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14. ABSTRACT : A. Mobile Communications Platform (MCP). The MCP's modular design permits a wide range of mission profiles. Additionally, the vehicle's design optimizes a graceful evolution of capabilities as new and improved telecommunications and telehealth technologies become available. Designed from the lessons learned in previous technology-development research projects, the MCP demonstrates CERMUSA's commitment to improving the delivery of healthcare, information, and education through the application of appropriate technologies to people in rural and underserved areas. B. Robotic Emergency Medicine and Danger-Detection (REMeD D) In many communities, steps are being taken to reduce the risk of an attack and improve the emergency response system's ability to respond to emergencies resulting from bioterrorist actions. In an effort to improve the civilian and military response to WMD attacks in rural areas, CERMUSA is conducting a research study to evaluate the application of robotics and advanced telecommunications technologies to existing emergency management and response authorities. While urban areas remain terrorists' most likely targets, the risk of a WMD attack on a rural population remains possible. As a result, the REMeD D project offers a model to follow when developing a system to prepare for and manage emergencies resulting from a terrorist attack implemented using weapons of mass destruction.

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I. Introduction

A. Mobile Communications Platform (MCP) Abstract

Poor highways, telecommunications and related infrastructures, geographic constraints, and extreme environmental conditions often contribute to the geographical seclusion of remote and isolated regions. This makes access to the highest quality healthcare and education to residents of these areas difficult and expensive. These same constraints also hamper the efforts of emergency responders serving rural and isolated populations to effectively communicate and respond to natural or man-made hazards. Recent advances in telecommunications technologies offer potential solutions to many of these problems. However, due to an array of social and financial pressures, many communities that could benefit from these technologies lack the capability to do so. Therefore, CERMUSA proposed the development of the Mobile Communications Platform (MCP) prototype vehicle.

The MCP is a vehicular solution that provides both telecommunications capabilities and a range of modular mission-specific tools that can be delivered and used at mass casualty scenes, remote clinic sites, or wherever a temporary broadband “footprint” is required. A modular telemedicine cart, based on a CERMUSA design for use in rural hospitals, constitutes this vehicle’s primary payload. The MCP can also serve as a fielded “command and control” center for emergency responders. Built on a Hummer H1 chassis, the MCP’s design accommodates both civilian and military transportation infrastructures and affords access even in challenging remote terrain. A satellite communications connection provides up to 1.2 mbps of bandwidth that can be used for video conferencing, computer networking, voice over IP (VoIP) telephones, and other IP-based applications. An 802.11b wireless system and integrated hardwire routing system provides support for a robust on-scene wireless local area network (WLAN), which allows improved communications between incident responders and superior situational awareness for command staff, both on scene and “behind the lines”.

The MCP’s modular design permits a wide range of mission profiles. Multiple tests and demonstrations in a variety of environments have shown the MCP’s ability to make use of existing technology infrastructures while seamlessly integrating its own technology array. Additionally, the vehicle’s design optimizes a graceful evolution of capabilities as new and improved telecommunications and telehealth technologies become available. For example, the MCP’s operational “footprint” may be extended using wireless technologies, such as a mesh networking. Mesh networking is defined as a subclass of mobile ad hoc networking that allows for continuous connections and reconfiguration around broken or blocked paths by "hopping" from node to node until the destination is reached.

Designed from the lessons learned in previous technology-development research projects, the MCP demonstrates CERMUSA’s commitment to improving the delivery of healthcare, information, and education through the application of appropriate technologies to people in rural and underserved areas.

B. Robotic Emergency Medicine and Danger-Detection (REMeD-D) Abstract

Since the attacks of September 11, 2001, Americans have become more aware of the potential threat of terrorist actions. In many communities, steps are being taken to reduce the risk of an attack and improve the emergency response system's ability to respond to emergencies resulting from bioterrorist actions. As a result, research studies have been performed to assess the present level of Weapons of Mass Destruction (WMD) readiness in these communities and suggest methods of improving their response capabilities in the event of an incident. The results of these studies suggest that robotics and communications technologies can be utilized to provide medical treatment to victims of bioterrorist attacks, and, when necessary, transport these victims from the site of the attack to a secure area.

In an effort to improve the civilian and military response to WMD attacks in rural areas, CERMUSA is conducting a research study to evaluate the application of robotics and advanced telecommunications technologies to existing emergency management and response authorities. The Robotic Emergency Medicine and Danger-Detection (REMeD-D) research project is a system of interoperable robots designed to remotely detect biological, chemical, or nuclear agents, locate victims, assess their physical condition, and then extract them to a safe location for medical intervention.
While urban areas remain terrorists' most likely targets, the risk of a WMD attack on a rural population remains possible. Moreover, any WMD attack, even in an urban population, can be widespread, affecting not only the immediate area but the surrounding rural communities. Therefore, when preparing for a WMD incident, rural areas must be able to assess their strengths and weaknesses in order to develop a rational, sustainable response plan, not only to serve their own communities, but also to effectively assist overwhelmed urban response units. The unique social, political, and environmental characteristics of rural communities create management and implementation obstacles that differ from the challenges that urban areas face when developing a system to deal with the threat of WMD. As a result, the REMeD-D project offers a model to follow when developing a system to prepare for and manage emergencies resulting from a terrorist attack implemented using weapons of mass destruction.

C. Executive Summary

Together, the MCP program and the associated REMeD-D project form the nucleus of a technology driven emergency response infrastructure. This project's principle question centered on the amalgamation of hardware and software in the areas of communications, sensing, and mobility; in short, could these various technologies be combined to form a system that could potentially be integrated into existing emergency response environments?

Because it is based on robust, mature technologies, the MCP project has focused on the packaging of those technologies and their related capabilities into a relatively compact form factor. Communications vehicles with similar capabilities have been developed and deployed in a variety of military and civil environments, but most of these have been designed around considerably larger vehicles that not only house the technology but also provide work space for multiple users. The MCP's compact design is based on the notion that this form factor is far better able to negotiate terrain denied to larger over-the-road vehicles, thus increasing its potential field of operations; and that once the communications capabilities are brought to wherever needed, working space can be borrowed or provisioned through any number of commonly available means. It is anticipated that the MCP's mobility and modular mission specific payload capability can be further demonstrated in support of ongoing and future CERMUSA research efforts.

Among the existing and proposed CERMUSA projects in which the MCP would prove useful:

- National Bioterrorism Civilian Medical Response Center (CiMeRC) - Tactical Communications Network for First Responders (TaCNet)
    - simulated police response to school shooting/hostage incident
- Wireless Test Bed
    - Delivery to scene, remote situational awareness, communications support and throughput for *ad hoc* mesh network research
- Keystone Innovation Zone (KIZ) program
    - Study potential of MCP communications services commercial applications
- CERMUSA and Monmouth University
- CERMUSA and Indiana University of Pennsylvania Research Institute
    - Civilian application of National Guard Civil Support Team Information Management System (CIMS)

The REMeD-D project successfully demonstrated a fusion of differing technology platforms operated by a common software architecture; however, significant questions remain regarding the potential practicability of such a system for automated patient extraction, either in battle space, or in civilian environments. On a positive note, the REMeD-D system does show considerable promise as a tool for far forward reconnaissance and situational awareness through its ability to deliver and manage a wide variety of environmental sensors – in short, a robotic equivalent of hearing, sight, smell, taste, and touch. TATRC has identified just such a research effort to which the majority of the REMeD-D system may be employed. Additionally, CERMUSA has identified an opportunity to use one portion of the REMeD-D system, an iRobot Packbot as a teleoperated or autonomous delivery system for the nodes that make up an ad hoc mesh network.

MCP Task List

1. Prototype/Project Definition
2. Prototype Requirements Definition
3. System/Data Requirements Definition
4. MCP Analysis and Design
5. MCP System Build/Prototype/Pilot
6. Implementation and Training
7. MCP Operational Sustainment

REMeD-D Task List

1. Technology/Programmatic market research
2. Programmatic needs assessment
3. Prototype build
4. Implementation and testing

Tasks 1 through 4 of the MCP project have previously been extensively reported following their respective conclusions in previous reports. This report focuses on Tasks 5 through 7. The REMeD-D project is effectively an extension of MCP Tasks 6 and 7. Of the five tasks identified under the REMeD-D program, this report will focus primarily on Task 4, but will encompass the project in its entirety, particularly from a technical perspective.

II. Body

A. Mobile Communications Platform (MCP)

Task 5: Mobile Communications Platform (MCP) Prototype System Build/Prototype/Pilot

a. Equipment Selection:

1. Vehicle/chassis selection

CERMUSA began searching for a candidate vehicular platform following a functional needs analysis. Based on the desired capability for carrying and establishing a complete telemedicine infrastructure for inclusion into rural hospitals or community facilities, the vehicle had to be large enough to carry a substantial amount of equipment. Including devices such as general exam cameras, otoscopes, computerized ultrasound, and specialized retinal cameras, the vehicle had to be capable of carrying several hundred pounds of embedded and relocatable gear.

Following an initial establishment of a capabilities/equipment list, The CERMUSA MCP team began scheduling site visits to observe technology integration into vehicular packages. Although the technological integration (communications, networking, videoconferencing, etc.) of these components in a mobile package was the focus, MCP staff took careful note of the vehicular form factors deployed.

Prior to these site visits, The CERMUSA MCP team anticipated that five platforms might be viable candidates for deployment. These platforms were:

- Civilian Hummer vehicle equipped with a communications enclosure
- Heavy-duty pickup with communications enclosure
- Heavy-duty SUV
- Full-size cargo van
- Box trucks/commercial freight vehicles

The overarching focus of the entire MCP project was “go-anywhere” telemedicine capabilities. Although most of the vehicles selected for evaluation had some level of off-road and utility capability (with the exception of box trucks/commercial freight vehicles, which were rejected for this very reason), none of them could match the Hummer chassis.

The Hummer platform had come to CERMUSA’s attention several years ago during a visit by the Army WINPOC (Warfighter Information Network Proof of Concept), a Hummer outfitted with a communications module used for the deployment of wireless wearable camera systems. The vehicle’s modular construction, ample power and towing capabilities, and unmatched off-road prowess made it the ultimate platform for deployment within the MCP project.

The CERMUSA MCP team also had the opportunity to observe several alternative arrangements via site visits to other research projects. Although large SUVs were adequate platforms for some satellite communications, their interiors were often cramped and unmanageable for the installation of large amounts of gear. Formal "rack space" had to be retrofitted to be fully functional. Similar issues were found to plague heavy duty pickups as well.

Although full-size cargo vans offered a very useful, utilitarian interior mounting surface and ample space for installations, all commercially offered units lacked serious off-road capabilities. The full and all-wheel drive systems offered by the manufacturers did not have adequate ground clearance and reinforced suspensions for extended off-road deployment.

