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Rapidly Installed Fluid Transfer System (RIFTS)

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ABSTRACT

Fossil fuels will continue to be the primary propulsion fuel for military aircraft, vehicles, and ground equipment for the foreseeable future. Water is the critical fuel to sustain the ultimate weapon, our soldiers. Distributing large quantities of bulk fuel and water required on the battlefield in the 21st century will require rapid deployment, installation, and recovery capabilities not inherent in existing petroleum and water distribution equipment. The Rapidly Installed Fluid Transfer System (RIFTS) will be designed to minimize strategic transport assets to deliver it to the theater of operation, will require fewer assets to deploy, will be easily recovered for redeployment, and will have an expected minimum service life of 15-25 years.

INTRODUCTION

Since World War II, distributing the required bulk liquid (fuel and water) at the right time and place in the battlefield has always been a challenge for the logistic operation and mission essential to the success of the battles. Without these commodities, the equipment will not operate and the soldiers will not be able to execute their tasks. Pipelines and hoselines have long since been recognized as the most efficient means to distribute the bulk liquids from one location to another location. This paper will address the issues of the existing Army bulk fuel distribution system and will discuss the benefits and issues of the new developmental system, RIFTS. The new system will resolve some of the deficiencies the Army faces today. For the purpose of this paper, the topic will focus on fuel distribution only.

BACKGROUND

CURRENT ARMY SYSTEM

The current Army bulk fuel distribution system is the Inland Petroleum Distribution System (IPDS) and was developed in the late 1980's. Until the advent of tactical pipelines, the distribution of fuel to forward areas depended on ground trucks, rail, and air. IPDS was designed to be a lightweight, rapidly deployable pipeline and terminal system used in undeveloped theaters. It provides the means to transfer, receive, store, and dispense bulk fuel to sustain the fighting weapons and vehicles.

Components

Major components of IPDS include aluminum pipe, pump stations, and fuel storage.

All components used on the main run of the pipeline are in 5-mile sets. Each set contains material required for a complete 5 miles. There are 1,404 sections of 19-foot long IPDS single-grooved aluminum pipe with coupling clamps and gaskets. The pipe is 6-inch in diameter with variable wall thickness and is packaged in 20-foot ISO containers with 156 sections of pipe in each of nine containers. An allotment of elbows and coupling clamps for directional changes and expansion/contraction devices, as well as gate valves, vent assemblies, pipeline anchors, culvert, overcouplings, and repair clamps are packed in four additional containers.

Each pump station is made up of two 20-foot length skid-mounted, 800 gallons per minutes (GPM), diesel engine-driven, mainline pumps. Each pump station also includes launcher and receiver assemblies, a dual in-line strainer assembly, and a floodlight set which are all stored in 20-foot ISO containers.

The IPDS fuel storage called the Tactical Petroleum Terminals (TPT), has the capacity to store 3,700,000 gallons in eighteen 5,000 barrel (210,000-gallon), collapsible fabric tanks. The TPT is modular with three identical fuel units. Each TPT also has one pipeline connection assembly.

Support equipments for IPDS include suspension bridge, gap crossing, stabilization equipment, pipe cutting tools, and other items.

<u>IPDS Shortfalls</u>

The Army has the responsibility to provide bulk fuel from the shore line inland to the operational forces. Using pipelines as the most efficient means, IPDS was designed to accomplish this mission. However, as the Army moves toward a single, seamless theater

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distribution system, IPDS lacks the technological ability to support the fast pace of the modern operations.

Labor Intensive and Lengthy Installation Process

The major shortfall of the IPDS is the amount of time and manpower that's required for emplacement and recovery. Installation of IPDS is a laborious and time consuming process. The Engineer Pipeline Construction Support Company is responsible for the construction and testing of the IPDS. The soldiers have to off load each of the 19-foot long pipe from the ISO container onto the medium tactical 5-ton truck. From the truck, the soldiers have to off load the pipe and place them on the emplacement trace and couple the pipe every 19 feet. The average installation rate is approximately 2 miles per day per company.

