased sophistication and efficiency of programming techniques. This will achieve higher speed and minimum use of hardware capacity per application, making possible a greater number of applications within a given hardware configuration.

(3) Third, and perhaps most important, are the algorithms used—the mathematical and logical manipulations that bring us to the bottom line result. This is an area that can militarily be closely controlled and where maximum leverage and advantage can be gained. However, to become highly competitive and a leader in this area requires that work be started now.

In fact, we can look forward to a period where weapon system upgrades will be made more by software changes rather than hardware modifications. This will demand much better ways to test, debug, modify, and manage software.

### Development Acceleration

A phenomenon occurs in the development of third world countries commonly referred to as leapfrogging. This is where an underdeveloped country can rapidly go from underdeveloped status to highly developed in a tightly compressed time period by using technologies and processes which evolved over a much longer period of time in the more traditional highly developed countries. They make direct use of what other cultures have developed and skip over many of the in-between evolutionary development steps.

There is no reason why the military industrial complex cannot leapfrog, too. Just because we have been on an

evolutionary path does not mean we have to stay there. There is no reason why we cannot get in the fast lane and leapfrog ourselves!

## The Logistics Environment

The overall environment in which these future systems will operate will, without a doubt, be very different from today. Logistics support systems will obviously also face the challenges and opportunities of this very different future environment.

### Technology

First and most obvious is technology. The computer revolution and communications revolution will be well advanced. Changes brought about by massive improvements in both computers and communications since the 1980s will have virtually changed society. Information networks will pervade the globe. Electronic complexity will have become so typical it will be accepted as routine. This does not necessarily mean trouble for the support community. As a matter of fact, one of the conclusions of the Defense Science Board 1981 Summer Study Panel on "Operational Readiness with High Performance Systems" was that there is "no direct relationship between advancing technology, complexity and readiness. Increasing complexity is not necessarily related to declining readiness."<sup>1</sup> Complexity, without a doubt, increases the *risk* of readiness degradation, perhaps even exponentially. However, through effective management, complexity can be made transparent and, consequently, cause no significant problems. The key is effective *management* of the complexity.

### Geopolitical

Outside the technology arena, there are other significant changes taking place. Air Force planners and industry's futurists predict geopolitical changes and new and shifting military and political alliances brought about by growth pressures in third world countries and by competition for scarce natural resources and critical materials. Also, there will be a growth in interrelated economic cartels, increasing occurrence of joint development ventures, and continuing rapid growth of international super corporations. Geopolitical changes of this type will adversely affect our ability to provide forward basing and prepositioning.

### Vulnerability/Survivability

Another important factor affecting the need for long-range high-volume deployment is the growing vulnerability of air bases to disruption and destruction. This vulnerability not only will force us into longer range deployment but also dictates that when the site of a conflict is reached, there will be a need to operate in a dispersed mode from small, difficult-to-equip forward operating locations.

### Pace of Conflict

Also, during that period, the pace of conflict will be extremely rapid. Military resupply will be far more difficult and industrial mobilization for resupply, as difficult as it is now, may be totally out of the question. Self-sufficiency of our military forces will be a growing necessity.

## Logistics Opportunities

Even with our perspective limited by today's knowledge instead of tomorrow's, we can, nevertheless, predict some of

the opportunities that might be exploited to provide supportable and supported future weapon systems. Some examples of applicable types of opportunities could be grouped into five categories:

- (1) Diagnostics.
- (2) Dynamic reconfiguration.
- (3) Data and planning.
- (4) Spares and materials.
- (5) Servicing.

### **Diagnostics**

Diagnostic capacity will be improved by dramatic advances in built-in test capability, widespread use of advanced integrated sensors, data fusion and analysis, and transference of experience horizontally across like or similar systems. Built-in test capability will be used much more extensively and will be considerably more accurate and thorough. Microminiaturization and increased sophistication will yield advanced low cost sensors for thermal, stress, acoustic, optical, and other conditions which can be implanted and embedded throughout the platform structure and subsystems. The sensors would have either self-transmitting or signal-reflective capability to produce a continuous data flow to regional receiver/relay units in data collection zones located throughout the aircraft, internetworked with a central maintenance control panel and computer. Self-transmitting transducers can even be imbedded within propulsion systems and other dynamic components. The number of sensors would be limited only by our ability to use the data effectively. Data from built-in test equipment and sensors can be processed through fusion algorithms, combined with experience data transferred horizontally from other like or similar weapon platforms and diagnostically presented from combined empirical and inferential processes to the maintenance control function. Diagnostic data thus obtained can be used either to reconfigure the system in a dynamic, real-time mode to provide redundancy, or to schedule maintenance or replacement actions.

### **Dynamic Reconfiguration**

This dynamically reconfigurable redundancy can cover a broad range of options to improve mission reliability and can readily be extended to improve logistics reliability. The options cover a range from software reconfiguration in individual integrated circuitry chips through horizontal and vertical integration among subsystems, crossing over across weapon system boundaries to integration between like and similar platforms, and finally to internetworks between airborne platforms and space, ground, or shipboard resources. Failures detected by built-in diagnostics would trigger the need for reconfigurations to maintain weapon system capabilities in priority order, considering a graceful degradation strategy in keeping with specific requirements of a particular mission. The reconfiguration processor would survey available reconfiguration resources from all the sources just mentioned and, after "consultation" with other platform computers to determine relative demand and priorities, would automatically reconfigure the failed system. Reconfiguration scenarios could be developed to cannibalize the capacity of lesser priority subsystems to provide resources to more important functions. Similarly, reconfiguration could occur within complexes of antenna systems or environmental systems (such

as cooling systems), and even accommodate such cases as failed landing gear by computer-controlled thrust vectoring integrated with flight controls.

### **Data and Planning**

Maintenance data could be accumulated by each airplane for historical and inferential purposes. Failure patterns developing over the fleet would signal the time to replace parts prior to failure, or prior to extended deployment where shop capability would not be available. Another article in this issue by Col Clark covers this area.

### **Spares and Materials**

Continually increasing spares costs and dispersed deployment will make it difficult to stock the required number of spares to support specific operational scenarios. This may tend to force us to build in more reliability, perhaps at excessive cost. Another solution may be to have two grades of spares—one for peacetime use, designed to peacetime life cycle cost (LCC) trade study decisions, and the other for wartime quality which would be good enough to last for perhaps 60 to 90 days (long enough to get the war going and allow movement of the "real" spares into the combat area from wherever they are). If different than for "peacetime-quality" parts, computerized instructions and installation modes should make these differences transparent to the maintenance technician so the value of training transfer from peacetime to wartime is not lost.

### **Servicing**

For servicing, built-in robots might be used for rearming to reduce the need for deployment of so many personnel. Additionally, servicing materials such as lubricants might be dispersed automatically from central reservoirs or remote reservoirs to reduce the manpower needed to be deployed to operating sites and to reduce turnaround time between missions.

## **Systematic Approaches**

A more logistically sensitive acquisition process and strategy will need to be developed to acquire the detailed, specific support capability. What is required is a process that makes it easier to evaluate bottom line supportability results—that makes it easier to make changes when problems are found, that makes it more difficult to defer concern about support and supportability, and that makes it easier to press for full performance of support characteristics than it is to accept less than the requirement.

### **Requirements Identification**

One of the most important systematic processes to help with achieving highly supportable and supported systems involves the determination of requirements. This is a very fundamental step but one which is difficult to do and with which we have achieved only limited success so far.

To be meaningful, readiness goals, requirements, and thresholds need to be derived from projected operational requirements of the new system. The Air Force is starting to do this and one example can be seen in the development

planning community work in certain future systems planning.

What is needed is to be able to model the supportability characteristics and total support system for each mission operational scenario, and then vary the characteristics and system parameters to determine sensitivities, trades, and optimums as they relate to the alternative conceptual and design configurations which are being modeled and evaluated in combat scenarios. This would be a totally interactive and integrated process that would evaluate total system performance over a period of time rather than just the performance at a particular "snapshot" point in time.

### Funding Flexibility

Funding flexibility is another area where significant improvement could be gained. Pressures to reduce funding levels in early program phases sometimes result in deferral of supportability concerns until later in the program's life. On the surface, this may appear logical because support is one of the most deferrable aspects of a developing program. Unfortunately, it is not yet well enough understood and commonly accepted that supportability needs to be designed in—designed in to early concept decisions and designed in to early engineering design decisions. It has been proposed that complete funding flexibility across appropriations and across fiscal years be given to program managers. This would make it possible and practical for the program manager to spend money in R&D phases to improve and balance reliability, maintainability, and supportability, and, consequently, reduce life cycle cost and improve readiness in the out-years.

### Analysis

Analytical models could be developed that would be so capable, powerful, and all encompassing that it will be possible to conduct iterative, interactive, internetted trade studies continuously across all subsystems and across all contractors and subcontractors throughout the design process. This would greatly reduce the problem of compartmentalized suboptimization.

### Incentives/Accountability

A fourth area is incentives and accountability. With requirements firmed up and an acquisition process that facilitates fruitful pursuit of those requirements, the remaining need is to motivate the people in the process to seek accomplishment of the needs.

Along with this, another concept is to integrate supportability influences and criteria so fully into the entire design process that they realistically become second nature, are easy to accomplish, cost little more, if any, and are impossible to take back out to save a few up-front design dollars.

### Measurement

A fifth area is measurement. Improvements in the requirements process will produce detailed quantifiable requirements. However, the achievement of these requirements takes place in an interactive development and design process wherein the degree of success is relatively unknown until the hardware is actually built and tested. We need to develop better measurement methods, using advanced predictive techniques, which would allow more accurate tracking of progress and corrective redirection of design efforts. These measurement processes ought to be self-refining, as learning experience is built up, and be structured to be used on each succeeding program with greater validity and ease of application.

### Bridging the Gap

Let us now focus on one aspect of future technology and bring it back to the present. Then we will discuss how we can apply it now to improve the effectiveness of our management process. This, in turn, will enable the acquisition community to face the future with the capability to be more effective.

The technology we refer to is artificial intelligence (AI), previously mentioned, and the area of application is the acquisition logistics function. We propose that the acquisition logistics function could be greatly enhanced by developing what is known as an "expert system." An expert system uses AI concepts to perform or assist in many of the more routine or identifiable parts of a function. For example, expert systems are used to assist in medical diagnoses and in determining the composite effect of a mix of medications.

In the case of acquisition logistics, it is feasible to load into a computer memory all of the regulations and requirements a logistics planner has to use. One would also load in the program characteristics that cause each required action to become operable, along with the time or event trigger that indicates when a certain action needs to be taken. The logistician could interact with the computer periodically, keeping the computer up-to-date on program characteristics, schedules, events, and actions accomplished. The computer, in turn, would keep the logistician current with what new requirements have to be met or what actions are now due, and provide him help on how to do them.

By using the computer, AI, and expert system concepts, the capability of the logistics planner would be greatly enhanced and augmented. Much of the routine part of his job would become computer-assisted, allowing more time for the thinking and planning part of his job.

Initiatives like this or, in fact, very different from this can and should be developed for all aspects of the acquisition process.

Note

<sup>1</sup>Defense Science Board. Report of 1981 Summer Study Panel on "Operational Readiness with High Performance Systems." USDRE. Washington, D.C., April 1982, p. 4.



***"The art of war is simple enough. Find out where your enemy is. Get at him as soon as you can. Strike at him as hard as you can and as often as you can, and keep moving on."***

*On the Art of War*  
by Ulysses S. Grant

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## The Logician as a Part of our Nuclear Deterrence

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Nuclear deterrence of Soviet forces is the primary task of our strategic forces. For deterrence to work, our forces and our determination to use them must be credible to the Soviets. For our forces to be credible, they must be of sufficient size and composition to survive and fight after a worst case situation such as that expected from a Soviet first strike. No matter how large our forces, however, they are useless if we are unable to direct their use. It is this very awareness then of the critical nature of command, control, and communications (C<sup>3</sup>) that prompted the President's recent emphasis on rebuilding our C<sup>3</sup> capabilities.

This is great general information, but what does it have to do with us? How can logisticians make strategic forces more credible to the Soviets? Are not our nuclear alert forces mission ready at all times? What if they faced a threat in a nuclear exchange that could either stop them cold or seriously reduce their effectiveness? Just such a threat is lurking out there, ready to trip up the best laid plans.

*"The EMP phenomenon . . . effects depend on where the weapon is detonated."*

The threat is called EMP and TREE. EMP stands for electromagnetic pulse and is the name given to one of the effects of the detonation of a nuclear weapon. A nuclear explosion does more than just create physical damage in the form of blast, radiation, and thermal effects. It also creates the EMP effect, an effect not otherwise found in nature. The EMP phenomenon is technically complicated since its effects depend on where the weapon is detonated. The part of the effect best understood by the scientific community is called high altitude EMP (HEMP) and is a large amplitude, high frequency electric and magnetic field produced by a nuclear burst outside the atmosphere (1:I-4). A blast, therefore, that does no physical damage can still give us plenty of concern.

A single high altitude explosion can produce electric fields extending over a ground surface several thousand kilometers in diameter with magnitudes of over 50,000 volts per meter. In plain language that means a single blast, at 50 kilometers over Omaha, Nebraska, would cover the entire continental United States with very short, high amplitude electrical energy which could ruin most semiconductors (2:I-10). The HEMP phenomenon is in fact similar to lightning but HEMP has a faster rise time and higher frequency spectrum, thereby nullifying the usefulness of most installed lightning protection (3:II-30).

*"TREE is an acronym for transient radiation effects on electronics."*

TREE is an acronym for transient radiation effects on electronics. When a nuclear weapon is detonated, it emits large quantities of gamma and neutron radiation that can directly ruin or upset electronics, depending on the proximity of the item to the blast. It should be clear then that a high altitude burst will create large voltages for a very short period of time and that all weapons create potentially harmful levels of radiation. So just how does this affect the Air Force mission?

We have witnessed an increase in our weapons systems effectiveness by the introduction of even more sophisticated electronics. The electronics progress has made the computer revolution possible, while computers have helped us build superb state-of-the-art weapons systems like the F-16 and the Space Shuttle. Vacuum tubes were systematically replaced with transistors; then the transistors were replaced with integrated circuits (ICs) of ever increased speed and capacity. We are now using extremely fast and dense ICs, very high speed integrated circuits (VHSIC). For example, our old air defense radars, such as the AN/FPS-93, used vacuum tubes while our new systems, e.g., Pave Paws radar, use solid-state phased arrays, with very impressive capabilities and great reliability improvements.

*"We now have relatively fragile electronics in many of our critical circuits."*

Even with all of this progress, there is also a very real and serious danger. Each successive generation of electronics has introduced components of greater susceptibility to electrical overloads, voltage spikes, and electrostatic discharge and radiation damage. As a result of this evolution, we have been forced to keep reducing the definition of what is "too much voltage." Our steady technological march has brought about our very vulnerability to the potentially disastrous effects of EMP and TREE. An electric motor or a vacuum tube can shrug off substantial overloads, while integrated circuits can burn up or be upset at relatively small current levels. We now have relatively fragile electronics in many of our critical circuits.

