INFRASTRUCTURE, THE FOURTH ELEMENT OF STRATEGIC MOBILITY

A Monograph
By
Major Gregory L. Gardner
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School of Advanced Military Studies
United States Army Command and General Staff College
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MAJ Gregory L. Gardner, USA

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The monograph makes four recommendations. First, doctrine needs to be updated to recognize the importance of infrastructure to strategic mobility operations. This should include strategic mobility infrastructure as the fourth pillar of strategic mobility. Second, strategic mobility infrastructure, both in the US and in other countries, should be considered when making force structure, capital investment, and basing decisions. Third, strategic mobility infrastructure should be a consideration when conducting research and development on military equipment. Last, DOD should adopt industry infrastructure standards to the greatest extent possible to ensure compatibility with commercial infrastructure.

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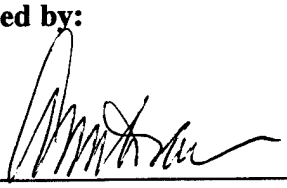

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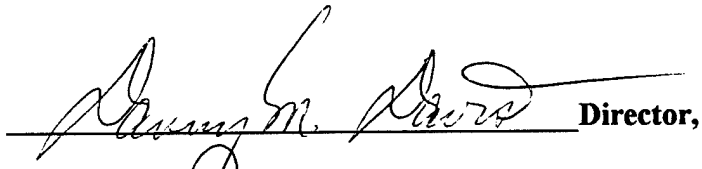

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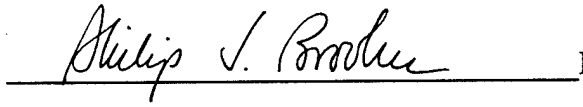

Director, Graduate Degree Program

Philip J. Brookes, Ph.D.

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ABSTRACT

INFRASTRUCTURE, THE FOURTH ELEMENT OF STRATEGIC MOBILITY

This monograph examines the impact of infrastructure on strategic mobility operations. Doctrine does not take a holistic view of strategic mobility. Getting equipment and personnel into a theater of war is only possible if sufficient ports, airfields, roads, and rail networks are available to support the deployment, reception, staging, onward movement, integration (RSOI), and sustainment of these forces. The adequacy of this infrastructure is a fundamental part of strategic mobility that was not sufficiently addressed in the 1992 Mobility Requirements Study (MRS), nor has it received enough attention when compared to the sea, air, and prepositioning elements of strategic mobility.

The monograph begins by reviewing the three pillars of strategic mobility - airlift, sealift, and prepositioning. It demonstrates that DOD has made progress towards meeting the goals set by the MRS, and that ongoing programs are improving capabilities. Next, it reviews DOD and service doctrine relating to strategic mobility, showing how doctrine has failed to keep up with practice. The monograph then evaluates the state of strategic mobility infrastructure both in the United States and OCONUS. The African Continent is used as a model for comparison with the United States and other industrialized nations. Examples from recent US operations are used to demonstrate the impact infrastructure has on strategic mobility operations.

The monograph makes four recommendations. First, doctrine needs to be updated to recognize the importance of infrastructure to strategic mobility operations. This should include strategic mobility infrastructure as the fourth pillar of strategic mobility. Second, strategic mobility infrastructure, both in the US and in other countries, should be considered when making force structure, capital investment, and basing decisions. Third, strategic mobility infrastructure should be a consideration when conducting research and development on military equipment. Last, DOD should adopt industry infrastructure standards to the greatest extent possible to ensure compatibility with commercial infrastructure.

The military strategy of the US is based on the ability to project combat forces and sustainment quickly to any part of the world. This strategy places great stress on the elements of strategic mobility, and thus, strategic mobility infrastructure is gaining increasing visibility within the DOD and Congress. The military needs to take the next step and incorporate strategic mobility infrastructure as an integral component of strategic mobility. The US must take a holistic approach to strategic mobility--one that incorporates all of the military, governmental, and commercial pieces of infrastructure in order to ensure the success of power projection operations.

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I. Introduction

The United States has fundamentally changed its Cold War era national military strategy focused on the containment of communism, to a strategy that emphasizes peaceful engagement. Since 1990 smaller, but numerous, regional threats have replaced the monolithic threat of the Soviet Union.

> "A new military strategy was developed and is now in its second stage of refinement. New approaches to readiness, sustainment, and modernization have been implemented. All of the Services have adapted their doctrines and are well on the way toward adapting their forces to the challenges of a different world....Significant numbers of forces have returned home from their overseas Cold War garrisons to support a new global power projection strategy."[1]

The dissolution of the Soviet Union and the Warsaw Pact resulted in a draw down of American military forces, a reduced forward presence, and an increased emphasis on the ability to rapidly project combat power and sustainment around the world in support of national security policy. Operations in Panama (1989), Southwest Asia (1990/91), Kuwait (1994), Somalia (1992), Northern Iraq (1991), and Haiti (1994), are examples of the types of conflicts that will dominate future American military operations.[2]

An understanding of the importance and complexity of strategic power projection capabilities led, in 1987, to the creation of the United States Transportation Command (USTRANSCOM). This command is comprised of what the Army terms the three elements of strategic mobility, also called the strategic mobility triad. Army Field Manual (FM) 100-17 defines the strategic mobility triad as airlift, sealift, and prepositioning assets. Joint Doctrine also identifies airlift, sealift, and prepositioned equipment as essential to US force projection capabilities.[3]

The 1992 Department of Defense Mobility Requirements Study (MRS), directed by Congress as a result of Operation Desert Shield/Storm, identified significant shortfalls across the strategic mobility triad. According to the MRS, airlift requirements exceeded the capability of strategic airlifters.[4] The recent acquisition of the C-17 as recommended by the MRS, while not yet in the quantity desired, has gone a long way toward addressing the strategic airlift shortfall.[5]

The MRS also addressed strategic sealift shortfalls. The study stated that sealift assets were unable to meet envisioned requirements and that the problem was compounded by the shipping industry's move away from breakbulk ships to container ships. While this move makes sense from a commercial perspective, it also means that fewer breakbulk ships are available for the Army to transport outsized cargo. Since the publication of the MRS, shortfalls have been mitigated by the acquisition of long range, medium speed, roll-on-roll-off ships (LMSR). While US sealift is still incapable of meeting tonnage requirements without significant assistance from allied or neutral countries, upon completion of planned and on-going construction and conversions, much of the shortfall will be alleviated.[6]

The prepositioning element of strategic mobility has downsized and shifted its focus to different areas of the world. In the Cold War world, large division-sized stocks of equipment were positioned in Europe to defend against the communist threat. The new prepositioning strategy is to place smaller, primarily brigade-sized, stocks at strategically important locations both on land and at sea. The recent fielding of an Army brigade set prepositioned afloat is an important addition to force projection capabilities.[7]

General Rutherford, Commander-in-Chief, United States Transportation Command (CINC USTRANSCOM), in recent testimony before congress, stated that the on-going and planned strategic mobility programs initiated in response to the MRS are improving the strategic mobility capabilities of the US armed forces. The continuation of these programs, combined with the reduction in DOD force structure, will keep US force projection capabilities viable.[8] However, there is an additional element that is critical to the strategic mobility equation. Both Army and joint doctrine recognize that the infrastructure required to support the strategic mobility triad is a necessary part of strategic mobility.[9] The CINC USTRANSCOM defined the basic elements of infrastructure when he described the facets of defense transportation.

> "Defense transportation is multi-faceted. It involves not only organic air, sea, and ground assets from four military services, but heavy reliance upon the US commercial airline, maritime, trucking, bus, pipeline, barge, and rail industries. It is also dependent upon airports, seaports, and roads both in this country and around the world."[10]

Building on this description, this paper defines strategic mobility infrastructure as consisting of five distinct, but interrelated, areas which can further be broken down into 14 more specific categories. The following table outlines the components of strategic mobility infrastructure.

Strategic Mobility Infrastructure

Air
- Airfields
- Commercial Airlines

Sea
- Ports
- Port Industries
- Barge and Inland Waterways

Pipeline

Inland
Terminal

Highway

Militarily Significant Highway Networks
Commercial Trucking Companies and Independents
Commercial Bus

Rail

Rail Lines
Rolling Stock
Motive Power
Commercial Railroads

The Department of Defense (DOD) believes that the strategic mobility infrastructure in the United States is sufficient to meet most military requirements.[11] As such, DOD, the Army, and many recent studies have concentrated on the shortfalls in airlift, sealift, and prepositioning identified in the MRS.[12] However, recent deployments have demonstrated serious shortfalls in infrastructure both at home and abroad. Operation Desert Shield saw the largest use of rail for unit deployments since the Vietnam War. The state of the rail, roadbed, and locomotives supporting numerous US military installations was in disrepair and could not support the levels of operation required by mobilization or deployment plans. This included both track, loading/unloading facilities, and locomotives.[13] Also, many installations lacked sufficient facilities or equipment for handling containerized cargo. "Operation Desert Shield/Desert Storm was the first military deployment that used a significant amount of containers, around 37,000 forty-foot equivalent units..."[14] This lack of modern facilities to handle container traffic gains more importance as the Army increases its reliance on containerization for unit deployments, ammunition movement, and sustainment.