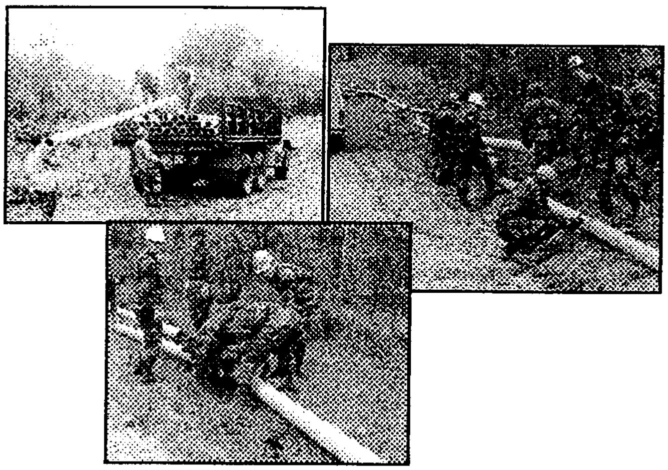


FIGURE 1 Soldiers offloading the pipe from the truck; installing an expansion loop; and installing the IPDS pipeline and connection every 19 feet.

Once the pipeline is all hooked up to the pumping stations and bag terminals, the system needs to be tested with water to check for leaks and to flush out any debris in the system before running actual products in the line. This is part of the cause to the lengthy construction time before the system is fully operational.

After successful testing to ensure proper operation, the IPDS is turned over to the Quartermaster Petroleum Pipeline and Terminal Operating Company (PPTOC) for operation and maintenance.

Future Force operations demand that combat systems be rapidly deployable to the theater, rapidly emplaced upon arrival, and rapidly relocated to support a fast moving non-linear battlefield. With the inherent extensive installation process, IPDS lacks the mobility to be recovered and moved quickly to a different location in time to support a changing mission if and when is required.

Strategic Lift

The second major shortfall of the IPDS is the enormous strategic lift requirements. The PPTOC is responsible for operation of up to 90 miles of pipeline, 6 pump stations, and one TPT. With one 5-mile pipeline set requiring 13 ISO-1CC containers, 6 containers for one pump station, and 77 containers for one TPT, a total of 347 containers would need to be transported. In addition, the ISO-1CC configuration causes a transportation constraint in which it requires special equipment for C-130 transport. Transportation assets are high demand items on the battlefield. Effective operation of IPDS will depend heavily on the availability of the transportation assets.

Other Shortfalls

Other short falls include

- High level of trace preparation
- High number of potential leak points (every 19 feet)
- Limited availability of repair parts as components become obsolete.
- Manual operations

LESSONS LEARNED FROM OPERATIONS IRAQI FREEDOM

Before the soldiers were given the order to cross the line of departure to start Operation Iraqi Freedom (OIF), CENTCOM commander needed to make certain that the fuel distribution system was in placed with sufficient quantities of fuel stocks on the ground in Kuwait to support combat forces to decisive victory. The Inland Petroleum Distribution System (IPDS) was used in conjunction with commercial pipelines and military trucks to accomplish that mission. To support OIF, 220 miles of IPDS were constructed; 20 pump stations were commissioned; and 6 Army tactical petroleum terminals (TPT) were constructed. A total of 1300 20-foot ISO containers were transported.

Despite the success having delivered 80 million gallons of fuel to support the war, shortfalls were identified in using the IPDS.

Lengthy construction time was required. With a well-trained construction company, the best time achieved was only 4-5 miles per day. That did not include the time required to flush and pressure test the system. Communication was unreliable. Although radios were procured to support the pumping operations, atmospheric conditions during nighttime and during some of the more severe sandstorms interfered with the radio transmission. There were times when the pumping operations were carried out without the knowledge of the conditions of the other pumping stations. Other shortfalls included the fuel storage bags failing, inability to maintain the IPDS pumps due to obsolete parts, and the lack of organic transport assets to support IPDS operations.