2. Selection of enclosure/manufacturer

CERMUSA directly contacted AM General to discuss options for purchasing a civilian-grade Hummer equipped with a communications enclosure. AM General recommended the purchase of a K-series civilian Hummer pickup. K-series Hummers are roughly equivalent to military-grade vehicles with minimal accommodations and are sold primarily for industrial and fleet deployment. AM General suggested that we make the purchase and perform any modifications through Danko Emergency Equipment, Inc., in Snyder, Nebraska. According to AM General, Danko was the only factory-authorized modification shop for civilian-grade Hummers in the United States. CERMUSA would be able to purchase the vehicle and integrated enclosure without worry of voiding any associated warranties. Due to the exclusive nature of Hummer's arrangement with Danko, this would also be a sole-source purchase. Based on the decision to pursue a Hummer chassis and Danko Emergency Equipment Company's exclusive arrangement with AM General, CERMUSA decided to purchase the MCP vehicle from Danko.

On July 11, 2002, Danko provided proposed structural diagrams to the CERMUSA MCP team for evaluation and equipment layout. The design was very similar to commercial enclosures for military Hummer vehicles and was based off of previous modifications performed by Danko for emergency and fire/rescue projects. The CERMUSA MCP team began working with the structural drawings in an attempt to fit all necessary telemedicine, computing, and audio/video components within the enclosure while maintaining a relatively comfortable and functional working environment. Initial floor plans were designed by CERMUSA staff as illustrated in Figures 1 and 2 on the following pages.

Figure 1

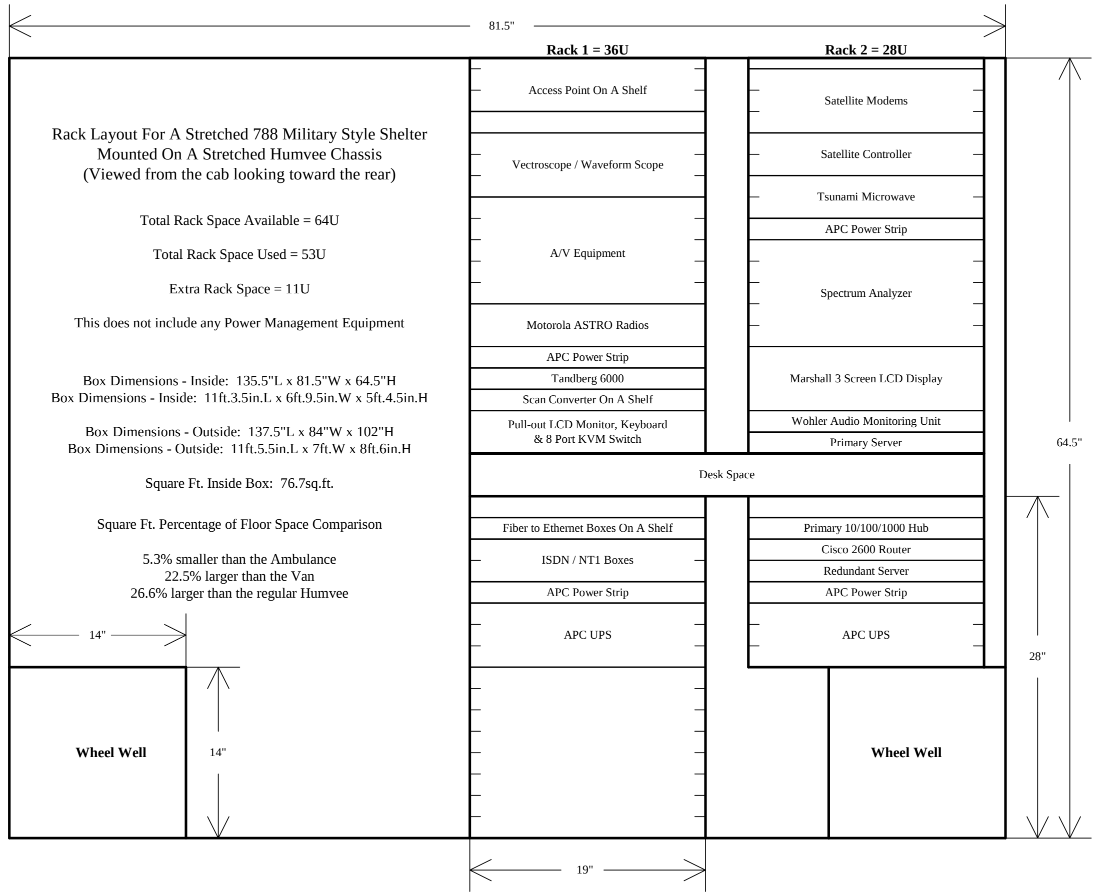
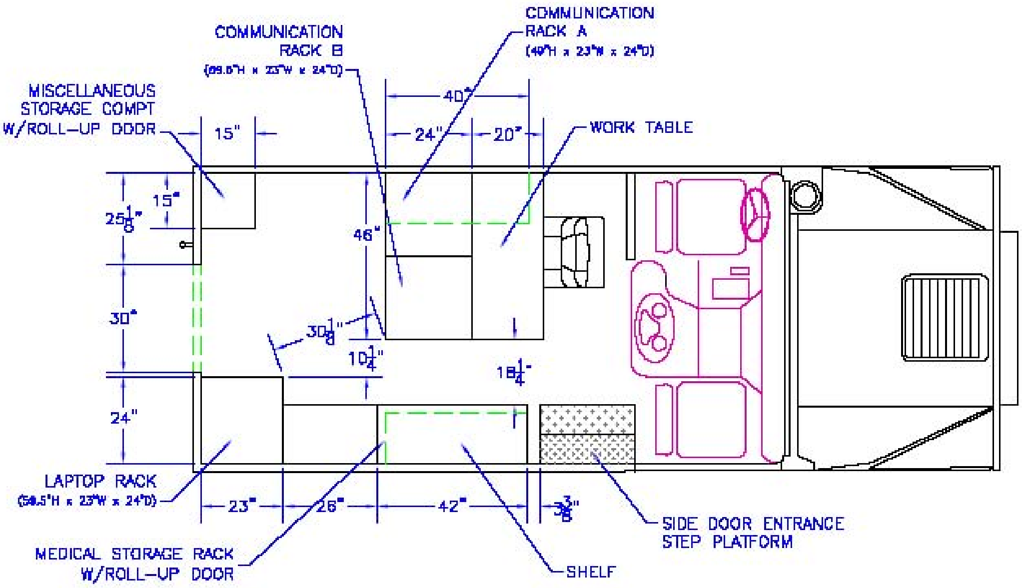
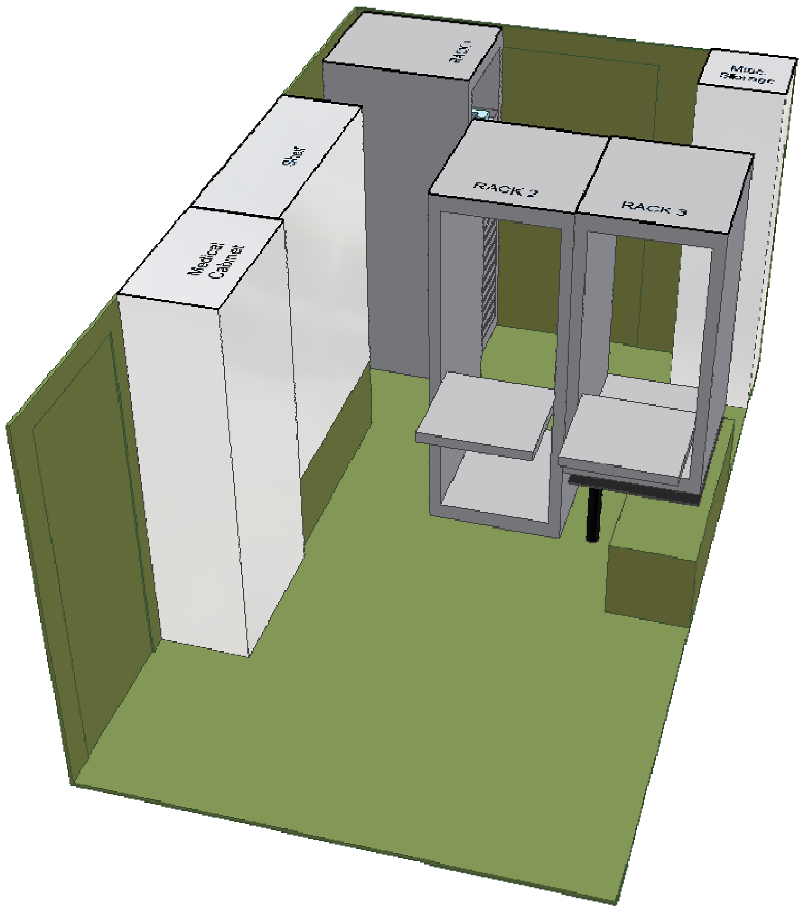

81.5"
Rack 1 = 36U
Rack 2 = 28U
Rack Layout For A Stretched 788 Military Style Shelter
Mounted On A Stretched Humvee Chassis
(Viewed from the cab looking toward the rear)
Total Rack Space Available = 64U
Total Rack Space Used = 53U
Extra Rack Space = 11U
This does not include any Power Management Equipment
Box Dimensions - Inside: 135.5"L x 81.5"W x 64.5"H
Box Dimensions - Inside: 11ft.3.5in.L x 6ft.9.5in.W x 5ft.4.5in.H
Box Dimensions - Outside: 137.5"L x 84"W x 102"H
Box Dimensions - Outside: 11ft.5.5in.L x 7ft.W x 8ft.6in.H
Square Ft. Inside Box: 76.7sq.ft.
Square Ft. Percentage of Floor Space Comparison
5.3% smaller than the Ambulance
22.5% larger than the Van
26.6% larger than the regular Humvee
Access Point On A Shelf
Vectroscope / Waveform Scope
A/V Equipment
Motorola ASTRO Radios
APC Power Strip
Tandberg 6000
Scan Converter On A Shelf
Pull-out LCD Monitor, Keyboard
& 8 Port KVM Switch
Satellite Modems
Satellite Controller
Tsunami Microwave
APC Power Strip
Spectrum Analyzer
Marshall 3 Screen LCD Display
Wohler Audio Monitoring Unit
Primary Server
Desk Space
Fiber to Ethernet Boxes On A Shelf
ISDN / NT1 Boxes
APC Power Strip
APC UPS
Primary 10/100/1000 Hub
Cisco 2600 Router
Redundant Server
APC Power Strip
APC UPS
64.5"
28"
14"
14"
Wheel Well
Wheel Well
19"

Figure 2


COMMUNICATION RACK B
COMMUNICATION RACK A
(40"H x 23"W x 24"D)
MISCELLANEOUS STORAGE COMPT W/ROLL-UP DOOR
WORK TABLE
15"
40"
24"
20"
15"
46"
30"
24"
LAPTOP RACK
MEDICAL STORAGE RACK W/ROLL-UP DOOR
23"
26"
42"
SHELF
SIDE DOOR ENTRANCE STEP PLATFORM

The CERMUSA MCP team approached Danko to ask for alternative designs that would generate greater interior space. Danko suggested cutting and extending the rear frame of the vehicle so that the overall enclosure size could be increased. Upon CERMUSA's request, Danko provided structural diagrams of the modified Hummer, such as the one shown in Figure 3, which increased the vehicle's length by approximately two feet.

