USAWC STRATEGY RESEARCH PROJECT

SUPPORTING THE COMBATANT COMMANDER: THEATER BRIDGE MANAGEMENT

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ABSTRACT

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As the US Army transforms to the Objective Force there will be a reduction in the number of engineer units and personnel on the battlefield. To support today's Legacy Force and tomorrow's Objective Force, the Army must reexamine its doctrine – it must become more proactive versus reactive. Engineers must become better at predicting when and where they will be required on the battlefield. The purpose of this paper is to focus on one critical engineer function, managing bridging assets at the theater level, and to maximize our capability today, as well as the capabilities of these assets that remain under the Objective Force. Tomorrow's Objective Force is dependent on high tempo operations and assured mobility – thus the continuing need for a viable bridging infrastructure to support military operations. An enemy's denial of the existing civilian bridging infrastructure could thwart the US military's land capability, or require a level of effort that may be beyond projected capabilities.

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PREFACE

This SRP attempts to capture and expand upon lessons learned from the Theater Bridge Management Study that has been ongoing within the Combined Forces Command, Seoul, Korea, for the past several years. Many outstanding US and Korean Army and Air Force officers have contributed to this project. Additionally, the Center for Army Analysis, the US Army Engineer School, the 412th ENCOM, and the Engineer Research and Development Center have all provided valuable assistance to this study.

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SUPPORTING THE COMBATANT COMMANDER: THEATER BRIDGE MANAGEMENT

ARMY TRANSFORMATION

"The present strategic pause – like the blessed European armed peace from 1871 to 1914 – is unlikely to last. While this pause endures, the U.S. armed forces have an opportunity to address fundamental weaknesses and ensure that we are prepared for our next war."[1] During an address to the Citadel, President Bush asserted that "to win the next war, we have to think differently. The enemy who appeared September 11th seeks to evade our strength and constantly searches for our weakness." To prepare for the next war, the U.S. military is undergoing one of the greatest periods of transformation in history. Many of the "truths" learned on previous battlefields will change as they are altered by new technologies, weapon systems, doctrine, and new types of units – as well as a new breed of adversaries! History has proved that no one can predict the next battlefield. Who would have imagined, even as late as the summer of 2001, the location or type of war that would unfold in Afghanistan later that year? Yet, with little notice, the US military operated across that entire desert country with an international coalition that had never been assembled before.

Engineers must be ready to deploy with minimal notice, to unfamiliar locations, and they must be ready to execute many essential and extraordinary tasks. Engineer missions span the entire battlefield – commencing before the first combat units arrive and continuing long after hostilities have concluded. The Legacy Force was designed and equipped to deploy to a mature theater. The Legacy Force is trained to meet an echeloned, doctrinally based enemy who shapes a battlefield with linear complex obstacles. However, on tomorrow's battlefield the US may be forced to operate in an austere, underdeveloped theater against either conventional forces, or against terrorists fighting on a nonlinear battlefield with asymmetric weapons and doctrine. Yet even against a conventional enemy, such as Iraq, the US may intend to fight nonlinearly.

This SRP proposes a methodology for maximizing the capabilities of the engineer units that remain under the Objective Force. Specifically, it focuses on managing bridging assets at the theater level. Bridges are always central features in war – battles and campaigns are often decided by an adversary's ability to hold a bridge or to destroy a bridge.[2] Today's Legacy Force requires massive logistical sustainment delivered through extensive Lines of Communication (LOC). Tomorrow's Objective Force needs assured mobility to conduct high-tempo operations. The employment of either of these forces requires a viable bridging infrastructure. An enemy's denial of the existing civilian bridging infrastructure could thwart US military land capability, or require a level of effort that they are unwilling to expend. A lack of bridging infrastructure in a potential area of operations could deny the US military otherwise valuable military options. Likewise, failure to properly anticipate future bridging requirements, and then to properly manage military bridging assets could also deny the US military options. There lies the basis for the need for a Theater Bridge Plan (TBP) and Theater Bridge Management (TBM).

STRATEGIC IMPLICATIONS OF BRIDGING

"Fighting and winning major theater wars is the ultimate test of our Armed Forces – a test at which they must always succeed."[3] US National Military Strategy specifies four strategic concepts that govern the use of forces to support strategic goals. Two of these concepts, "strategic agility" (the timely concentration, employment, and sustainment of US military forces anywhere, at our own initiative, and at a speed and tempo that our adversaries cannot match) and "power projection" (maintain flexibility to respond swiftly to crises with force packages that can be rapidly adapted to the environment in which they must operate) can be accomplished only by a land force with access to adequate bridging infrastructure within the theater of operations.[4] Future adversaries may execute an area denial strategy (massive or total destruction of civilian bridging infrastructure). This tactic is more likely in areas where the US has no permanent presence or where only limited civilian infrastructure exists.[5] Such an area denial strategy could convince the US, and her coalition partners, that freedom of movement within the country is either too difficult, too time-consuming, or beyond their capabilities.[6]

THE OBJECTIVE FORCE CONCEPT

The basic structure of the Objective Force is radically different from that of the legacy force. The Objective Force is designed to free the American military from the constraints of conventional thinking. The Objective Force is a modular force. Modularity allows for horizontal control, rather than the traditional vertical command structure. Corps, division, brigade, and battalion headquarters may cease to exist in the Objective Force. Instead, specially tailored units will deploy to execute specific missions.

The Objective Force relies heavily on assured mobility, which is the "actions that guarantee the force commander the ability to deploy, move and maneuver where and when he desires without interruption or delay to achieve his intent."[7] The fundamental imperatives of assured mobility are to see first, understand first, act first, and to finish decisively.[8] Proper planning and employment of bridging assets across the theater is critical – destroyed bridges are an impediment to both tactical and operational maneuver. Proactive planning and analysis enables an attacking army to identify solutions and adjust maneuver and logistics plans. Under the Objective Force structure, the US Army must perfect its ability to plan and execute the TBP to ensure that the enemy's destruction of bridging does not deny assured mobility.

"Improvements in durability, reliability, fuel efficiency, and precision munitions will reduce sustainment demands and sustainment infrastructure...."[9] The Objective Force relies on technology advancements to reduce logistics requirements and enhance the inherent mobility capability of each new combat system. But there are physical limits to the amount of reductions and enhancements that can be obtained through technology. A noncontiguous and non-linear battlefield does not guarantee secured ground lines of communication between forward maneuver forces and rear sustainment units. So, sustainment operations will either have to move with the supported maneuver unit during the attack, by air over enemy controlled areas, or by large scale logistics convoys with dedicated force protection assets.[10] It is doubtful that aerial resupply alone can provide all the ammunition, fuel, food, repair parts, and the other classes of supply required by tomorrow's Objective Force. As a result, resupply by ground convoys across terrain that was at one time controlled by the enemy will continue to be a skill-set the US Army must execute. Therefore, infrastructure support and battlefield engineering will continue as an engineer core competency within Objective Force.