All of this is nice, but where does the Air Force logistician fit in? Since EMP and TREE are effects expected in any nuclear exchange (either a general or theatre nuclear war), clearly our weapons and their support structures to be used in these types of battles should be protected against them, but are they? Some of our primary strategic systems, such as the Minuteman III ballistic missile fleet, are fully protected against EMP/TREE; but not all of our bombers, alert force vehicles, communications and power systems, or even the base klaxon system are fully protected. These systems are vulnerable because we have failed to commit sufficient resources to fix this potentially serious problem. The need for protection from these effects is well known at the highest

levels of our government. Our Secretary of Defense, Caspar W. Weinberger, responding to an article on EMP in the Jan 83 issue of *Science* 83, recently said (4:21):

While it would be naive to say that economical and implementable solutions are in hand to counter all EMP effects on all military systems, major improvements have been made. . . . I can assure you that these efforts are not being taken in vain; that they are not merely 'window dressing'; that we now have effective EMP protection for certain critical communications systems; and that we will continue to seek new and better means of EMP protection. . . . We must have the means for a measured, flexible response to such an attack. EMP effects make this type of response more difficult to execute, but these effects are being overcome.

***"... the vital Air Force logistics support... and... training... needed to support these systems are still in their infancy."***

Because EMP and its effect are a relatively new concern, the commitment to solve the problem lags and gets caught in a juggling of previous priorities and funding limitations. Progress is being made in the design of our new strategic weapons systems, such as the B-1B and the E-4B, which are being protected as they are acquired; *but* the vital Air Force logistics support infrastructure and the rules, regulations, training, and techniques needed to support these systems are still in their infancy. The logistics world is well behind supporting what the engineers are designing. Therefore, a logistician must do all he or she can to assure system reliability and survivability in war. These concerns are not new, but we are not making much progress (5:12). In the remaining paragraphs, I will make some suggestions.

A system which is protected or "hardened" against EMP/TREE normally employs special design features such as extra shielding, additional grounding straps, and special electrical transient protection using diodes and filters. Effective hardening is accomplished by controlling the topology of the system to keep the harmful effects away from the sensitive electronics. Each of these special features must be periodically checked to ensure they still serve their ultimate design objective, since the operator will not be aware of failure or degradation. Many of these devices characteristically fail in a passive manner, showing no evidence of failure.

***"... only in battle are we able to check our EMP/TREE protection systems."***

Since we no longer are allowed to test nuclear weapons in the atmosphere, we cannot directly check the effectiveness of our systems nor can we be certain we understand the effects of every weapon our enemies could direct against us. To check reliability, we try to simulate weapons effects, with devices like the large electronic pulsers used at the Air Force Weapons Laboratory (AFWL), but all simulations and estimates have definite limitations. The hard fact remains that only in battle are we able to check our EMP/TREE protection systems. This is yet another case of where we must fight with what we have on the first day of the war and will not be permitted additional time to solve our problems.

In addition to not recognizing a failure, what would we do if we found one? If a hardening device or critical component is

***"How do we predict the system's EMP protection?"***

found to be malfunctioning and there are no spares, would the system be declared not mission capable supply (NMCS)? What if the repair would take a couple of hours, yet we needed an alert vehicle right then? How many devices can be bypassed without affecting the system's protection? How "hard" or effective is the system? How do we predict the system's EMP protection?

***"... systems can be seriously degraded without any awareness on our part."***

These types of questions are not normally raised since we cannot easily check complex systems, such as an aircraft, and our guidelines in AFR 65-110, *Aerospace Vehicle and Equipment Inventory, Status, and Utilization Reporting System (AVISURS)*, do little to help our people make these decisions. The EMP protection of the E-4B National Emergency Airborne Command Post is as much a part of its required mission systems as are its communications and flight equipment, but it can be very difficult to detect critical failures in the EMP hardening features. These protection systems are very different from a system that tells you it is broken by not working; these systems can be seriously degraded without any awareness on our parts.

One of the first questions a professional logistician should ask is how do you test these special devices? What type of test equipment do you use? How often should they be tested? How are the technical orders marked and how are our maintenance and supply people trained? These are just some of the questions that need answers. Do the local civil engineers or the aircraft sheet metal folks even know about EMP/TREE? Corrosion control normally means painting surfaces to retard corrosion, yet with EMP systems we often require bare metal-to-metal finishes to ensure electrical conductivity. If we do not train our maintenance folks right, they will automatically paint bare metal when they see it, even though paint will ruin the EMP protection. It is critical that we understand these conditions.

We have recently seen examples where EMP protection devices were bypassed by poor maintenance practices without the people even realizing what they had done. In one example, a TV wire was run through an EMP protected door of a building, bypassing the protection systems. The person only wanted to watch TV on a graveyard shift, but that action resulted in giving EMP a free path into the building, bypassing the expensive, complex safeguards. Many hardening features appear senseless to the uninitiated, hence the great necessity for awareness training for each and every one of us.

The current official guidelines used to support these types of systems are few. The basic direction is contained in AFR 80-38, *Management of the Air Force Systems and Survivability Program*. While it is a start, it fails to include some of the very basic definitions used in this unique discipline. The latest DOD standard on the marking of engineering drawings contains two critical definitions, those for hardness critical items (HCIs) and hardness critical processes (HCPs), but they are not included in any Air Force regulation or manual (6:234).

A recently issued Department of Defense Instruction (DODI) 4245.4, *Acquisition of Nuclear Survivable Systems*, adds a few more pieces to the puzzle, but it has not yet been implemented in Air Force regulations. I would suspect few base-level organizations have a copy of these documents nor do they have anyone to call for help. There is still no Air Force technology center for this discipline; there is no place where experts could help our people with the problems they find. As a result of this management vacuum, we may be trying to "reinvent the wheel" time and time again in terms of support equipment, technical orders, and parts control programs and training. Another issue that arises is how and when do we acquire the trained engineers at the air logistics centers (ALCs), especially when it takes about four years to be adequately trained in hardness engineering.

*"We need common support equipment to test the system down to the line replaceable unit level. . . ."*

There is a pressing need for comprehensive military standards, data item descriptions needed for acquisition, ways

to assess and quantify the relative hardness of the system, and the development of an effective DOD-wide parts control program for EMP/TREE components. We need common support equipment to test the system down to the line replaceable unit level; depot support equipment; and, most of all, sufficient numbers of trained personnel.

The immediate problem with nuclear hardened systems is not a question of indifference or ignorance since the Minuteman program at Ogden Air Logistics Center is working on one set of answers; the problem now is getting the Air Force and DOD to set up the rest of the program complete with funding. If we do not address this problem soon, we may find that, just when we need our electronic "force multipliers," they have become electronic "force reducers."

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4. *Science 83*, March 1983, p. 21.
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**ALJ**

#### *Item of Interest*

#### **"Year of Supply"**

In July 1984, Lieutenant General Leo Marquez, Deputy Chief of Staff, Logistics and Engineering, HQ USAF, designated FY85 as the "Year of Supply." His purpose is to ensure all Air Force members are aware of the significant amount of effort being expended by the supply community to provide faster and more responsive support. This new fiscal year also allows supply people the potential to start new projects to improve supply support and the quality of work life.

The Supply Policy and Energy Management Division (HQ USAF/LEYS) held a kick-off luncheon on 1 October 1984 to announce the objectives and plans to the Office of the Secretary of Defense and senior Air Staff logisticians. The media are already providing appropriate coverage of this event and future articles will focus on the major initiatives completed, the benefits derived, and the people responsible for making them happen.

The supply community will focus its attention upon those 43 Harvest Resource initiatives as designated by the Air Staff (HQ USAF/LEYS). These initiatives are designed to improve the way the supply community does its business, supports its customers, and enhances its own supply corps.

To make the "Year of Supply" a success, the key elements are awareness, involvement, and commitment. Every individual has the opportunity to make a contribution towards this event, but it will only happen if logisticians everywhere become involved.

#### *Most Significant Article Award*

The Editorial Advisory Board has selected "Combat Logistics: The South Atlantic" by Group Captain R. N. Whittaker, MBE, RAF, as the most significant article in the Fall issue of the *Air Force Journal of Logistics*.

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## Small and Sure: A New Concept in Theater Airlift

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### Introduction

Retirement of the C-7 Caribou from the Air Force inventory was a bittersweet experience. From some quarters came expressions of sadness that the reliable old steed would no longer serve her riders. Other quarters were optimistic that the new beast would bear greater burdens than the old workhorse. When the C-7 Caribou retired from the inventory at Maxwell Air Force Base, Alabama, in October 1983, the C-130 Hercules became the principal cargo aircraft of the 908th Tactical Airlift Group, Air Force Reserve. This aircraft can fly higher, faster, and farther, and can carry much more cargo than the Caribou. But, with a payload of 43,000 pounds, it is clearly a large aircraft. The Caribou was the last small cargo aircraft. What has the Air Force lost by failing to replace its small cargo airlifters?

The Caribou, also known as the DeHavilland DHC-4, was first produced for the US Army in 1958. It was a short takeoff and landing (STOL) aircraft capable of operating from unpaved strips less than 1,500 feet long. The original production model could lift 7,300 pounds or 32 passengers, but these heavy gross weights limited its range. The Caribou was also capable of airdropping smaller loads of troops or cargo under combat conditions and was thus the smallest of the tactical airlifters. The Air Force made extensive use of these capabilities during the Vietnam conflict and usually loaded it to 60% of its weight capacity. This utilization rate was higher than the rates of the larger tactical airlifters. The Caribou flew mostly routine logistics resupply missions; emergency missions accounted for less than 2% of the sorties. Despite its STOL capability, the aircraft made only 27% of its mission landings on fields less than 2,500 feet in length. Only 1% of the missions flown in the Republic of Vietnam were combat airdrops.<sup>1</sup> This experience suggests that the Air Force has not lost much combat capability by replacing the Caribou with a larger airlifter.

Unfortunately, Air Force has lost a significant degree of flexibility. Three airlift missions can be met with a small aircraft. First, there is still a logistics mission for small loads. Second, small theater airlifters are needed to support larger aircraft of the Military Airlift Command (MAC). And, finally, a new, small aircraft is the centerpiece of a revolutionary concept in assuring distribution of theater logistics. In other words, replacement of the Caribou should satisfy requirements for conventional theater airlift, MAC support, and assured distribution.

*“ . . . underuse of tactical airlift aircraft has been attributed to the nature of the mission.”*

### Conventional Intratheater Airlift

Generalizations about the requirements for airlift within a theater are difficult. In the first place, every theater of the world is physically unique. The distances involved, the number of available airfields, the adequacy of ground transport, and the size of the deployed forces are only a few of the variables in the equation for theater airlift. Nonetheless, some elements are constant. One of these elements is the timely movement and resupply of forces within the theater. To accomplish this mission, MAC is prepared to move forces into battle through airland or airdrop operations. Forces can be resupplied by airdrop much the same as they were resupplied at Khe Sanh, but an established airlift channel is necessary for routine resupply. A channel is simply a route designed to move passengers and cargo between two points on a regularly scheduled basis. Channel requirements can range from heavy, more than daily service to light weekly service. A fiat of tactical airlift is that every station requires some regularly scheduled service even if it is only to exchange a few sacks of mail for small amounts of cargo. These underused channels are a fact of life in both peacetime and wartime theaters.

Traditionally, this underuse of tactical airlift aircraft has been attributed to the nature of the mission. In testimony before Congress in 1975, General Paul Carlton, Commander, MAC, remarked:

The low cabin loads generated through small bases and outposts contribute to a distorted picture of airlift capability based on ton-miles . . . . Responsiveness and flexibility to meet fluctuating theater tactical requirements establish the effectiveness for tactical airlift forces rather than ton-mile computations.<sup>2</sup>

The extent to which use of airlift has become less efficient has recently been revealed through a new analysis tool called the Channel Productivity Improvement Program. An unofficial survey of this report over a three-month period shows that approximately 72% of the C-130 channel missions carry less than 40% of their capability.<sup>3</sup> Although some of these missions may have required C-130s because of cargo cube or mission range, a lack of cargo for small stations accounted for most of the empty space. What are the options for solving this problem?

*“This dilemma could be resolved with the addition of a small airlift aircraft to replace the Caribou.”*

Economy would dictate less frequent service or reduction in the size of aircraft assigned to these underused channels. Less frequent service would allow more cargo to build up at the

shipping aerial port and would thus ensure fuller airplanes and more economical service. Clearly, this would deprive the deployed units of the primary attribute of airlift service—speed of delivery. One is not surprised that the using command or branch of service determines the frequency of service required for these low-use channels. Therefore, the only option available to MAC is to provide the service with smaller aircraft. The Caribou provided this service in Vietnam, but similar service would be impossible today because the Hercules is both the largest and the smallest intratheater airlifter. This dilemma could be resolved with the addition of a small airlift aircraft to replace the Caribou.

When commercial airlines in the United States (US) faced similar problems, they abandoned routes of low use and made them available to commuter airlines. In operating large aircraft on heavily travelled routes, the major airlines found that it was not in their financial interest to serve every airport capable of generating a passenger. But, without a system to feed passengers into their major stations, the airlines would leave a substantial number of customers without service. The solution was to employ small, economical turboprop aircraft used by commuter airlines around the country. These companies make a profit in flying the same routes on which companies flying larger aircraft lost money because they provide a desired frequency of service at low cost. Commuter aircraft can carry up to 30 passengers or approximately the same payload carried by the Caribou. A comparison of the operating costs of the Hercules with the costs of operating a typical small aircraft shows the advantages of fitting the airplane to the job.

The C-130 is a large, complex aircraft designed for multiple wartime roles and is thus more expensive to operate than a typical small cargo aircraft, such as the Shorts Skyvan. The Skyvan, a twin turboprop aircraft, uses approximately 600 pounds of fuel for an hour of flight. The Hercules has four engines and burns almost 5,000 pounds per hour. But the Skyvan is a slower airplane that cruises at 160 knots versus 280 knots for the C-130. Commuter airline operators have found that cruising speed is not a major determinant on a route that serves many stations, since they spend much of their transit time on ground operations, taking off, or landing. The smaller aircraft requires three crewmembers while the Hercules requires five. The C-130's complex systems require 25 maintenance man-hours to keep the aircraft flying for only one hour, but the comparatively simple systems on the Skyvan require only five hours for each flying hour. The C-130 aircraft is fitted with hundreds of pounds of electronic and other equipment necessary for the combat airdrop role, but little of the equipment is needed on routine logistics missions.

*"Modern proven aircraft, such as the Skyvan, are available for less than \$2 million per aircraft."*

MAC now has the opportunity to match mission requirements with the appropriate aircraft. With all of its advantages for transporting small loads, the Caribou was an old airplane that burned aviation gas instead of jet fuel. Years of rugged service had limited its reliability and made it difficult to maintain. Modern proven aircraft, such as the Skyvan, are available for less than \$2 million per aircraft. Unmodified or off-the-shelf, these planes could assume the theater logistics role on routes of low use, and free a similar number of C-130s, which currently cost \$11 million each, for

the airlift role in theater combat. But the small aircraft can make an even greater contribution in the area of MAC support and assured distribution.