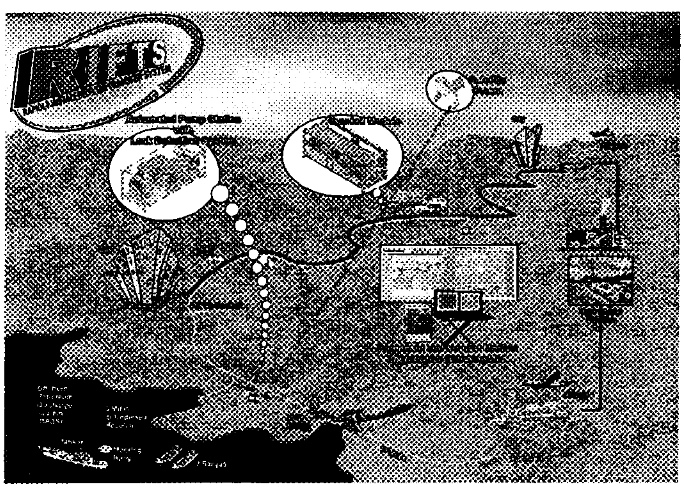
From the OIF experience, success stories were told about the use of IPDS to support the war. Nevertheless, a need was shown that a more flexible, deployable, recoverable, and reliable fuel distribution system is required for victories of the future operations.

RAPIDLY INSTALLED FLUID TRANSFER SYSTEM (RIFTS)

Several years prior to the OIF event, the Army realized the need to re-evaluate the existing processes/methods by which the Army currently delivers bulk fluid on the battlefield. History verified the deficiencies in providing sufficient amount of petroleum and water to support even the smallest fighting force. Through the various recent analysis, alternative conduit technologies have become promising which can be applied to bulk fluid distribution. With the integration of these alternative technologies, the RIFTS is being developed to eliminate the bulk fluid resupply deficiencies by providing a rapidly deployable, easily constructed cross-country distribution system. The Operational Requirement Documents (ORD) was established and approved in August 2000.

OPERATIONAL CONCEPTS

The RIFTS is a bulk liquid distribution system. The RIFTS will be used in support of fluid distribution from the port of entry, forward into the theater as far as security and equipment availability allows. With the use of a rapidly installed conduit, the system can provide the ability to rapidly transfer petroleum and water while decreasing traffic on main supply routes. Using a minimum of manpower, the RIFTS moves large quantities of fuel to intermediate and head storage terminals. The RIFTS can be deployed to support wartime and peacekeeping operations. The RIFTS is ideally suited for operational areas that do not have adequate petroleum, water and transportation infrastructure. The system can be deployed and operated over various terrain and obstacles that bulk tankers are not able to negotiate.



COMPONENTS

The RIFTS will include all the components necessary to deploy, operate, and recover the system. Major components of the system include the Conduit Module, the Automated Pumping Station (APS), the Command and Control Module (C2M) with leak detection capability, and the Computer Based Planning Aid. The RIFTS is a developmental program and will integrate the use of commercial off the shelf items within its components.

<u>Conduit Module</u>

The Conduit Module includes the collapsible high pressure conduit and the emplacement and retrieval devices (ERD). It provides the main distinction between the RIFTS and the IPDS. The collapsibility characteristic of the conduit allows the use of a hose reel type powered device to emplace and retrieve. This affords the system to be employed at 20 miles per 20 hrs day and retrieved at 10 miles per 20 hrs day. This provides ten times faster emplacement rate over the IPDS. In May 2002, the feasibility of meeting the emplacement and retrieval rates were verified through the technological demonstration that was conducted at Fort Pickett, VA. Two different ERD prototype concepts were used at the demonstration.

Conduit

The collapsible high-pressure conduit presents the most technological challenge of the RIFTS system. From two separate reports, Alternative Materials for Inland Petroleum Distribution System Pipeline Conduit in 1999 and RIFTS Conduit Study Report in 2002, findings were made that the use of a traditional collapsible type hoseline is the best alternative for the RIFTS application. The ideal RIFTS conduit is lightweight, flexible, collapsible, and able to withstand an operational pressure of 740 pound per square inch (psi) with a burst to operational pressure ratio of 3 to 1. Although pressure is not part of the ORD requirement, a conduit that has all the added features and still maintain the pressure capability of a hard wall pipe would allow a direct replacement of the IPDS pipe.