ENGINEER COMMAND AND CONTROL

During previous wars, large engineer force structures allowed engineers to decentralize command and control of engineer missions to the lowest possible levels. With sufficient engineers and materials in theater, engineers were able to execute missions in a reactive mode. However, success of the Objective Force requires the full exploitation of the operational maneuver potential of the Army. Management of bridging assets is critical to accomplish this. No longer will there be the luxury to be reactive in execution. Army engineers must be proactive. The size of the engineer footprint will be smaller than in the past. Yet the type and the magnitude of the missions assigned to the engineers will not decrease. Engineer units and assets must be better managed. Modular engineer packages (with supporting doctrine) that can be assembled and deployed with minimal notice must be developed. Managing bridging at the theater level is one of these critical missions that must be proactively executed. Design of a modular engineer package that can support bridging missions at the theater level is critical for success on future battlefields under the Objective Force structure.

ESTABLISHING THE BASELINE FOR THEATER BRIDGE MANAGEMENT

TYPES OF BRIDGING MISSIONS

Execution of bridging across the theater is an extremely complicated operation. Repair of a damaged or destroyed bridge is not simply a one-time task. Each destroyed bridge will normally be repaired or rebuilt several times. As ludicrous as that sounds, this is reality. There is no "silver bullet" bridge that can be employed quickly under fire, with minimal equipment and forces, and that can meet the expanding through-put requirements of a maturing battlefield. Assault bridging is expensive, and there is very little of it. Constructing bridges with host nation supplies is cost effective, but too labor and equipment intensive to be utilized during contact with the enemy. Combined Forces Command (CFC), Seoul Korea, categorizes three types of bridging missions: assault, support, and Lines of Communication (LOC) (Figure 1).

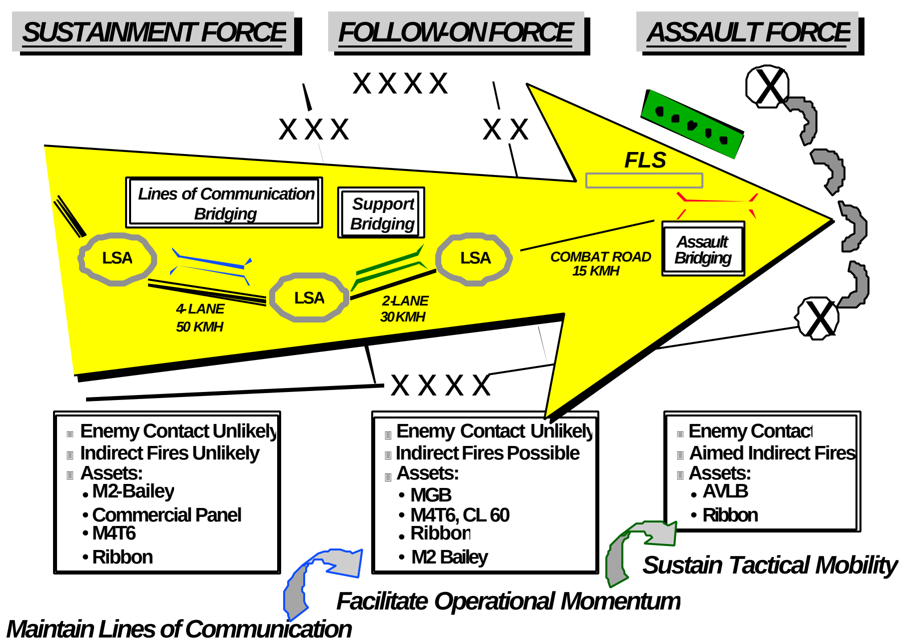

FIGURE 1: TYPES OF BRIDGING MISSIONS [11]

Assault bridging is employed while in contact with the enemy and exposed to direct and observed indirect fires. Assault bridging rapidly projects combat power across a water obstacle or dry gap at a faster rate than the enemy can maneuver and direct his counterattack forces. It minimizes the impact of the river on the ground commander's ability to maneuver his forces.[12]

Assault bridging assets can be quickly emplaced, but they are expensive and quantities are limited. Because of this, assault bridging assets must be recovered and "leap-frogged" forward to support the maneuver fight.

Support bridging is executed when enemy contact is unlikely (except for unobserved indirect fires). Support bridging operations replace critical assault bridging systems so that they may be reused forward by maneuver units. Support bridging begins to develop main and secondary supply routes. Although normally using standard military bridging sets, support bridging may employ commercial bridging systems. Currently the U.S. does not have any support "float" bridging assets. However, some allies (South Korea – CL60 Float Bridge) still have support bridging assets in their inventory.[13] This type of Korean bridging, however, has the reputation of being poorly maintained.

LOC bridging operations are conducted when enemy contact is very unlikely and there is no imminent threat of direct or indirect fires. LOC bridging frees up all military bridging (assault and support) so that it can be reutilized forward. LOC bridging improves theater supply routes to meet required wartime requirements. LOC bridging will normally bring Main Supply Routes (MSRs) back up to pre-war capabilities. Civilian construction materials and commercial bridging systems are normally utilized to construct LOC bridges.

PLANNING ASSUMPTIONS

The US will never have perfect knowledge of the status of bridges within an area of operations until the US military controls the terrain they are built on. During the planning process, planning staffs must make assumptions when developing the engineer portion of the theater plan. The following discussion seeks to identify what types of assumptions are required, and to establish baseline values for those assumptions. As part of ongoing planning efforts, Combined Forces Command (CFC), Korea, has worked hard to identify optimum planning figures for the theater of operations. The following analysis includes some of these findings.

To become proactive in managing theater bridging, it is important to develop a methodology to determine how much damage will be inflicted by the enemy on which bridges. Because there are many variables that affect this analysis, the ability to perfectly predict the status of the bridges during an attack is not possible – but the effort must be made. A good place to start is to look at bridges from the enemy's point of view. Utilizing this approach, three categories of bridges can be defined. These categories classify the value of each bridge to US maneuver forces. The categories support the decision-cycle of either rebuilding or by-passing destroyed bridges. These categories are already being utilized by terrain teams within U.S. Army MTOE units.

Category 1 (Bypass Easy) includes all bridges that are easily bypassed within the immediate area. The bypass may be facilitated by a ford site or suitable stream and bank conditions. Category 2 (Bypass Difficult) includes those bridges that have a bypass (bridge or ford) within a two-kilometer range. Category 3 (Bypass Impossible) indicates there is no way around this type of bridge. To cross a Category 3 gap, military forces must repair the bridge or build a replacement. When a unit approaches a Category 1 (Bypass Easy) bridge that has been damaged or destroyed by the enemy, a unit will simply utilize the bypass and go around it. The US Army will not expend any bridging materiel or effort. Therefore, during the planning process, it is safe to assume that an enemy will not damage or destroy Category 1 (Bypass Easy) bridges.