Figure 3



Proposed payload bay interior layout

Prior to placing the order, CERMUSA discussed the frame modification with TATRC project management. TATRC was concerned with the overall structural stability of a modified frame, as well as the design philosophy of using nonstandard vehicle architecture. Based on further discussion with the Tank Automotive and Armament Command (TACOM), TATRC chose to disallow the purchase of a modified Hummer chassis. TACOM suggested that, if interior volume were an issue, CERMUSA should evaluate the Stewart and Stevenson FMTV (Family of Medium Tactical Vehicles) platform, such as the example shown in Figure 4.

Figure 4

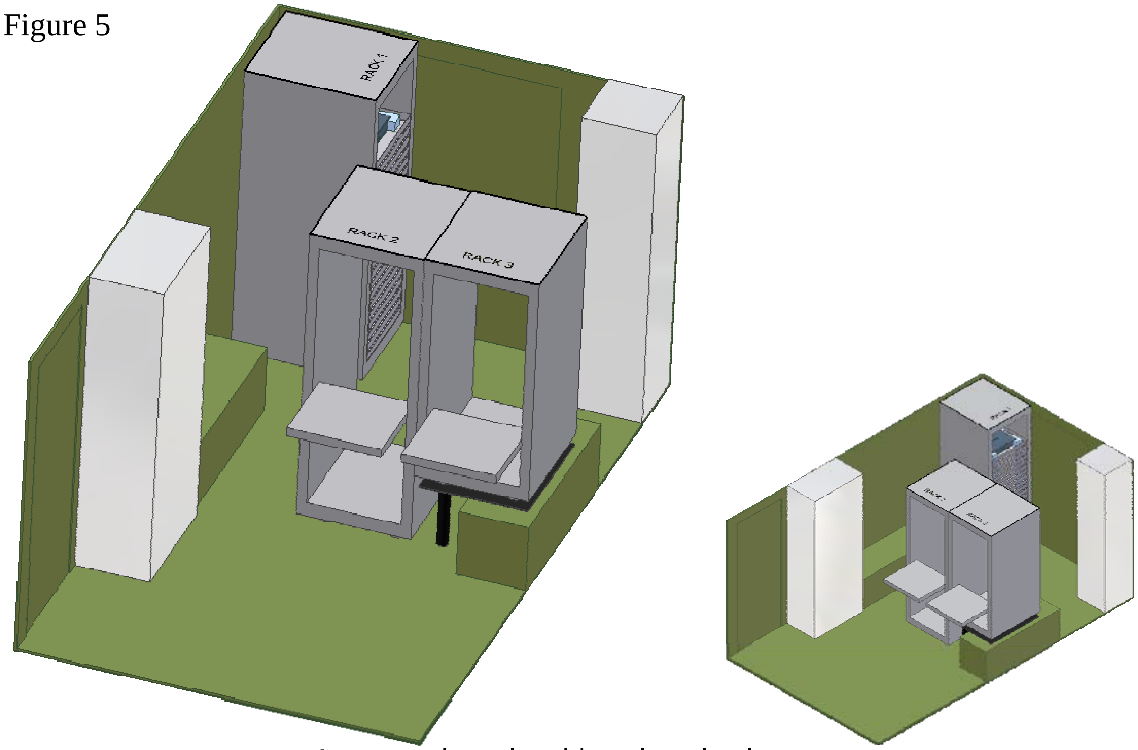
Photo from Army Fact File:
http://www.army.mil/fact_files_site/fmtv/index.html

The MCP team rejected the use of the FMTV platform for several reasons. First, the FMTV was substantially larger than the Hummer, creating a larger-than-desirable technical footprint. Second, unlike the Hummer, the FMTV was not a civilian-grade vehicle and was sold primarily to military audiences. Third, though a flexible and capable platform, the FMTV was not easily or inexpensively modified to accommodate a communications enclosure.

CERMUSA chose to proceed with a standard size Hummer H-1 K-series pickup chassis with communications enclosure, as originally planned. Despite the interior becoming more cramped than desirable, the MCP team determined that a standard chassis could be made to work satisfactorily. TATRC project management approved the plan, and on 10-13-2003, CERMUSA submitted a purchase order for the Danko-modified Hummer. The design of the communications enclosure is shown from two angles in Figure 5 on the next page.

The CERMUSA team made some changes on the drawing, based on later functional requirements. These changes included removal of the storage cabinet located in the compartment's right rear, as well as relocation of another cabinet in front of the left wheel well to behind the wheel well.

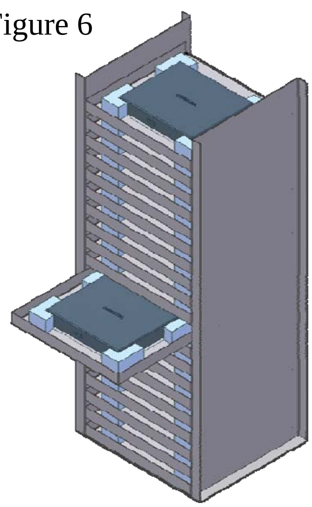
Figure 5



Approved payload bay interior layout

The shock-mounted laptop rack assembly is shown in Figure 6. Approximately 20 laptop computers were to be stored and transported in the racks upon completion of the vehicle.

Figure 6



The design of the rack included a power strip that would be used to charge the computers while they are being stored. Although this assembly shipped with the vehicle, it was later removed to allow room for installation of a powered lift gate. The life gate will be discussed in detail later.

3. Satellite/infrastructure selection:

The MCP's mission dictated that the vehicle be capable of creating a communications infrastructure by either utilizing existing on-site bandwidth, or, in the absence of such facilities, by creating its own infrastructure via satellite communications. The communications applications within the MCP would include videoconferencing, Internet access, voice communications, and computerized medical peripheral networking. CERMUSA IT assessed the sum total minimum bandwidth requirement as 512kbps, bi-directional.

Based on extensive market research, CERMUSA identified a list of viable candidate vendors/research projects that could provide "hands-on" examples of the kinds of satellite communications we were seeking. The CERMUSA MCP team evaluated the merits of each example and assembled a list of agencies worthy of site visits. This list and subsequent evaluations (as published in a previous MCP report) is as follows:

- ViaSat Satellite Service through Arrowhead Space and Telecommunications
- ViaSat Immeon bandwidth-on-demand satellite service through GCS
- Inmarsat through Raytheon's First Responder Emergency Communications System
- A turnkey satellite communications system offer by On Sight Communications
- FEMA Mobile Emergency Operations Vehicle (MEOV)

ViaSat Satellite Service Demonstration, Clarksburg, MD – October 2, 2002

i. In Attendance

CERMUSA Staff: Vicki Pendleton, Tom Bender, and Dave Wolfe. ComSat Laboratories Staff: Cal Zenner. Arrowhead Staff: Mike Shakarji.

ii. Purpose of Visit

ComSat Laboratories, a subsidiary of ViaSat, is a broadband on-demand satellite solutions provider. They manufacture and sell the LinkWay 2000 satellite terminal. This unit, along with a roof-mounted or pull-behind satellite trailer will provide a vehicle with a high speed IP connection to the outside world. Arrowhead Space and Telecommunications is a value-added reseller/integrator and ComSat dealer from the Virginia/Washington D.C. area.

iii. Summary of Visit

ComSat's entry into mid-bandwidth (384Kbps-4mbps) relocatable satellite communications is the Link Way 2000 system; deployed for mobile data and video communications via KU band satellite. Below is a list of options and specifications of the LinkWay 2000 system:

- There are two satellite setups for vehicular mounting. The turnkey solution is a fully automated dish positioning system. This type requires at least half of a full rack for positioning equipment, the LinkWay 2000 unit, and a Cisco Router. The turnkey setup also requires extra AC power, possibly from a generator or inverter. With a non-turnkey solution, there is a very small amount of rack-mounted equipment needed, but in turn, the dish must be pointed manually.
- The smallest satellite for a vehicle is a 1.2 meter KU Band dish. Deployment of a small mobile dish requires the fixed receive dish to be larger.
- The satellite dish can be mounted to the top of a vehicle or to a pull-behind trailer. Roof-mounted dishes can be folded for a low profile during transport.
- A UNIX-based computer is required at the downlink location to run the receive site. The computer equipment can be rented or bought from ComSat.
- Bandwidth is available from 512Kbps to 4Mbps half or full duplex with on-demand service or unlimited usage contracts.

- Owing to the use of satellites in geosynchronous orbit, there is a ¼ second delay to the satellite and another ¼ second back to earth along with a very small delay to pass through the land based switching equipment. A delay of less than one second would be acceptable for streaming video applications and audio telephony.
- Protocols supported include IP, Frame Relay, ATM, and ISDN.
- ComSat recommends a Cisco 2600 Series Router to route and combine all data traffic over the satellite link.

ComSat's LinkWay 2000 system provides a total high speed broadband communications solution to a mobile vehicle environment. An automated turnkey solution would greatly reduce the amount of manual set-up required. Because of the small size, the vehicular dish can be easily mounted to the roof of a van or SUV. The dish will operate in adverse weather conditions such as heavy rain or snow, although a small decrease in bandwidth may be seen due to rain fade. The satellite requires a 40 degree line of sight view of the southern sky for proper operation. The Cisco Router would allow for automated switching between various forms of bandwidth (ISDN, satellite, etc).

The LinkWay 2000 system is capable of providing adequate bandwidth for video conferencing, data, and IP traffic. CERMUSA IT staff would need to couple the LinkWay 2000 system with an appropriate router, based on the final medical data requirements. This system will meet all anticipated bandwidth needs of the MCP project.

For more information: www.viasat.com
www.arrowheadsat.com
www.cisco.com

iv. Relevance to MCP User Requirements

ViaSat offers a variety of options for satellite communications that may fit well within the MCP concept. Almost all components/services are available as either turnkey or integrator packages, allowing a great amount of flexibility in selecting a vehicular platform. As several other companies offer similar services, vendor quality and price will be key criteria for selecting the right approach/vendor. Arrowhead Space and Telecommunications has a strong reputation for quality and service in the satellite community.