Currently, there are no commercially available hoseline that can meet all of the stated requirements. The fuel distribution hoselines that are being used in the armed services, are lightweight, collapsible hoses which use through-the-weave extrusion construction with polyurethane polymer as the cover and liner and polyester fiber as the reinforcement. The operational pressure capability is no more than 150 psi with diameter sizes of up to 6 inches, and the burst pressure is no more than 600 psi.

To develop the RIFTS conduit, the manufacturers recommend the use of traditional collapsible hose construction method, integrating the woven or braided high-tenacity reinforcement fiber and encapsulated with an extruded polymer. Some of the key requirements for the conduit are listed below:

Finished Hose properties

- Tensile and flexural strength (burst pressure of 2220 psi)
- Burst to working pressure ratio of 3 to 1
- Fuel resistance
- Ozone and UV resistance
- Abrasion and cut resistance
- Field repairable
- Operating Temperature (160 °F of fluid temperature)
- Coupling

Fibers

- Flexibility to allow a layflat configuration
- Strong adhesion to the polymeric hose lining and cover
- Should not succumb to flexural fatigue
- Abrasion and cut resistance
- Creep resistance under normal operating condition. Elongation of no more than 3%.

Cover/Liner Polymer

- Strong bonds to the reinforcement fibers
- Liner must have a low coefficient of friction

For the 2002 Fort Pickett technological demonstration effort, one hose manufacturer maximized the use of polyester as reinforcement and constructed a 6-inch diameter layflat hose with a burst pressure of 1125 psi, half the desired pressure requirement. To produce a higher pressure hose, it requires the use of higher tenacity fiber. Several potential fibers for the development of RIFTS conduit are identified:

1. VECTRAN - a Liquid Crystal Polymer
2. Zylon - a rigid-rod isotropic crystal polymer
3. Spectra – Ultra High Molecular Weight Polyethylene
4. Kuralon – Polyvinyl Alcohol

All of these fibers have a much stronger tenacity than the common polyester fiber, which is commonly used in the hose industry. However, between cost trade off and some performance characteristics, a blend of these fibers might be used to cut down on cost and/or to supplement some of the required characteristics.

The RIFTS conduit will afford the space saving while provide similar flow distribution capability as the hard wall pipe.

Emplacement and Retrieval Device (ERD)

The RIFTS conduit will be stored, deployed, and retrieved using the Emplacement and Retrieval Devices (ERDs). Some of the requirements were resulting from the 2002 technology demonstration's lesson learned. Each ERD is a flatrack mounted, powered, motor-driven device and stores a minimum of one mile of conduit. The ERD will be able to lay the conduit a minimum of 8 feet outside the edge of a road without the emplacement vehicle having to leave the road surface. The devices will be configured with ISO-1C dimensions and be capable of being handled by the Palletized Load System (PLS) and the HEMTT Load Handling System (HEMITT-LHS) using only the load handling system. The ERDs have the capability of employing and retrieving the conduit over any terrain that the emplacement vehicles are capable of traversing. With the use of the ERDs, the RIFTS will be able to meet the emplacement and retrieval rates of 20 miles per day (mpd) and 10 mpd respectively. The ERD operator uses a wireless control panel to operate the system and a wireless headphone to communicate with the driver of the emplacement vehicle.

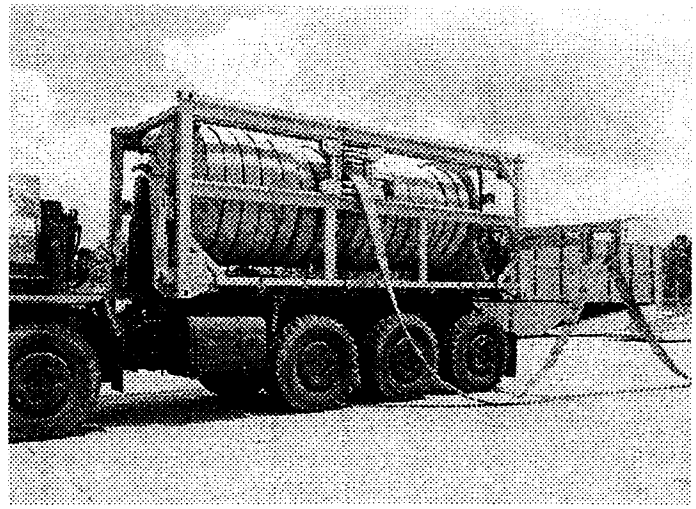


FIGURE 2: ERD prototype by KECO Industries

The ease of operation of the ERD will depend upon the characteristic of the conduit. The flexibility, the collapsibility, the size of the coupling, and the weight of the conduit will all affect the effectiveness and smoothness of operations.