## Support for Military Airlift

Intertheater cargo airlift is performed primarily with C-5 and C-141 aircraft that transit many airfields, both in the US and in overseas areas, to accomplish their mission. Unlike aircraft used by the commercial airlines, these aircraft are frequently called upon to onload or offload cargo at bases that are not included on the normal route structure maintained by MAC. In such instances, they are isolated from normal maintenance support en route. When an aircraft breaks down at one of these locations and base maintenance personnel are unable to correct the problem, MAC must then support its aircraft from another location, normally by diverting another C-141 or C-130 to a base where maintenance personnel and parts are available. The rescue aircraft is then routed through the base where the broken aircraft is located. If an empty depositioning aircraft is not available, a loaded aircraft is used, and cargo or passengers may be displaced from this aircraft to make room for the maintenance team. The rationale for "bumping" some user cargo for maintenance equipment is that a payload of cargo will be affected if the broken aircraft is not quickly repaired. Therefore, repair of that aircraft is given a higher priority. This system works well in peacetime operations because aircraft are usually scheduled for large blocks of ground time at home stations between missions and the diversions consume this "slack" time.

*"... the number of diversions to carry maintenance support in peacetime is not recorded accurately..."*

Forecasting the magnitude of this support in wartime, however, is difficult for at least three reasons. First, the number of diversions to carry maintenance support in peacetime is not recorded accurately, since many of the diverted planes are trainers or depositioning aircraft. Experience has shown that an average of four such diversions are necessary every day in the eastern half of the US alone. This figure suggests a conservative worldwide figure of 10 per day. Second, the daily use rate for MAC strategic aircraft is expected to quadruple in wartime from the current 3 hours per day to more than 12 hours.<sup>4</sup> Although the number of breakdowns at stations en route will increase, it will probably not increase proportionally with the use rate because, in wartime, many aircraft will fly with problems that would ground them in peacetime. Thus, the number of wartime diversions will be somewhat less than 40 per day. Of course, an empirical formula is not available, since MAC has never used its entire fleet under such high use rates. It approached this figure during the 1973 Arab-Israeli conflict when it used 63% of its C-5 fleet at an average rate of five hours per day and 26% of the C-141 fleet at eight hours per day.<sup>5</sup> Finally, the problem of unsupported breakdowns en route is further complicated by field closures during combat conditions. A study by the Rand Corporation in 1978 notes that a number of strategic airlift sorties will be diverted from their scheduled offload and maintenance bases and that moving support to the recovery bases would be a problem. And the problem is magnified by the questionable availability of C-130s for such

movements.<sup>6</sup> In addition to the difficulty of forecasting the number of diversions, such a method of operation suffers from other inherent drawbacks.

*"The problem of supporting airlift flow has plagued airlift planners since the earliest air supply missions."*

For example, the entire routine for support of strategic airlift aircraft en route will face a much more tenuous situation during wartime. Planning for wartime operation is based on maximum use of all airlift resources; that is, aircraft, crews, and airfields are scheduled to get the most value from the resources available. Because of this tight scheduling, breakdowns or other disruptions in the airlift timetable will cause repercussions throughout the system, and little slack time will be available to divert additional aircraft for maintenance support without causing further disruption. Furthermore, airfields with broken MAC aircraft on the ramp provide fewer parking spots, and this will cause further slowing of the airlift stream. Some means are necessary to provide the required maintenance support rapidly without diverting the flow being supported. The problem of supporting airlift flow has plagued airlift planners since the earliest air supply missions. For example, while Lieutenant General William Tunner was conducting airlift operations over the Hump to China during World War II, he expressed dismay that he had to expend so much of his capability just to support his maintenance requirements.

The problem is worse today because there are fewer large transports. Each aircraft represents such a large percentage of the total transportation available that its loss for even a few hours will be more detrimental to the flow. This implies that broken aircraft must be fixed faster and that the opportunity cost of diverting an aircraft to support it will be much greater. Since most of these support teams are quite small—an average of two maintenance personnel, a toolbox, and some small parts—an entire C-141 is not necessary to move them. They could easily deploy on a C-130, but most planners consider the C-130 fleet unavailable for additional tasking during wartime because of their deployment and combat airlift requirements. How, then, could small airlift aircraft solve this problem?

During the deployment phase of war when the flow of strategic airlift would be the heaviest, small aircraft similar to the Caribou or the Skyvan would alleviate problems caused by breakdowns in the flow. Most of the required maintenance teams would fit easily on such an aircraft, and, if only two of these aircraft in the theater were designated for MAC support, they could provide maintenance almost on demand. Since a team would not need to wait for a diverted C-141, it would arrive sooner and make the necessary repairs more quickly. Today, the crew of a broken aircraft often waits more than a day for maintenance support, but a responsive, dedicated aircraft would probably enable the crew to fly the plane out the same day. This improvement would reflect the goal of Tunner and every MAC planner—greater performance from the airlift system.

*"The EDS addresses . . . the argument for new, small airlift aircraft."*

## Assured Intratheater Distribution

The Air Force Logistics Command (AFLC) has developed an imaginative plan called assured distribution for increasing the logistics support of tactical air units in Europe. The concept is based on a study by the Rand Corporation concerning the effect of improved redistribution of logistics in the European theater during a war.<sup>7</sup> The Rand study forecast that implementation of assured distribution could generate 600 tactical air sorties per day. Three improvements in the theater logistics system are included in the concept: logistics command and control, in-theater warehousing, and a European distribution system (EDS). The first two improvements are major operations in themselves, but they are not germane to this discussion. The EDS addresses the very heart of the argument for new, small airlift aircraft.

As the Rand study points out, the need for this system is based primarily on the redistribution of aircraft parts to meet the unique demands of combat forces. The uncertainty of fighting a war applies most acutely to forecasting resupply requirements because similar units throughout the theater will use parts and supplies at different rates. This discrepancy will lead to supply imbalances or familiar instances of one base having aircraft grounded for parts that are plentiful at another base. To correct this discrepancy, the new logistics concept calls for a command, control, and communications system to discover imbalances and identify the solution. In-theater warehousing is designed to shorten the supply pipeline, make the units less susceptible to supply surges, and provide the source of parts that will flow through the distribution system. The distribution system itself is not unique in design, but its implications for military airlift operations are revolutionary.

The EDS calls for an airlift network to distribute critical aircraft parts throughout the theater. A fleet of small cargo aircraft similar to the Skyvan would operate a scheduled service to every European base in the network on a daily basis. The route structure would permit overnight service between most of the stations in Europe and would resemble the system used by Federal Express in the United States. This system, often called a hub-and-spoke operation, centers around a common redistribution point, the hub. Each day, an aircraft from the fleet visits every airport served by the system and picks up parcels as it makes its way toward the hub. By the middle of the night, all of the aircraft have arrived, and all the parcels have been sorted by destination. After the aircraft are loaded, they depart on their spokes and drop off the cargo through the early morning hours. In this manner, delivery from any station to any other station can be accomplished overnight in most cases.

*"Surging to war operations will involve increasing the use rate and curtailing routine crew training."*

Some fundamental changes were incorporated into the military system, since it is designed for combat operations. The forward warehouses and hubs are being designed for mobility so they can be relocated if their security is threatened. The routes can be rapidly revamped to account for unit movements or dispersal within the theater, and the size of the fleet is based on wartime requirements, with a limited

distribution network in peacetime. Surging to war operations will involve increasing the use rate and curtailing routine crew training. Even during wartime, the fleet is designed so aircraft will be available to support unforecast requirements on a "you call, we haul" basis. Naturally, the design of the aircraft is central to the capability of this system to perform its mission.

The Air Force has written a request for proposal that describes the capabilities needed in the EDS aircraft, which will carry the F100 jet engine as its single largest piece of cargo.<sup>8</sup> Based on studies of aircraft parts transferred between bases in the past, estimates are that at least 96% of these parts would fit on an aircraft designed to carry the F100 engine. Emphasis is also placed on the ease of servicing and maintainability of the EDS aircraft. In striving for simplicity, the Air Force has requested an off-the-shelf aircraft with a proven record of airworthiness and maintainability. The final determinant is low acquisition and maintenance costs. The competition includes the cost of purchasing 13 aircraft in 1984, maintenance support for these aircraft for their lifetime, and options to purchase 46 additional aircraft during the next two years. Although the contract will be designed to minimize system cost, the aircraft must satisfy specific operational demands.

*"When the demands of war are applied to the EDS requirements, a specific type of aircraft begins to take shape."*

When the demands of war are applied to the EDS requirements, a specific type of aircraft begins to take shape. To overcome the obstacle of interdicted runways, the aircraft must be capable of short field operations on paved or unpaved surfaces, and this requirement translates to a capability of taking off with a 4,200-pound payload in 1,750 feet and landing in less than 1,500 feet. The maximum payload must exceed 5,000 pounds. Operated by a three-member crew, this multiengine turboprop will be capable of carrying a 2,800-pound load for 700 nautical miles, and it must cruise at 140 knots or better. Since the combat capability of many other aircraft will depend on the reliability of this aircraft, it must be capable of on time departure at least 96% of the time, and turnaround time at bases en route must not exceed 30 minutes. The aircraft envisioned is a small, reliable, rugged airlifter similar in many respects to the old Caribou. In fact, when the Rand study examined the alternatives for building an EDS, one of the options was a modernized C-7. What are the implications of this distribution system for the future of theater airlift?

If assured distribution can deliver its promised improvements in theater logistics, then there is a great probability that its popularity will spread to other combat theaters. The advancement of war-fighting capabilities through improved distribution blends well with the combat-oriented image recently developed by AFLC. The command anticipated multitheater requirements and included options to purchase additional aircraft in the request for proposal. Other theater commanders are now studying the EDS with an eye toward application of the concept in their theaters. The implications are that this system has a great potential for growth and, as such, warrants careful management. If the system proves beneficial to Europe, it may well offer a universal benefit applicable to any theater. This development

will introduce a need for a deployable CONUS-based theater distribution system capable of setting up and operating within designated theaters. Careful management will be needed for this potential expansion to ensure a cost-effective and efficient system.

As the airlift operator for the Department of Defense (DOD), MAC will ultimately be tasked to train, deploy, and operate these systems. In the interest of airlift efficiency, these multiple systems must be standardized to the extent permitted by operational requirements. If the missions and equipment are similar, then training, operating, and administering the systems will benefit from economies of scale. Should a surge require augmentation from one theater to another, similar systems would make this transition possible. In anticipation of a successful European system, the feasibility of multiple theater operations should be studied from the perspective of worldwide standardization. In this most unique role of the small cargo aircraft, both the innovator—AFLC—and the operator—MAC—have a mutual stake in the efficient development of the system.

*"Small airlift aircraft can . . . replace larger C-130 aircraft on low-use channel runs."*

## Conclusion

Emphasis on expansion of airlift has been directed for many years toward procurement of larger aircraft, but the expense of buying and maintaining these systems has kept the fleet smaller than most experts deem necessary. In the process, the small airlift fleet has all but disappeared. The Research and Development Subcommittee of the House Committee on Armed Services expressed dismay in 1970 at the lack of effort to modernize the tactical airlift force and recommended replacement of the C-7 and C-123.<sup>9</sup> Perhaps recognition that small airlift aircraft can actually generate more sorties for the larger airlifters, coupled with the new requirement for a theater distribution system, will rekindle interest in this subject.

Small airlift aircraft can, in many cases, replace larger C-130 aircraft on low-use channel runs. This step would be most advantageous from the procurement standpoint, since the price of the small plane is less than one-fifth the price of the Hercules. And operating costs are much lower for the smaller aircraft. The C-130s would then augment the combat airlift force. Unregulated commercial airlines have proven that the use of small aircraft to serve small markets is an economically rational concept. It also seems rational for MAC. Therefore, the command should first determine the channels that consistently underuse the C-130. It should then consider the cost effectiveness of using small aircraft to operate on these channel missions and request funding to procure these aircraft. In addition to generating tactical airlift sorties, a small airlifter can also enhance the flow of strategic airlift.

Strategic airlift is the umbilical cord of every theater deployment, but it consists of a limited number of large, expensive aircraft. A breakdown at some point in the flow causes problems throughout the system when resources are tightly scheduled. It is no longer economically feasible to move maintenance teams around the system in otherwise empty C-141s, and the diversion of additional aircraft from the flow only complicates problems caused by the original breakdown. Small airlift aircraft dedicated to MAC support

can deliver these repair teams faster without additional diversions. To solve the problem, MAC planners must devise a method to track and analyze the frequency of diversions to support maintenance requirements and apply this data to wartime constraints. They must next forecast the number of diversions expected in combat, measure the feasibility of using the proposed small aircraft to satisfy these requirements, and request funding for the system on the basis of its cost effectiveness. Once again, the value of the small aircraft is not its small size but the number of large aircraft sorties it generates.

Just as the generation of fighter sorties led to the development of the EDS, the application of the same principles to other theaters may lead to further deployment of the concept. If the system is so valuable in Europe, then theaters with minimal existing transport should benefit even more. At the center of this revolutionary concept of assured distribution is the small reliable cargo aircraft. The challenge to the Air Force in this case is to ensure that the system is developed with efficient operations in mind as requirements expand from a single-theater concept to worldwide deployment. Innovators of the system at AFLC must continue to pursue similar programs and customers in every theater and ensure that a unit whose combat power is multiplied in one theater is not degraded by the lack of assured distribution in another theater. MAC coordinators should follow these developments closely to ensure that the system is ultimately designed for efficient airlift operations.

Now is the time to replace the Caribou. The three arguments leading to this conclusion do not suggest three fleets of small aircraft; they suggest one fleet with three distinct theater missions. This force may require more than the 64 aircraft in the original package, but, if the cost analyses require more, this is the time to determine the requirement. The Air Force

must act while the contract is fresh and the infrastructure for the fleet is being assembled. Twenty-five years of technological development have produced a class of small but sure aircraft, the keystone of a new concept in theater logistics. Let us not miss the opportunity to rationalize theater airlift operations.

Editor's Note: USAF policy reviews said,

"The USAF has not identified any requirement for a small tactical (intratheater) transport of the type advocated by the author. The feeder type operation mentioned in the article would now be performed by the Army helicopter fleet. In fact, the case can be made that the replacement for the C-7 in the Army when they were transferred to the AF was the CH-47 helicopter. Since the present feeder system to small bases is responsive to the needs of the Army, that service appears happy with the arrangement and there is no need for us to commit resources for a competing system."