Another important element of strategic mobility is the infrastructure at destinations around the world. Assessing and influencing the capabilities of this type of infrastructure

is difficult and can be rendered impossible due to political or economic considerations which restrict access to infrastructure, facilities, and personnel. However, this in no way diminishes the importance of outside the Continental United States (OCONUS) infrastructure to strategic mobility. The US deployment to Somalia was severely constrained by inadequate seaport, airport, and ground transportation infrastructure in Somalia which was also in a poor state of repair due to inattention and damage from the on-going internal disorder.[15] Both the Army and DOD consider OCONUS infrastructure as a part of the intra-theatre transportation network. Doctrine looks at OCONUS infrastructure and its impact on theater logistics, but does not take a holistic view of strategic mobility by looking at the impact OCONUS infrastructure has on strategic mobility capabilities. Getting equipment and personnel into a theater of war is only possible if sufficient ports, airfields, roads, and rail networks are available to support the reception, staging, onward movement, integration (RSOI), and sustainment of these forces. The adequacy of this infrastructure is a fundamental part of strategic mobility that was not addressed in the 1992 MRS, nor has it received sufficient attention when compared to the sea, air, and prepositioning elements of strategic mobility.

II. Strategic Mobility Overview

Strategic mobility capability shortfalls have been significantly reduced since the publication of 1992 MRS and the subsequent Mobility Requirements Study-Bottom Up Review Update (MRS-BURU) in March, 1995. This progress has taken place in all three legs of the Strategic Mobility Triad. General Fogelman, then CINC USTRANSCOM, testified before the House Armed Services Committee in 1994 that, while current assets did not meet requirements then, recent progress has made our strategic lift systems and programs more capable than in the recent past.[16]

Considerable progress has been made toward correcting problems identified by the MRS and the subsequent Army Strategic Mobility Program (ASMP), and the MRS-BURU.[17] The three studies identified required improvements in all three legs of the strategic mobility triad. Airlift requirements centered around the need to replace the aging C-141 with the C-17 Globemaster III. Sealift requirements involved purchasing or rebuilding additional roll-on/roll-off (RO-RO) ships and improving the maintenance funding of the ships assigned to the Ready Reserve Fleet. The ASMP determined that additional sets of Army equipment needed to be prepositioned both at sea and on land to ensure deployment timelines could be met.[18]

The down-sizing of the US Army and other services, has significantly reduced the requirement for strategic transportation capabilities. The number of active Army divisions went from 16 in 1992, to 10 in 1996. During the same period of time the number of Air Force wings was also reduced. While there is no direct correlation between the reduction in active duty forces and the amount of strategic lift assets required to support a specific

mission, it is logical to assume that there is a corresponding decrease in required strategic lift assets.[19] Fewer deploying units equates to some level of reduction in strategic lift requirements for both deployment and subsequent sustainment operations.

The US Air Force has made progress towards meeting MRS and ASMP requirements for its airlifter fleet. The addition of the C-17 to the operational inventory has greatly enhanced operational capabilities.

Aircraft[20]	1992	1996
C-141	230	214
C-5	109	104
C-17	0	22
KC-10	54	54

The side of this story not evidenced by the numbers are the programs undertaken to ensure the viability of the C-141 and C-5 fleet until their retirement. Both aircraft have undergone structural and engine improvements to extend their service life and improve their operational readiness rates.

The C-17 is the key to future strategic military airlift viability. In November 1995, the DOD made the decision to continue to acquire the C-17 as the Air Force's core airlifter. Funding for the first 40 aircraft is appropriated through Fiscal Year 1996. Currently, a total of 80 additional aircraft are planned for purchase at the rate of 12 to 15 per year, although McDonnell Douglas and the DOD are discussing acceleration of this schedule to complete the procurement of the remaining 80 aircraft in five (5) years. When the 120 aircraft total is reached sometime after the year 2005, the US airlifter fleet will be

in better shape than anytime in the recent past.[21] The key question that remains to be answered is whether or not the forced retirement of the C-141 fleet due to age limitations will seriously reduce airlift capabilities before enough C-17s can be built to make up for these losses.[22]

Military sealift capabilities have been significantly enhanced since the publication of the 1992 MRS. Not only have new ships been converted or purchased, but the maintenance, and hence readiness, of the Ready Reserve Fleet (RRF) has dramatically improved since Operation DESERT STORM.[23] RRF ship activations during Operation DESERT SHIELD/DESERT STORM were on the average nine (9) days late, while during Operation UPHOLD DEMOCRACY, RRF ship activations were an average of 38.6 hours early. The MRS-BURU attributes this improved performance to increased funding for ship maintenance.[24] Actions completed, currently underway, or planned include the addition of 19 LMSR ships, and two container ships.[25] These last two container ships are critical to future deployments because of DOD's recent emphasis on the use of containers for deployment and sustainment, and recent operational experience. The preponderance of sustainment supplies in Operation Desert Shield/Storm were transported in containers. Future deployments will use containers for most sustainment, and nearly all ammunition transported into theater.[26]

While the increase in LMSR and container ships is important, foreign flag vessels are still required to meet the requirements set forth in the MRS. The emerging critical need is for container ships. This is a surmountable problem as the vast majority of commercial ships under construction are container vessels designed to handle the booming commercial container market.[27]

The greatest improvement in military sealift capabilities is in the area of timeliness. The increase in the numbers of LMSR and container vessels has improved DOD's ability to quickly deploy critical combat forces during the initial phases of a conflict. These ships enable heavy Army forces to speed up their loading/unloading times and transit times during a deployment. However, these vessels do not greatly improve DOD's ability to sustain its forces. If host nation support (HNS) is not available within a theater, then the burden of shipping sustainment supplies will fall on container and breakbulk ships coming from CONUS or another theater.

The prepositioning leg of strategic mobility has also seen extensive changes over the last four years. The Army has shifted the prepositioning focus from concentration on Europe to smaller, strategically placed sets of equipment. The large equipment stocks in Europe have been reduced. In their place are smaller, typically brigade-sized, sets of equipment configured to support contingency missions. These brigade-sized sets of equipment, like the Maritime Prepositioned Squadrons, are strategically placed to enable the National Command Authority (NCA) to quickly place heavy ground forces in position to respond to a major regional contingency.[28]

While DOD Maritime Prepositioned Squadron capabilities have remained relatively static in recent years, the Army has completed its deployment of one heavy brigade set and related support equipment at sea. The Army has also made significant progress in placing ground based, brigade sized sets of equipment in three locations. Two heavy brigade-sized sets of equipment have been placed in the Persian Gulf, in Kuwait and Qatar, with the third brigade set being located in Italy. The end effect created by both the ground and

sea-based prepositioned unit sets is an increase in the flexibility afforded to regional commanders and the NCA.[29]

DOD has made progress towards meeting the goals set by the MRS for the three pillars, air, land, and prepositioning, of strategic mobility. The operational introduction and continued production of the C-17 have given the Air Force Mobility Command a significant boost in both flexibility and capability. The addition of new FSSs and RO-ROs provides the NCA the ability to quickly deploy additional heavy combat forces into a theater. The addition of prepositioned brigade sets of equipment in the Mediterranean and Southwest Asia, along with the prepositioned brigade at sea, ensures that the US can react rapidly to regional threats. Ongoing improvements to the airlift, sealift, and prepositioning pillars of strategic mobility have increased, and will continue to expand, the strategic mobility capabilities of the US armed forces.

III. Infrastructure and Strategic Mobility

Infrastructure, the fourth element of strategic mobility, has received less attention by the DOD and Congress than the other strategic mobility elements of airlift, sealift, and prepositioning. However, its importance is beginning to be recognized within the DOD. "In DESERT SHIELD/DESERT STORM, 85% of the dry cargo moved by sea and 15% moved by air. However, at some point, 100% of the unit equipment, ammo, food, medicines...had to move by surface from "fort to port."[30] A corollary of General Fogleman's statement is that all of this materiel also moved from an OCONUS port or airfield to the location where it was used or consumed within the destination theater. His comment also underscores the increasing importance of CONUS and OCONUS transportation infrastructure to the strategic mobility of the US armed forces. Bottlenecks in any part of the transportation system directly affect the flow and output through the pipeline. The strategic transportation system is a complex, interactive system that must be analyzed and managed in a holistic fashion.

DOD and Army doctrine are outdated when discussing strategic transportation. This is especially true when referring to the element of infrastructure. While this statement is a criticism of current DOD and Army doctrine, it is also a realization that the DOD has not taken the time nor resourced the effort to rewrite this doctrine. It is important for the DOD and the Services to capture the significant changes being discussed and implemented to ensure continuity of effort between and within the services. Regarding strategic transportation infrastructure, there are three broad elements of doctrine that have fallen behind current thoughts and practices in both DOD and the Army.