When a unit approaches a Category 3 (Bypass Impossible) bridge that has been damaged or destroyed by the enemy, a unit must repair or replace the bridge. That unit has no option; there is no way to cross the river without rebuilding the bridge. Therefore, during the planning process it is easy to argue that an enemy who is determined to stop US forces will destroy all Category 3 type bridges. During the planning process, the definition of Category 1 (Bypass Easy) and Category 3 (Bypass Impossible) bridges makes it a simple process to predict intent of enemy actions with respect to bridge. However, Category 2 (Bypass Difficult) bridges require more analysis to determine the intent of the enemy.

If the enemy destroys a Category 2 (Bypass Difficult) bridge, an attacking maneuver force has options. That maneuver force can either fix or replace the destroyed bridge, or they can take a bypass route. But if the bypass route has a bridge on it, the enemy may target it for destruction also. No historical data could be found to determine what percentage of Category 2 (Bypass Difficult) bridges have been destroyed in the past. Therefore, to identify a starting point for planning, the assumption is made that fifty percent of all Category 2 (Bypass Difficult) bridges will be damaged by the enemy. The planning value of “fifty percent” was determined by the mathematical average between the Category 1 (Bypass Easy) and Category 3 (Bypass Difficult) planning figures. Although not backed by historical analysis, it is adequate to initiate planning. It should be adjusted and refined as actual data is collected within the theater of operations. Table 1 lists the three bridge categories and the estimated percentage of bridges targeted.

Bridge Category	Percent Destroyed
Category 1 (Bypass Easy) (Easily bypassed within the immediate area)	0%
Category 2 (Bypass Difficult) (Adequate bypass (bridge or ford) within 2 kilometers)	50%
Category 3 (Bypass Impossible) (No available bypass, must repair or rebuild the bridge)	100%

TABLE 1: BRIDGE CATEGORIES AND PERCENTAGE OF BRIDGES TARGETED

The next planning requirement is to determine a methodology for estimating the extent of damage that will be inflicted on each bridge targeted by the enemy. Two key assumptions drive the methodology for this planning process. The first assumption is that the enemy will not completely destroy every bridge that they target. It is important to note that US Army intelligence staffs routinely assume that an opposing force will totally destroy all bridges as they retreat.[14] There are several reasons why total destruction of bridges will not be the standard. The degree of destruction depends on the amount of explosives required and time needed to plan, assemble, transport, and execute the complete demolition on targeted bridges while concurrently executing other traditional mobility, counter-mobility, and survivability missions. Second, during the heat of battle, the enemy's primary objective in targeting bridges is to slow down or stop attacking maneuver forces within their engagement areas. To accomplish this, he needs only to ensure that he damages existing bridges beyond US assault bridging capabilities (18 meter gap for the Assault Vehicular Launched Bridge (AVLB) – 24 meter gap for the Wolverine). Finally, the total destruction of bridges would deny him any capability to conduct future counterattacks while severely crippling his country's ability to rebuild during post-hostility reconstruction in return for only minimal immediate tactical gain. So for the purpose of planning, a trend observed by the author on multiple bridges in Bosnia will be utilized. In Bosnia, many of the damaged bridges had only a single pier destroyed. Destroying a single pier on a bridge is a quick, simple operation. The result of destroying a pier is the destruction of two spans. Additionally, the opposing force that has to repair the bridge has to first contend with the two damaged spans that are a hindrance to repair efforts. Therefore, using Bosnia as an example, each bridge targeted by the enemy will have one pier destroyed, resulting in two spans damaged beyond repair.

Another source of bridge damage will be the direct result of US Air Force (USAF) deep attack operations. Deep attacks are high risk operations executed against critical high value targets. Because of this, normally only Category 3 (Bypass Difficult) bridges will be targeted by USAF. Routine US policy is not to destroy the entire bridge, but to limit destruction to the minimum required, which normally involves only a single span.[15] The planning assumptions discussed above already assume that two spans will be destroyed by the enemy on every Category 3 (Bypass Difficult) bridge. Therefore, utilizing the planning process described above, the damage USAF inflicts is already addressed.

The next step is to determine the actual amount of damage inflicted on each bridge that is targeted by the enemy. To accomplish this it is important to know the span lengths of all Category 2 (Bypass Difficult) and Category 3 (Bypass Impossible) bridges along the route of attack. There are several methods to accomplish this. Taken from an appropriate angle or during periods of pronounced shadows, aerial or satellite photography is an efficient way to determine the number and length of spans on selected bridges. However, it is doubtful that ideal photography will be available of every bridge of interest. Human Intelligence (HUMIT) sources offer an excellent means to determine span lengths. Ideally, the length of every span on every bridge within the theater could be identified, yet is it highly unlikely that this will occur. Once the span lengths of several bridges on the routes of interest are identified, a pattern can be established that enable engineers to predict span lengths along the entire route by the overall length of the bridges. Table 2 depicts the estimated damage that bridges targeted by the enemy will receive. Table 2 assumes that an enemy will normally destroy only a single pier on each bridge. The only exception to this rule is bridges that cross major rivers. On bridges that cross major rivers a worst case scenario is assumed. The enemy will normally inflict substantial damage on bridges that cross major rivers, his intent is to ensure that they cannot be repaired during the war. This trend was observed in Europe during WWII and in Korea during the Korean War.

Bridge Category	Length of damage
Small (less than 18 meters)	No Damage
Medium (10-meter spans)	20 meters
Large	
• 20-meter spans	40 meters
• 30-meter spans	60 meters
Major Rivers	80 meters

Note: Damage will be collocated on enemy side, with a common pier destroyed. Abutments will remain intact.

TABLE 2: ESTIMATED BRIDGE DAMAGE.

The best historical data available on losses incurred to Assault Float Bridging (AFB) assets during employment comes from the bridging operation conducted on the Sava River in Bosnia in 1995. This recent operation utilized current bridging equipment and doctrine during the crossing of a major river during a real-world military operation. Although there were no losses to enemy direct or indirect fires, this operation provides a wealth of data for future operations.[16] Based on the data from the Sava River in Bosnia, 1995, Combined Forces Command, Korea, devised a methodology to predict losses to AFB assets. CFC's system identified three factors; Maintenance, Loss, and Damage (MLD). In their process they estimated three different factors for MLD for AFB assets. An MLD of 10% is assessed to all bridging operations conducted as part of supporting effort operations. An MLD of 20% for main effort river-crossing operations conducted early during the campaign and an MLD of 30% for main effort river-crossing operations conducted in support of decisive operations later in the campaign. The additional 10% increase for the main effort river-crossings conducted later in the operation takes into account wear-and-tear on the bridges by multiple employments.[17]

Another method of developing MLD values for AFB involves the use of computer modeling of the theater Operations Plan (OPLAN). A part of normal computer modeling of OPLANS by agencies such as the Center for Army Analysis (CAA), Ft Belvoir VA, includes determining the attrition values for combat units during major battles. Although the details of this analysis do not normally include specific types of engineer equipment, the results of the analysis can be interpreted to satisfy engineer needs. It can be logically argued that AFB assets involved in a river crossing operation will incur losses from enemy fires that approximate the losses inflicted on the lead combat units involved in the operation. So this loss estimate is added to losses attributed to maintenance in determining the MLD.