#### Notes

- <sup>1</sup>HQ USAF, AFGOA, *Analysis of C123 and C130 Airframe Utilization in RVN*, 1968, pp. 1-4.
- <sup>2</sup>Research and Development Subcommittee, House Committee on Armed Services, *The Posture of Military Airlift*, 94th Congress, 1st Session, 1975, p. 69.
- <sup>3</sup>Military Airlift Command, Transportation Directorate, "Channel Productivity Improvement Report," July, August, September 1983.
- <sup>4</sup>US Congressional Budget Office, *US Airlift Forces: Enhancement Alternatives for NATO and Non-NATO Contingencies*, April 1979, p. 15.
- <sup>5</sup>Rand Corporation (Project AIR FORCE), *Capabilities for Military Airlift to Third Areas: 1973 and Mid 1980s*, 1979, p. 20.
- <sup>6</sup>Rand Corporation, *Vulnerability of Strategic Airlift Operations in Reinforcing NATO*, 1978, p. 40.
- <sup>7</sup>Rand Corporation, *Combat Benefits of a Responsive Logistics Transportation System for the European Theater*, 1981.
- <sup>8</sup>HQ AFSC/ASD, "European Distribution System Aircraft (EDSA)," Request for Proposal, 17 July 1983, p. 35.
- <sup>9</sup>Research and Development Subcommittee, House Committee on Armed Services, *The Posture of Military Airlift*, 94th Congress, 2nd Session, 9 April 1976, p. 7.

This paper reflects the views of the author and does not imply Department of Defense endorsement of factual accuracy or opinion.



#### ► FROM 27

In summary, it is clear that future US forces will need a global responsive capability that provides universal coverage, adaptability, quick reaction, and effectiveness. The Air Force should be the cornerstone of such a capability, yet shortcomings in the planning process could prevent such a development.

Stepping back from current planning, it is possible to identify four global responsive alternatives: transatmospheric systems, long-range/endurance aircraft systems, minimum support deployable aircraft systems, and indirect support capabilities. Within each of these alternative categories, a specific example has been presented to illustrate the nature of the alternative. It is suggested that exploration of such concepts, and continued planning outside the constraints of conventionally defined mission areas, could pay large dividends.

#### Notes

- <sup>1</sup>Freeman, Roscoe. Introduction to Vol I, Chapter 5, "Global Resources," AWC Reading, 16th Edition, September 1981.
- <sup>2</sup>"Petroleum Supply Monthly," US Department of Energy, Superintendent of Documents, Washington DC, June 1982.
- <sup>3</sup>Singer, S. Fred. "The Coming Revolution in World Oil Markets," *Wall Street Journal*, 4 February 1981, page 26; "What is Happening to World Oil?," *WSJ*, 10 March 1982, p. 22.

- <sup>4</sup>*Congressional Handbook on US Materials Import Dependency/Vulnerability*, Report to the Subcommittee on Economic Stabilization of the Committee on Banking, Finance, and Urban Affairs, House of Representatives, 97th Congress, 1st Session. Congressional Research Service, Library of Congress, US Government Printing Office, Washington DC, September 1981.
- <sup>5</sup>Meyer, Herbert E. "How We're Fixed for Strategic Minerals," *Fortune*, 9 February 1961, pp. 68-71.
- <sup>6</sup>*Congressional Handbook on US Materials Import Dependency/Vulnerability*. Congressional Research Service, Library of Congress, US Government Printing Office, Washington, DC, September 1981.
- <sup>7</sup>Ibid.
- <sup>8</sup>Hansen, James. "High Strategic Stakes in Southern Africa," *National Defense*, May-June 1982, pp. 42-46.
- <sup>9</sup>Janke, Peter. "The Soviet Strategy of Mineral Denial," *Soviet Analyst*, Vol 7, No. 22, 9 November 1978, p. 5.
- <sup>10</sup>*Congressional Handbook on US Materials Import Dependency/Vulnerability*. Congressional Research Service, Library of Congress, US Government Printing Office, Washington, DC, September 1981.
- <sup>11</sup>*Treaties in Force*, Treaty Affairs Staff, Office of the Legal Advisor, Department of State, January 1981.
- <sup>12</sup>Ibid.
- <sup>13</sup>Hansen, *National Defense*, pp. 42-46.
- <sup>14</sup>Feasibility Study of Reusable Aerodynamic Space Vehicle, SAMSO TR 76-223, Volume III, Contract FO 4701-76-C-0102, Boeing Aerospace Company, September 1976.
- <sup>15</sup>Continuous Patrol Aircraft (CPA) 'Quick Look,' Aeronautical Systems Division (AFSC), ASD/XRM, 1 March 1982.
- <sup>16</sup>Advanced Technology Light Attack System (ATLAS) IR&D Review Briefing, Vought Corporation, 14 April 1981.

(This analysis was presented at the Air University Air Power Symposium in February 1983.)





# CAREER AND PERSONNEL INFORMATION

## *Civilian Career Management*

### **Logistics Civilian Career Enhancement Program (LCCEP)**

In October 1980, the LCCEP came on-line and began to operate a central referral activity and provide career counseling to Cadre members. Since that time, there have been many changes in the program.

In 1980, there were 1,148 career program positions to be filled centrally through the LCCEP. Today, that number has increased to 1,913. In the first year of operation, 125 jobs were filled through LCCEP. During FY84, this figure increased to 248.

Through LCCEP, spaces are available to program participants to attend AFIT Graduate Logistics Training, a 15-month educational program conducted at Wright-Patterson AFB, Ohio. Civilian employees and their military counterparts study a rigorous program that is not only stimulating but which provides a springboard to greater responsibility within the Logistics arena. Graduate Logistics Education in civilian institutions has been used in some instances to obtain needed knowledges, skills, and abilities through an accelerated learning process versus a slower process of on-the-job training or a series of courses through other government facilities. Perhaps the best opportunity offered through LCCEP is the career broadening program. Individuals with identified developmental needs may apply for career broadening assignments. These needs must be documented and benefits to the Air Force must be examined. Career broadening positions are available through LCCEP to provide specific broadening experiences. The positions are structured with duties that will provide the required learning experiences. AFR 40-110, Volume IV, *Logistics Civilian Career Enhancement Program (LCCEP)*, gives specific details on how to identify, verify, request, and compete for these career broadening positions. Another program that is being explored is Training With Industry which will work under much the same principle. Needs will be identified, training will be matched to meet those needs, and benefits to the Air Force will be assessed.

The LCCEP receives some quotas for Executive Seminar courses. These are allocated directly from Office of Civilian Personnel Operations (OCPO) to individuals who have indicated a need for these courses. Course requirements are input into the mechanized system by the local Employee Development Section of the Civilian Personnel Office where they show up as required training.

Participants in the career program have worked hard at self-development and have demonstrated excellence on the job. As a result, competition gets stiffer from year to year for training/development and promotion opportunities. As the LCCEP matures, we expect our training development function to expand. It is imperative that civilian employees realistically look at their short- and long-range goals and adequately assess their training and developmental needs. With this assessment, training can be requested which will serve as verifying requirements to the LCCEP for purposes of budgeting and allocating training quotas. Career broadening assignments can be an enriching experience which meets both personal goals and Air Force needs.

Source: Suzanne H. Gorden, OCPO/MPKCL

## *Military Career Management*

### **Contracting and Manufacturing**

With the recent attention the Air Force is receiving on the issue of acquisition, we will discuss how the Air Force Manpower and Personnel Center (AFMPC) emphasizes people resources in meeting the growing demands in the acquisition area.

In the past year-and-a-half, the contracting and manufacturing career field (AFSC - 65XX) has grown by 200 new authorizations for officers and over 250 for enlisted personnel. In response to the increases, as the new officers and enlisted people have been assigned to this career field, a dilution of the experience base has occurred across-the-board. In addition, as we continue to acquire people to meet the growing increase in contracting/manufacturing authorizations, the speed in bringing the new personnel on-board lags behind the growth in authorizations.

Lower manning and limited experience have effects on the assignment process. Some of the bigger impacts are:

a. Grade substitution will become even more commonplace—especially at the lieutenant colonel and major level.

b. Some officers may have less than three years time-on-station when they make another continental United States (CONUS) move to fill key positions.

For lieutenant colonels and below, actions to increase the 65XX manning are being directed in five major areas.

a. Increase accessions over previous years.

b. Direct flying and technical training eliminees to the 65XX career field.

c. Increase number of crossflows, particularly among engineers.

d. Return former 65XX officers to contracting/manufacturing duties.

e. Decrease levy requirements for 65XX officer crossflowing out of the career field.

The net result of these actions has brought 257 officers into the contracting career field this fiscal year to counter the loss of 185 officers. We are projecting 65XX lieutenant colonels/lieutenants manning to equal the overall support officer average of 96% by summer 1985.

The large increase in enlisted authorizations projected for the start of fiscal year 1985 is unprecedented, and the ability of the commands to immediately use a large influx of inexperienced personnel is limited. The recovery growth via PALACE BALANCE and retraining efforts reflect a prudent approach to rebuild enlisted contracting manning without overtaxing the gaining units for on-the-job training (OJT) requirements. Our immediate response to the activities that incur the large growth is to increase their manning commensurate with the average enlisted contracting manning. Additionally, we will mix experienced and inexperienced enlisted contracting people into units in a way that represents a cross-section of the entire enlisted contracting community. Under this plan of action, enlisted contracting manning will be equal to the worldwide enlisted support average of approximately 96% by the summer of 1985.

Source: Lt Colonel E. C. Humphreys III, AFLMC/ROSI

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# Global Responsive Aerospace Systems Planning

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*If Europe and America may be called the front, the non-sovereign nations and colonies, with their raw materials, food, and vast stores of human materials, should be regarded as the rear, the reserve of imperialism. In order to win a war, one must not only triumph at the front but also revolutionize the enemy's rear, his reserves.*

Joseph Stalin, 1921

## Introduction

This article began with informal discussions of the reality of Air Force planning procedures and the problem of defining new Air Force systems to meet the possible needs of the United States (US) in an uncertain future. The intent was to step back from established current planning and formalized requirements statements, and take a fresh look at basic global problems in search of relevant, high payoff aerospace concepts that could improve future Air Force capability.

Although the use of military force may not be the most desirable means of solving particular global problems, the ability to project power is an essential factor in achieving international political objectives. Without attempting to create detailed scenarios, the authors examined three US vulnerabilities and their power projection implications. Vulnerabilities were not hard to find, and the requirements they suggested diverge somewhat from those typically developed in more conventional analyses.

## Global Vulnerabilities

### National Security Objectives

Thinking about the application of force to support national security objectives calls for a brief examination of what these objectives might be. For simplicity's sake, let us condense any discussion of them to the protection of US security and the survival of NATO.

### Critical Dependencies

With US security and NATO survival as a base, a review of the world scene turned up three conditions that could properly be termed US vulnerabilities: Dependence on imported petroleum, dependence on imports of a number of minerals essential to the maintenance of a modern industrial economy, and dependence on a wide network of sea/air lanes.

### Petroleum Dependency

It is well known that the US relies on petroleum imports to help satisfy its high per capita energy requirements, but it is

not only US import dependence that causes concern. Common market and Japanese dependencies are also heavy. Except for England and Norway, which were self-sufficient due to North Sea oil, Western European countries imported two-thirds of their oil from the Middle East in 1981 and Japan three-fourths. Not as well known are (1) the short run variability of US petroleum import dependence, (2) the location of sources of imported petroleum, and (3) the long run outlook for petroleum dependence or independence.

The percentage of US consumption which is imported is not stable. In 1977, for example, the US was importing approximately one-half the oil it was using. By 1981, that proportion had fallen to 37%.<sup>1</sup> By April 1982, the last full month for which final figures were available when the study was undertaken, imports had fallen to 25%.<sup>2</sup> Recession and conservation efforts, due to rising oil prices, had brought about reductions that would have seemed impossible a few years earlier. However, any rise in economic activity in the US is likely to put renewed pressure on oil supplies and imports.

By April 1982, Mexico was furnishing almost as much oil as Saudi Arabia and roughly two-thirds as much as all of Arab OPEC. All of OPEC, Arab and non-Arab combined, furnished 43% of US imports (11% of US consumption).

Although the US remains vulnerable to supply interruptions in the short term, the situation may improve. According to predictions from the Energy Policy Research Center at the University of Virginia, oil's high price will bring about widespread substitution of other fuels for available crude oil and more efficient refining of crude oil into gasoline. After some period of time, there is even a possibility of Western Hemisphere self-sufficiency.<sup>3</sup>

### Strategic Mineral Dependency

Of 29 strategic and critical minerals included in the national defense stockpile, there are, according to the Congressional Research Service of the Library of Congress, 8 "... for which the industrial health and safety of the United States is most vulnerable to supply disruptions."<sup>4</sup> Of these eight, five have been called by *Fortune* magazine, "The metallurgical Achilles heel of our civilization."<sup>5</sup> Table 1 shows those eight, with the latter five identified by asterisks, and shows the percentage of current US usage that is imported and the primary sources for each.<sup>6</sup> Furthermore, Figure 1 shows clearly that, as severe as US dependency is for many minerals, Western Europe and Japan are even more dependent on mineral imports.<sup>7</sup>

While the US imports minerals from almost all over the world, Table 1 shows that, for certain critical minerals, the countries in the southern part of Africa are extremely important suppliers.<sup>8</sup> There is some disagreement among authorities as to whether or not the Soviet Union is waging a "resource war" against the West, with logical arguments supporting the position that it is.<sup>9</sup> But, even if it is not,

economic competition alone could be expected to "... dramatically change the world supply/demand status for the materials thus involved and, necessarily, will strongly affect US attempts to maintain the necessary level of mineral imports."<sup>10</sup>

CRITICAL MINERAL IMPORTS		
MINERAL	PERCENT IMPORTED	PRIMARY SOURCES AND PERCENT OF IMPORTS COMING FROM EACH
Bauxite/Aluminum	94	(Bauxite) Jamaica 42, Guinea 32 (Aluminum) Australia 78, Jamaica 17
Chromium*	91	Republic of South Africa 49 USSR 12, Philippines 9, Turkey 8
Cobalt*	93	Zaire 42, Belgium-Luxembourg 16, (original source: Southern Africa), Zambia 13, Finland 6
Columbium	100	Brazil 66, Canada 9, Thailand 7
Manganese*	97	Republic of South Africa 26, Gabon 19, Brazil 13, France (ore from Africa and Brazil) 12
Platinum Group**	87	Republic of South Africa 53, USSR 22, UK 12
Tantalum	97	Thailand 35, Canada 13, Malaysia 10, Brazil 9
Titanium*	47	(Ilmenite) Australia 84, Canada 32 (Rutile) Australia 84 (Titanium Dioxide) West Germany 35 (Sponge Metal) Japan 72, USSR 21

\* "Achilles heel" minerals (see text)  
 \*\* Platinum, Palladium, Rhodium, Iridium, Osmium

Table 1.

Three critical mineral-supplying countries are found in Southern Africa: Zaire (formerly the Belgian Congo), Zimbabwe (formerly Southern Rhodesia), and the Republic of

South Africa. These dominant suppliers of certain essential materials appear potentially vulnerable to unrest, subversion, and, in the first two cases, Soviet client influence. Other source countries such as Australia are quite stable but nevertheless lie at the end of long supply routes. It is apparent that sources in Southern Africa and elsewhere could become increasingly insecure and supply lines extending from them increasingly fragile.