First, Joint and Army publications only recognize three elements of strategic mobility- - the strategic mobility triad of airlift, sealift, and prepositioning.[31] There are numerous references to infrastructure in both joint and service manuals. However, while these manuals refer to the importance of infrastructure, none recognizes infrastructure as an integral component of strategic mobility.[32] Analysis conducted for and following the publication of the MRS expanded the definition and scope of strategic mobility. In testimony before the House Armed Services Committee in 1993, General Fogelman, then CINC USTRANSCOM, referred to infrastructure as the fourth pillar of strategic mobility. The ASMP and the MRS-BURU have both reinforced the CINC USTRANSCOM's assertion by giving more importance and thought to strategic mobility infrastructure. However, this view has yet to be formalized in DOD or published service doctrine.[33] Current DOD and service publications still define strategic mobility as a triad consisting of airlift, sealift, and prepositioning.

Second, Army manuals view OCONUS infrastructure as an element of theater transportation and logistics. While Army Field Manuals 100-5 and 100-17 recognize the importance of infrastructure to deployment and RSOI neither manual takes a holistic approach to strategic mobility. Infrastructure is viewed as a supporting player to intra-theater transportation and logistics instead of being an integral part of strategic mobility extending from the loading docks at a CONUS installation through to the receipt of supplies, equipment, or personnel at the using unit. This outlook is shortsighted and is not in concert with the views presented in the MRS-BURU, ASMP, and recent testimony by General Rutherford, CINC USTRANSCOM.[34]

Last, the term infrastructure is not well defined in military literature. Air Force Manual 1-1, volume II, defines infrastructure as a tangible source of the instruments of national military and nonmilitary power.[35] JP 1-02, DOD Dictionary of Military and Associated Terms, defines infrastructure as, "A term generally applicable to all fixed and permanent installations, fabrications, or facilities for the support and control of military forces."[36] It also includes definitions for national, common, and bilateral infrastructure, which more clearly identify the owner of the infrastructure in question. A key difference between the Air Force and DOD definitions is that DOD defines infrastructure in purely military terms, while the Air Force views infrastructure as having both military and nonmilitary components and application. Army Field Manual 100-5 defines infrastructure in terms of logistics, communications, space support, and an element of mission, enemy, tactics, terrain, and troops (METT-T).[37] The word "infrastructure" has varied meanings in military literature. "Infrastructure" is used in the context of politics, economics, military power, and information. The word is used without regard to a common understanding by all elements of DOD. For these reasons it is important for the reader to keep in mind the definition proposed at the beginning of this paper.

Strategic mobility infrastructure is an integral part of strategic mobility. The military must take a holistic approach to strategic mobility. That approach will include the aircraft and ships that physically move personnel and materiel. It must also include the elements of infrastructure that move personnel and materiels, and support those ships and aircraft. The airfields that serve as air ports of debarkation (APOD) and air ports of embarkation (APOE), along with those enroute airfields that support the flights, can determine the airflow into a theater of operations. The health of the commercial airline industry is

directly related to the numbers of aircraft available for use in civil reserve air fleet (CRAF) missions.

Like airfields, sea ports of debarkation (SPOD) and sea ports of embarkation (SPOE) directly impact the flow of ships and the personnel and materiel they carry. Port industries that provide services such as heavy lift, materiel handling, and storage are important to the smooth and efficient operation of SPODs and SPOEs. These port facilities and services are especially important in a theater of operations where the lines of communication go through or into underdeveloped countries. These countries often have few, if any, port facilities capable of supporting large deployments.[38] The barge and inland waterway systems in the US and in theaters of operation are important to the movement of bulk commodities such as fuel. These capabilities directly support and can make up for shortfalls in other modes of transportation.

Pipelines provide military planners the capability to move large amounts of liquids, usually fuels, both in the US and a theater of operations. Militarily significant pipelines are broken down into the two categories of inland and terminal pipelines. The best known example of a military inland pipeline is the Central European Pipeline System (CEPS) in Europe that stretches from the English Channel ports to various locations in Germany. Fixed pipelines such as CEPS and portable pipeline systems greatly increase the quantity of fuel moved from port to general supply units, and provide redundancy for other modes of movement. Terminal pipelines support the on-load and off-load of bulk liquids from storage to ship or aircraft and back. These facilities are important to the rapid transfer of these bulk liquids. Ports or airfields that lack these facilities require military augmentation to be effective.

The infrastructure supporting highway transportation falls into three categories; the highway networks themselves (which include the roads, bridges, drainage, etc), commercial trucking companies and independents, and commercial bus companies. The networks and companies providing services form an integral piece of the transportation network by moving people and materiel from installations, depots, and industries to their APOEs and SPOEs, and from APODs and SPODs into a theater of operations. Trucks and buses provide the most responsive and often the cheapest means of overland transportation. During Operation Desert Shield/Storm, the US relied heavily on the truck and bus industries both in the US and in Saudi Arabia. Host nation support (HNS) trucks made up for a serious shortfall of US Army truck transportation assets in theater.

The last important piece of strategic mobility infrastructure is rail transportation. Rail infrastructure consists of the commercial railroads and three elements of military rail; rail lines, rolling stock, and motive power (locomotives). It is necessary to differentiate between the military and commercial aspects of rail infrastructure because most military installations are responsible for the operation and upkeep of rail lines, rolling stock, and motive power to support installation operations. Commercial railroads are often incapable of providing support on a military installation.[39] Rail performs many of the same basic functions as highway transportation; moving materiel from installations, depots, and industries to SPOEs. A primary difference between rail and highway transportation is the greater flexibility and speed of highway transportation, and the greater hauling capacity of rail. The increased use of containers by the military for both ammunition and sustainment transportation has increased the importance of both highway and rail transportation to successful strategic mobility.

Strategic mobility infrastructure is a vital component of the strategic mobility of the US armed forces. Each piece that supports the land, sea, or air portion of strategic mobility performs unique functions, which if allowed to degenerate, is capable of causing delays or failure in a deployment operation. DOD plays a critical role, along with private industry and other government agencies, in improving and ensuring the continued viability of strategic transportation infrastructure.

IV. The State of Strategic Mobility Infrastructure

The state of strategic mobility infrastructure ranges from excellent, in such areas as commercial and military airfields in the US, to simply non-existent, as in the total lack of militarily useful ports and rail facilities in some less developed countries. Due to the wide diversity of availability and capability in strategic mobility infrastructure, all elements of this infrastructure must be examined both in the US and overseas in order to arrive at a holistic assessment of the state and capabilities of strategic transportation infrastructure required to support strategic mobility. This paper provides a selective analysis of areas where the US has declared national interests around the world, showing the diversity of quantity and quality of resources and facilities to give the reader an appreciation of the range and scope of strategic mobility infrastructure issues.

Air Transportation Infrastructure

Air transportation is the quickest means available for the US military to project combat power into a theater. By air, the Army can deploy an airborne brigade from Fort Bragg to Southwest Asia in under 82 hours.[40] This same brigade would take over a week to close the same distance if it traveled by sea. Along with the transport of units, air transportation also performs the equally important task of delivering critical sustainment supplies into a theater. The delivery of Patriot missiles from the manufacturer to using units during Operation DESERT STORM was only possible because of air transportation. While the aircraft and crews receive most of the much-deserved credit for these operations, the infrastructure that supports them is an integral component for success.

The infrastructure supporting air transportation is complex. It varies from the personnel that make the system work, the electronic devices that are required for today's modern aircraft, to the runways and structures used by both people and machines. For simplicity, this paper defines infrastructure in terms of systems that support a primary function, with the understanding that there are numerous sub-systems within the primary system. For air transportation there are two (2) primary systems -- the airfield complexes and the commercial airline companies. These systems exist both in the US and overseas, to include the US commercial airline industry which is becoming increasingly multinational.

Airfields

Airfield capability and capacity are factors consisting of many sub-elements. Runway length, ramp space, and approach radars are prime considerations. However, many other factors effect the ability of an airfield to handle air traffic. Other areas which must be considered are fuel handling capacity and availability, available maintenance services, cargo handling capability, de-icing capability, hours of operation, and the conditions under which access will be allowed. The United States Air Force has the capability to make up for shortfalls in many of these areas. However, these resources are limited and cannot quickly improve things such as runway length and ramp space problems.

Generally, airfield infrastructure around the world is adequate when compared to other types of infrastructure. The continued success of both the international passenger and air freight markets have contributed to the number and quality of airfields around the world. The US is particularly wealthy in regards to both commercial and military airfields. In 1995 the US had over 1,631 paved airfields that were capable of handling C-5 and

Boeing 747 aircraft, to include the support needed to keep them flying.[41] This number of airfields and the associated services that they provide give the US military numerous options when conducting strategic deployment operations.

Airfields located outside the US are not of the same overall quality or quantity. The high end of the spectrum are airfields located in Western Europe where Germany, France, and England have respectively over 144, 137, and 214 paved airfields capable of handling large military and commercial aircraft. The other end of this spectrum is Africa, which ranges from South Africa which possesses 61 paved airfields capable of handling large military and commercial aircraft, to Liberia, which has two runways long enough to handle these aircraft. The shortfalls associated with many of the African and other less developed countries airfields are the lack of available ramp space, the low load bearing capacity of the pavement, and the lack of services offered at these airfields[42].