GCS Satellite Service Demonstration, Rochester, NY – October 10, 2002

i. In Attendance

CERMUSA Staff: Vicki Pendleton, Tom Bender, Rob Dillon, and Dave Wolfe. GCS Staff: J. Todd Morrison and Vance Kannapel.

ii. Purpose of Visit

GCS is a broadband on-demand satellite solutions provider. They manufacture and sell Immeon bandwidth on demand satellite systems. These units, along with a roof-mounted or pull-behind satellite trailer will provide a vehicle with a high speed IP connection to the outside world.

iii. Summary of Visit

GCS technical staff provided a full walk-through of their staging, testing and manufacturing facilities. In addition to satellite components, GCS also performs a number of custom applications, including military enclosures and stand-alone communications facilities. One of the most noteworthy applications showcased was the Immeon system, which allows satellite users to pay only for accrued usage of airtime rather than reserving large blocks of time.

Below is a list of options and specifications of the Immeon system:

- There are two satellite setups for vehicular mounting, a fully automated turnkey solution, and a manual dish. The turnkey solution requires approximately 10 units of rack space for the positioning equipment; far less than the LinkWay 2000, which required at least half of a full rack. The non-turnkey solution requires the dish to be pointed manually and does not require quite as much rack space.
- The smallest satellite for a vehicle would be a 1.2 meter KU Band dish with a stow height of 1ft. 8 in. Deployment of a smaller mobile transmit dish would require that a larger dish of at least 2.4 meters be installed at the downlink site.
- Two downlink methods are available. In a point-to-point setup, CERMUSA would own all equipment including the uplink and downlink dishes. In a point-to-multipoint system, the signal would be brought down to a Network Operation Center (NOC) (a ground based hub of dial-up communications lines) in Norcross, GA and then back to CERMUSA over ISDN or IP.
- Bandwidth is available from 9.6Kbps to 4Mbps full duplex with on-demand service or unlimited usage contracts.
- A delay of less than one second is common with the Immeon satellite service. This delay would be acceptable for streaming video applications and audio telephony.
- A Cisco 2600 Series Router is required at each end to combine and separate all data traffic over the satellite link.

- With the Immeon system, video and audio transmissions take priority over IP data traffic such as the Internet.

GCS's Immeon bandwidth on demand system provides a total high speed broadband communications solution to a mobile vehicle environment. Because of the increased automation, a turnkey solution would be quicker and less complex to set up. The satellite dish is small enough to be easily mounted to the roof of a van or SUV and would be operational anywhere in the continental U.S., Alaska, and Hawaii. The Immeon system is capable of operation in adverse weather conditions such as heavy rain or snow. A small decrease in bandwidth may be seen due to rain fade, but GCS stated that call drops are guaranteed not to occur. The satellite requires a 40 degree line of sight view of the southern sky for proper operation. The provided Cisco Router would allow for automated switching between various sources of bandwidth connected to the MCP.

Adequate bandwidth is available for video conferencing at 384Kbps along with data and IP traffic. CERMUSA IT staff would need to couple the LinkWay 2000 system with an appropriate router, based on the final medical data requirements. This system will meet all anticipated bandwidth needs of the MCP project.

For more information: www.globalcoms.com
www.cisco.com

iv. Relevance to MCP User Requirements

GCS was one of the most responsive entities we dealt with in regard to explanations, demonstrations, and on-site visits. CERMUSA already owns a portable Inmarsat flyaway system, which was purchased from GCS, and we have been impressed with their service and technical support. Additionally, GCS has an excellent support system and service center and is committed to ongoing service and support. GCS offers a variety of options for satellite communications that may fit well within the MCP concept. Almost all components/services are available as either turnkey or integrator packages, allowing a great amount of flexibility in selecting a vehicular platform. As several other companies offer similar services, vendor quality and price will be key criteria for selecting the right approach/vendor.

Raytheon First Responder Vehicle Demonstration, Crystal City, VA – December 10, 2002

i. In Attendance

CERMUSA Staff: Vicki Pendleton, Hema Patel, and Dave Wolfe. Raytheon Staff: Kenneth E. Knotts – Program Manager

ii. Purpose of Visit

Raytheon Communications designed and constructed a First Responder Emergency Communications System built on a Chevy Suburban platform. In the event of a natural or man-made disaster where land-based communications infrastructure is damaged or overloaded, this vehicle can arrive on scene and link existing out-of-band two-way radio systems together and establish communications to the outside world.

iii. Summary of Visit

A CERMUSA contingent met Raytheon staff at a National Guard Armory in Crystal City, VA, to see a live demonstration of the First Responder Emergency Communications System. This system, geared towards EMS providers, is primarily a mobile radio bridging station designed to cross connect multiple, non-compatible radio voice systems. In addition, The Emergency Communications System also offers low-end video and multimedia capabilities. The First Responder Vehicle offers multiple communications paths as follows:

- A one foot manually pointed roof-mounted satellite dish provides a 64Kbps Internet and streaming video connection via Inmarsat international satellite. Due to bandwidth constraints, the video is half-duplex (real-time video can only be transferred in one direction at a time).
- A Globalstar satellite telephone provides voice communications from anywhere in the world via 52 low-orbit satellites.
- An 802.11b wireless LAN allows for streaming video to be sent from the emergency scene back to the vehicle via camera-equipped laptop computers using video over IP technology.
- A JPS Communications multi-band two-way radio audio interconnect system provides multiple platform radio bridging. The unit consists of several computer programmable repeater stations and an easy to understand graphical user interface (GUI). The system encompasses all two-way radio frequency bands including Low Band, High Band (VHF), UHF, and 800MHz UHF. Once the vehicle arrives at an accident scene, all the available communications channels must be decoded and programmed into the system, which makes the repeaters compatible with all participating police, fire, and EMS radios.

The major attribute of the First Responder Emergency Communications System is the ability to link multiple bands of voice radio traffic quickly and easily with a GUI. The

GUI that controls the JPS system is intuitive for the end user, enabling personnel to make changes very quickly. The First Responder platform does not offer an automated solution, meaning that communications must be established manually. The satellite dish must be positioned by hand and the radio interconnect system must be manually programmed for each channel to be used shortly after arrival on scene. Communications are controlled from the rear hatch area or the back seat. Like other wireless communications systems, heavy rain or snow fall may narrow the satellite bandwidth due to rain fade. The satellite requires a 40 degree line of sight view of the southern sky for proper operation.

For more information:
www.raytheon.com
www.thefirstresponder.com
www.globalcoms.com
www.globalstar.com
www.jps.com
www.chevrolet.com

iv. Relevance to MCP User Requirements

Raytheon's vehicle platform, a Chevy Suburban, adequately houses all equipment for their application. The Suburban has available 4WD and should not have a problem with inclement weather conditions or off-road situations. All equipment is powered from a DC to AC inverter using the vehicle's twelve volt electrical system. A vehicle this size, although very adaptable and adequate for the First Responder Emergency Communications vehicle, may still not be sufficient to house our communications equipment, medical peripherals, and personnel for the MCP project.

Raytheon does not offer any communications solutions specifically tailored to meet our medical needs for the MCP. Maximum satellite bandwidth is limited to 64Kbps, the equivalent of one of our Inmarsat Video Phone systems. Based on discussions with CERMUSA telemedicine personnel, we anticipate that MCP requires at least 384Kbps for video plus additional bandwidth for data and medical devices. Although the Raytheon platform provides wireless and wired LAN connections, the total amount of available data bandwidth is not adequate. Aside from the wireless camera systems mentioned, all equipment in the vehicle is securely mounted and not portable for installation into community centers or other locations. The Raytheon system may be more relevant to the MCP project depending on the amount of emphasis CERMUSA places on potential emergency disaster response applications.

On Sight Communications Demonstration, Loretto, PA - December 18, 2002

i. In Attendance

CERMUSA Staff: Kent Tonkin, Tom Bender, and Vicki Pendleton. On-Site Staff: Mark Gaynor and Mark Shue.

ii. Purpose of Visit

On Sight Communications offered systems in telecomm, video conferencing, telephone, Internet, data, and fax available by satellite anywhere wired or wirelessly. On Sight designed and constructed a complete wireless communications solution built on a standard commercial van platform.

iii. Summary of Visit

On Sight Communications had previously provided CERMUSA with a remote wireless video call demonstration of several of their services and products. In an effort to prove the functionality of these services in a rural environment, On Sight brought a satellite communications van to CERMUSA headquarters in Loretto, PA, for a live demonstration. CERMUSA IT and telemedicine staffs identified a series of test locations throughout our operational area to test the connectivity of the On Site system. These test locations were intended to be very difficult areas for wireless connectivity due to terrain (valleys surrounded by hills and heavy vegetation).

Below is a list of specifications for the On Sight vehicle:

- A light 1.2 meter KU Band fully automated satellite dish is mounted to the roof of the van. The vehicle can be operational within 20 minutes of arrival at a scene.
- Bandwidth is available up to 2Mbps. The cost is based on speed and usage. There is no contract or monthly fee.
- The satellite link provides real-time full-duplex 384Kbps video at 30 fps, Voice over IP, and the capability to multiplex 24 channels of voice, data, and fax. The satellite link does not act as an ISP. High speed web access can be provided via the link as well.
- A wireless LAN on the 802.11b protocol provides a high-speed IP data link from the van to a VTC unit inside a building up to 1500 feet away. This system will work with any standards-based (H.320/H.323) VTC equipment including Tandberg and Polycom.
- An external interface panel is provided on the van as backup to the wireless system or a scenario when a wired connection is required or available.
- Self-contained power is available with the extended version van. The generator provides 8+ hours of operation. The onboard batteries provide enough power for lighting, heating, and air conditioning. In addition, the van may be plugged into

an ordinary 20 amp shoreline outlet when generator or battery power is not required or is undesirable.

- The van is fully carpeted and will accommodate up to four people in the office area with access to a printer, copier, fax machine, two computers, a VCR, cell phone, and satellite phone for audio telephony anywhere in the world.

On Sight provided both standard and custom communications solutions and offered to design and construct a communications platform to meet any need. All equipment is designed to be securely mounted in a van or SUV platform, resulting in a self-contained vehicle that does not require any wired connection for operation.

The On Sight solution provided adequate satellite bandwidth available for video conferencing and data transmission (up to 2mbps). The satellite requires a 45 degree line of sight view of the southern sky for proper operation and will operate in adverse weather conditions such as heavy rain or snow. A decrease in bandwidth may be seen due to rain fade. Ultimately, as bandwidth is adequate, medical equipment compatibility depends on the router used with the satellite equipment.

For more information: www.on-sight.net
www.ford.com
www.tandberg.net
www.polycom.com

iv. Relevance to MCP User Requirements

Following a brief administrative presentation, the On Site staff, accompanied by several CERMUSA IT and telemedicine personnel, relocated the vehicle to several test sites in Cambria and Blair Counties within a twenty mile radius of the Saint Francis University campus. On Sight Communications successfully demonstrated this vehicle in the mountains of western Pennsylvania with little difficulty. Video conferencing calls were placed from the mobile office to CERMUSA's conference room. Clear video calls were established and sustained with no trouble on either end, regardless of terrain or vegetation. During the second test call, On Sight personnel had to move the van several feet to obtain a clear line of sight to the horizon.