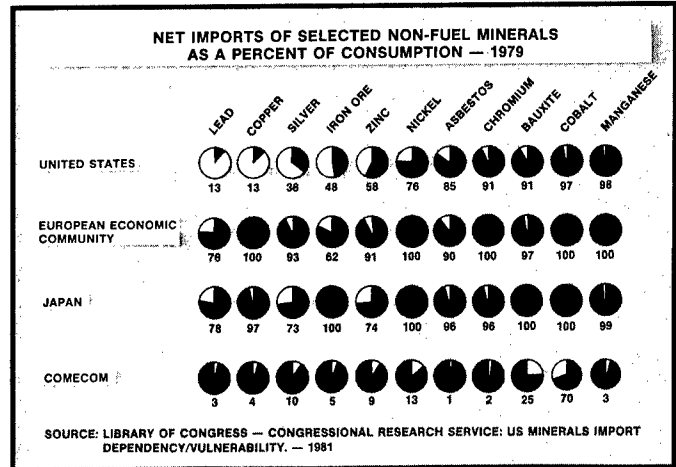


Figure 1.

### Sea/Air Lane Dependency

A third critical dependency of the US and its allies is in their use of world sea and air lanes. While sea and air lane access is *essential* in peacetime, it is *critical* in war. Every recent US conflict has seen us relying on extensive use of sea and air lanes for supply and deployment of armed forces.

Because of world geography, the routes that ships must take are dictated by a relatively small number of choke points: the Panama Canal, Cape Horn, the Strait of Gibraltar, the Cape of

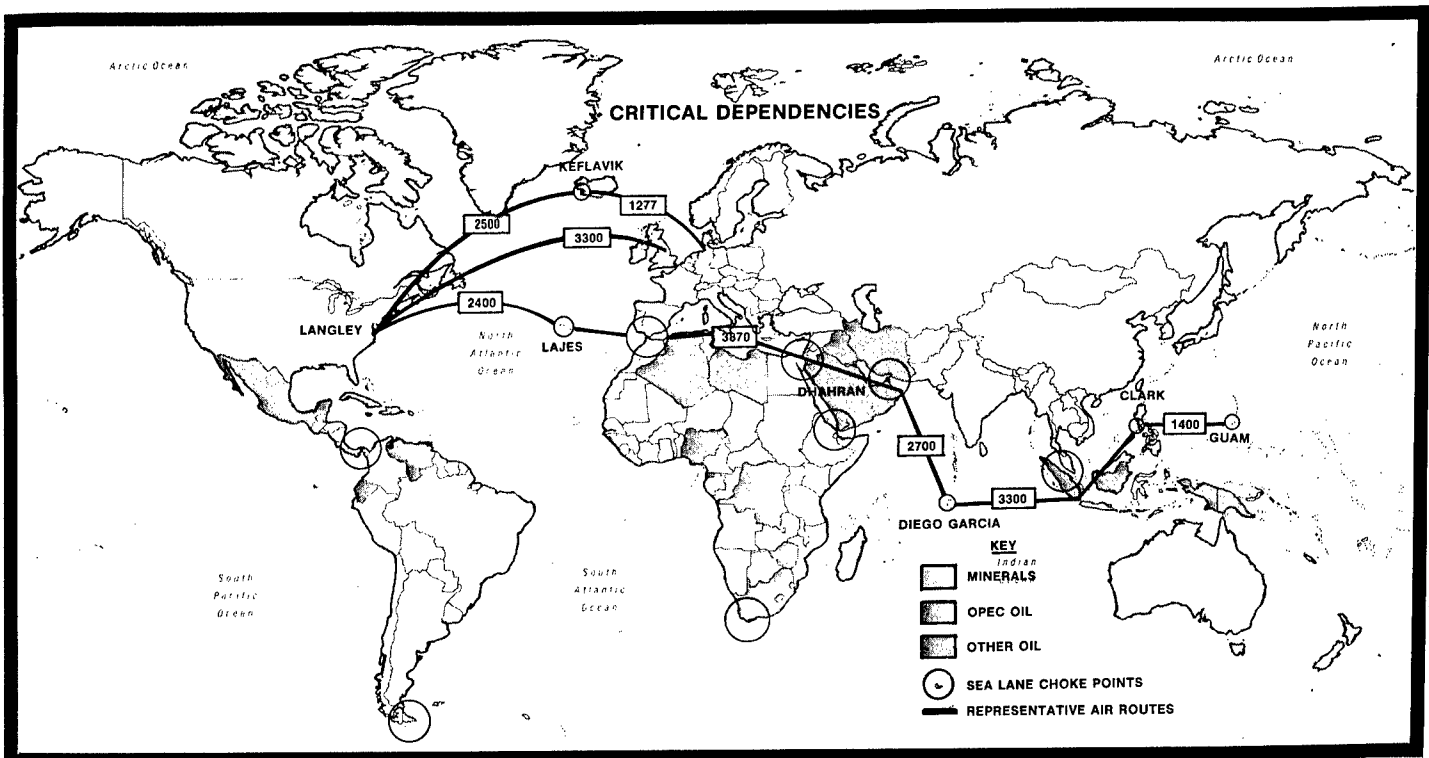


Figure 2.

Good Hope, the Suez Canal, the Gulf of Aden, the Strait of Hormuz, and the Strait of Malacca (Figure 2). A hostile power controlling one or more of these choke points could seriously impact our peacetime trade and, potentially, our wartime deployment capability.

Many air lanes are important to the US (Figure 2). Such air routes are obviously less restricted by geography than are sea routes; nevertheless, they are constrained by over-flight restrictions and the need for intermediate stopping points.

### Dependency Summary

Petroleum, mineral, and sea/air lane dependencies are highlighted in Figure 2. A picture emerges of global dependency with particular emphasis on several areas: the entire continent of Africa, Southwest Asia, Southeast Asia, and the area in the vicinity of Central America.

### Treaty Involvements

Much of Air Force's planning and requirements analysis appears to be driven by US NATO obligations; however, the US has a myriad of other treaty agreements on the books.

A compilation of US treaties and other international agreements, published by the Department of State, lists various US treaties and agreements currently in force and lists 98 countries as having various kinds of defense and military treaties involving the US.<sup>11</sup> Whether or not any particular treaty might be considered likely to draw the US into conflict (some are over 40 years old and some regional agreements included countries such as Cuba in their original form), the existence of such a multiplicity of agreements does suggest that among such a large number might be those which at some time could lead to the use of force.

A summary of major US military related treaty involvements is shown in Figure 3.<sup>12</sup> It is not our purpose to provide an authoritative assessment of the implications of

these treaties; however, the reader may gather two useful insights from this figure. First, while these treaties presumably strengthen the US position by providing various assets, such as basing rights, use of support facilities, and possibly direct military cooperation in case of conflict, they also require that the US possess a military capability to honor widespread obligations. It is apparent the military capability required to honor potential treaty needs would embody both global reach and the ability to adapt to a variety of possible future circumstances.

Second and, possibly of greater importance, there is a pronounced *lack* of major treaty arrangements covering critical areas of the globe discussed above—the continent of Africa and Southwest Asia. This suggests that, if US military operations were required in these areas, assets such as bases, support facilities, and military cooperation might not be available.

### Soviet Global Power Projection

Expressed Soviet intentions and current Soviet activities are the primary reasons for viewing dependencies and treaty involvements as global concerns. A sobering statement made by Joseph Stalin in 1921 introduced this paper. More recent Soviet leaders have obviously not forgotten the importance of those words to Soviet policy:

Over half a century later, Leonid Brezhnev offered to Somali President Siad Barre a surprisingly candid account of Soviet intentions. In 1973, Brezhnev stated that the Soviet aim was to gain control of the "two great treasure houses on which the West depends: the energy treasure house of the Persian Gulf and the mineral treasure house of Central and Southern Africa."<sup>13</sup>

With these statements in mind, it is interesting to consider current activities of the Soviet Union. There is a high level of Soviet activity on the continent of Africa, in Southwest and Southeast Asia, and in the vicinity of Central America. It is

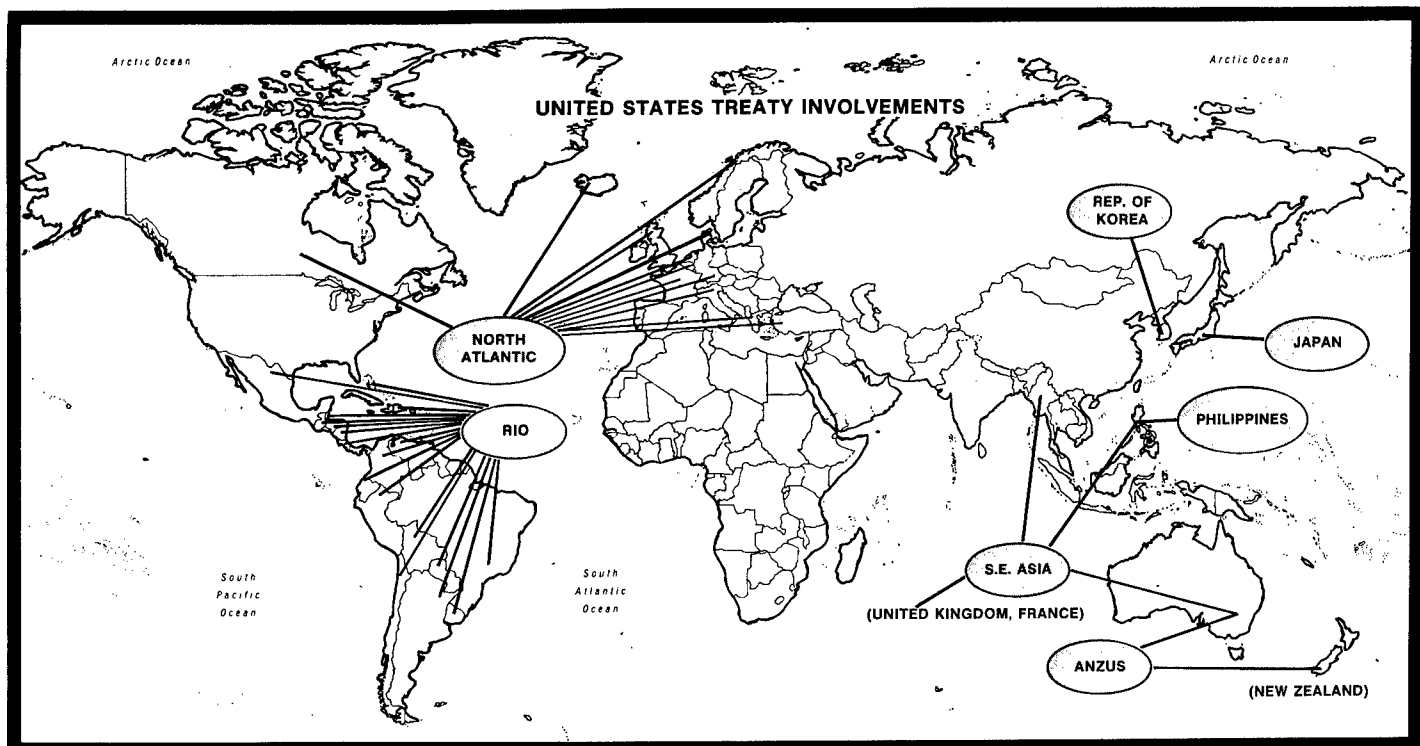


Figure 3.

apparent that these activities are consistent with stated Soviet intentions as quoted from Stalin and Brezhnev. There is a striking geographical correlation between areas of Soviet activities and areas on which the US and its allies are critically dependent for resources to keep their modern economies operating.

### **Basic Military Needs**

From this discussion of global concerns, it is possible to draw useful conclusions regarding the general characteristics US military capability must possess to be potentially relevant to the type of concerns that have been discussed. We will refer to a capability having the following attributes as a "global responsive capability."

### **Global Coverage**

The global span of dependencies and treaty involvements has been shown. In addition, there remains the threat of military conflict in Europe, in Southeast Asia, or with the Soviet Union. Accordingly, it is clear that the US must possess the capability to apply military force as needed anywhere in the world.

### **Responsiveness**

The global military capability must be responsive in two senses: First, it must be adaptable to the situation at hand, to a variety of climates and topographies, and to levels of conflict from counterinsurgency, through limited war, to all-out nuclear war. Also, forces must be able to operate without well-established treaty arrangements and without established local bases, support facilities, and local military cooperation.

Second, such a military capability should be capable of fast reaction. It is possible the conflict can be avoided altogether if sufficient and appropriate military force can be applied, or be available for application before the opponent can establish a position.

### **Air Force Deficiencies**

It is clear that no single branch of the armed forces, by itself, can provide this broad global responsive capability. However, because of its mobility and rapid responsiveness, the Air Force would be a key component in providing a global responsive capability. The following section broadly characterizes deficiencies of the current Air Force in filling this role and considers some limitations of the Air Force's planning approach.

### **Current Capabilities and Limitations**

In terms of the general locations of combat aircraft and their major support bases worldwide, it is readily apparent that the USAF is positioned for possible conflict with the Soviet Union in Europe and in East Asia. In general, the US relies on the rapid movement of forces between the CONUS, Europe, and East Asia as needed. However, perhaps more significantly, the current USAF approach relies entirely on the rapid *deployment* of combat aircraft, along with support facilities, for other theater operations.

Due to limited resources available for this project, no detailed evaluation was made with respect to the rapidity and effectiveness with which our current Air Force can be moved;

however, some general observations are possible:

(1) Tactical aircraft being moved must be ferried. For inter-theater distances, this is a complex operation requiring multiple refuelings.

(2) Current aircraft require hard surface runways and extensive support facilities, preferably within a few hundred miles of the combat area.

With these observations in mind, a key geographical limitation comes to mind immediately. US combat aircraft and major support bases are frequently far from potential trouble spots, and there are very significant areas where the US has no treaty relationships to draw on for local bases and support facilities. We found an absence of recently completed treaty relationships with current independent governments in Africa. Covering Africa from available current major support bases would require an operating radius of 3,000 to 4,000 nautical miles (NM).

As for planning future capabilities, whatever the intent may be, the apparent result of the planning process is that we generally attempt to overcome deficiencies through an essentially independent upgrading of each mission area. For example, for a deficiency identified in the airlift area, the baseline plan is to upgrade current C-5s and C-130s, produce more C-5s, and develop advanced airlifters. The same type approach seems to be true in the other mission areas.

Air Force planners work extremely hard to prepare logical, well thought-out plans with the constraints of mission areas prescribed by the planning process. We are suggesting, however, that because of the compartmenting of thinking into mission areas, the nature of the solutions to mission area deficiencies is largely preordained. Within each mission area, the planning process calls for more and better systems of the same general type. Since this process tends not to produce solutions that transcend the mission area boundaries, promising innovative possibilities may be overlooked.

Some shortcomings of current Air Force capability vis-a-vis the desired global responsive capability have been covered. In general, we find that US forces and major support bases are located far from potential trouble spots. While much detailed evaluation could yet be done, it seems reasonable to conclude that the current Air Force does not provide the needed global responsive capability. Furthermore, while the current planning process is logical within discrete mission areas, it tends to be compartmented and, consequently, may overlook promising possibilities for overcoming current deficiencies.