An example of this situation occurred during Operation RESTORE HOPE, when US Air Force aircraft caused major damage to the airfield at Mogadishu because the aircraft were heavier than the runway was designed to support. This, coupled with the lack of ramp and parking space for aircraft, severely limited the delivery of supplies via air transport during the operation.[43] The airfields in Saudi Arabia caused similar delays and constrained subsequent inland transportation operations during Operations DESERT SHIELD/DESERT STORM.

> "Airlift operations were constrained because operations were largely limited to a single airfield: Dhahran. Although Saudi Arabia has many large airfields, they did not all have the infrastructure necessary to support large airlift operations – large fuel supplies, hydrant refueling systems, material-handling equipment. ...Unfortunately, Dhahran could normally handle only about 30 missions a day, because of infrastructure limitations and the other uses being made of the airfield."[44]

Another major cause for delay during Operations DESERT SHIELD/DESERT STORM was the availability of en-route airfields. These en-route airfields provided fuel and maintenance support as well as becoming bases from which tanker aircraft could support in-flight refueling of the transport aircraft. "The airlift to the Gulf relied heavily on the facilities provided by Torrejon, Rhein-Main, and Zaragoza. These three bases supported 61 percent of the entire airlift flow."[45] With a reduced overseas presence, US access to facilities like these is becoming a problem. "Zaragoza is no longer available to AMC. Access to Torrejon...is questionable, and Headquarters USAFE is facing increased pressure to either close or reduce operations at Rhein-Main."[46]

Airfield strategic mobility infrastructure in the US is strong and provides adequate capability to support force projection operations. The same cannot be said for airfields outside of the US. These facilities range from excellent to non-existent. Many of those facilities capable of handling large military and civilian transport aircraft are limited by a lack of fueling capability, ramp space, or tarmac strength. A growing problem with airfields outside of the US is availability. Airfields once available to the US are being closed or civilianized, making access to the remaining airfields more difficult.

Sea Transportation Infrastructure

Sea transportation is the next category of infrastructure to be analyzed. In many respects, the generalities made about air transportation infrastructure can be made for sea transportation infrastructure. Namely, that the infrastructure located in the US is modern and has a large capacity, whereas the infrastructure located outside of the US varies

greatly in both quantity and quality. In spite of the improvements made in the transportation of cargo by air, sea transportation remains the primary means for moving military supplies and equipment. "During Operation Desert Storm/Desert Shield...86.6 percent of dry cargo moved by sea. When petroleum, oil and lubricant cargos are included in these totals, 94.7 percent of all cargo was moved via sealift to Southwest Asia."[47] The relatively high cost of air transport when compared to sea transport of large and heavy supplies and equipment will ensure that sea transportation remains the primary method of moving military cargo in the near future.

The infrastructure that supports sea transportation can be broken down into three broad categories; ports, port industries and facilities, and barge and inland waterways. Ports are defined as the physical piers, berths, and anchorages available for docking and unloading a ship. Port industries are an integral part of port operations and consist of such services as materiel handling equipment, longshoremen, terminal pipeline and storage facilities, and terminal railways. Barge and inland waterways are not as closely tied to port operations as port industries, although they often support the movement of materiel from where it is manufactured to the port. In this way both provide services much like highway and rail transport operations. Each infrastructure element is important to strategic sealift.

Ports

The 1994 MRS-BURU stated that sufficient port capacity exists in the US to support all envisioned deployment scenarios. Operation DESERT SHIELD/DESERT STORM provided the largest test of that capacity since the Korean War.

> "Enormous as it was, the Desert Shield/Desert Storm operation should be viewed in perspective. During 1990, commercial U.S. ports together (a total of 180) handled nearly one billion short tons of import/export cargo and approximately 10 million cruise passengers. That represents nearly 200 times the volume of military cargo and 20 times the number of troops sent to the Persian Gulf through the relative handful of ports that the Defense Department actually used during the operation. Despite the demands placed on them by the emergency, the U.S. commercial port system proved fully capable of meeting its responsibilities to the nation's security and to its vital commercial interests."[48]

The important point is that the US commercial ports had the capacity to handle the DESERT SHIELD/DESERT STORM military traffic without serious degradation to their own commercial interests. It must be noted that delays were encountered at nearly every port used during Operation DESERT SHIELD/DESERT STORM; however, these problems were not related to the physical properties of the port facilities, but rather to the commercial industries providing port services.[49]

Ports located outside of the US are of the same range of quality and quantity as the airfields located overseas. The ports that the US has access to in Western Europe, Korea, Japan, and Saudi Arabia are among some of the most capable in the world. "...[T]here are few areas in the world that can receive military deployments with the extensive infrastructure in place that the US realized in Saudi Arabia. The modern, made-to-fit ports, cranes, materiel handling equipment, and transportation assets and network expedited the arrival, off-load, and build up of forces."[50] The following chart provides a good comparison of capabilities for ports supporting MRCs in Korea and Southwest Asia.

CONUS and OCONUS Seaport Berth and Throughput[51]

Port Name	Berth Type				Daily Throughput Capacity STONS
	Breakbulk	RO/RO	FSS	Container	
Ad Daman	6	15	5	8	75,412
Jubail	4	8	0	4	33,614
Pusan	9	15	11	8	90,408
Pohang	0	10	5	3	45,126
New York	33	8	1	2	213,710
Oakland	10	9	9	3	68,838
Savannah	4	3	3	5	39,860

The other end of this spectrum was experienced in Somalia during Operation RESTORE HOPE in 1992.

Due to the decision not to use Logistics Over The Shore (LOTS) operations in Somalia, the port of Mogadishu became the critical link in the deployment chain.[52] However, the capacity of the port of Mogadishu was insufficient to meet requirements. "Shipping deliveries were below theoretical capacity largely because of capacity constraints at Mogadishu. There was only a single berth capable of handling FSSs so these ships (all six loaded with Army cargo) had to be metered into the port one after the other."[53] The capacity problem was aggravated by the need to bring humanitarian supplies through the Mogadishu port. "During the first 37 days Army cargo flowing through the port at Mogadishu was only about 20 percent of the total. Appropriately, given the

Restore Hope mission, humanitarian cargos amounted to 37 percent of the throughput during the same period."[54]

While Somalia provides one example of port problems encountered in third world countries, it is informative to look at the other African ports in comparison to Somalia and the US. The chart at appendix 1 shows the disparity of port capability between African nations and the US. What it does not show is the disparity between the quality of facilities both within Africa and between Africa and the US. The difference between the port of Alexandria, Egypt and Mogadishu is nearly as great as that between Savannah, Georgia and Mogadishu. It is important to emphasize that there are eight African countries that do not have the capability to off-load RO-RO type vessels. Three African countries have no ports that are capable of handling containers. Also, many of the ports listed suffer from the small number of berths that plagued US operations in Mogadishu.

Port Industries

Port industry problems at US ports during Operation DESERT SHIELD/DESERT STORM pointed to potential shortfalls during future deployments. As US ports have modernized and shifted their capabilities towards the handling of bulk commodities such as crude oil, and the growing container market, there has been a subsequent impact on the industries that are integral to the operation of these seaports. This impact has changed both the equipment used to support on and off-load operations, and it has influenced both the quantity and type of personnel that work for port industries.

First, the materiel handling equipment used by port industries has shifted from cranes and lifting devices used to handle breakbulk cargo to cranes and advanced lifting devices

designed to handle containers. While some equipment can handle both breakbulk cargo and containers , they are usually optimized to manipulate one or the other. In keeping with this trend the DOD has initiated programs to take advantage of the container handling capability in both the US and around the world. The problem is that a large amount of military cargo cannot be efficiently containerized and must be shipped as breakbulk cargo. A lack of equipment to handle breakbulk cargo could affect future strategic mobility operations.[55]

The same issues occurring with materiel handling equipment are also affecting the personnel that operate the equipment and load/unload vessels.

> "As with shipping, containerization has produced wholesale changes in cargo handling procedures, substituting machines for manpower. As traditional breakbulk shipping of a generation ago has been shouldered aside by this technological regime, a major result has been a steady decline in the pool of skilled longshore labor. Military ocean transport, however, remains heavily dependent on labor intensive breakbulk shipping."[56]

Shortages of longshoremen during Operation DESERT SHIELD/DESERT STORM were overcome through creative management and the use of Military Traffic Management Command personnel. However, with the steady decline of available manpower, future deployments could be affected.

> "During the early stages of Desert Shield, serious labor shortages were encountered at some of the loadout ports...This problem will grow in severity in the years ahead, meaning it will become increasingly difficult and possibly impossible in the not-too-distant future to mount out a Desert Shield-scale force"[57]

The intermodal revolution that has changed American port industries has also affected other countries' port industries in much the same way. Machines are taking over the skilled jobs of stevedores and other port workers while the port materiel handling

equipment has been optimized to handle container cargo rather than breakbulk. However, the lack of capital and the cheap cost of labor has held back port and port industry modernization in some less developed nations. The net result is a large disparity in port industry capabilities between regions and nations of the world, making it difficult for the DOD to optimize the modes and methods for shipment of goods by sea.