The MLD figures developed above take into account that the AFBs are replaced in a timely fashion. Doctrine calls for the bridges to be replaced by support bridging within 72 hours, which is almost impossible to accomplish.[18] Even so, AFB assets should be replaced within the doctrinal 72 hour period. There are several reasons for this. First, there will never be enough roads, and there will always be too many vehicles attempting to traverse them in both directions. If AFBs are not replaced quickly, they will not be able to stay within the traffic flow pattern of the lead maneuver elements. If this occurs, it will be difficult to get them moved forward thru the follow-on units. As a result, they may not be in position to support the next river crossing. Second, the longer AFB assets are left on the water, the more losses they will incur due to maintenance. AFBs are critical pieces of equipment that will always be in short supply. They must be preserved, especially the bridge erection boats, which incurred heavy losses during the Sava River crossing due to maintenance. Table 3 and Table 4 list additional planning assumptions to assist the planning process.

<u>BASIC ASSUMPTIONS</u>:

- TPFDD US Army bridge companies will be fully sourced.
- RSOI of bridge units will take 12 days.
- River-crossing dates are the result of G3 modeling efforts.
- All AFB assets will be “leap-frogged” forward from one crossing to the next, excluding MLD.
- It takes 7 days to recover, rehab, and move forward, a military float bridge set.
- Units emplacing AFB assets will stay with the bridge after emplacement.
- Replace AFB assets after 72 hours of use.

<u>MAINTENANCE, LOSS AND DAMAGE (MLD)</u>:

CFC Methodology:

- Main Effort (Initial Crossings) 20% loss
- Main Effort (Decisive Crossings) 30% loss
- Supporting Effort Crossings 10% loss

Computer Modeling Methodology:

- Assign attrition values assessed to lead maneuver units

TABLE 3: PLANNING ASSUMPTIONS FOR ASSAULT FLOAT BRIDGING

BASIC ASSUMPTIONS:

- Replace Bailey bridges after 30 days.
- Replace MGB bridges after 10 days.
- Bailey is the standard for planning support and LOC bridging.
- Pier kits are required to span any gap longer than 40 meters.
- 10 days to recover, rehab, and move forward, a military bridge set.
- Host Nation repair will bring the bridge back up to prewar standards.

MAINTENANCE, LOSS AND DAMAGE (MLD):

- 20% MLD is assessed to all bridge sets upon recovery.

TABLE 4: PLANNING ASSUMPTIONS FOR SUPPORT AND LOC BRIDGING

Part of CFC's work in Korea identified a need for pier kits. When the Estimated Bridge Damage planning assumptions (Table 2) are applied across the Korean Theater of Operations, the resulting bridge damage exceeds 40 meters on multiple occasions. As depicted in Table 5, pier kits are required to span any gaps longer than 40 meters. Although two Medium Girder Bridge (MGB) sets with a link kit can span 46 meters, this is not normal practice because of the scarcity of MGB link kits and the demand for MGBs to be employed in the assault "fixed" bridging role. Pier kits can be constructed out of commercial materials or by utilizing Bailey bridge parts. The former being the better option because the Bailey bridge option requires a special kit and these bridges will be in high demand. Commercially produced pier kits are available on the civilian market and may be available from the host nation with prior planning. It is important that requirements for pier kits be identified early in the planning process and closely managed during execution. Commercially produced bridges may also be available.

There are many different types and designs of commercially produced bridges currently available throughout the world. The Mabry Johnson Compact 200 is an outstanding example of a commercially available bridge produced by a firm in England. This bridge, a descendant of the Bailey bridge, has been employed by US engineers in Bosnia. Another commercially produced Korean bridge is shown in Figure 2. Like the Mabry Johnson Compact 200, this bridge kit will span two 40-meter gaps. Also like the Mabry Johnson Compact 200, it provides a Military Load Class (MLC) 100 capability with two lanes of traffic. This set also includes the pier kit located in the center of the bridge. The cost of this bridge set is approximately $700 thousand US dollars. Given wartime contracts, civilian construction firms, such as the one above, will provide invaluable sources of bridging stocks. As mentioned earlier, there are many different commercially produced bridges available throughout the world. Most steel mills of moderate size should have the capability to prefab metal trusses and steel girders that can be employed as an LOC bridge. Additionally, new technologies are being developed by industry that that will aid military operations. For rapid repair and replacement of bridges, industry is currently developing bridging kits made from carbon fiber composite materials. These components are lightweight and man-portable. This technology, adapted to military specifications, would reduce logistical transportation requirements, as well as on site materiel handling requirements.[19]

FIGURE 2: EXAMPLE OF A CIVILIAN PRODUCED BRIDGE AND A PIER KIT.

DETERMINING MILITARY LOAD CAPACITY

Being able to determine the Military Load Capacity (MLC) for bridges within the area of operations is critical to the success of the theater plan. This can be accomplished by utilizing construction drawings, recent inspection reports, and on-site inspections of each individual bridge. Even if this is possible (many of the bridges will be controlled by the enemy), the time it would take (two to six man-hours per bridge) makes such detailed analysis of routes extremely time and labor intensive. As a result, it is normal to determine MLC from the traffic on the route observed from satellite photography, or from information obtained thru HUMIT sources. The results of this process are normally conservative, resulting in unnecessary limits being placed on the mobility of friendly forces.

In an attempt to correct this situation, the Engineer Research and Development Center (ERDC) has an ongoing project (Rapid and Global Bridge Assessment for the Military) that attempts to develop a systematic methodology to provide rapid yet accurate bridge assessments across all regions of the world. The methodology utilizes a unique machine learning approach designed to extrapolate “high resolution” assessment of individual bridges to other similar bridges that have not been assessed. This methodology assesses bridges at either of three distinct “levels” of resolution: low, medium, or high; with successively higher indicating increased accuracy and decreased conservatism of the load rating. This concept enables military engineers to convey to their commanders a “confidence” value to the answers they are providing. Thus ensuring additional emphasis is placed on improving the assessments.[20]

Low resolution assessments are normally the result of various intelligence sources and a base knowledge of existing civilian designs correlated to similar military loadings. Low resolution assessments represent the lowest accuracy and highest degree of conservatism. High resolution assessments are based upon physics-based structural analysis models similar to those used by civilian highway engineers. They are certainly the most desirable and provide answers with precision close to that required for public safety on US highways. High resolution assessments may be achievable for a select few bridges in the early stages of a military operation. It is doubtful that this level of analysis could be achieved for all the bridges along a given route in a reasonable period of time. That is why ERDC designed the Medium Resolution Assessment (MRA).