### **Conceptual Possibilities**

As promised in the introduction, we will now "step back from current planning" and ask: How might the Air Force provide a global responsive capability? This is clearly a broader question than asking how to improve the Air Force's airlift capability, aerial refueling capability, or other mission area capability. What follows are some "brainstorming" thoughts suggested by the foregoing question, provided to stimulate further thought, not as a final answer to the question.

### **Global Responsive Alternatives**

The following are four areas where new concepts might meet at least part of the need for a global responsive capability:

- **TRANSATMOSPHERIC SYSTEMS**
  - On-demand, quick turnaround, from flexible basing
- **LONG-RANGE/ENDURANCE AIRCRAFT SYSTEMS**
  - Global airborne capability from main bases
- **MINIMUM SUPPORT DEPLOYABLE AIRCRAFT SYSTEMS**
  - Rapid deployment to austere forward operating locations
- **INDIRECT SUPPORT CAPABILITIES**
  - Quick reaction influence without direct involvement

These global responsive alternatives represent different ways to project power on a global basis. Transatmospheric systems would be capable of operating in both space and atmosphere; they would offer the potential to reach any point on earth within perhaps two hours after launch. Long-range/endurance aircraft systems operate in the atmosphere and would be designed to reach any point on earth nonstop from established bases. Minimum support deployable aircraft systems would be designed specifically to be quickly deployable to forward operating locations; once there they would be readily supportable, effective combat aircraft. Indirect support capabilities would be tailored for use where the US wishes to influence the outcome of a conflict without directly involving US forces.

### Transatmospheric Systems

Concepts in this category could be derivatives of the space shuttle program. Key features that would need to be developed for a practical military capability would include reliability, reusability, launch-on-demand capability, rapid sortie-to-sortie turnaround, and a capability for conventional/flexible basing.<sup>14</sup>

An example of a weapon in this area would require a system that could take off horizontally, operate in low earth orbit (100 NM altitude) with a design requirement payload of 10,000 pounds (in polar orbit), and land unpowered.

### Long-Range/Endurance Aircraft Systems

The key feature of this alternative would be the capability for unstaged global coverage from existing bases. Figure 4 pictures a long endurance concept developed in connection

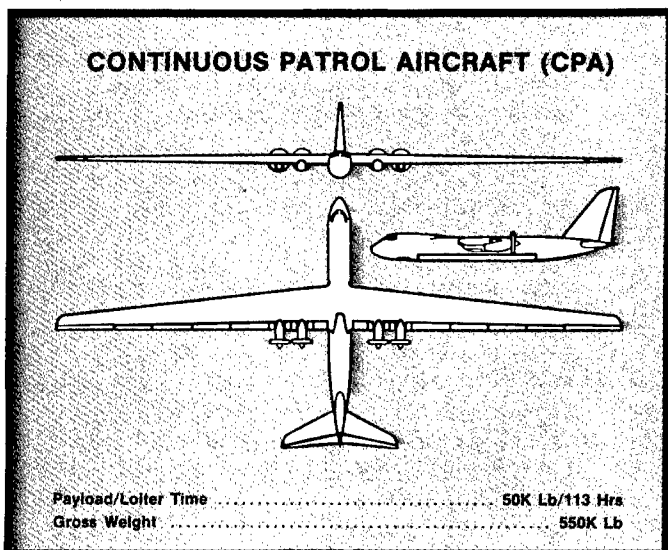


Figure 4.

with efforts to define an airborne basing mode for the Missile-X.<sup>15</sup> This aircraft could remain airborne continuously for 113 hours without refueling, with a 50,000-pound payload, at a 20,000-foot altitude and a 200-knot airspeed.

### Minimum Support Deployable Aircraft Systems

This concept would feature rapid deployability, capability for immediate operation on arrival, ability to operate from austere forward operating locations, and ready supportability.

An example of this alternative is pictured in Figure 5.<sup>16</sup> This is a small aircraft featuring folding wings, modular weaponry, and modular avionics. It would be deployable on transport aircraft (2-4 on a C-130E or 15-30 on a C-5A).

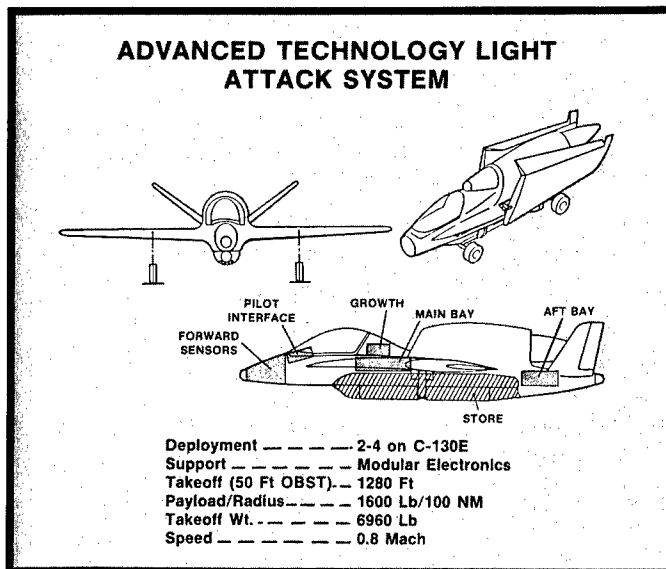


Figure 5.

### Indirect Support Capabilities

Key features to be developed under this alternative would include: the ability to support indigenous air forces which might be equipped with a mixture of equipment, some of which might be of other than US manufacture, and a capability to react quickly anywhere in the world.

Examples for this alternative would include add-on subsystems, parts, munitions, intelligence, supplies, and training. To illustrate, many add-on systems could be conceived to enhance the capability of various indigenous aircraft in the world's air forces. One might be the General Electric 30-mm Gun Pod pictured in Figure 6. TO 21 ▶

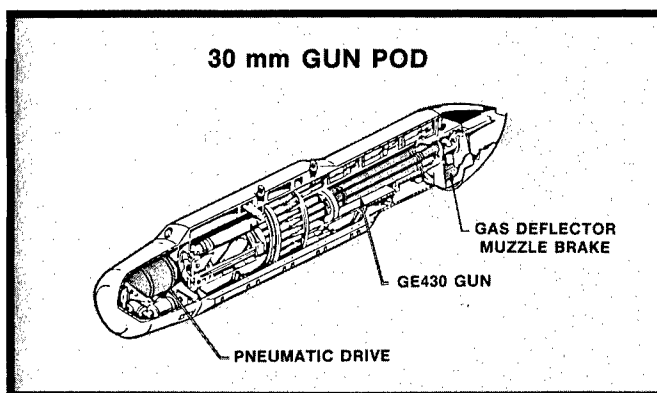


Figure 6.

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## New Technologies—Their Impact on Air Force Depot Repair

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### Abstract

Recent technological advances have changed or altered the nature of the Air Force depot repair work load and have required corresponding changes in repair processes. This paper reviews key technological advances and discusses how they will shape the nature of this work load in the future.

### Introduction

The mission of the Air Force Logistics Command (AFLC) is to provide goods and services to support the weapon systems of the United States Air Force (USAF), along with the systems of many allied nations. As weapon systems respond due to changing threats and new capabilities made possible by advancing technologies, so must the logistics aspects of supporting those systems change.

AFLC's former Commander, General James P. Mullins, has confronted the promises and problems that emerging technologies present to the business of providing the logistics support necessary to maintain our combat capability. According to General Mullins, "From the logistics perspective, the interesting thing about new technology is that it tends to feed on itself, generating greater support requirements which, in turn, demand even greater use of technology. State-of-the-art weapon systems today need state-of-the-art logistics support—and a lot of it."

Determining precisely what that state-of-the-art logistics support will be in the near future is not always possible, but there is value in estimating the major changes in AFLC's logistics support work load that will likely occur in the next few years.

For the long term, AFLC and its counterpart development command, the Air Force Systems Command (AFSC), are working to develop an Air Force that requires virtually no logistics support. Therefore, increasing the reliability and durability of future weapon systems is a major thrust of that effort. For the present, however, AFLC must continue to provide the logistics support that is essential for the combat readiness and sustainability of a mixed bag of weapon systems—from state-of-the-art systems built with reliability and maintainability in mind (like the advanced tactical fighter) to aging weapon systems that rely on hard-to-find parts and require extensive servicing.

This article investigates some of the technologies that will affect the future of AFLC's depot repair work load. While some technologies have made the biggest initial impact in the design stage of weapon systems, most, however, show a significant impact on and a need for early consideration in the logistics support process itself.

### Technologies

#### Microelectronics

Microelectronic devices have proliferated at an exponential rate since the introduction of the first microprocessor in 1971. Their application and utility continue to expand.

Miniaturization, epitomized by the DOD very high speed integrated circuit (VHSIC) effort, is the breakthrough which will lead to improved system performance, reliability, and simplified maintenance through fault detection and self-healing circuitry. However, unless the cost is low enough for remove/replace/discard options, the advent of VHSIC devices represents performance increases of several orders of magnitude over the chips of the early 1970s.

To provide some comparison, the world's first electronic digital computer, the ENIAC, weighed 30 tons and operated on the power of over 100 lighthouses at a speed of 5,000 operations per second. The VHSIC chip weighs several ounces, requires the power of a single nightlight, and operates at a speed of 25 million operations per second (or one calculation every four nanoseconds).

It is projected that, in the very near future, silicon chips will hold a million transistors. By the early 1990s, each chip may well contain 10 million devices. These devices will most likely perform a *billion calculations per second*. Advances in the architecture of computers will lead to even greater increases in capability. Perhaps changes in architecture alone will lead to power increases of one million by the 1990s. These advances truly represent a revolution in microelectronics.

The proliferation of disposable and readily reprogrammable microelectronic devices will change the nature of AFLC's repair work load in many areas, including avionics, automatic test equipment, and jet engine repair. It could also dramatically change the nature of stockage, storage, and distribution operations.

Both on the flight line and at the depot, interactive audiovisual technical orders, computerized and displayed via miniature eyepieces and headphones that advance on voice commands, will interact with the mechanic and only advance at the operator's capacity for knowledge and comprehension. The application of microelectronics to technical orders should result in significant decreases in troubleshooting and repair times and increase the effectiveness of repair. Miniaturization is also making possible the inclusion of ever more sophisticated data collection devices on board the aircraft that will provide performance and fault analysis information for use at the depot.

This trend promises to make the implementation of a two-level maintenance concept for future Air Force aircraft feasible. Elimination of intermediate level maintenance could

significantly increase mobility for combat units. Today's aircraft require staggering amounts of avionics support equipment in the field and highly skilled technicians to test and repair or replace malfunctioning avionics systems. Aircraft of the future are expected to be designed to require significantly less logistics support in the field.

The Air Force logistics centers will continue to shift away from traditional repair work loads to the specialized requirements of microelectronics, especially in avionics. Repair work load will decrease, due not only to increased reliability but also to reduced troubleshooting time made possible by improved diagnostic capability. Self-testing circuits may divert their functions from faulty circuits to functional circuits and thereby allow in-flight failures to be transparent to the operator but fully documented for the maintenance crew when the craft is safely back at the base. Built-in test and fault diagnostics should reduce the maintenance skills required for routine repairs. However, should the built-in test system fail, suffer battle damage, or require reprogramming due to the changing threat, highly skilled personnel will be essential. Therefore, total reliance on a "remove and replace only" maintenance concept would be shortsighted and probably would not work in a wartime environment.

However, the new microelectronics technology is not all a bed of roses; there are some drawbacks. Despite the fact that on-chip testing will alleviate much of the current burden of manual test and does hold the promise of eliminating the intermediate test phase altogether, the development and implementation of diagnostic procedures and test requirements for the depot will be more complex. If it becomes necessary to do depot repair, technical skills and the equipment required could also be complex.

Additionally, microelectronics introduces problems associated with packaging, handling, and repair. The devices themselves are subject to environmental damage from heat, humidity, and static discharge. They are also difficult to manage from a configuration standpoint.

## Software

Miniaturization, together with increased software capacity, is leading to a tremendous growth in the use of embedded computers. Indicative of this trend in the DOD is a projection by the Electronics Industries Association, which shows a 28-

fold increase alone during this decade (Figure 1). The Air Force's share of those 280,000 embedded computers in 1990 is conservatively estimated to be 80,000.

AFLC's ability to effectively support the proliferation of computers in aircraft, communications devices, and weapons will be put to the test in the 1990s. Major challenges will include recruiting and retaining engineers, forecasting AFLC's support requirements for this burgeoning growth in embedded computers, and developing integrated software support capabilities at the logistics centers.

Although AFLC is normally responsible for maintaining weapon systems that have been developed and produced under the direction of the AFSC, a significant portion of AFLC's support of embedded computers is heavily developmental and over the long term involves the introduction of new system capabilities and performance improvements. Embedded computer software support tasks include problem solving, software and firmware engineering, software redesign, hardware engineering, system testing and integration, and verification and validation. Configuration control of software will also be an important task and a challenge that will require special attention and the development of new management techniques. All these considerations apply to system software, applications software, and support software, and will have an impact on maintenance management and control requirements.

While the reliability of individual components of embedded computer systems is increasing, the overall complexity of the total system is also growing. As the complexity of the total system increases, so does the potential for failure due to faulty connections or other situations that result in suboptimization. An important concern for AFLC is the need to replicate the weapon system and all its peculiar subsystem interfaces in a laboratory environment. This will require sophisticated avionics integration support facilities and skilled engineers/technicians for repair.

The availability of advanced software development tools is extremely important to AFLC. At present, the kind of developmental programming that represents a large portion of embedded computer software work load relies heavily on the skills of human engineers and programmers. Ongoing efforts to develop more and better computer-based programming tools and the use of higher order languages and standard software architecture could result in big payoffs in reduced personnel requirements for embedded computer software support.

In the meantime, AFLC faces a tremendous challenge in recruiting and retaining people with the skills required to accomplish the growing software support work load. The management and technical support of embedded computer systems, and particularly the change process for software, is an engineering intensive activity. Both current and projected national demands for software professionals far outstrip the supply. A Scientific Advisory Board Study noted that, even today, AFLC is sparsely manned and undergraded to perform its software support tasks. Grade level controls for civilian workers have made it difficult for AFLC to retain engineers in the work force.

Before leaving the area of microelectronics and computers, it is worth noting that computers not only make weapon systems more capable, but they make possible great strides in the potential of logistics management information systems. The AFLC has a massive program underway to upgrade information systems and the supporting data processing and telecommunications system.

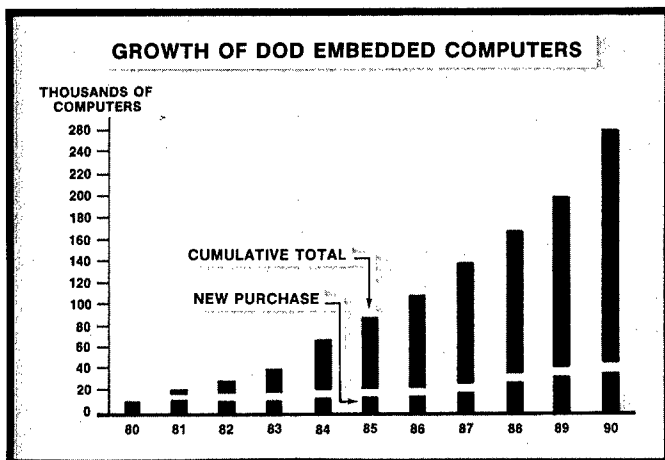


Figure 1.