Inland Waterways

Inland waterway traffic in the US provides a redundant mode of transportation for military needs. US highway and rail transportation have the capacity to efficiently haul military commodities that can be transported on inland waterways. However, the military utility of inland waterways is much greater in other areas of the world where highway and rail capabilities are not so robust. In Europe, the major tributaries and canals support a strong commercial transportation economy. The North Atlantic Treaty Organization uses this capability in peacetime and plans for its use in wartime. Inland waterways, while inflexible, are capable of moving large quantities of bulk supplies, such as fuel and ammunition, to make up for shortfalls in other modes of transportation. Many areas of the world which do not possess good highway and rail routes have navigable inland waterways that can be used to transport military cargo.[58]

Land Transportation Infrastructure

Land transportation infrastructure is the part of strategic mobility infrastructure that usually begins and ends the movement of personnel and cargo. Personnel are moved by bus or truck from their installation to an airfield or a seaport. After arriving in theater the

personnel are transported by bus or truck to their equipment or gaining unit. Freight cargo, equipment and supplies, essentially follow the same flow. Cargo is moved by truck or rail from an installation or depot to a seaport or airfield. Upon arriving in theater the cargo is transferred to trucks, rail, or intra-theater cargo aircraft for delivery to using units.

Land transportation infrastructure consists of two primary elements; highway, and rail. While there is some duplication of capability, primarily between highway and rail transportation, each mode fills a unique demand placed on it by strategic mobility requirements. Highway transportation provides the quickest and most flexible means of delivering cargo to a destination. It can deliver cargo directly from the point of origin to the point of destination with minimal delays. Rail transportation is capable of transporting large quantities of bulk and outsized goods in a reasonable time and often at a lower cost. Rail is dependent on highway transportation to deliver cargo from a railhead to the point of destination.

The intermodal shipping revolution that has affected the sea mode of transportation has also greatly impacted the land modes of transportation. Intermodal transportation is not a mode of transportation by itself, but rather the use of a standardized container that can be transported over many modes of transportation. This allows shippers to lower costs by maximizing the strengths of each mode of transportation. While the DOD was instrumental in the development and use of early containers, the commercial market has led the development of standards and methods in intermodal transportation during the decades of the 1970s, 80s and 90s. Highway and rail are both critical links in the intermodal transportation equation.

Highway

Militarily significant highway transportation infrastructure can be broken down into three categories; militarily significant highway networks, commercial and independent trucking companies, and commercial bus companies. In the US and most other nations, the militarily significant highway networks are funded by a central government through taxation. The US Strategic Highway Corridor Network (STRAHNET) is an integral component of the National Highway System (NHS).[59] This system, much like Germany's autobahn system, was designed and built to facilitate military strategic mobility.

Militarily Significant Highway Networks

The US Strategic Highway Corridor Network, "...designed for the movement of defense personnel and equipment, consists of the 43,500 mile Interstate System and 16,300 miles of non-interstate highways."[60] This system is one of the best in the world and capable of supporting military requirements. The strength of this system is demonstrated by the fact that the Army identified only one key improvement to highway network infrastructure in the ASMP.[61]

In contrast to the quality and quantity of militarily significant highway networks in the US, other nations possess a wide variance of both quality and quantity. This ranges from Germany, which has 501,282 kilometers of well maintained, paved highways, to Zaire, a country over six times the size of Germany, which has 2,800 kilometers of paved highways and Kazakhstan, over seven times larger than Germany, which has 108,100 km of paved and graveled highways.[62] The paucity of militarily significant highway networks in various parts of the world is often exacerbated by the poor condition, weak sub-

roadbed, and light bridges along the routes, making them marginally useful in supporting heavy military traffic. These factors limit the viability and capacity of highway transportation in many areas of the world.

Commercial Trucking Companies and Independents

The face of the commercial trucking industry in the US has changed over the past 15 years. Large interstate trucking companies such as Schneider National Inc., J.B. Hunt Transport Services Inc., and Yellow Freight System Inc. now dominate an industry once dependent on smaller, regionalized trucking firms and numerous independent owners/operators. Another major change in the trucking industry is emergence of truck and rail partnerships conducting intermodal container operations. In intermodal operations, trucks pick up containers from a centralized intermodal rail yard or seaport and deliver the container to the consumer rather than hauling freight from the point of origin to destination. The end result of these changes in the US is an efficient trucking industry that has driven costs down through competition and good management while still being capable of quick point of origin to destination delivery. The US commercial trucking industry is capable of meeting current and future DOD strategic mobility requirements.[63]

The OCONUS commercial trucking industries, while varied in quantity, are generally capable. While countries such as Germany and France have well developed, quality trucking industries which are heavily relied on by NATO, few places in the world do not possess a commercial trucking industry. An example of this was during Operation DESERT STORM/DESERT SHIELD, where the US and coalition forces were able to

contract for large amounts of trucking support. The equipment and operators came from various countries in the region and were able to make up for significant shortfalls in coalition capabilities. Given that the US Military possesses a relatively large amount of trucking assets to support military operations, shortfalls in host nation truck transportation support is not as critical as other elements of strategic mobility.

Commercial Bus Companies

The commercial bus industry in the US has been in decline over the past several decades. The impact of the airline industry and private automobile have reduced the passenger market share of the bus industry. However, commercial bus companies, to include contract carriers, continue to retain sufficient capacity to meet strategic mobility needs. One of the reasons for the retention of this capability is the short distances that most military passengers are transported by bus. During deployments, buses only transport military passengers to the nearest air port of embarkation (APOE); for most military installations a distance of under 50 miles. The commercial bus industry in countries other nations is often stronger and more capable than those in the US. This is primarily due to the need for other nations to rely more heavily on public transportation due to monetary reasons or geographical location.

Rail

Rail infrastructure is the second element of land transportation infrastructure. Rail provides land heavy lift capability for strategic mobility. The infrastructure that supports this rail capability is different from the other elements of strategic mobility infrastructure. The difference is that DOD both maintains and operates that portion of the rail

infrastructure located on and supporting military installations. The DOD also owns and maintains the motive power (locomotives) used to move rolling stock on the installation and position rolling stock for pick-up and delivery to commercial railroads. In some cases, commercial railroads are incapable of operating on military installations due to the state of the rail infrastructure.[64] DOD recognition of the poor state of rail infrastructure at military installations is evidenced by the results of the ASMP which identified over $245 million in upgrades and purchases.[65]

Rail Lines

Rail lines at military installations in the US received inadequate maintenance and funding prior to the publishing of the MRS and the ASMP. These documents highlighted numerous problems with the quality and weight of the rail lines at key military installations during Operation DESERT SHIELD/DESERT STORM.[66] Fort Stewart's experience was typical of many military installations.

"Fort Stewart, Ga., which deployed the first heavy division to Saudi Arabia quickly recognized that its facilities simply weren't up to the task. Its 1950s-era railroad buckled under the weight of armored vehicles. Its ammunition supply point and rail loading area were heavily congested – raising safety concerns while slowing down the deployment."[67] Many installations were only able to meet shipping requirements due to the intense efforts of contractors and the Army's 757th Transportation Battalion in repairing and upgrading rail lines.[68]

In 1992, General Johnson, then CINC USTRANSCOM, identified the need to upgrade the daily railcar loading capacity of key military installations.[69] However, many of these improvements remain uncompleted. The General Accounting Office stated in

1994 that current Army plans (outlined in the ASMP) showed that many projects will not be funded by fiscal year 1999. Budget cuts since 1994 have pushed back many programs even further.[70] Until required improvements are completed and on-going maintenance properly funded, rail lines will continue to be a problem affecting strategic mobility at military installations.

Rolling Stock

The DOD has owned rail rolling stock since the American Civil War. After the demise of the Army Rail Service in the 1960s the number and types of rail rolling stock were reduced. Today, the DOD relies on commercial railroads and car suppliers to provide the majority of military requirements both in the US and overseas. However, as the Army learned during Operation DESERT SHIELD/DESERT STORM, commercial railroads were unable to meet DOD rolling stock requirements during the initial surge of deployment.[71]

To make up for industry shortfalls, DOD maintains a small fleet of cars that supplement the fleet of commercial cars. The large majority of these cars are heavy duty flat cars, designed to transport heavy vehicles, such as tanks or self-propelled howitzers. DOD needs these cars to meet surge requirements during deployments. These rail cars are positioned at strategically important installations across the US that are home to the Army's quickly deploying heavy divisions. The DOD, as part of the ASMP, is upgrading rail rolling stock by purchasing 1,945 new or used railcars. These railcars are projected to be purchased by FY 1999 and when available will meet requirements identified by the ASMP.

Motive Power

Like rolling stock, the DOD has maintained a fleet of locomotives since the American Civil War. Today's DOD locomotive fleet is small in both the number and size of locomotives, and often inadequate for the tasks assigned. Most DOD locomotives were originally built during the 1940s and 1950s, with a few built during the 1970s. Many have been rebuilt at the DOD's only rail rebuild facility at Hill Air Force Base in Utah. Even with rebuilding, the outdated technology in these locomotives make them increasingly difficult and expensive to maintain. Their mission is to provide switching services on military installations to support both day-to-day operations and deployment operations.