At the time of this demonstration, On Sight primarily sold on-demand bandwidth, all of which was routed to a downlink site in Cincinnati, Ohio, where the calls were routed through ground-based lines. In essence, the satellite provides relocatable connectivity back to a gateway, where calls become part of the public switched telephone network (PSTN). CERMUSA may also wish to deploy a point-to-point (direct satellite connection rather than satellite to gateway connection) as a part of the MCP prototype.

Although further discussion may be necessary to determine if the same mobile hardware can support point-to-point and point-to-gateway calls, On Sight made an impressive case for their services. Their hardware fit in a maneuverable commercial vehicle. They had already considered the concept of extending video and medical services into existing facilities rather than making the vehicle the facility (thereby greatly increasing the size and reducing mobility). Due to their understanding of our goals and application, as well as their flexibility and willingness to prove their functionality in our working environment, On Sight is definitely a quality contender to perform contract work on the MCP prototype for CERMUSA.

Since this demonstration in 2002, On Sight Communications has ceased operations.

FEMA Communications Vehicle Demonstration, Maynard, MA – January 27, 2003

i. In Attendance

CERMUSA Staff: Kent Tonkin, Tom Bender, and Dave Wolfe. FEMA Staff: Pat McCann and Edward Ewing Jr. III. Titan Corporation: Udo R. Schaller.

ii. Purpose of Visit

The Federal Emergency Management Agency in Maynard, MA has several Mobile Emergency Response Service (MERS) vehicles. Each of these mobile units provides one or more crucial communications paths needed on scene at a major disaster.

iii. Summary of Visit

FEMA maintains a number of relocatable communications vehicles, each of which serves a specific purpose in an overall communications scheme. The Mobile Emergency Operations Vehicle (MEOV) is the core of the FEMA field communications system, acting as a central hub and command center. The MEOV contains a variety of communications and computing components, enabling it to establish voice, video, and data connectivity regardless of available local services.

The MEOV chassis itself is expandable to provide usable office/command space; the undercarriage is also equipped with load stabilizer poles to level the vehicle on uneven ground. The MEOV can also be used in tandem with a relocatable repeater system consisting of a series of box trucks (approximately 13 feet high) equipped with microwave dishes. These mobile repeaters provide extra line-of-site microwave communications paths with small dishes mounted on extendable masts on the roof of each vehicle. A pull-behind trailer provides storage for the microwave dishes and accompanying hardware. These vehicles are manufactured for FEMA by The Titan Corporation.

Below is a list of options and specifications of the MEOV:

- A KU-Band satellite mounted on the roof of the vehicle provides the primary high-speed communications pipeline while a DSS satellite is used to watch news and weather from around the world.
- An external patch panel provides hard-wired links to the communications network on scene.
- A rack-mounted Compaq server coupled with a Cisco 3600 router manages all communications within the rear of the unit.
- A Polycom VS4000 rack-mount video conferencing codec, camera, 42” plasma screen, and a VCR facilitate easy video conferencing capability at 384Kbps.
- A PBX is provided on-board for POTS phone service in any situation.

- A complete office area with computers, a printer, fax machine, and copier provide for on-site command/administration use.
- An M-SAT phone and Garmin Street Pilot GPS are provided in the cab for driver use.
- A 20kW on-board generator provides power when commercial service is not available.

In summary, FEMA's Mobile Emergency Operations Vehicle provides a total communications solution in an emergency. FEMA also demonstrated a standard-size van they developed for disaster scene communications on a smaller platform. Included in this vehicle were several bands of public safety radios, satellite TV service, laptop computers, and phone/fax service. Although much less spacious than the MEOV, this vehicle is a good first-try approach at in-house custom construction.

The latest vehicles in use by FEMA are custom designed and constructed by The Titan Corporation out of Albuquerque, NM. Titan will design the vehicle and all communications paths per customer request.

For more information: www.fema.gov
www.titan.com

iv. Relevance to MCP User Requirements

The MEOV is a well-designed system for establishing relocatable command posts in the event of extended-period emergencies. The methodology is flexible, rapidly reconfigurable, and large enough in scale to accommodate a large number of users. Although some of the core technologies, such as KU-band satellite, are applicable to the MCP concept, the overall size and physical architecture are not. The MCP is intended to use existing buildings rather than establish an independent, self-contained command center. Additionally, the MCP must also be smaller and more maneuverable in order to negotiate successfully the varying terrain in rural and remote Pennsylvania. Although the MCP may eventually serve in emergencies, it is not intended to function as a long-term command center.

These site visits, combined with the previous research, distinguished several points:

1. Point-to-point and point-to-commercial downlink were both options with distinct advantages and disadvantages. While point-to-point provides direct access into a host network, point-to-commercial downlink removes a substantial amount of downlink site maintenance from the satellite user.
2. True on-demand high speed (512kbps and up) services were now becoming available.
3. The old model of reserving blocks of airtime was not as desirable as the on-demand model.
4. The highly mobile Hummer chassis was a better solution for us than the majority of the vehicular systems we saw, including large box trucks and rear-wheel-drive cargo vans.

Following completion of these site visits, MCP staff developed a request for proposals (RFP) for the installation and integration of a complete satellite communications and networking system. This RFP specified the need for "on-demand" types of satellite communications, with options for both point-to-point and point-to-commercial downlink configurations. Additionally, this RFP gave vendors the option of suggesting alternative or novel approaches; CERMUSA included this statement to avoid missing potential new or emerging technologies that might have been missed in the market survey.

While developing the RFP to accommodate both point-to-point and point-to-commercial solutions, the MCP team chose to continue overall planning based on a point-to-point satellite communications solution because of the overall flexibility and control offered by this configuration. All vehicular-based satellite transmission equipment was compatible with either point-to-point or commercial downlink configurations, meaning that future decisions to change this configuration would be easily accommodated. Point-to-point would allow for easy extension of existing CERMUSA network/online capabilities, resulting in a more efficient use of existing technology resources. The following points drove the MCP group to make this decision:

- Point-to-point link would allow the MCP to be an extension of the CERMUSA network, allowing more efficient control over the entire network
- Point-to-point link would eliminate external variables, particularly unknown quality of service (QoS) over the commodity Internet
- Point-to-point allows the optional use of a virtual private network (VPN) for security and data privacy, while a point to commercial link would require the use of a VPN
- Point-to-commercial link would have incurred higher cost due to per-minute or per-megabit usage and hosting charges

Based on a competitive bid process, GCS, Inc. of Victor, NY, won the contract on February 11, 2004. GCS had impressed CERMUSA staff with the variety and breadth of expertise and installations. The contract dictated that GCS would integrate and install all networking, satellite communications, and videoconferencing gear in collaboration with CERMUSA technical staff. Installation was scheduled to begin on January 12, 2005.

4. Original data/networking path:
CERMUSA IT originally devised two general networking infrastructure plans to integrate the MCP. Using a point-to-point satellite architecture, show in Figures 7 and 8 below, CERMUSA would use a virtual local area network (VLAN) to tie the vehicle's networking and communications directly into the network; in essence, the vehicle would be a direct extension of the CERMUSA network. Using a point-to-commercial downlink architecture, as illustrated in Figure 9, CERMUSA would use commercially-available downlink sites to "dial-in" to the network, most likely via Internet/ISDN, and then tunneling into the CERMUSA network by way of a virtual private network (VPN). The StarWire satellite architecture selected by competitive bid would support either scenario.