If enough high resolution assessments are achieved, then construction tendencies within specific geographic regions can be discovered and the results extrapolated in a logical manner to other similar bridges that have only undergone low resolution assessments. The similarity of bridges is based on age, design, and comparable dimension (such as span length). Results of ERDC’s analysis indicates that their methodology was able to reduce the error of low resolution assessments by more than 50 percent while only requiring high resolution assessments from just 3 percent of the total bridges. MRA results are promising and ERDC’s methodology should be considered for theater planning.[21]

STANDARDIZED BRIDGE DATABASE

An adequate theater level-bridge database, with procedures for updating during hostilities, is critical to success of the Objective Force. Currently across the Army multiple bridge databases exists within higher headquarters. Normally these bridge databases are managed within the G2, the G3, the G4, and the engineer staff section. As a rule, the only commonality between the separate databases is the fact that none of them have been properly updated or maintained. This was the situation that existed within Combined Forces Command Korea.[22] Each database utilizes different data fields and formats. These databases must be consolidated into a single database that is utilized across the entire theater of operations. It would be ideal if the engineer staff had the mission to create and manage the single bridge database. However, in most headquarters, because of the number of separate staffs that utilize the database, the G3 is the primary staff responsible for a bridge database. But the G3 has neither the time, nor the expertise to manage a bridge database so this responsibility is usually passed on to the G2. The G2 is too narrowly focused on bridges as targets in the maneuver box to spend the time and energy required to ensure the database meets the needs of all the organizations that need it across the entire theater of operations. Engineers must be proactive and fight for the lead in creating and managing a consolidated bridge database. Five issues must be addressed to ensure successful development and use of the bridge database. First, the database must contain all the data-fields required by each of the staff sections within the headquarters, and by all subordinate commanders. Second, the management of the database must involve each of the parties mentioned above. Third, every unit and organization, to include host nation organizations, must have access to and – more importantly – must accept and utilize this bridge database as the single theater bridge database. Fourth, the database must include the entire theater of operations – from the point of entry forward across the entire depth of the enemy held terrain. Finally, this database must be an integral part of any future Objective Force command and control system.

As the Objective Force doctrine is developed, the data-fields of the bridge database must be standardized across the entire Army. This will ensure that reconnaissance data input by units spearheading the attack will be readily available to multiple organizations and staffs. Every organization on the battlefield will benefit from a single bridging database. From the theater level planning staffs who conduct future planning and who manage military bridging assets; to the engineer battle labs in the continental US who will be involved in the development of repair designs to replace military bridging kits; to the theater level logistics units who will assemble the necessary repair packages and ship them forward; to the follow-on engineer units who will repair and rebuild damaged bridges; and finally, to the host nation leadership who will eventually assume responsibility for the bridging infrastructure during post combat operations.

ERDC is also working on an automated bridging reconnaissance tool to assist engineers in the field called IBARR (Intelligent Bridge Assessment, Repair, and Retrofit). Although still under development, when complete it will provide PC (Personal Computer) or PDA (Personal Data Assistant) based capability for engineers to execute bridge recons and to develop high-resolution MLC assessments of bridges. The graphics intensive and user friendly system allows more reliable input of bridge site data than currently possible with the Army Form 1249 (Bridge Site Reconnaissance). Additionally, IBARR computes MLC values in terms of Normal, Caution, and Risk levels of crossings (NATO STANAG 2021, Edition 6, draft).[23] IBARR is a high tech engineer planning tool that will be vital to the Objective Force.

MANAGING BRIDGES AT THEATER LEVEL

THEATER BRIDGE MANAGEMENT TOOL

This SRP has assessed the need for management of bridges at the theater level; development of baseline planning assumptions to support bridge management; and what engineer assets are needed to execute this mission. Now it will address Tactics, Techniques, and Procedures (TTP) for managing bridges at theater level. This concept is best demonstrated utilizing a simple spreadsheet. However, a spreadsheet program only allows the tracking of bridging missions, units, and assets along a singular linear path; it will not track complex routes that contain multiple parallel routes with operationally different timelines. To accomplish these real world scenarios requires more complex programmable software. Figure 3 depicts a scenario that can be used to demonstrate the process of TBM.