The Conduit Module will reduce the logistic footprint by as much as 50 percent and will reduce manpower requirements for operation.

Automated Pumping Station (APS)

The Automated Pumping Station (APS) will also be flatrack mounted and transported by the same vehicles as the ERDs. The RIFTS APS will be diesel engine-driven and able to withstand a pressure of up to 2220 psi. The RIFTS will be capable of transferring up to 1,000,000 gallons of fuel each day, equivalent to 800 gallons of fuel per minute.

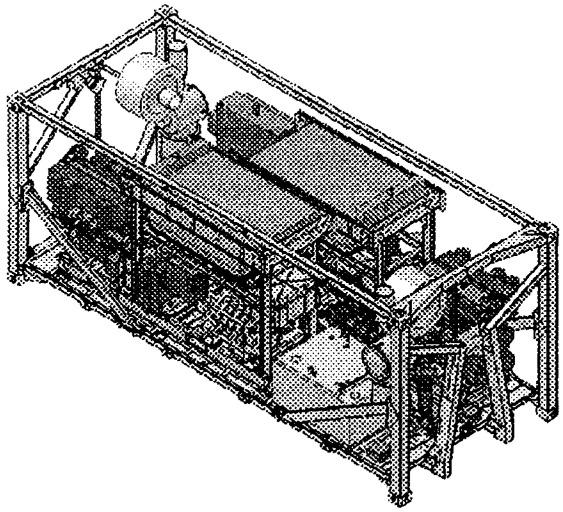


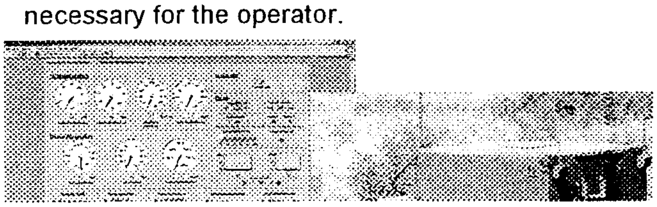
FIGURE 3: APS Concept Design

The main advantages of the RIFTS APS over the IPDS pumping station include ease of installation, automated operation, and reduction in size and support equipment. Instead of two skid mounted pump, the RIFTS APS will incorporate two pumps on one flatrack with the dimension of an ISO-1C container. In addition, each APS is equipped with an automated control system to provide real-time operational control and status of the APS. This includes regulation and control of the pump assemblies; signal conditioning and A/D conversion of the instrumentation; send and receive commands from the Command and Control Module (C2M) and local user interface; and safety and system protection. The APS will be modular in design to allow ease of maintenance and repair. The APS will also have a logistic footprint reduction of 50% over the existing IPDS pumping station.

Command and Control Module (C2M)

The RIFTS Command and Control Module (C2M) is an added feature for the bulk fluid distribution operation. The requirement is to provide a C2M to control up to 50 miles of conduit and is the central command for the distribution operation of the RIFTS. The C2M is comprised of two main functions, system control and leak detection. The C2M displays real-time status information between pumping stations, provides real-time remote control of pumping stations, and performs leak detection of the deployed distributed system. The C2M requires only one operator for operation.

The C2M will be configured inside an International Organization for Standardization Tactical Operations Center (ISO TOC) or a Standardized Integrated Command Post System Rigid Wall Shelter (SICPS RWS). The shelter will be environmentally controled and provide the workspace, power, and lighting necessary for the operator.



Leak Detection

Leak Detection is another added feature for the bulk fluid distribution operation and incorporated as part of the C2M. Currently, leak detection for the IPDS is a manual task and unreliable. A leak is noted if a sudden pressure drop from the pumping station is observed. This requires the soldiers to constantly monitor the pumping station operation. In addition, the size and location of the leak will not be known. The leak detection capability for the RIFTS will have the capability to automatically detect and locate small leaks (loss of 10 gallons per minute (gpm) anywhere along the RIFTS), or a leak rate of 1.25 % or the total flow. Instrumentation will be incorporated in each APS and will not require additional installation and retrieval to the RIFTS.