Figure 7

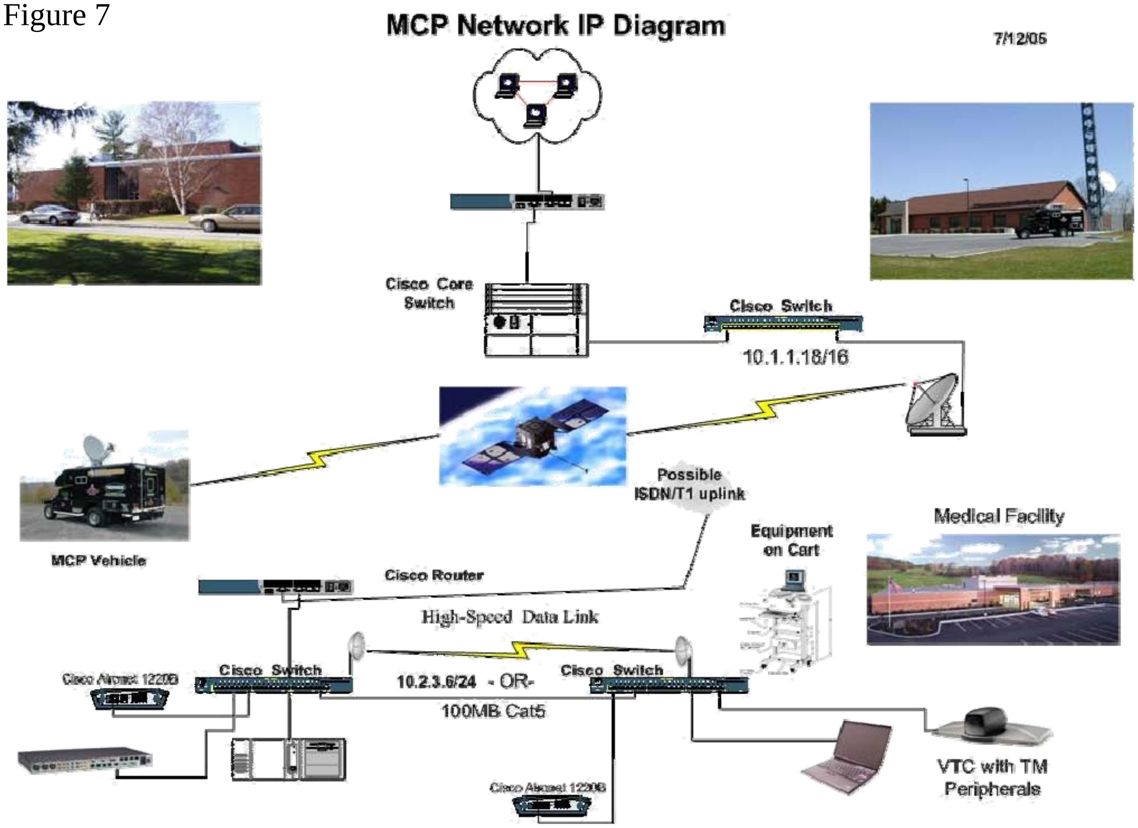


Figure 8

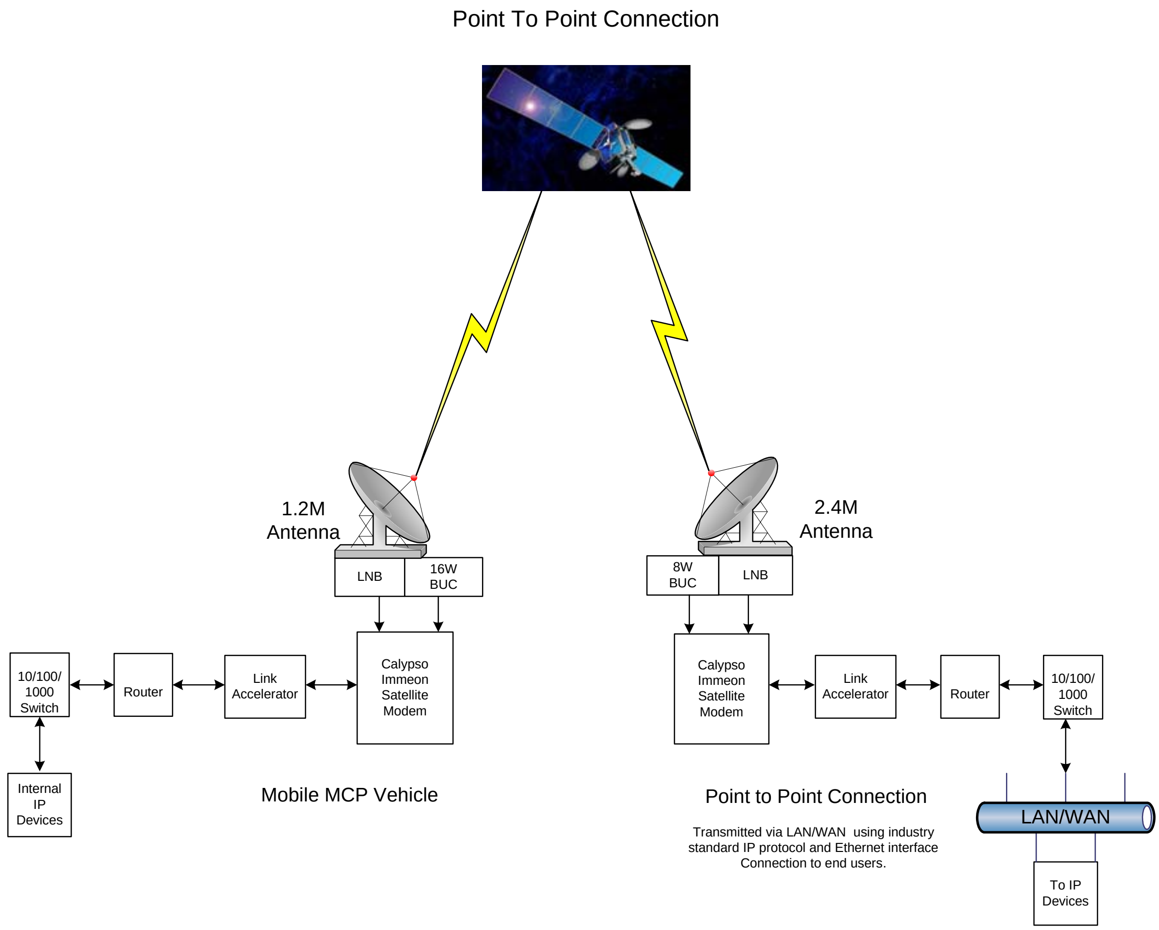
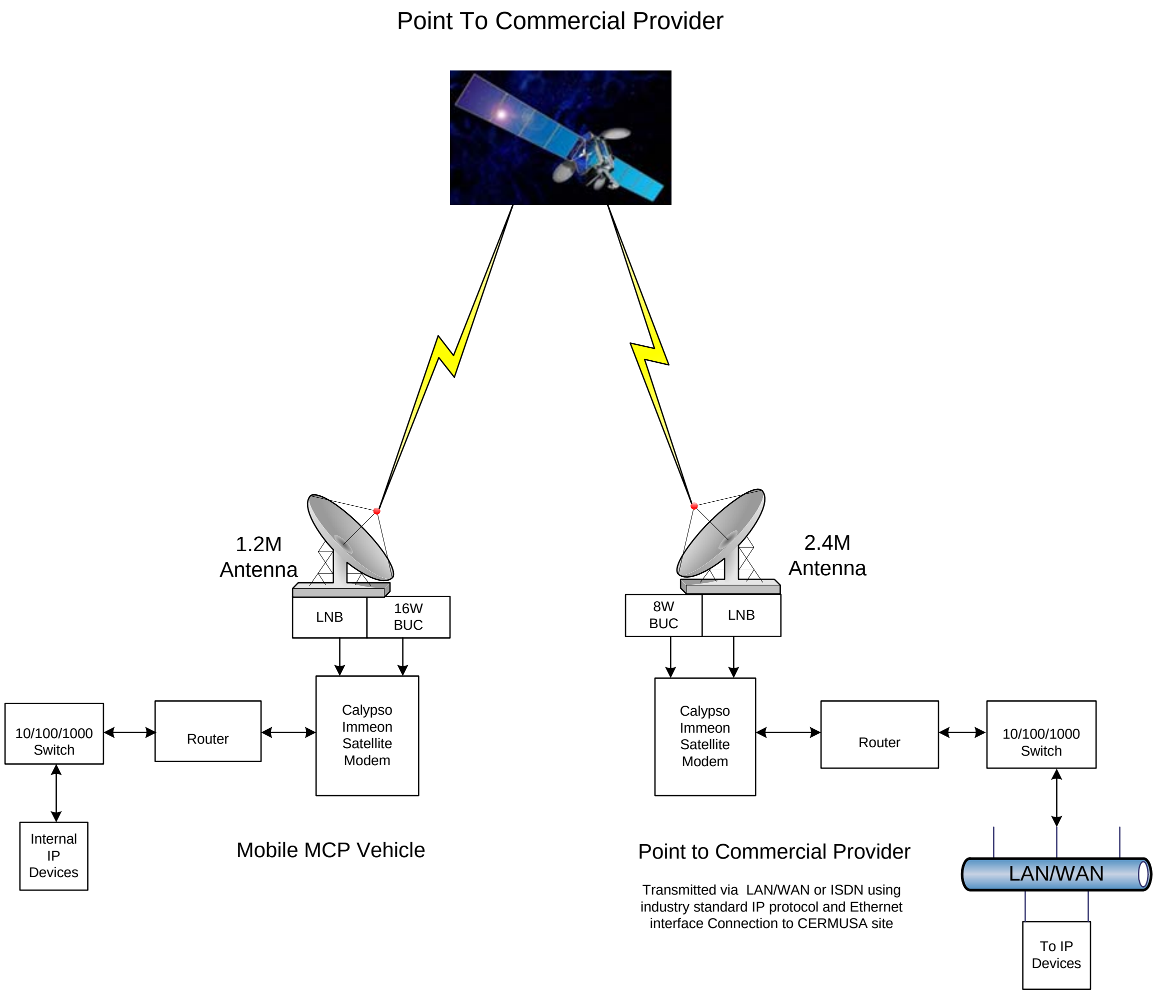

Point To Point Connection
1.2M
Antenna
LNB
16W
BUC
2.4M
Antenna
8W
BUC
LNB
10/100/
1000
Switch
Router
Link
Accelerator
Calypso
Immeon
Satellite
Modem
Calypso
Immeon
Satellite
Modem
Link
Accelerator
Router
10/100/
1000
Switch
Internal
IP
Devices
Mobile MCP Vehicle
Point to Point Connection
Transmitted via LAN/WAN using industry
standard IP protocol and Ethernet interface
Connection to end users.
LAN/WAN
To IP
Devices

Figure 9



The MCP data network was created to facilitate IP-based communications in the most diverse, adjustable, extendable, stable, and secure manner as possible. The MCP vehicle was conceptualized and configured with its own contained network that can be up-linked or extended via wired or wireless, un-tethered links. The network was designed using CERMUSA's Best Practices research model by first reviewing what services the vehicle was intended to provide and by then evaluating the requirements of a data network to support the vehicle's mission. Following this evaluation, appropriate technologies and equipment could be identified and tested to comprise the network.

CERMUSA IT evaluated several off-the-shelf networking companies for network hardware, including Cisco, 3Com, and Netgear. Cisco hardware was selected for the following reasons:

- Cisco is a stable, world-class networking company with a diverse range of networking gear
- CERMUSA IT staff has an existing working knowledge of Cisco gear
- Cisco gear is proven to work with the satellite and wireless gear chosen for the vehicle.

Ultimately, the point-to-point architecture was chosen as the preferred method, although either method could be implemented based on the overall design. A Cisco 2651XM router was selected as the main "brain" of the network; as such, several additional interfaces were installed adapting all connected devices.

The router was equipped with an interface to accommodate a satellite link of up to 1.5Mbps symmetrical bandwidth to the Internet via the satellite base station at CERMUSA/Saint Francis University (note the prevalence for a point-to-point satellite communications architecture). While the system was designed around a bandwidth availability of 1.5Mbps, in actual practice it was expected (and has been the case) that bandwidth is normally served in the 512 to 768Kbps range.

The MCP satellite link was initially set up to be inside the CERMUSA firewall using network address translation (NAT) technology. Telephone connectivity was conceptualized to be a point-to-point VoIP calling system consisting of one to several analog voice to IP bridges with 900MHz phones connected at the MCP and an IP-to-analog base station at CERMUSA, which would be plugged into an analog port linking the Saint Francis University phone switch. This entire system would most effectively be used via a point-to-point satellite communications architecture.

All physical network connections were intended to be routed through a Category 5 (Cat5) patch panel for quick assignment to specific devices, switches, or routers, depending on the mission.

The server architecture that would be required within the MCP was required to facilitate a variety of data and communications applications. This server was conceptualized initially to be the Windows-based server to perform network services such as DNS, DHCP, and WINS, and could serve as a Windows domain controller if needed. The server could also operate as an application server for any internal MCP software needs. Finally, the server could function as a dual-booted server if other operating systems, such as Linux, were required for future applications.

CERMUSA chose the server and related hardware in much the same way as the networking gear. The HP/Compaq Proliant server was selected because of its great track record and proven reliability through the excellent performance of 10 similar servers that CERMUSA owns and relies on for daily operational computing services.

The MCP network is also extendable to reach beyond the walls of the vehicle in several ways. First, there is a Cisco 1200 Wireless Access Point inside the vehicle used for laptops and PDA's to surf the web, run voice/video data applications, and communicate with telemedicine equipment. The wireless range is roughly a five hundred foot radius from the rear of the MCP, and can be extended using additional radios in a point-to-point configuration. We initially had two CERMUSA owned Tsunami 45Mbps DS-3 radios ear-marked to be used in the MCP.