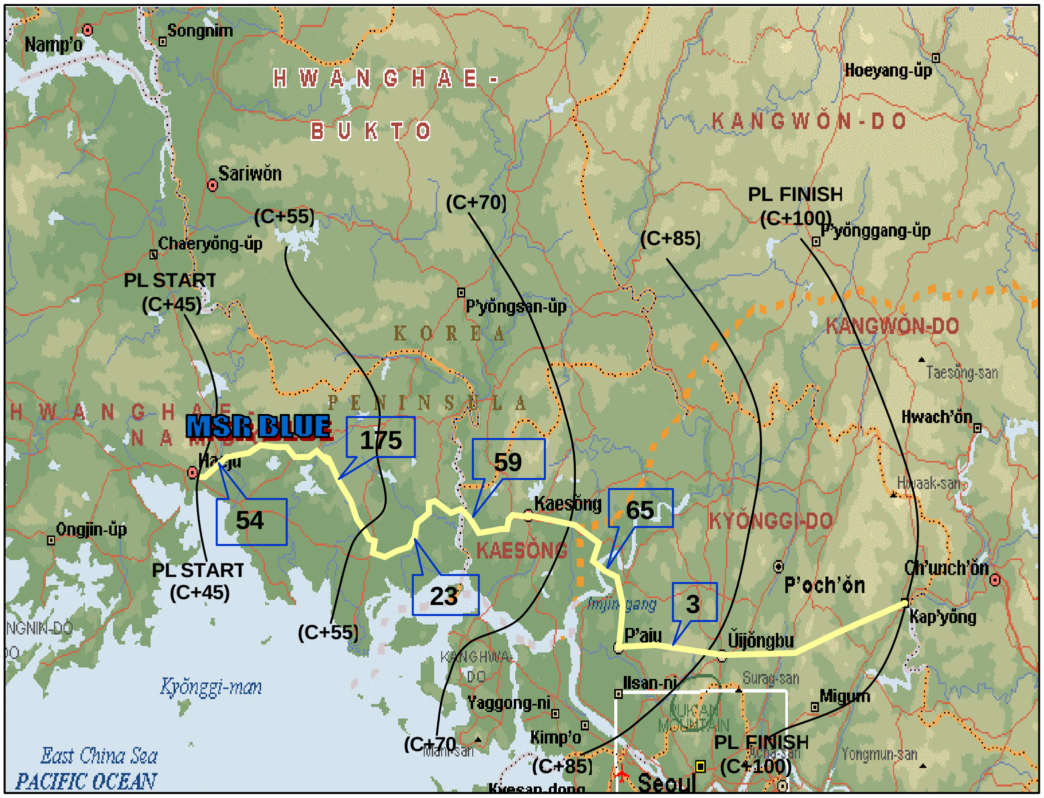

FIGURE 3: THEATER LOGISTICS SCENARIO – MSR BLUE

As shown on the map, Main Supply Route (MSR) Blue is not a single road or highway. It is consists of segments of multiple routes. Bridges should be managed by the way they are aligned along maneuver and logistical routes of advance. This supports the way the Legacy Force fights and executes sustainment operations. This also gives the Army the opportunity to classify routes by the minimum load classification of the weakest bridges, by the number of lanes, or by the type of route (road or rail). If a route includes multiple MLC-45 bridges it does not make sense to reconstruct damaged bridges along this route to any capability greater than MLC-45, unless the plan requires all the bridges on the route – damaged or not to be rebuilt. Identifying the MLC is critical to the logistics community; it allows them to plan for which vehicles and what types of loads they send over which routes. If multiple MSRs are available, the logistics' community can utilize lower class roads as return routes for vehicles that are empty.

Overlaid on the map are operational graphics that depict friendly rates of advance. Graphics such as these enable the time identification of when lead maneuver forces will reach various bridges along the route. Comparing these data points to the results of the bridge damage analysis (Table 2) provides the timeline requirements of when the damaged or destroyed bridges need to be repaired or replaced. This gives the theater-level engineer staff officer the ability to project when damaged bridges must be repaired or replaced to support the theater plan. With this information, it is easy to identify what bridge kits, construction materials, and engineer units are required. Equipped with this planning data, an engineer staff can project these requirements in advance, ensuring the right materials and the right units arrive on site at the correct time. If these materials do not exist within the theater of operations, knowing the projected rate of advance enables the logistics community time to acquire them.

Table 5 shows the bridge database, which displays the data on the bridges in the area of operations. Normally, this data will be incomplete. Data on bridges that is needed for planning, but is not yet available, should be identified as one of the commander's Priority Intelligence Requirements (PIR). But until that data is known, it must be been assumed. In Table 5, all assumed data appears in bold print. The spread sheet is a living document and must be updated as information becomes available. The first section of the database (Standard Data Fields) contains all the physical descriptive data fields that are normally tracked on bridges. The second section (Planning Data) depicts the results of the planning assumptions (Table 3 and Table 4) on the bridges along MSR BLUE. In this second section, the amount of damage expected at each bridge is identified, as well as the maneuver timeline (FLOT column). The damage figures are based on the planning assumptions; as actual damage data becomes available, the database should be updated. The final three sections (Assault Bridging, Support Bridging, and LOC Bridging) indicate where bridging assets are actually allocated to support the theater plan. In this section, engineers can determine if sufficient bridging materials are available to support the theater plan. For the purpose of this example, friendly forces do not have any support bridging assets capable of spanning an 80-meter gap over a major river.

STANDARD DATA FIELDS									PLANNING DATA			ASSAULT BRIDGING					SUPPORT BRIDGING										LOC BRIDGING				
Bridge #	Route #	UTM Coordinates				Bridge #			Damage		FLOT	Float					Float				Fixed						Float			Fixed	
						Length (m)	Bypass (Rating)	River Width (m)	Damage (Planning/Actual)		(C+)	Build (C+)	Remove (C+)	Mission (B/R/F)	RIBBON (Req/Avail)		Build (C+)	Remove (C+)	FLOATBRIDGE (Req/Avail)		Build (C+)	Remove (C+)	BAILEY (Req/Avail)		Pier Kits (Req/Avail)		Build (C+)	Remove (C+)	MLC	Build (C+)	Host Nation Support
MSR BLUE (PL Start to PL Finish)												Bridging Assets Available				8.0				200M				18.0		4					
B01	HW54	55Y	XX	12345	12345	160	II		60		45										45	75	1.5	16.5	1	3				75	yes
B02	HW54	55Y	XX	55555	55555	52	II				46																				
B03	HW54	55Y	XX	55555	55555	87	I				46																				
B04	HW54	55Y	XX	23456	23456	200	III		60		48										48	78	1.5	14.0	1	2				78	yes
B05	HW54	55Y	XX	34567	34567	83	II		40		50										50	80	1.0	13.0						80	no
B06	HW 175	55Y	XX	55555	55555	245	II				51																				
B07	HW 175	55Y	XX	45678	45678	80	III		40		52										52	82	1.0	12.0						82	yes
B08	HW 175	55Y	XX	56789	56789	57	II		40		55										55	85	1.0	11.0						85	no
B9	HW 175	55Y	XX	55555	55555	76	II				57																				
B10	HW 23	55Y	XX	22333	22333	76	II		40		58										58	88	1.0	10.0						88	no
B11	HW 23	55Y	XX	55555	55555	76	I				58																				
B12	HW 59	55Y	XX	55555	55555	76	I				59																				
B13	HW 59	55Y	XX	55555	55555	76	II				59																				
1ST MAJOR RIVER																															
B14	HW 59	55Y	XX	33444	33444	180	III		80		60																			135	yes
CROSSING SITES																															
B14A		55Y	XX	33555	33555		III	160			60	60	63	Rx4	1.0	7.0															
B14B		55Y	XX	33556	33556		III	160			60	60	63	Bx1	2.0	5.0															
B14C		55Y	XX	33557	33557		III	160			60	60	70	Bx1	2.0	3.0	70	95	160m	40m							95	INDEF	60		
													MLD		1.0	2.0															
B15	HW 59	55Y	XX	43567	43567	35	II		20		62										62	92	0.5	10.5						92	no
B16	HW 59	55Y	XX	55555	55555	27	II				63																				
B17	HW 59	55Y	XX	55555	55555	27	I				64																				
B18	HW65	55Y	XX	55555	55555	14	I				65																				
B19	HW65	55Y	XX	11223	11223	49	II		20		68										68	98	0.5	10.0						98	no
B20	HW65	55Y	XX	22112	22112	207	III		60		70										70	100	1.5	8.5	1	1				100	yes
B21	HW65	55Y	XX	55555	55555	62	I				71																				
B22	HW65	55Y	XX	33221	33221	46	III		20		73	3 AFB Sets Recovered				5.0					72	102	0.5	8.0						102	no
2ND MAJOR RIVER																															
B23	HW65	55Y	XX	33322	33322	260	III		80		74																			135	yes
CROSSING SITES																															
B23A		55Y	XX	88877	88877		III	280			74	74	77	Rx4	1.0	4.0															
B23B		55Y	XX	88777	88777		III	310			74	75	78	Bx1	2.0	2.0											78	INDEF	60		
													MLD		0.5	1.5															
B24	HW65	55Y	XX	55555	55555	69	I				78																				
B25	HW65	55Y	XX	55555	55555	31	II				80																				
B26	HW65	55Y	XX	67854	67854	97	II		40		82										82	112	1.0	7.0						112	no
B27	HW65	55Y	XX	55555	55555	13	III				86										1.5 BB sets recovered			8.3							
B28	HW3	55Y	XX	55555	55555	22.1	I				87										1.5 BB sets recovered			9.5							
B29	HW3	55Y	XX	54678	54678	110	II		60		90										90	120	1.5	8.0	1	0				120	yes
B30	HW3	55Y	XX	55555	55555	73.4	II				93										2 BB sets recovered			9.5							
B31	HW3	55Y	XX	55555	55555	100	I				96										1 BB set recovered			10.3							