Switching at many military installations must still be performed by government owned and operated locomotives because the rail lines on the installation will not support the weight of modern diesel locomotives.[72] A recent analysis of military installations stated that about 58 percent of these facilities relied on commercial switching. It also noted that those installations using government locomotives for switching found those locomotives inadequate both in pulling capacity and readiness rates.[73] Government locomotives were not addressed as a problem by either the Mobility Requirements Study, Bottom Up Review or the ASMP. The inadequacies of the DOD locomotive fleet will grow with the age of the fleet. Due to this inadequacy and the current inability of commercial railroads to switch many installations, DOD should address this growing problem.

Commercial or State Railroads

Commercial railroads in the US are in better shape, both in equipment and track, than ever before. Deregulation of the commercial railroad industry has strengthened companies and lowered costs to shippers. Operation DESERT STORM/DESERT SHIELD demonstrated the capabilities of the rejuvenated railroad industry. "Railroads moved tens of thousands of carloads of equipment, supplies and ammunition. 16,000 cars were moved to the ports and not one of them was late."[74] General Fogleman summed up both the importance of commercial railroads to the DOD and their condition during his tenure as CINC USTRANSCOM. "The health of the 38,800 mile-long Strategic Rail Corridor Network (STRACNET) is directly tied to the economic viability of the commercial rail carriers which own the track. Today's rail system currently meets defense requirements..."[75]

In contrast to the railroad industry in the US, the rail industries in other countries present a mixed bag of capabilities. European countries such as Germany and France, and Asian countries such as Japan and South Korea possess exceptionally capable rail systems that are either state run or subsidized. These rail industries are capable of hauling both freight and passengers with equal efficiency. The other end of the spectrum consists of nations whose economic situation or geography support only a minimal rail capability. While these nations may use rail as a primary means of transporting people and freight within their country, often the state of the rail lines, locomotives, and rolling stock are decrepit, outdated, or localized in operation. These rail industries are of minimal use in supporting strategic mobility operations.[76]

Operation DESERT SHIELD/DESERT STORM provides an interesting case for comparison. "Although Saudi ports were described by coalition commanders as among

the best in the world, related infrastructure such as railways was inadequate. As a result, the US forces found they relied more heavily than expected on trucks."[77] Although Saudi Arabia possesses railways, their size and location made them of little use to coalition forces. The Saudi economy, based on the oil trade, does not support a large railway infrastructure like that in Europe. By way of comparison, Appendix 2 provides an enlightening look at the scope of differences between African nations and the US and Europe. It is important to remember that while this chart compares some capabilities, it does not appraise the serviceability of equipment or personnel training which can have a dramatic impact on capabilities.

The capabilities of the railroad industries in the US are more than adequate to meet DOD requirements. However, the same cannot be said for all other nations. When considering strategic mobility options, the US will be restricted by the state of the railroad infrastructure in many nations. These nations will either not possess railroad infrastructure or the condition of the railroad infrastructure will be in poor repair or limited in scope, as to be unusable.[78]

V. Conclusion

US force projection operations since the Panama invasion in 1989 have demonstrated the importance of strategic mobility infrastructure to the success of force projection operations. With minor exceptions, the strategic mobility infrastructure in the US proved capable of meeting DOD requirements in all operations, to include Operations DESERT SHIELD/DESERT STORM, the largest US deployment since the Korean War. However, the strategic mobility infrastructure in other nations, where US forces deployed into, was not always capable of meeting DOD needs.

The world class Saudi ports of Ad Daman and Jubail were important to the speed of the US deployment efforts. The numerous large and capable airfields located in Saudi Arabia and along the flight routes adequately supported the largest US airlift operation in history. These modern, efficient ports and airfields were the keys to the success of the US deployment efforts. The port and airfield facilities located in Somalia that were used to support Operation RESTORE HOPE were the antithesis of those in Saudi Arabia. These facilities restricted deployment operations, creating conditions that were only acceptable in the context of the Somalia mission.[79]

Railroad and highway infrastructure play an important part in strategic mobility operations both in NATO and Korea. The lack of useable railroad infrastructure in Saudi Arabia forced the coalition to rely on highway infrastructure to support land transportation needs. Highways in Saudi Arabia were congested and too few in number. While tactical units could travel over the desert, most logistics vehicles were restricted to, or performed with greater efficiency, on highways.[80]

Strategic mobility infrastructure, both in the US and in other countries, is vitally important to the success of our force projection strategy. The infrastructure associated with the ports, inland waterways, airfields, railways, and highways dictates both the size and the speed of the military response. Recent force projection operations undertaken by the US have demonstrated both the capabilities and inadequacies of strategic mobility infrastructure around the world. The DOD must weigh these factors as future plans and forces are developed.

In 1993, General Fogleman, then CINC USTRANSCOM, proposed that infrastructure should be viewed as the fourth pillar of strategic mobility. This increased emphasis was a direct result of the infrastructure shortfalls noted in the MRS. In the years following General Fogleman's statements, both the DOD and Congress have given increased attention to strategic mobility infrastructure issues. The ASMP identified numerous infrastructure upgrades, repairs, and new construction requirements necessary to meet strategic mobility demands in the US. However, the DOD has not gone far enough. Two areas need to be addressed; the indoctrination of infrastructure as the fourth pillar of strategic mobility, and the inclusion of OCONUS infrastructure as an integral element of strategic mobility infrastructure.

Currently, all DOD and service doctrinal publications state that their are three pillars of strategic mobility; airlift, sealift, and prepositioning. Even though a case has been made for including infrastructure as the fourth pillar of strategic mobility, the DOD has not changed its doctrinal approach. Including infrastructure as the fourth pillar of strategic mobility will raise the awareness level of military leaders and thus help ensure that sufficient and continuing effort is given to maintaining the integrity of these vital

assets. Institutionalization of the importance of strategic mobility infrastructure is the best way to ensure that infrastructure continues to support military requirements.

One shortcoming in General Fogleman's assessment of strategic mobility infrastructure was that his definition only included infrastructure located in the US. This view is consistent with current military doctrinal manuals which consider OCONUS infrastructure as an element of theater transportation operations. However, this view merits reconsideration in light of the rapidly changing commercial and military transportation systems. The seamless integration of transportation modes through the standardization of shipping containers and the partnerships between commercial shipping companies blur the line between military strategic and theater transportation. The DOD should reconsider this doctrine and include OCONUS infrastructure as a subset of strategic mobility infrastructure.

Strategic mobility infrastructure is not an end to itself. It exists only to support the movement of forces and materiel to their destination. As such, infrastructure must be viewed in a holistic manner, as an integral part of strategic mobility. Because of the impacts and constraints that infrastructure places on strategic mobility, the DOD should include strategic mobility infrastructure as factor in the decision making process. While this would include the obvious deployment considerations, it would go much farther and deeper. Three areas merit further consideration. Each is important, but is only a part of the complete equation.

First, strategic mobility infrastructure, both in the US and in other countries, should be considered when making decisions regarding force structure, capital investment, and basing decisions. Installations and units located in areas close to commercial activities and

markets are both cheaper to support and quicker deploying. Commercial transportation industries make their largest profits by concentrating their efforts and resources in areas with dense traffic. DOD should take advantage of the market in these areas whenever possible. Units and installations situated away from major transportation trunks cost more to move and sustain.

Capital investment decisions should be made in light of their impact on strategic mobility infrastructure considerations and vice-versa. Capital investments can directly affect the impact of infrastructure on strategic mobility operations. An example of this occurrence is the fielding of the C-17 Globemaster III. The C-17, besides having a greater cargo capacity than the C-141, is capable of landing on shorter, unimproved runways. This ability directly impacts airfield infrastructure in that numerous additional airfields are available for use by strategic airlifters and airfield throughput capacities are increased. In essence, a capital investment decision reduced the need for and impact of strategic mobility infrastructure.

Second, strategic mobility infrastructure should be a consideration when conducting research and development on military equipment. While not the prime consideration, it is important to consider the infrastructure used to transport equipment and supplies during their design. Developers should consider such things as the dimensions and maximum weights of standard shipping containers, railcars, aircraft, and materiel handling equipment. This consideration should also include international standards and practices. Because a piece of equipment is compatible with transportation equipment in the US does not mean it is compatible in Europe, Asia, or Africa.

Third, the DOD should adopt industry infrastructure standards to the greatest extent possible to ensure compatibility with commercial infrastructure. This includes such things as international container standards, materiel handling equipment standards, dimensional and weight standards, and hazardous cargo standards. While there are sound tactical reasons for not meeting standards in some cases, the military should strive to align itself as close to commercial practices as possible. The primary advantage to adopting industry and international standards is the ability to use the most efficient, capable, and numerous forms of commercial transportation. As the DOD grows ever more dependent on commercial transportation, compatibility with industry standards will become more important.