## Composites

The advanced composites (epoxy matrix, selectively reinforced with nonmetallic fibers such as graphite, boron, or kevlar) and the even newer metal matrix components are prime candidates for use in aerospace structural applications where substantial weight needs to be saved. Advanced composites also offer advantages of increased strength per unit weight, fatigue and corrosion resistance, and aeroelastic tailoring—using the directional properties of composites (similar to bias belted tires) to control bending and twisting under aerodynamic stress. Since corrosion and fatigue cracks emanating from fastener holes are presently high cost problem areas in metallic structures, the Air Force is counting on the lack of both corrosion and fatigue cracking in composites to significantly reduce maintenance costs. By the year 2000, molecular composites may provide ten times the strength of aircraft of the 1950s and 1960s and temperature tolerances above 2000 degrees Fahrenheit.

These advantages have naturally led to an expansion of the use of composites in the aircraft industry. For instance, the B-1B composite applications, which are limited to secondary structures such as doors and fairings, are nevertheless significant. Although the B-1B weapons bay doors are a secondary structure, they are complex substantial structures and represent a good portion of the bottom of the aircraft. The C-17A, currently being developed, includes composites in control surfaces as well as the secondary structures. Procurement of the F-16XL will involve the application of composites in the wing skin primary structures, which is similar to the Navy's F-18. The advanced tactical fighter could expand composite utilization to as much as 60% of the structural weight and involve both the fuselage and the wing substructure.

A concentrated effort is required to make sure composite structures are supportable. Despite the many advantages of composites, certain of their characteristics can adversely affect aircraft structure. These characteristics include increased moisture absorption and a greater susceptibility to low velocity impact damage. Non-visible low velocity impact damage may also complicate the inspection and maintenance procedures required.

Normal maintenance activity therefore needs to be accommodated in design. Edge damage, impact dents, and punctures are the most common types of damage during maintenance. These can often require removal of the part followed by lengthy repair times in the shop.

The hot bonding currently required for the F-15 and F-16 honeycomb skin requires a long cure time for the adhesives. These bonded repairs also require complete removal of moisture from both the composite laminate and the honeycomb core cells, as the laminate structure can be damaged if moisture is not removed prior to bonded repair. Current repair practices need to account for laminate moisture. The solution to this problem may yet lie in the research and development (R&D) area of non-autoclave curing.

Finally, battle damage repair needs more consideration at the design phase of composite structures. Repair under combat conditions would be a challenge. Adhesives need to be developed which are quick curing and do not require refrigeration or heat applications. Development work is being done in this area. AFLC is well aware of the need to investigate those repair problems created through the increased

use of composites in Air Force weapon systems. The Sacramento Air Logistics Center has been established as a program management office and maintenance demonstration center for advanced composite repair techniques. Once developed, the techniques will eventually be transferred to the other four air logistics centers.

## Propulsion Technology

New designs should produce more reliable and maintainable engines. Advanced engines will be less complex with fewer rotating parts and simpler structures. In addition, manufacturers are being required to test new engines more extensively to include those portions of the flight envelope and operating scenario that put the most stress on an engine. The result is that new engines should be fielded with a higher degree of maturity and operational confidence. Useful life of engines in the field will lengthen, and the requirement for depot pipeline spares will decrease.

The engine maintenance concept is now shifting from the emphasis on whole-up engine repair to the repair of individual modules. This emphasis should make it easier to maintain engines in the field. Field units can quickly repair engines through module replacement, returning their modules rather than whole engines to the depot for repair. Modularity will also make cannibalization easier. Although cannibalization is not a repair procedure the Air Force likes to see used in peacetime, it usually is a crucial support concept in war.

The focus on repair of modules, rather than whole engines, will also change some aspects of the depot repair process. Repair procedures must be developed to ensure a high level of confidence for module repair and testing, since the depot generally has to test these modules without the benefit of integration into a whole engine. New testing and repair capabilities are being developed by AFLC in response to increasingly critical specifications for materials, close tolerances in design, and the tendency to operate engines close to their design limits. Engine repair centers are using ultrasonic and eddy current techniques for nondestructive disc inspection. Laser measurement techniques, coupled with computer analysis, are providing rotor stacking processes that dramatically improve concentric alignment and reduce vibration at high speeds. Eventually, integrated inspection and repair centers, based on the linkage of separate automated modules, could be incorporated into the engine depots.

Historically, engine control systems have been hydromechanical, employing mechanical cams, linkages, bellows, and hydraulic servos. Future engine controls will employ digital electronics and incorporate built-in test and serial digital data links. Eventually, diagnostic systems will take advantage of this change by fully integrating into the control system, substantially reducing the requirement for add-on sensors and information processors. Improved diagnostic capabilities should lead to substantial improvements in maintainability. However, these advances will also result in an increased need for skilled people at the depots to maintain engine control software and interpret the results of diagnostic systems. Advances in propulsion technology will create new demands on repair depots; however, anticipated increases in reliability and maintainability will not be realized unless the repair capabilities of the centers are aggressively expanded.

## Optoelectronics

Optoelectronics, the use of optical signal processors and fiber optic signal carriers, has been identified by the Defense Science Board as one of the technologies which will have a massive impact on our future capability. For instance, electromagnetic interference can be induced in copper or other metallic wires when they are exposed to electromagnetic field disturbances such as lightning or operating electric motors, etc., but the same effect cannot be readily induced in fiber optic cables. This resistance also makes fiber optic cables more immune to the effects of electromagnetic pulse (EMP) than metallic wires. Electromagnetic pulse made famous in nuclear war films is similar to lightning except that it occurs in a much shorter time interval and can defeat normal shunting circuits. Fiber optics may therefore offer a form of nuclear hardening.

Fiber optic cables do not emit stray electromagnetic fields and, as a consequence, do not "leak" signals to adjoining wires or fiber optic cables. Fiber optics therefore provides a measure of electronic security. Another problem associated with conventional wiring, but absent in fiber optic applications, is signal distortion due to the ground loop; i.e., the interference and noise generated in the common ground of adjacent electrical systems.

A fiber optical wire can carry far more information than a metallic one. In today's avionics architecture, one fiber optic cable may replace several metallic ones. Since a fiber optic cable is lighter than metal (one-fifteenth the weight in some applications), the aircraft weight savings may indeed be significant. Some of the weight savings are offset, however, by the need to use printed circuit boards to convert the electronic signals to light and back again. The reduced volume of fiber optic cables may allow for additional equipment to be installed.

Other advantages include the potential cost savings and the great abundance of the raw material from which fiber optics are made. In addition, fiber optic cables are far less susceptible to degradation due to moisture, corrosion, and oxidation than metallic wires, and they are safer in explosive environments since they do not produce a spark.

Just like microelectronics technology, fiber optics has drawbacks. Fiber optic connectors must be precision designed for proper alignment to prevent loss of signal, and even minute shifts which may occur as the result of normal vibration and in-flight stress may cause misalignment. In addition, splicing fiber optic cables (either by arc welding or by epoxying) is not a simple process and requires considerable skill. Because the use of fiber optic cables is expected to increase, Sacramento Air Logistics Center is leading the effort to better define what kind of skills, equipment, and facilities will be involved in fiber optic logistics support.

## Lasers

Lasers will become more common as their applicability spreads from "smart munitions" to other areas. Much of aircraft electrical circuitry may be replaced by smaller, lighter optoelectronic systems employing low power injection laser diodes. In fact the Aerospace Guidance and Metrology Center at Newark, Ohio, has been using lasers for over ten years for such operations as balancing the gyros used in inertial navigation systems, a repair ideal for lasers. The laser serves

as a low-reaction force drill to cleanly remove small amounts of material without harming the delicate assembly. The precision with which the beam can be aimed results in perfect balance of the wheel. The center also uses lasers to calibrate precision measuring equipment to set standards. High energy lasers are finding increased usage in industrial applications. Lasers perform such operations as cutting, welding, drilling, heat treating, surface cladding, alloying, and other machining processes. AFLC is assessing the use of these and other applications for the depot maintenance environment.

## Nondestructive Testing

Testing of both materials and finished products has always been a major part of any quality control program. The tests can range from visual inspection for conformance to standards to sophisticated probing for minor flaws hidden below the surface. In the past, tests were used that stressed a part until it broke; however, the trend today is the increasing use of nondestructive testing (NDT).

Nondestructive testing is already an important part of the Air Force's depot repair process. The criticality of NDT capability should grow due to the increased use of new materials in which small flaws can have unpredictable and possibly grave consequences and the continuing desire to operate weapons systems at, or near, their limits of physical tolerance.

Fortunately, advances in NDT technology are leading to techniques which are more effective at differentiating between serious and harmless flaws. Nondestructive testing processes are incorporating greater use of automated testing and computerized signal data processing. This will help avoid errors when test results are interpreted, lower the skill requirements for human inspectors, and speed up the testing process. Six major techniques are used for NDT: radiography, ultrasonic testing, eddy currents, acoustic emission, liquid penetrant, and magnetic flux. Advances have been made in each area and we will look at some of those as follows:

*Radiography* has been used for many years and is probably the most commonly used NDT method. The use of different types of rays (like gamma or neutron) and new digital enhancement techniques are increasing the sensitivity of this testing. Better radiographic "pictures" are now being produced through computer enhancement of radiography results. Sharp "real time" images on computer TV screens have replaced the old still X-rays on photographic film. These advances have been a boon to the testing of rocket motors and jet engines.

Computer tomography is increasing the information provided through radiography. In this technique, a computer constructs a two-dimensional cross-sectional representation of an object based on X-rays taken from various angles. Computer tomography images contain more than 100 times the information available in two-dimensional radiographic images. Problems in getting good image resolution from computer tomography are now being solved, making it probable that this process will be commonly used in the near future. AFLC is now working on a computer tomography system to detect adhesion and porosity flaws in solid rocket motor components.

*Ultrasonic testing* detects below-the-surface flaws based on the reflection of high-frequency sound waves that are beamed into a material. In the past, numerical readouts of flaw

dimensions produced by ultrasonics were interpreted by skilled technicians. Computer enhanced techniques can produce images of flaws that are easier to interpret. Laser-based ultrasonics can reveal flaws down to the submicron level, using an acoustic microscope to produce electrically magnified images of the flaws. Acoustic holography techniques that employ sound as well as laser beams to produce multi-dimensional images of flaws are being "debugged" and may soon be commonly used.

*Acoustic emission* testing has been successful in detecting flaws as they develop by monitoring high-frequency sounds emitted as material cracks. This testing is useful in detecting cracking and predicting failure of ceramics, composites, and metal welds. For example, Lockheed is developing a flying flaw detector for use on aircraft wings to predict and prevent catastrophic wing failures.

Continuing advances in NDT should have payoffs in both the production and repair of Air Force weapon systems. Quality control processes can, in many cases, be automated, with computers comparing the results of NDT with those of established standards. This capability will be useful in the depot environment, where many inspection and evaluation processes are labor intensive. The repair of sophisticated electronics, new man-made materials, and weapon systems that must perform in demanding environments will require increasingly sophisticated testing.

### Robotics

Today, industrial robots comprise only a small percentage of the new uses of the microprocessor. In its simplest form, the robot is a mechanical device that can be programmed to move under automatic control. Normally, in industrial settings, robots are programmed to perform the same task over and over. Fruitful applications include welding, painting, and a wide variety of materials handling tasks.

Despite many potential applications, robots have not yet made a very large impact on industrial processing in the United States. Many industrial tasks are unstructured and require the ability to see, feel, and adjust quickly to changing circumstances. These capabilities are largely beyond those of today's robots. Although there is much to be done, particularly in the area of software development, before robots will be able to "think" and "see," robots will eventually be adaptable to a wide variety of tasks.

However, the automated factories envisioned by Toffler in *The Third Wave* will not be upon us in the next couple of decades without a national reordering of priorities and a massive investment in robotic technology. Today, in the United States, there are only about 5,000 industrial robots in use. It is estimated there will be 35,000 installed robots in America by 1990. Integrating robot technology into the industrial base will be a massive effort. Effective use of robots will require a complete redesign of the nature of industrial tasks, as well as redesign of factories to accommodate different work flows.

The Air Force Wright Aeronautical Laboratory is developing the technology to build robotic subsystems (sensors, microprocessors, mechanical design, language development, learning, real-time controls, etc.). The next step will be to demonstrate the technological feasibility of integrating the subsystems and to conduct a demonstration to prove the applicability of robotics to defense manufacturing and depot maintenance. The San Antonio Air Logistics Center

is the demonstration site for an automated process for plasma spray of engine parts. The process integrates computer, robotics, and a parts-handling system and is expected to increase productivity as well as remove personnel from an undesirable environment.

### Conclusion

The technological advances that are leading to the development of weapon systems with incredible capability are also creating a whole new dimension of logistics support challenges. Fortunately, technology also offers the means of dealing with these challenges. AFLC is a microcosm of the nation's industrial base, which is being profoundly affected by today's technologies. Many segments of the industrial base are moving away from the mass production methods that typified the "old" industrial age and toward the rapid customized production made possible by harnessing new technologies.

Driven by the unique needs of the Air Force combat commands, AFLC has been in the business of "customized" logistics support for a long time. New technologies can make that support tremendously more efficient.

When considering future depot maintenance work load, one also has to bear in mind the tendency of the Air Force to continue to operate weapon systems long after their original planned disposal dates. The Air Force is faced today with a shrinking pool of contractors willing or able to provide spares for out-of-production systems. This means that Air Force depots may be required to produce more and more of the parts needed to keep older systems flying. "Remanufacturing" of critical long lead time parts can be faster and more efficient through the use of automated manufacturing systems at the depots.

For the AFLC, the future may bring about not so much a change in the nature of the mission being performed, but a tremendous increase in the capability to accomplish that mission. The technological revolution will allow an efficient and rapid response to an array of diverse logistics needs. The key will be to creatively consider how to develop new methods of support that fully exploit rapidly changing possibilities created as the third wave breaks across the horizon.

The key considerations in the process of planning for the shape of future depots will be flexibility to meet unique and changing requirements, capacity to rapidly surge repair and production techniques to meet rapid increases in demand during war or contingencies, and efficiency in providing logistics support.

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## Terricolous Future

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... Long before people chopped down trees with stone axes or made tents of animal skins they took shelter in caves. ...