TABLE 5: BRIDGE MANAGEMENT TOOL

The bridging requirements to support the theater plan are identified on the Bridge Management Tool (Table 5). From this spread sheet, developed during the mission analysis portion of the planning process, the bridging missions (to include locations and materiel requirements) have been identified for all three types of bridging missions in support of the entire theater plan (Table 6). This process enables engineers to identify any shortages or additional requirements. This concept allows engineers to plan concurrently with the operations and logistics planners – providing timely engineer input on proposed courses of action during the consolidated staff planning process. From this list, it is a simple process to identify engineer units and materials required to execute the bridging missions. However, actually resourcing these requirements (US, coalition, or host nation) is entirely a different story. There will always be more requirements then resources available. But, this methodology will allow the commander to better prioritize the units and assets available to support the plan. Although this process is relatively quick and simple, it is far from perfect. It must be continually updated as real world information is obtained. This process enables the engineer staff officer to conduct planning during the mission analysis phase of the staff estimate and then provide input to the commander about the ability of engineers to support various courses of action.

		MSR BLUE		
ASSAULT BRIDGING MISSIONS:				
C+Dates	Mission	Grid Coordinates	Assets Required	
C+60 to C+63	AFB Raft (4 ea)	55YXX3355533555	1 MRBC	
C+60 to C+63	AFB Bridge (1 ea)	55YXX3355633556	2 MRBC	
C+60 to C+70	AFB Bridge (1 ea)	55YXX3355733557	2 MRBC	
C+74 to C+77	AFB Raft (4 ea)	55YXX8887788877	1 MRBC	
C+75 to C+78	FB Bridge (1 ea)	55YXX8877788777	2 MRBC	
SUPPORT BRIDGING MISSIONS:				
C+Dates	Mission	Grid Coordinates	Assets Required	Pier Kit
C+70 to C+90	Float	55YXX3355733557	160 meters	
C+45 to C+75	Fixed	55YXX1234512345	1.5 Sets Bailey	yes
C+48 to C+78	Fixed	55YXX2345623456	1.5 Sets Bailey	yes
C+50 to C+80	Fixed	55YXX3456734567	1.0 Set Bailey	
C+52 to C+82	Fixed	55YXX4567845678	1.0 Sets Bailey	
C+55 to C+85	Fixed	55YXX5678956789	1.0 Set Bailey	
C+58 to C+88	Fixed	55YXX2233322333	1.0 Sets Bailey	
C+62 to C+92	Fixed	55YXX4356743567	0.5 Sets Bailey	
C+68 to C+98	Fixed	55YXX1122311223	0.5 Set Bailey	
C+70 to C+100	Fixed	55YXX2211222112	1.5 Sets Bailey	yes
C+72 to C+102	Fixed	55YXX3322133221	0.5 Set Bailey	
C+82 to C+112	Fixed	55YXX6785467854	1.0 Sets Bailey	
C+90 to C+120	Fixed	55YXX5467854678	1.5 Set Bailey	yes
LOC BRIDGING MISSIONS:				
C+Dates	Mission	Grid Coordinates	Assets Required	Host Nation
C+78 - INDEF	Float	55YXX8877788777	310 meters/2 lanes	
C+95 - INDEF	Float	55YXX3355733557	160 meters/2 lanes	
C+75	Fixed	55YXX1234512345	60 meters/2 lanes	yes
C+78	Fixed	55YXX2345623456	60 meters/2 lanes	yes
C+80	Fixed	55YXX3456734567	40 meters/2 lanes	
C+82	Fixed	55YXX4567845678	60 meters/2 lanes	yes
C+85	Fixed	55YXX5678956789	30 meters/2 lanes	
C+88	Fixed	55YXX2233322333	60 meters/2 lanes	
C+92	Fixed	55YXX4356743567	60 meters/2 lanes	
C+98	Fixed	55YXX1122311223	40 meters/2 lanes	
C+100	Fixed	55YXX2211222112	60 meters/2 lanes	yes
C+102	Fixed	55YXX3322133221	30 meters/2 lanes	
C+112	Fixed	55YXX6785467854	30 meters/2 lanes	
C+120	Fixed	55YXX5467854678	60 meters/2 lanes	yes
C+135	Fixed	55YXX3344433444	60 meters/2 lanes	yes
C+135	Fixed	55YXX3332233322	60 meters/2 lanes	yes

TABLE 6: MSR BLUE BRIDGING REQUIREMENTS

THEATER BRIDGE MANAGEMENT CELL

In order to effectively manage bridging at the theater level, a dedicated Theater Bridging Management Cell (TBMC) is needed to support the combatant commander. The TBMC must be able to anticipate theater bridging requirements, synchronizes engineer assets, and integrate into JTF headquarters. The organization must be able to quickly deploy, be self-contained, be completely mobile, and possess reach-back capability (such as the Tele-Engineering Suit) allowing it to tap into resources back in the states. Lastly, it must include or have access to an Army terrain team to ensure that it has the capability to construct or modify electronic maps, analyze satellite photography, and to interface with theater and/or national collection assets. The minimum personnel and equipment required by the TBMC to execute these missions are listed in Table 7. The TBMC can be built from an existing theater staff or can be organized in the states and brought in to provide support to a theater staff. This cell should also be responsible for managing the consolidated theater bridge database and provide the necessary expertise on this mission in support of the G3, G4, and G2. The TBMC enables the engineer planning effort in theater to become proactive rather than reactive.