The military strategy of the US is based on the ability to project combat forces and sustainment quickly to any part of the world. This strategy places great stress on the elements of strategic mobility, and thus, strategic mobility infrastructure is gaining increasing visibility within the DOD and Congress. The military needs to take the next step and incorporate strategic mobility infrastructure as an integral component of strategic mobility. The US must take a holistic approach to strategic mobility--one that incorporates all of the military, governmental, and commercial pieces of infrastructure in order to ensure the success of power projection operations.

Appendix 1

African Port Capabilities[81]

Country	Container Capable Ports	Ro-Ro Capable Ports	Total Ports in Country
Algeria	2	4	15
Angola	2	0	11
Benin	1	1	2
Cameroon	1	2	9
Congo	1	1	2
Cote D'ivoire	1	2	2
Djibouti	1	1	1
Egypt	4	4	26
Equatorial Guinea	0	0	5
Eritrea	2	2	2
Gabon	2	0	10
Gambia	1	1	1
Ghana	2	2	2
Guinea	1	1	2
Guinea-Bissau	0	0	1
Kenya	1	1	2
Liberia	2	0	4
Libya	4	5	15
Madagascar	2	1	10
Mauritania	1	1	2
Mauritius	1	0	1
Morocco	4	4	15
Mozambique	3	2	7
Namibia	1	1	3
Nigeria	6	4	17
Senegal	1	1	4
Sierra Leone	1	0	3
Somalia	3	0	4
South Africa	4	6	9
Sudan	0	2	2
Tanzania	2	2	9
Togo	1	1	2
Tunisia	5	5	10
Zaire	2	1	4
United States	76	68	160
Turkey	9	12	41
Belgium	5	5	8

Appendix 2

African Rail Capabilities[82]

Country	Km of Rail	Loco-motives	Rolling Stock	(Tonnes) Max Axleload	(Meters) Gauge	(Millions) Freight Tonnes	(Million) Tonnes-km
Algeria	4,772	198	10,042		1.432\1.055	9.90	2,400.00
Angola	2,648	41	1,761	19	1.067\.600	2.80	45.30
Benin	578	20	296		1.000\		250.00
Cameroon	1,104	69	1,647	20	1.000\	1.21	592.00
Congo	510	37	1,735		1.067\		399.00
Cote D'ivoire							
Djibouti							
Egypt	4,751	820	12,008		1.435\	11.20	3,210.00
Equatorial Guinea							
Eritrea	117	3 ?			.950\		
Gabon	668	51	883	23	1.435\	2.50	
Gambia							
Ghana	953	32	810	16	1.067\	0.80	
Guinea	662	30	500		1.000\		7.30
Guinea-Bissau							
Kenya	2,652	198	6,490	18	1.000\	2.20	1,282.00
Liberia	267	24	72		1.435\		
Libya							
Madagascar	883	19	644	20	1.000\	0.29	60.00
Mauritania	704	29	1,200	26	1.435\	8.20	5,635.00
Mauritius							
Morocco	1,907	144	9,713		1.435\		4,415.00
Mozambique	2,988	164	7,081	20	1.067\762	0.90	572.00
Namibia	2,382	73	1,624	16.5	1.065\	1.68	1,074.90
Nigeria	3,505	189	4,653		1.067\1.435		
Senegal	904	29	691		1.000\	2.00	
Sierra Leone							
Somalia							
South Africa	19,641	4,486	138,749	29	1.065\610	166.40	91,402.00
Sudan	4,764	205	6,938	16.5	1.067\	1.00	972.00
Tanzania	2,600	120	2,186	14.7	1.000\	1.20	1,263.00
Togo	525	10	240		1.000\	0.08	
Tunisia	2,152	189	5,220	21	1.435\1.000	11.80	2,224.00
Zaire	366				1.067\		
United States	196,000	18,594	Unk	39	1.435\		416,904.00
Turkey	10,386	670	19,132	20	1.435\	14.60	8,215.00
Belgium	3,396	926	20,508	24	1.435\	63.40	8,084.00

Endnotes

[1] John Shalikashvili, Chairman, JCS, Prepared Remarks before the House National Security Committee Hearing, United States House of Representatives (Washington, D.C., February 8, 1995). p. 8.

[2] John H. Tilleli Jr. GEN, "Force Projection: Essential to Army Doctrine," Military Review (January 1994), p. 15.

[3] Joint Chiefs of Staff. JP 4-0, Doctrine for Logistics Support of Joint Operations, (Washington D.C.:, Joint Chiefs of Staff, 27 January 1995). p. I-11.

[4] Tilleli, p. 16.

[5] Ronald R. Fogleman, CINCUSTRANSCOM, Prepared remarks before the House Armed Services Committee, United States House of Representatives (Washington D.C., March 1994). p. 6.

[6] Ibid. p. 4.

[7] Robert A. Chilcoat, and David S. Henderson. "Army Prepositioning Afloat" Joint Forces Quarterly (Spring 1994). p. 54.

[8] Robert L. Rutherford, CINCUSTRANSCOM, "Excerpt, 23 February 1995", Defense Transportation Journal (June 1995). p. 18.

[9] Army doctrine discussing infrastructure is found in FM 100-17, and is found in the ASMP. DOD manuals, including the recently updated JP 4-0 only discuss the triad of airlift, sealift, and prepositioning. However, testimony before Congress by recent USTRANSCOM Commanders recognizes the importance of infrastructure in the strategic mobility equation.

[10] Hansford T. Johnson CINCUSTRANSCOM, Presentation to the Committee on Armed Services, United States House of Representatives (March 10, 1992). p. 15.

[11] Fogleman, p. 3.

[12] While each of the studies conducted after Operation Desert Storm and Desert Shield include some mention of the necessity of upgrading CONUS infrastructure, the requirement is clearly seen as having secondary importance when compared to airlift, sealift, and prepositioning. Another tool for measuring importance is funding. When compared to the dollars spent on airlift, sealift, and prepositioning, infrastructure is given significantly less importance.

[13] Fogleman, p. 10.

[14] Johnson, p. 19.

[15] David Kassing, Army Deployment for Restore Hope: Analysis and Issues (Rand Corporation, July 1993). p. 17.

[16] Fogleman, p. 4.

[17] The ASMP is the plan developed by the Army in 1993 to address strategic mobility issues within the Army's area of responsibility. It provides solutions to problems identified in the 1992 MRS.

[18] James Kitfield, "The Long Haul" Government Executive (March 1995). pp. 30-36.

[19] Strategic mobility requirements are based on two factors; surge and sustainment. Even though the Army has only ten divisions, the surge requirement to move the initial divisions to a theater has not changed in type of quantity. However, the sustainment part of the equation has changed. Since the Army can only send 10 active duty divisions to any theater, then only 10 divisions must be sustained, requiring less sustainment transportation.

[20] Not surprisingly, no author agrees on the number of aircraft in the Air Force inventory at any given time. There are several probable reasons for this occurrence. The C-17 is in production and is therefore in a state of flux for at least the near future. The number of 22 C-17s reflects figures provided by the Air Force section of the Army's Command and General Staff College as of February, 1996. The numbers of C-5 aircraft in the inventory vary from 118 to 109 depending on the source. The numbers of C-141 aircraft vary the most from author to author, with the numbers running from a high of 226 to a low of 187. Some variance in numbers is no doubt caused due to aircraft lost in accidents. It is also possible that some authors are including aircraft used for training while others only include aircraft assigned to operational squadrons.

[21] Richard Aboulafia, "Military Transports" Aviation Week & Space Technology. (January 8, 1996). p. 18.

[22] Kitfield, p. 34.

[23] Fogleman, p. 4.

[24] Joint Chiefs of Staff, Mobility Requirements Study Bottom Up Review Update.(SECRET) (Washington D.C.: Joint Chiefs of Staff, 28 March 1995). p. IV, B-10,11 (UNCLASSIFIED).

[25] Fred E. Elam, Major General and Mark Henderson, Lieutenant Colonel, "The Army's Strategic Mobility Plan," Army Logistician. (May-June 1992). pp. 4-5.

[26] John Deutsch, Testimony before the Senate Subcommittee on Regional Defense and Contingency Forces, Committee on Armed Services, United States Senate. Department of Defense Authorization for Appropriations for Fiscal Year 1994 and the Future Years Defense Program (June 22 1993). pp. 65-66.

[27] Ibid.

[28] Chilcoat, p. 52.

[29] Ibid., p. 54-55.

[30] Fogleman, p. 3.

[31] Fogleman, p. 1. JP 4-0 and FM 100-17 are the only two DOD joint publications or field manuals that recognize the strategic mobility triad. There are no DOD manuals that currently recognize infrastructure as the fourth pillar of strategic mobility even though this concept was put forward by General Fogleman during his tenure as Commander, TRANSCOM.

[32] Different manuals focus on various aspects of infrastructure. FM 100-5 stresses its importance to theater transportation and tactical mobility. FM 100-17 views infrastructure as either the CONUS element supporting strategic mobility, or the theater element supporting intra-theater movement. Joint Publications view infrastructure as the support base for everything from space, to communications, logistics, and intelligence systems. The Air Force in AFM 1-1 view infrastructure primarily as a strategic target to be protected or attacked.