Leak detection on a flexible conduit has never been done in the industry. A proof of concept demonstration was conducted using a commercial pipeline management system. The system is a statistical conduit leak detection system that incorporates pattern recognition functions. It detects changes in the relationship between flow and pressure using available measurement data. When a leak occurs, the system will detect changes or patterns in the decrease in conduit pressure and discrepancies between the inlet and outlet flow-rate. It reduces the chances for false alarm by statically processing and trending data. Modification was made to tailor to the tactical and flexible conduit application. Overall, the system performed well on a two-inch hoseline system. It was capable of detecting leaks as small as 0.5 %. Furthermore, the time to detect these leaks ranges from a few seconds (for the larger leaks) to a few minutes (for the small leaks); larger the leak, shorter the detection time. The leak location also follows the same trend as leak detection; larger the leak, more accurate the leak location. The error ranges from 0.5 % to 18%. The system is also capable of detecting initial leaks that exists prior to the APSs are in operation. It is a robust system which doesn't cause false alarm even in transient events such as initial packing of the conduit. Further development of this system will be done for the adaptation to the RIFTS operation.

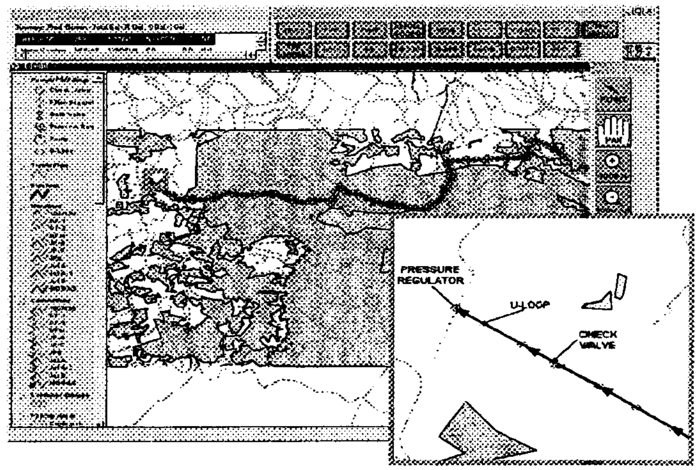
Communication System

Communication System is the data connection path between the C2M and the APSs and it's an important aspect to the success of the remote and automated operations. The communication system is capable of transmitting and receiving the data of up to 15 APS over a 50 mile radius and has an aggregate data rate of at least 50 kilobits per second (kbps). A robust and reliable system is needed in order to take advantage of the remote and automation features of the RIFTS. Options are available for either a wired or wireless system. The wired system will take the form of the DSL technology. A shielded buried distribution cable will be connected between the C2M and all the APSs. The wireless communication options include the Line-of-Sight (LOS) radios and satellite based modems. The LOS radio communication is simple for implementation. However, LOS communication may not work for long distance or hilly or rough terrain which would require repeater devices to extend data transmission range. The satellite based modem is a more preferable option for the digital data transmission. The only LOS required is between the RIFTS communication system to the satellite transceiver. However, many commercially available satellite modems have a lower bandwidth and thus it's inadequate for the data rate transmission required by the RIFTS. Nevertheless, a high bandwidth satellite based communication is being developed and will be ready for Army used. The Army's standard Force XXI Battle Command, Brigade and Below (FBCB2) Blue Force Tracker (BFT) is a digital command and control (C2) system that communicates by satellite. It provides reliable means of communication for units operating hundred of miles from higher headquarters but has low bandwidth. Efforts are currently underway to increase bandwidth and lift the current 576-byte message size limitations. The FBCB2-FBT will be ideal for the RIFTS communication system. Other factors for communication system consideration include spectrum allocation (U.S. versus foreign), interference (from other transmission or jamming), worldwide usability, data encryption (for security), and system commonality (use of existing assets when possible for reduced logistics). The use of more than one communication option will be required to provide flexibility and redundancy.