Personnel:

- OIC (EN LTC)
- NCOIC (12B30)
- Shift leaders (EN CPT) (2 ea)
- Operation NCO (12B20) (2 ea)
- Terrain Analyst (81T20) (2 ea)
- Terrain Analyst (81T10) (2 ea)
- Clerks (12B10) (4 ea)

Equipment:

- Tactical Expandable Shelter (with M928) (1 ea)
- M988 with Shelter and SINCGARS (2 ea)
- Laptop Computers with Printers (2 ea)
- SIPNET/GCCS compatible
- DTSS-L
- M988 with Shelter and SINCGARS
- Laptop Computer with Printer
- GP Small Tent
- GPS
- HP Kayak System w/Plotter
- TACSAT and Tele-Engineering Suite
- Topography Database
- Trailer Mounted Generator

TABLE 7: THEATER BRIDGE MANAGEMENT CELL

CONCLUSION

This SRP proposes a methodology to manage bridging assets and units at the theater level to support the combatant commander. As the Army transforms, changes to the U.S. Army force structure will not allow engineers the flexibility to decentralize command and control of engineer bridging assets across the theater of operations as has been done in the past. The requirement of the Objective Force's high-tempo operations and the need to achieve assured mobility (see first, understand first, act first, and to finish decisively) will place additional requirements on engineers to properly plan for and employ theater bridging assets. Engineers must be proactive in the management of bridging assets to fully exploit the operational maneuver potential of US military land forces. To accomplish this, a modular engineer organization, that can support both JTF headquarters and combatant commanders with the management of bridging operations, must be developed. The design of this organization must enable it to be quickly assembled with enough flexibility to support operations from combat to disaster relief. The organization must be equipped with "reach-back" technology so that it can engage civilian engineers back in the U.S. for design work to support bridging operations. Repair designs that are developed in the states can be electronically forwarded to Logistic Support Areas within the theater rear so that repair packages can be assembled and shipped forward to the designated bridge in time to link up with the emplacing engineer unit. It must be self-contained, with all required equipment, personnel, and published doctrine. Bridge management also requires an updated doctrine that includes a methodology to predict the bridging requirements across the theater, and a bridge management tracking system that allows the synchronization of engineer units and bridging assets to ensure that they link up at the correct time and place on the battlefield. Finally, to be effective TBM must have the capability to create, manage, and distribute a single bridging database for the entire theater. This database must be updated with real time bridging data collected from all available high-tech and human intelligence (HUMIT) sources. Only by closely managing bridging operations at theater level can the US ensure that the correct engineer assets arrive at the appropriate location in time to support the commander. Failure to accomplish this will bring operational and strategic momentum to a grinding halt.

WORD COUNT= 6,674

ENDNOTES

[1] MacGregor Knox and Williamson Murray, ed. Dynamics of Military Revolution 1300-2050, (Cambridge, MA: Cambridge University Press, 2001), 194.

[2] Stephen Ambrose, Pegasus Bridge, (New York: Simon and Schuster Inc., 1988), 10.

[3] Bill Clinton, A National Security Strategy for a Global Age, (Washington D.C.: The White House, December 2000), 27.

[4] Department of Defense, National Military Strategy of the United States of America, (Washington D.C.: U.S. Department of Defense, September 1997), 3.

[5] Clinton, A National Security Strategy for a Global Age, 17.

[6] Thomas G. Mahnken, "America's Next War" The Washington Quarterly, 16 No. 3 (Summer 1993), 171-184.

[7] Department of the Army, Objective Force Unit of Employment Concept (Final Coordinating Draft), TRADOC Pamphlet 525-3-92 (Ft Monroe, VA; U.S. Department of the Army, November 2002), 52.

[8] Brigadier General Randy Castro, "Assured Mobility and the Objective Engineer Force," briefing slides with scripted commentary, Fort Leonard Wood, MO, U.S. Army Engineer School, 25 November 2002.

[9] Department of the Army, Objective Force Unit of Employment Concept (Final Coordinating Draft), TRADOC Pamphlet 525-3-92, 46.

[10] Department of Army, Operations, Field Manual 3-0. (Washington, D.C.: U.S. Department of the Army, 14 June 2001), Chapter 6, p. 55.

[11] Scott, Donahue, Dynamic Assault Float Bridging, (Seoul, Korea: Headquarters Combined Forces Command, May 2000), 5.

[12] Department of the Army/Marine Corps, River Crossing Operations, FM 90-13/MCWP 3-17.1 (Washington D.C.: U.S. Department of Army/US Marine Corps), 1-1 to 1-3.

[13] Combined Forces Command, "Theater Bridge Management Plan," (Seoul, Korea: Headquarters Combined Forces Command, May 2002), Author's unclassified working notes.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Department of the Army/Marine Corps, River Crossing Operations, 9-5.

[19] SAIC Strategies Group, Engineer Capabilities Study: A Path to the Future, (A study conducted for U.S. Department of Defense, Joint Staff J-4 Engineer Division: McLean, VA 22102, 30 September 2002), 3.

[20] James Ray and Cary Butler, "Rapid and Global Bridge Assessment for the Military," (Working Draft) (U.S. Department of the Army, Engineer Research and Development Center, Vicksburg MS, January 2003), January 2003, 1 - 6.

[21] Ibid.

[22] Combined Forces Command, "Theater Bridge Management Plan," Author's working notes.

[23] James Ray and Cary Butler, "Rapid and Global Bridge Assessment for the Military," 11.

BIBLIOGRAPHY

Ambrose, Stephen. Pegasus Bridge. New York: Simon and Schuster Inc., 1988.

Castro, Randy, Brigadier General. "Assured Mobility and the Objective Engineer Force." briefing slides with scripted commentary. Fort Leonard Wood, MO, U.S. Army Engineer School, 25 November 2002.

Clinton, Bill. A National Security Strategy for a Global Age. Washington, D.C.: The White House, December 2000.

Donahue, Scott. Dynamic Assault Float Bridging. Seoul, Korea: Headquarters Combined Forces Command, May 2000.

MacGregor, Knox and Williamson Murray, ed. Dynamics of Military Revolution 1300-2050. Cambridge, MA: Cambridge University Press, 2001.

Mahnken,Thomas G. "America's Next War" The Washington Quarterly 16, No. 3, Summer 1993.

Ray, James and Butler, Cary. "Rapid and Global Bridge Assessment for the Military." (Working Draft) U.S. Department of the Army, Engineer Research and Development Center, Vicksburg MS, January 2003.

SAIC Strategies Group. Engineer Capabilities Study: A Path to the Future. (A Study Conducted for Joint Staff J-4 Engineer Division) McLean, VA 22102, 30 September 2002.

U.S. Department of the Army. Objective Force Unit of Employment Concept (Final Coordinating Draft) TRADOC Pamphlet 525-3-92. Ft Monroe, VA; U.S. Department of the Army, November 2002.

U.S. Department of Army. Operations. Field Manual 3-0. Washington, D.C.: U.S. Department of the Army, 14 June 2001.

U.S. Department of the Army/Marine Corps. River Crossing Operations. FM 90-13/MCWP 3-17.1. Washington D.C.: U.S. Department of Army/US Marine Corps.

U.S. Department of Defense. National Military Strategy of the United States of America. Washington D.C.: U.S. Department of Defense, September 1997.

U.S./R.O.K. Combined Forces Command. "Theater Bridge Management Plan." Seoul, Korea: Headquarters Combined Forces Command, May 2002, Ongoing study to address bridging requirements in Korea.