5. Security

CERMUSA built several layers of security built into the MCP network to comply with HIPAA regulations. They are as follows:

- Password security – each piece of equipment would be required to have a strong password and must be changed in according the CERMUSA Security Policy. Strong passwords are typically alphanumeric and must be periodically changed.
- Network Address Translation – NAT would be setup on the MCP router to protect the laptops and other software based equipment from Internet-based attacks
- Virus scan, spyware, software updates – All Windows-based equipment would be kept up-to-date and protected from attacks while on the Internet or opening email messages and attachments
- MAC address filtering – MAC address filtering would be enabled on the wireless network access points to only permit allowed computers on the MCP network
- WEP/WPA encryption – WEP/WPA would be deployed to protect wireless transmission of personal, medical, and educational data from being read
- VPN Encryption - Some applications on the telemedicine cart laptop could rely on an encryption tunnel VPN over the wireless links and back to the CERMUSA base station, where most data is housed
- CERMUSA Security Policy – The CERMUSA security policy has physical and electronic security regulations in place to protect the integrity of all CERMUSA prototypes and projects, which would include the MCP.

6. Telemedicine equipment selection

The telemedicine hardware and software selected for the MCP project incorporated the following elements for the sustainability and future use of the MCP:

- Equipment Maintenance and Upgrade Costs
    - Cost of the equipment “consumables” (i.e. bulbs, prophylactic covers, etc) were kept extremely low
        - For example, the cost of replacing a bulb in a video medical peripheral was between $30 and $50.
- User Friendliness
    - The majority of computerized and video medical peripherals functioned in a manner consistent with equivalent non-telemedicine equipment
        - A trained medical practitioner familiar in the use of an otoscope could be trained to adapt to a video-equipped otoscope within several minutes
- User Requirements
    - All scopes and medical devices were selected by medically-trained members of the MCP working group based on anticipated applications
- Medical Device Life Cycle

    - The majority of all devices selected for deployment within the MCP were upgradeable via hardware add-ons or downloadable software
- Technical Support
    - First line support to be provided by the well-trained CERMUSA IT staff
    - Additional support for all software and hardware available directly through the equipment vendors.
        - The majority of devices were purchased from companies with established relationships with CERMUSA

The evaluation and selection of peripheral equipment began in the early stages of this project and has continued through its conclusion. During the performance of Task 5, baseline technologies were identified, evaluated, and selected. As new technologies emerged and as additional uses for the MCP were identified, they have been incorporated into the MCP as additional or replacement components.

Video peripherals:

Video peripherals include all forms of imaging acquisition and transmission technologies. As the MCP's IT infrastructure emerged as a miniaturized, mobile version of CERMUSA's base IT architecture, the ability to gather and transport video forms the foundation under which all other data distribution is built. Thus, an important aspect of building the IT infrastructure centered on the selection of video conferencing equipment.

Tactical II video teleconferencing unit: This ruggedized portable videoconferencing system is the heart of the MCP's modular video communications. This unit consists of a multi-standard (h.320/h.323) Tandberg 880 in a "hardened" shipping container that can be wired or wireless. The Tactical II is equipped with native 802.11 "a" and "b" protocol wireless local area network (WLAN) cards. In the absence of WLAN connectivity, the unit can also be wired to a network via an integrated 10/100 Mbps LAN card. This unit was configured to either dial into the Tandberg 6000 built into the MCP chassis or to remote video teleconferencing units, for the purposes of remote medical consultation or situational awareness.

Because the Tactical II is also capable of running on direct current (DC), CERMUSA IT staff modified the unit by adding four cell batteries to power the VTC unit. These batteries were 12 volts and 5.0 Amp each. A parallel power cable was designed to power up the VTC unit by pulling the power out of the four cell batteries. The cell batteries could be charged together or separately. The total time for recharging of the batteries was two hours. This feature enabled the videoconferencing unit to operate completely free of wires, meaning that it could be placed into field operation sans wired power and still maintain contact with the MCP network.

CERMUSA IT has deployed various Tandberg videoconferencing systems into a wide variety of environments. In the course of other research, a second comparable ruggedized teleconferencing system manufactured by Aethra, Inc. had been evaluated by

CERMUSA IT and determined to be inferior to the Tandberg system. Based on that earlier analysis, the Aethra system was not considered for the MCP application.

Sony handheld video camera: CERMUSA IT staff added a Sony DCR-TRV 11 handheld video camera to the Tactical II to complement the fixed focus integrated camera. This camera could be deployed for both situational awareness (i.e. room shots, outdoor shots) and telemedicine activities (wide shots of limbs or range of movement). This detailed visual capability was anticipated to be an asset to assist remote medical staff in making diagnoses on patients and/or gaining remote visual intelligence an emergent situation. The camera also had the ability to save still or motion video to a memory stick or tape for archival or store-and-forward purposes.

Frontline Communicator: This device emerged as a potentially valuable asset to the MCP program as the project's focus was transitioning from Task 6 to 7. The Frontline Communicator is a wearable wireless video communications system based on a Hewlett Packard IPAQ PDA platform. The system includes a headset camera, a secondary handheld camera, a transmitter, and head-worn microphone. The transmission module enables the user to establish real-time audio/video communication over IP, with someone located at a distance. The transmission module is a type of audio/video CODEC (coder/decoder) that is worn on the waist and is connected to the headset camera with a wire. The transmission module is powered by a rechargeable, lithium ion battery, which also powers the headset and camera. The Frontline Communicator is capable of two-way audio and one-way video transmission via integrated 802.11b WiFi networks. Audio and video receiving is accomplished via free pc-based software using a modified proprietary derivative of the H.323 standard. Both the head-worn and handheld cameras can be used for transmitting real-time video and still images. The manufacturer also claims compatibility with Bluetooth and certain digital cellular data networks, such as Verizon's EVDO service.

CERMUSA selected this device for the purposes of providing improved situational awareness exterior to the MCP vehicle, and the device's potential for deployment in clinical/triage situations (i.e. mobile dermatology or incident response). CERMUSA has executed a nondisclosure agreement with the manufacturer, Audisoft Technologies, to participate in development of upgrades and modifications to the Frontline Communicator that would increase its value as a telemedicine tool.

For more information: http://www.tandberg.net
http://www.aethra.com
http://www.sony.com
http://www.audisoft.net

Medical data peripherals:

The CERMUSA MCP team took a modular approach to the packaging and transportation of the medical peripherals. The equipment was grouped based largely on function, allowing the entire telemedicine system to be simultaneously accessed by multiple users.

For example, depending on the environment and the situation, different groupings of equipment (telemedicine cart, Terason Ultrasound case, nonmydriatic digital camera, and portable x-ray) could be simultaneously deployed on different patients or groups of patients.

The majority of telemedicine medical peripherals were purchased from American Medical Development (AMD) via competitive bidding.

ENT Scope with camera and illumination source: The ear, nose, and throat scope is a modular camera and illumination system with an analog video output. The illumination source is integrated in a platform box that also houses the lamp, video processor, and power supply. The fiber optic camera cable attaches to a handheld device made for endoscopic applications. The hand piece also includes a coupler that attaches to the camera cable so other medical devices can be attached.

This ENT scope can be used to perform examinations of the outer-ear canal, eardrum, and middle ear, as well as the lower sinus and upper throat. The standard analog video output may be directly connected to a videoconferencing unit or PC capture card for either real-time video or store-and-forward image diagnosis.

Ophthalmoscope: This device is a video-enabled peripheral used to identify disorders of the eye. The main lens module of this device connects to the coupler of the ENT device, thereby using the same illumination and video conversion systems. The standard analog video output may be directly connected to a videoconferencing unit or PC capture card for either real-time video or store-and-forward image diagnosis.

General Exam Camera: The general exam camera is an extremely versatile imaging peripheral with an analog output. This lightweight handheld camera includes a built-in image capture button, fluorescent illumination, and gamma image correction. Although deployed primarily for dermatology purposes, the general exam camera is versatile enough for a number of applications, including dental imagery and full-body scans. The camera's small size and integrated controls make the camera unobtrusive to include in general medical examinations. The camera comes with a 50X zoom lens, which includes a flexible balance rod for placing against the patient's skin to provide optimum focal length. This rod can be covered with protective sleeves. The camera can also be placed on a small tripod to take closer pictures of a wound or other area of interest. The standard analog video output may be directly connected to a videoconferencing unit or PC capture card for either real-time video or store-and-forward image diagnosis.

Intraoral Camera System: The intraoral camera system is a single-lens, single-wand system that can be used in a multiple operator environment. This scope is used to examine the oral cavity (mouth, teeth, throat, and gums). The standard analog video output may be directly connected to a videoconferencing unit or PC capture card for either real-time video or store-and-forward image diagnosis. This camera also includes an integrated freeze frame capture system. The controls for this system are mounted on the wand for ease of use by the operator. Transparent plastic sheaths can be used to cover the camera lens in order to prevent contamination or spread of infection.

Panasonic Rugged Laptop: At the time of the evaluation, the Panasonic Toughbook was regarded as the industry standard for ruggedized computing. This laptop is shock tested and liquid/chemical resistant, making it a logical choice for mobile deployment. Powered by an Intel Pentium-M processor running at 1.400 GHz, storage devices include a 40 GB hard drive and DVD/CD-RW drive that can be used to copy patients' to optical archive. The laptop is running Microsoft Operating system XP and Microsoft Office Professional 2003. Additional software to manage the various telemedicine peripherals and telecommunications systems includes:

- SmartSteth
- IQMark Diagnostic Workstation
- Adapter USB control
- Norton Anti-Virus
- Adobe Reader 7.0
- Intel wireless software supporting the 802.11a protocol

The software versions are updated when newer versions are made available by the vendors.

All data gathered from the medical peripherals can be saved in a folder located on the Panasonic laptop for that clinic, doctor, or designated end user with access to that folder via a protective password. This data can also be copied to a storage media such as CD-R, or saved to a USB flash drive device. By adhering to established security guidelines, the patient medical data gathered will not be compromised by outside medical personnel and remains in compliance with HIPAA guidelines.

Should the telemedicine cart be brought back to a same location at a future time, the medical staff can update their storage devices with the new data.

Many of the software-based medical devices were designed to integrate with a comprehensive medical monitoring suite known as IQmark Diagnostic Workstation. IQ Diagnostic Workstation is a software package that serves as a rudimentary patient data management utility by managing all tests performed on a patient using an IQmark digital diagnostic device. Those devices (described in detail in this section) are as follows:

- IQmark Digital ECG
- IQmark Digital Holter (cardiac function monitor)
- IQmark Digital Spirometer (respiration function monitor)

The software will also organize and store digital information that is gathered from electronic weight scales and vital sign monitors that can be connected to the computer via a COM port. The IQmark software can also deploy a hardware configuration menu that will auto-detect the make and model of each medical device and is not limited to a specific manufacturer.