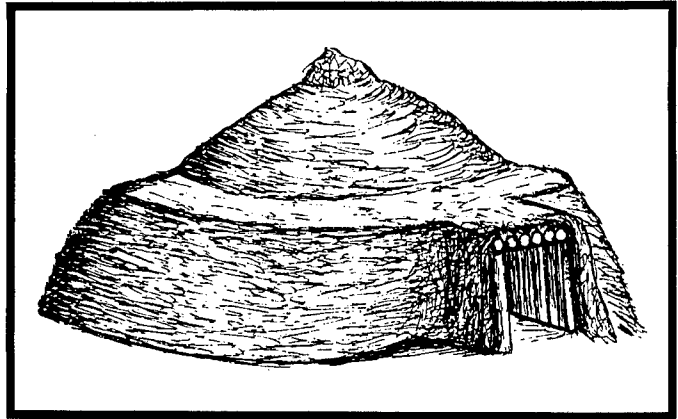
Prehistoric earth dwellings have been located in large numbers throughout Nebraska and the Dakotas. The American Indians, who inhabited the Great Plains, lived in well-constructed earthen lodges before white men ever crossed the Mississippi River. Many of our mammalian biological relatives rely on underground niches to survive. They are described as terricolous.

Terricolous comes to us from Latin, *terricola*, and means land dweller. *Terriculture* refers to futuristic subterranean living, but is a word that has not yet been added to most English dictionaries. Underground living, subsurface Earth—these are phrases that we will hear more about in the future.

Bring up the subject of living underground in contemporary circles of conversation, and you will—more than likely—be contested with either brutish, atavistic, troglodytic survival ridicule, or the widespread popular attitude that it is not a viable *enviromical*\* or nuclear survival alternative. “To live underground is not aesthetic, too expensive, of no value in a direct hit actuality, and so on.”

One purpose of this paper is to point out that Sweden, Switzerland, the Chinese Republic, the USSR, and many other countries other than our own have *already* established many in-roads into this mode of living. For instance, Sweden can protect at least 80% of its small population in nuclear shelters for a short period of time. In a practical sense, however, it may be misleading to suggest that underground buildings should be constructed exclusively for shelters. Progressive engineers and architects should consider them as practical structures for year-around use and also design them capable of providing further shelter options in times of emergency. One need not go far to find successful examples. Opal miners in Australia, although motivated by pursuit of gems, do tunnel elaborate homes into sandstone and then complete them with swimming pools and other luxuries.

To stimulate our thinking in a small way, I would like to develop a reasonable outline of the advantages of terricultural living and suggest a positive attitude toward this futuristic form of habitation.



Indian Earth Lodge Found Throughout US Midwest (1700–1885).

Military construction and logistics have led the world in engineering development and establishment of most *existing* underground facilities. While many military and civilian people are not “in” on high-level decisions to produce massive, expensive construction projects, a positive attitude about working and living underground, for at least part of the day, is definitely in need of development. We need to think about living and working underground because this home style will surely accelerate in necessity as the twenty-first century develops. Over 6,000 Americans have *already* moved into some type of underground home.

Also, when individuals and families declare support of development of underground facilities—and even put free enterprise consumer pressure on contractors to build livable homes that are *at least* partially subterranean—it will strengthen our national security. This idea for a tougher (or less vulnerable) America is only part of a futuristic thesis, but there are many who agree with the writer.

The following is an outline of advantages for the future that may well be derived from living underground (to include homes and government buildings that are at least partially subterranean). Underground living:

(1) Conserves farmland, trees, and wildlife areas for *ecological* purposes (economy and environment working together).

(2) Conserves energy, stimulates the economy (new construction), and helps to preserve the environment. It is thus *enviromical*. Conserving energy also facilitates conservation of a natural atmospheric composition. This helps to prevent world climatic changes and decreases the threat of acidic rain water.

(3) Provides a place for emergency residence in the event of a nuclear attack or accident (to include a fallout shelter for survivors of blast and thermal effects).

(4) Provides an instant shelter for unusually severe weather conditions; i.e., tornados, hurricanes, earthquakes, high winds, etc.

**“Military construction and logistics have led the world in engineering development and establishment of most existing underground facilities.”**

\*Enviromics: Theoretical future science to establish a positive free enterprise technology and environment.

(5) Is expensive but permanent. The additional costs of earth moving are, at least partially, balanced by the reduced costs of exterior surface area finishing.

(6) Provides the way, as construction site land surface area decreases, to deal with high slope lots and previously rejected building sites. When a southern solar exposure is possible, hillside locations can provide for weather resistant, efficient homes and working places.

(7) Expands otherwise crowded development. In metropolitan areas (Kansas City already has a large complex), underground conference halls, warehouses, and shops can provide instant shelters for many otherwise helpless people in the event of a national nuclear emergency.

(8) Saves energy which would reduce the dependency on imported oil; conserve natural gas; and provide for time to transition into solar, geothermal, and hydrogen alternatives with minimal growing pains.

(9) Enables use of existing earth-moving equipment and diesel fuels and provides work for unemployed people while the costs are still relatively economical.

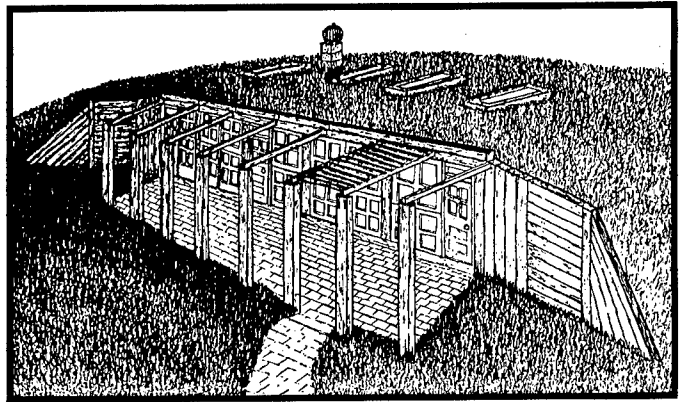
(10) Provides experience and knowledge for the construction of future colonies beneath the extremely hostile environments of other planets. (On Earth it has already been learned that survival on the polar icecaps is facilitated by constructing subterranean structures to escape the winds and cold temperatures.) In more temperate climates, underground structures, mine shafts, and caves could be developed for logistics management and storage functions.

*"... one of the most exotic and advanced military underground facilities in the world presently lies within and beneath Cheyenne Mountain in Colorado."*

Those of us in the military are aware that one of the most exotic and advanced military underground facilities in the world presently lies within and beneath Cheyenne Mountain in Colorado. The caverns, tunnels, and rooms of NORAD (North American Aerospace Defense Command Facility) were carved out of rock and reinforced with steel and shotcrete. Its air supply is from external vents and from recycled air pumped through sophisticated filtering systems.

Over a million pounds of explosives were used to blast out more than 693,000 tons of granite to create a virtual underground city that comprises NORAD's worldwide air and space attack warning systems. More than 85 computers and millions of miles of communications lines are operated by some 1400 military and civilian personnel from the United States and Canada.

On a smaller scale, but equally interesting, is the award-winning Terraset elementary school in Reston, Virginia. It was built at the time of one of America's first energy crises in 1973, because the people in Fairfax County, Virginia, planned a revolutionary new school that would conserve energy in the face of rapidly escalating fuel prices. Today, Terraset is a hill with a school inside it! By excavation contractors dug out the top of a hill, constructed a 10-inch thick reinforced concrete shell building, and then replaced tons of dirt for insulation. Bituthene coating seals the walls against water leakage and mildew. With the help of a funding grant from a Saudi Arabian university, a solar heating and cooling system for Terraset was



Basic Earth-Sheltered House.

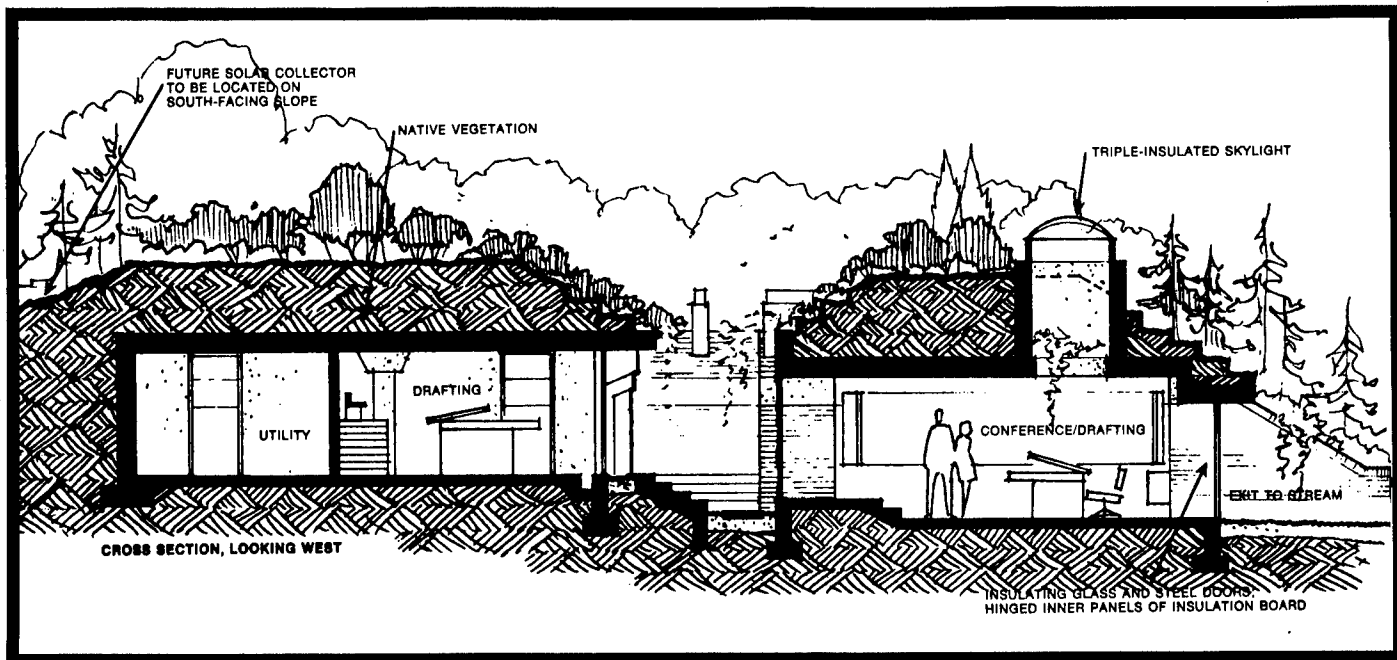
researched and developed. Solar panels collect energy and heat is distributed through about 5,000 square feet of tubing. An evaporator and lithium bromide spray system also provide for cooling in the hot months of the year. The systems recycle heat from people, lights, and equipment, and maintain a pleasant school environment.

With an electrical backup system for unusual weather, the Terraset complex uses about 30% to 50% less electrical energy than that normally required by a conventional aboveground, non-solar facility. A computer directs maximum use of free energy before turning to auxiliary sources. Dirt protects those inside from external extremes of heat and cold in two ways. Soil makes good insulation, and it has a high thermal mass.

Terraset also makes use of other design features to provide a pleasant environment. Roof overhangs outside the large window areas protect the windows from direct sun rays in the summer. A minimum of 5 feet of overhang helps the classrooms stay cool when it is hot outside. These same overhangs admit the sun's rays in the winter when the sun is lower in the sky and the warmth is welcome. Forty-two percent of the school's perimeter is exposed window area. This permits much natural lighting and keeps the children in contact with the outside environment. From most places within the center of Terraset, the out-of-doors is visible in three or more directions. A 100 square foot skylight directly over the library adds to the school's natural light sources. Its elevated location above the surrounding roof helps create an open, airy atmosphere.

When Terraset opened in February 1977, the use of earth sheltering and solar energy in a large, commercial building was very rare. Predictions were made about the amount of energy to be saved by each of Terraset's features, but little previous data were available to back up the assumptions. Since 1977, Terraset has been a technically rich source of feedback to designers and innovators in the field of alternate energy use. Findings, both positive and negative, are helping to shape the next generation of energy efficient buildings.

In Kansas City, Missouri, part of the extensive limestone mine workings under urban areas has been turned into accommodation for light industrial activities. The Kansas City project has proven ideal for the most extensive general-purpose underground development of the world. Based on extended old mine workings, this underground space contains a wide variety of functions. These include a warehouse and storage complex, conference hall, tennis courts, and grocery storage facilities. Well-insulated from any changes in temperature, underground spaces are particularly suited to storage of food and other perishable goods because very little



Underground Office at Cherry Hill, New Jersey.

energy is required to keep them cool. This fact is of special value to logistic architectural planners of the future.

resources available to improve and develop it. The free enterprise system should lead the way.

### Epilogue

Most people that are remembered from history had a vision and concern about the present and what it may mean for the future. Today, the future that is planned, with appreciation for conservation of Earth's resources and environment, becomes more critical as a function of time. And those people who do that planning will be remembered for their visions.

Underground construction is expensive but so is all new work. However, right now, there are still energy and labor

*"The world's next dimension may well be underground. . . ."*

The world's next dimension may well be underground by necessity for survival, and it may support the conservation of resources and environment in conjunction along with near space development and the projection of humans into the solar system. The bottom line is, I predict, to define an abstract of efficiency between both lower and higher. **ATL**

### Item of Interest

#### USAF States Policy for Asset Repair

In a 29 October letter, Brigadier General Richard L. Stoner, Director, Maintenance and Supply, HQ USAF, directed the MAJCOMs to implement the following policy:

- Ensure maximum base-level repair is accomplished in accordance with technical orders. We want to repair as much as possible at base level and stop the flow of reparable assets from reaching disposal.
- Promote the use of the AFTO Form 135, Repair Change Request. This form can and should be used to request changes in repair coding and report inconsistencies.
- Reinstate the Reparable Review Board. Joint chairs should be alternated between Supply and Maintenance and a real tracking system that shows parts costs should be established.
- Involve Quality Assurance/Control in the review of candidates for disposal. Staff assistance teams and other teams will make this a review item.

Editor's Note: Watch for more on assets and disposal in our Spring issue.

***"This is not a war of ammunition, tanks, guns, and trucks alone. It is as much a war of replenishing spare parts to keep them in combat as it is a war of major equipment."***

Newspaper Correspondent Ernie Pyle,  
*The Sinews of War: Army Logistics, 1775-1953*, by James A. Huston

*We are currently experiencing an explosion of new Information Resource Management (IRM) capacity in the logistics community. Every key logistics process, function, agency, and echelon employs a wide and growing range of logistics information processing capabilities. New innovations employed properly will reduce other resource requirements, improve responsiveness, and ultimately produce and support improved combat readiness and sustainability of our warfighting forces. But caution is in order! As we enter this exciting world of distributed processing, relational data bases, efficient networking, and high-speed transfer of data, we must carefully rethink and reconstruct our information systems architecture. There is a clear need for laterally distributed information to manage logistics processes and a need for logistics resource data to enter the vertical stream of command and control information. But if we do not properly separate these two fundamental functions, as we design our new architecture, we will find combat commanders managing maintenance work orders and maintenance chiefs feeding hungry information systems instead of generating aircraft.*

*Our IRM challenge is to be intelligent in our application of information system technology—to ensure future information systems serve us and to ensure our goals are improved resource management, improved decision making, and, most importantly, improved warfighting capability.*

*Major General Alfred G. Hansen, USAF, Director, Logistics Plans and Programs, DCS/Logistics and Engineering,  
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