Computer Based Planning Aid

Computer Based Planning Aid is a tool used for trace planning prior to deployment. It is a stand-alone application that incorporates Geographic Information System (GIS) elements to support optimal conduit trace planning for the RIFTS. The planning aid will provide an optimum deployment trace, location of the APS and associated equipment, and a materials list of components required to install the system. A prototype is being developed and will be using one or more of Microsoft's .NET languages (C#, VB.Net, J#), VB6, and ESRI's ArcObjects libraries. Functional features include:

- Specific map location / area of operation – include elevation and location data.
- Conduit start, mid and end locations
- Foundation data input which include design constraints, optimization criteria, and emplacing/recovering platform mobility constraints.
- Conduit trace – generate the optimal trace, placement of APS and associated equipment, and complied equipment list
- print reports / save results
- Edit trace / recalculate equipment placement and list once deployed in the field.



Variety of National Geospatial-Intelligence Agency (NGA) digital terrain and mapping data will be used to provide accurate trace planning. Data include, but not limited to Vector Map (VMAP), Foundation Feature Data (FFD), and Digital Terrain Elevation Data (DTED).

The planning aid is being developed to communicate/ interact with the C2M.

PROGRAM STATUS AND ROADS AHEAD

RIFTS is a developmental program. Milestone A was obtained in March 2003 and a sole-source, cost-type contract was awarded to Southwest Research Institute (SwRI) in April 2003. SwRI was contracted to design and fabricate a fully functional RIFTS technology demonstrator which includes five miles of conduit, five ERDS, one APS, and one C2M.

After recent OIF lessons learned, the Army combat commanders requested the acceleration of the RIFTS program. As a result, an evolutionary acquisition approach is being implemented through the development and fielding of incremental RIFTS capabilities divided into Block I and Block II. Block I will include the development of RIFTS conduit module and all the auxiliary equipment. Block II will include the development of the APS, the Command and Control Module with the leak detection system, a Computer-based Planning Aid, and all the auxiliary equipment.

Due to the change in acquisition strategy from a traditional to an incremental development approach, the contract has been modified to support the development of both Block I and Block II. The scope of work has increased to include the development of the 750-psi conduit and to fabricate an additional of 5-miles of Block I components with all the necessary logistics requirements and data deliverables to support the planned system testing and the MS C decision.

The incremental development strategy provides the means to accelerate the production and fielding of critical RIFTS modules while continuing to develop and integrate new technologies to enhance overall system capabilities and performance. The program has entered the Concept and Technology Development (CTD) phase. A milestone C decision to include full production release for Block I will be sought at the end of this phase. BLK II will seek for a milestone B decision to allow the program enters into the System Development and Demonstration (SDD) phase.

US ARMY RDECOM-TARDEC Petroleum and Water Business Area will assemble and lead the Integrated Product Team (IPT) through the CTD phase. The Product Manager for Petroleum and Water Systems (PM PAWS) will assume lead program management responsibilities of the RIFTS program at Milestone B, guiding the block development efforts into initial production and fielding. RIFTS is the first PM PAWS program to utilize the evolutionary acquisition approach.

CONCLUSION

RIFTS is a tactical bulk liquid transfer system with the objective that it's mobile enough so that it can follow the forces whenever the mission changes. Distribution of fuel and water is vital to the success of the current and future battlefield. Using the state of the art technology, the Conduit Module will increase the deployment rate by ten-fold over the existing system, with a minimum of 20 miles per day (mpd). The Automated Pumping Station will increase mobility by becoming smaller in size and provide the minimum fluid throughput of 850,000 gallons of per day. The Command and Control Module and the Computer Based Planning Aid will increase alertness and response time by providing a quick optimum route for system layout and provide real time system operational status. The leak detection capability will provide fast location of leak points in cases of fuel distribution. In addition, the RIFTS will dramatically decrease the strategic lift requirement by as much as 50% and will be C-130 transportable. Also, it will cut down the amount of manpower required for installation and operation. The RIFTS will be responsive, deployable, agile, versatile, and sustainable, and will feed into the lethality and survivability of the fighting force.

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