[33] Fogleman, p. 1. While it is possible manuals in process will contain this language, no current manuals refer to the four pillars of strategic mobility.

[34] Rutherford, p. 18.

[35] United States Air Force. Air Force Manual 1-1 Volume 2. Basic Aerospace Doctrine of the United States Air Force. (Washington D.C.: Department of the Air Force 1992). p.

[36] Joint Chiefs of Staff. JCS Pub 1-02 Department of Defense Dictionary of Military and Associated Terms (Washington D.C.: Joint Chiefs of Staff, 1994). p. 184.

[37] Department of the Army. Field Manual 100-5 Operations (Washington D.C.: Department of the Army 1993). pp. 2-17 and 3-5. FM 100-5 and most other manuals

take a very broad view of the term infrastructure. Basically, infrastructure is any fixed element that supports military operations.

[38] Lloyd's Ports of the World 1994. pp. 1-78. This assessment uses the African Continent as an example. It is based on both the numbers of ports available and their ability to handle the types and quantities of ships used in US strategic mobility operations.

[39] Numerous problems with the rail infrastructure at military installations were identified in the MRS BURU. This problem is serious because the capabilities and upkeep of the rail lines at many installations is so poor that commercial railroads cannot use the lines. This requires installations to spot and pick up cars from sidings located along commercial rail lines. Most of the motive power owned by the DOD is old and prone to breakdown; the newest locomotives were originally built in the 1960s, with most dating back to the 1940s and 50s.

[40] Department of the Army, Deputy Chief of Staff for Logistics, Army Strategic Mobility Program Briefing, (Undated). The Army claims that when the C-17 becomes available in sufficient numbers it will be able to close that same airborne brigade in 54 hours.

[41] Central Intelligence Agency, The World Factbook 1995 (Washington D.C.: Central Intelligence Agency, 1996). p. 444.

[42] Ibid., pp. 246, 390.

[43] Kassing, pp. 17-18. During the first 42 days of RESTORE HOPE AMC could have delivered about 85,000 tons of supplies by air. Airfield conditions in Somalia limited deliveries to the extent that actual deliveries were only 30% of the estimated capability.

[44] John Lund, Ruth Berg, Corrine Replogle. Project AIR FORCE Analysis of the Air War in the Gulf. "An Assessment of Strategic Operational Efficiency" (Santa Monica, CA.: RAND, 1993) pp. 40-42.

[45] Ibid. p. 82.

[46] Ibid.

[47] Fogleman, p. 111.

[48] Rexford B. Sherman, "Ports At War: "Operation Desert Shield/Desert Storm" Defense Transportation Journal, (April 1992). p. 14.

[49] Ibid. p. 16. The largest problem related to ports encountered during the loadout was a lack of hardstand that could be used for storage space. As units moved their equipment to the ports the congestion of materiel caused delays. The military has made some progress

towards assisting the ports in funding militarily useful port improvements for such things as paving to support tracked vehicles, helicopter landing pads and other such things. However, many of these projects remain unfunded and are not projected to be completed until after FY2000.

[50] Stephen P. Ferris, "Crisis in Strategic Sealift" Army Logistician (March-April 1996) p. 29-30.

[51] Mobility Requirements Study Bottom Up Review Update (SECRET). pp. C-31, C32 (UNCLASSIFIED). The MRS BURU lists these figures as planning assumptions. As such they do not represent total theoretical capacities of the ports, but rather what the planners believe will be available to the military to accommodate strategic mobility requirements. The value of this table is for comparison of the relative facility capabilities.

[52] Kassing, pp. 25-26. The decision to not use LASH capabilities was based on both safety and capability factors. The high sea states along the Somali coast increased the risk to personnel performing LASH operations. Also the American Cormorant, which carried watercraft for the LASH operation, was undergoing repairs in England. The draft of the LASH ships were too great for them to enter Mogadishu and offload at pierside. Therefore, the DOD made the decision to send the ships back to Diego Garcia to offload cargo so they could enter the Mogadishu harbor.

[53] Ibid. p. xiii.

[54] Ibid. p. xiv.

[55] Rexford. p. 14-16.

[56] Ibid. p. 16.

[57] Ibid.

[58] An excellent example of this phenomenon is in Central Africa. A good example is Zaire, which possesses 5,138 km of rail and 2,800 km of paved roads, but boasts 15,000 km of navigable inland waterways.

[59] Fogleman. p. 10.

[60] Ibid.

[61] Army Strategic Mobility Program Briefing. This one upgrade was at Ft. Campbell, a highway bypass. While roadwork improvements are constantly being done, this was the only one identified by the ASMP as a strategic mobility enhancement.

[62] Central Intelligence Agency, pp. 159-161, 223-225, 466-468.

[63] Thomas J. Donahue, "Trucking Industry Played Key Role in Desert Shield/Storm", Defense Transportation Journal (June 1991). p. 26.

[64] An example of this phenomenon occurred at Tooele Army Depot during Operation DESERT SHIELD/DESERT STORM. The rail at the depot was light (70 pound rail was the heaviest) and the roadbed at the depot was in extremely poor condition at several locations. The end result of these conditions was that the lightest commercial locomotives were incapable of operating on the installation's tracks. The roadbed also limited the weight of cars loaded with ammunition to less than their full capacity. The locomotives used by the depot were old, small (most were built before 1956), and were capable of moving very limited numbers of cars (normally only two or three cars) at one time. These problems resulted in slowdowns and workarounds in the shipment of ammunition.

[65] Army Strategic Mobility Program Briefing

[66] Fogleman, p. 10.

[67] Donna Miles, "Deploying America's Army", Soldiers, (August 1994). p. 27.

[68] The 757th Transportation Battalion is the only rail battalion in the Army. It is a US Army Reserve unit. During Operation DESERT STORM/DESERT SHIELD the 757th was stretched thin due to missions all over the United States. Also, this unit is not equipped with state of the art equipment used by commercial railroads and rail repair companies.

[69] Johnson, p. 15. General Johnson's comments were driven by the original Mobility Requirements Study findings.

[70] Norman Rabkin, "Strategic Mobility: Serious Problems Remain in US Deployment Capabilities" United States General Accounting Office Testimony before the Subcommittee on Readiness, Committee on Armed Services, House of Representatives. (April 26, 1994). p. 7.

[71] Philip E. Brou, Jr. "The Army Strategic Mobility Program and Land Based Prepositioning Alternatives," Defense Transportation Journal (May 1992). pp. 11-17. Commercial delivery of railroad rolling stock during Operation DESERT SHIELD/DESERT STORM averaged 7 days from time of request to delivery at the loading site. This performance by the rail industry is actually very good when compared to normal industry standards. Commercial railcars in service are scattered throughout the nation, often on other railroad lines. These cars must be located and shipped to a requesting installation. The problem for DOD is that unit deployment timelines require railcars to be spotted for loading within 48 hours of request.

[72] The weight of modern diesel locomotives has increased over the past 30 years. Commercial railroads have discarded lighter, four axle, locomotives in favor of heavy, six axle locomotives because of greater tractive effort and thus efficiency. The end result is that whereas in 1960, 50 pound rail would support many of the new locomotives being produced by locomotive manufacturers, it is unable to support the locomotives that dominate the rosters of modern railroads. In the interim, DOD has not upgraded many rail lines to heavier weights at military installations

[73] Robert S. Korpanty, "Rail Deployment at CONUS Installations" Army Logistician (March-April 1994). p. 19.

[74] Edwin L. Harper, Dr. Summary of Speech to 47th Annual NTDA Forum, Defense Transportation Journal (December 1992). pp 15-16. While the authors statement that no rail cars were late getting to the ports may be true, commercial railroads were still unable to meet DOD requests for specialized railcars during the first week of the operation.

[75] Fogleman, p. 11.

[76] Jane's World Railways 1995-96. pp. 388-807.

[77] John Boatman, "Success behind the "Storm" front" Janes Defense Weekly (11 May 1991). p. 787.

[78] This assessment is based on the state of the world railways outlined in Jane's World Railways 1996. As already discussed, many nation's railways are incapable of supporting the scale of US operations. This is due to small quantities of engines and rolling stock, rolling stock too small to handle a large percentage of US equipment, and tracks which will not support the weight of US equipment.

[79] Kassing, p. xiii.

[80] Boatman, p.787.

[81] Lloyd's Ports of the World 1994. pp. 1-176, 632-646, 651-655.

[82] Jane's World Railways 1995-96. pp. 388-807. It is important to note two facts concerning the figures for the United States. First, the quantity of rolling stock in the United States is not listed by Janes. The most probable reason for this omission is the difficulty of keeping up with the vast quantities of new production and retirements. By way of comparison the United States builds more new rolling stock per year than most African nations own. Second, the United States figures for millions of tonnes per kilometer is for only one class 1 railroad; the Burlington Northern Railroad prior to its merger with the Atchison, Topeka & Santa Fe Railway. Janes does not provide figures for the United States as a whole. However, by way of comparison, the United States has seven class 1 railroads and numerous class 2 (regional) and class 3 (short-line) railroads.

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