The hardware and software requirements of the IQmark software were as follows:
- 90 MB of disk space when installed
- PC/laptop is required to have a Pentium class 500 MHz or faster processor.
- Windows Operating system 98, NT, 2000, XP
- VGA display containing 640x480, 800x600, 1024x768, 1280x1024, or higher resolution.
- Minimum 256 colors

The software features included the following items:
- Patient list search feature
- Patient data screens
- Electronic fax support
- Multi patient report screen search and report criteria
- Support for IQmark SpiroPDA

Smart Steth: The Smart Steth is a PC-based stethoscope capable of capturing and transmitting heart sounds in either real time or on a store-and-forward basis. This device utilizes a USB audio capture module attached to a standard stethoscope to convert analog audio into digitally captured files. Smart Steth software converts the audio files into visual phonocardiogram wave forms, which can be viewed while listening to a patient in real-time or on recorded playback. By using Net Meeting, a free H.323 desktop video conferencing software found on all recent versions of Microsoft Windows, audio and phonocardiogram wave files can be transmitted to other locations, as long as the receiving end has a Smart Steth receiving apparatus. In addition to H.323 data streams, the SmartSteth can also be connected to a video conferencing device by using a standard H.320 RS-232 data port.

IQmark Digital Spirometer: The IQmark Digital Spirometer can be used in real-time or store-and-forward mode to measure the lung capacity of patients. This device interfaces with a PC via the IQmark diagnostic workstation software, and may be used with both adults and pediatric patients to assess, evaluate, describe, measure, and monitor the status of pulmonary health, diseases, and conditions. It meets the standards of the American Thoracic Society.

The software for the Spirometer can be installed on a Windows-based PC and can perform FVC (forced vital capacity), VC (relaxed vital capacity), and MVV (maximal voluntary ventilation) tests, generating full page reports. The spirometer uses a disposable pneumotach mouthpiece, greatly reducing the possibility of cross contamination between patients. Patient reports include such data as lung age and COPD risk, and test results can be gathered over time for trend analysis. A report can be generated in graphical or tabular format with the data and may be distributed via store-and-forward, real-time data sharing, or graphic sharing via VTC. The spirometer must be calibrated on a daily basis with the included 3-Liter syringe that comes with the device.

IQmark Digital ECG: The IQmark Digital ECG is a portable non-invasive device that interfaces with a PC via the IQmark diagnostic workstation software and can record 12-

lead ECG's for real-time or store-and-forward data gathering and analysis. The physical interface of this device is nearly identical to a standard 12-lead system; these leads are placed on a patient in the same manner as a traditional ECG system. Once collected, numerical data and graphical representations may be transmitted real-time, via summary reports, or viewed via VTC.

WelchAllyn Vital Signs Monitor: The WelchAllyn Vital Signs Monitor is a non-invasive device that gathers a patient's systolic and diastolic blood pressure, pulse rate, temperature, and oxygen saturation (SpO2). The front of the device contains an LCD display showing the patient's vital signs. A single unit contains all associated probes and attachments, and multiple devices may be used simultaneously. The vital signs monitor also includes an RS232 computer interface for upload of stored data from the monitor to a computer, network, or nurse call system. The vital signs of the patient are transmitted into the IQmark software located on the laptop and are stored with the patient data information for that date. This monitor is attached to the laptop via USB. The vital sign data is then imported onto a page within the IQmark software that is saved with the patient medical record. This medical record can be printed or emailed. The data can also be imported into a nurse call system using analog dial-up.

Life source Medical Scale: This scale meets the statutory electromagnetic compatibility as directed by 89/336/EEC. The scale has four ways of gather weight data: normal weight, BMI, memory, and target weight. Up to 31 weight measurements can be stored to memory. Patient weight must be manually entered into the IQMark software package, as this device does not have data upload capability.

Samsung Monitor: The Syncmaster 710 mp monitor serves as a reference device for the various inputs and outputs for the medical scopes and PC peripherals. The light weight of this LCD monitor contributes to the cart's easy mobility. The monitor has two 10lb air loaded springs so when the top lid of the cart is removed, the monitor swings up to full height for easy viewing. There is a VGA connection connecting to the Panasonic laptop. The monitor is capable of displaying any standard digital or analog video source and has built-in internal speakers.

4 x 1 Switcher: This switcher is a RCA audio/video input and output box that allows a user to select between four RCA devices. CERMUSA is using the switcher box with the scopes. By selecting a different button, 1 – 4, a different camera image can be routed to the Samsung monitor. The switcher is also set up with an external cable that can be plugged into a VTC unit for real-time transmission.

USB Hubs: These devices are used to share up to four USB devices over a single USB port on the laptop.

USB 2.0 card: This card converts a standard PCMCIA laptop slot for use as a USB 2.0 port.

Cisco Access Point: The Cisco Aironet 1200 series is a network device that creates a wireless local area network. As configured, the card operates in the 802.11b protocol, but can support 802.11a and 802.11g operations. The access point is the device that receives data and transmits data to the MCP network. The Cisco access point can be set up in a clinic environment to perform wireless transmission between the telemedicine cart and the wireless Tactical II unit if patients are outside or located in other areas of the building.

HP DeskJet 450 Printer: This printer will be used to print down reports or images from the various medical devices on the telemedicine cart. The reports and/or images can be printed in color or black and white.

Cisco Switch Catalyst 2950 series: This switch distributes each incoming and outgoing message frame based on the Media Access Control (MAC) address of each physical device connected to the network. In this instance, the switch is used to connect the laptop access point with the current network (clinic) or the MCP network. The switch on the telemedicine cart can be used along with a clinic's existing infrastructure to connect additional medical equipment.

SmartXR Portable X-Ray Unit with Transport Stand: The portable x-ray unit MinXray Smart XR HF100H was designed to be taken into nursing homes, patient's homes, military field, correctional institutions, and anywhere the x-ray machine could be brought to the patient. The x-ray unit is designed to be mounted on a stand to provide easy mobility and to be used for full body radiology. The x-ray has the following features:

- The x-ray unit has shorter exposure time than conventional x-ray machines.
- Uses high frequency full wave rectified power supply makes maximum use of electrical input, minimizes potentially harmful lower kV x-rays.
- The unit has an ultra high resolution timer adjustable to provide a maximum of 80 mAs.
- The stand has a leg span of 34 inches and wheel span of 20 inches.
- When the device is not in use, it can be folded down and stored on the MCP till it is needed.

Nonmydriatic Retinal Camera System: The Topcon TRC-NW6s Nonmydriatic retinal camera system is a digital camera system that captures images of the eye. The retinal camera connects via USB cable to a laptop running IMAGEnet 2000 software. This software acquires and manages the images generated from the camera. These images can be viewed real-time (full size or thumbnail view via IMAGEnet 2000) or via store-and-forward.

The Nonmydriatic retinal camera system is equipped with its own wheeled carrying case. The camera weighs approximately fifty-four pounds, and generally requires two people to carry the camera sans case. The case contains the camera, Canon printer, USB cable for printer, printer cartridges, power supplies, a Gateway laptop with IMAGEnet 2000 installed, and a Nikon digital camera that attaches to the top of the nonmydriatic camera.

By using the Nikon digital camera, the Nonmydriatic camera can capture 6.1 megapixel resolution with a 45 degree and 30 degree fields. The user can capture a more effective level of illumination for each image that is taken with the camera.

The nonmydriatic retinal camera is easy to align; controls, monitor, and patient are in direct alignment, making it easy to acquire retinal photographs. A pupil as small as 3.7mm can be photographed using the 30 degree coverage angle. Flash setting is configured either automatically or via a manual set-up. A full screen image with a 30 degree coverage angle gives the medical provider a larger image that contains information that is more detailed. By having the ability to cover more area, the provider can make enhanced diagnoses of the condition of the eye.

A primary proposed use for this camera is as part of a diabetic screening. Diabetics often develop secondary diseases, including glaucoma and diabetic retinopathy. These types of eye disorders might be caught in the early stages via the use of a nonmydriatic retinal camera.

Terason Ultrasound System: This system is housed in its own protective case, which includes a Gateway laptop and power supply, Terason 4C2 transducer (ultrasound device), gel, Canon printer with power supply, printer paper, and spare printer cartridges. The Terason Ultrasound software is installed on the Gateway laptop and runs on a standard Windows XP operating system. This system can be deployed using a single or dual monitor for the image display; the image refresh rate is up to 100 frames per second, in true color (32 bit).

The Terason Transducer utilizes a FireWire (IEEE 1394) port on the laptop to rapidly capture and convert analog ultrasound images to digital video input. The system can also be connected to a VCR (or other video recording device) or a printer for image output. The laptop housing the ultrasound system is equipped with standard analog video outputs, for connection to a standard television monitor, VCR, or other recording device. Captured videotapes could be sent by mail to a consulting doctor or made part of the patient's file. Additionally, the video output of this device could also be connected to the video input of a videoconferencing unit, thereby allowing real-time transmission of an examination in progress. The transducer scope is a curved array with 128 elements; the array footprint is 66 mm, with a maximum depth is 240 mm. Multi-frequency and Doppler modes include, power Doppler, directional power Doppler, color Doppler, and pulse wave spectral Doppler. Three other transducers are available for the Terason ultrasound system, model 4V2, 8EC4 and 10L5. The different types of transducers are used for different parts of the body and organs. The arrays vary, as does the number of elements and footprints.

Ultrasound images can be sent real-time to a receiving station, or store-and-forward and the information can be provided to a primary care physician at a later date via e-mail. Images are stored in the following Windows-supported file formats: JPEG, BMP, TIFT, and AVI files. Since the ultrasound session can also be recorded using a VCR or other video recording device, recordings can be sent and played by end users for diagnosis.

Viewing format is ultimately determined by the receive site's image reading software and capabilities. The total weight of the case is approximately 10 lbs. with all the hardware components inside.

Medical Supply Case for Telemedicine Cart: A separate carry case has been prepared to carry the various scope covers, thermometer covers, gloves, alcohol wipes, and batteries for the hardware that requires them. By housing these supplies in their own case, there is less chance that the protection covers would become contaminated with viruses or bacteria than if they were to be housed in the same telemedicine cart with the medical peripherals. The clinical personnel should remove the required number of covers before seeing patients and CLOSE the case before patient enters the examination room. The "used" scope covers and other medical waste will be disposed of by current medical guidelines designated by the OSHA medical boards.

The original concept was to hand carry all medical peripherals in separate storage cases into the given medical location and set up each device as the medical staff required. The cases would be stored on board the MCP (a metal rack was originally designed just for this purpose) until the need arose for a specific device to be deployed. A table would be used at the location to set-up all hardware for the clinic personnel. An equipment check-off sheet would be attached inside each telemedicine case and a CERMUSA staff member would verify that all components to that device were placed back into the cases before leaving a site. Figure 10 shows how the cases for the telemedicine equipment were originally designed and set up.

Figure 10

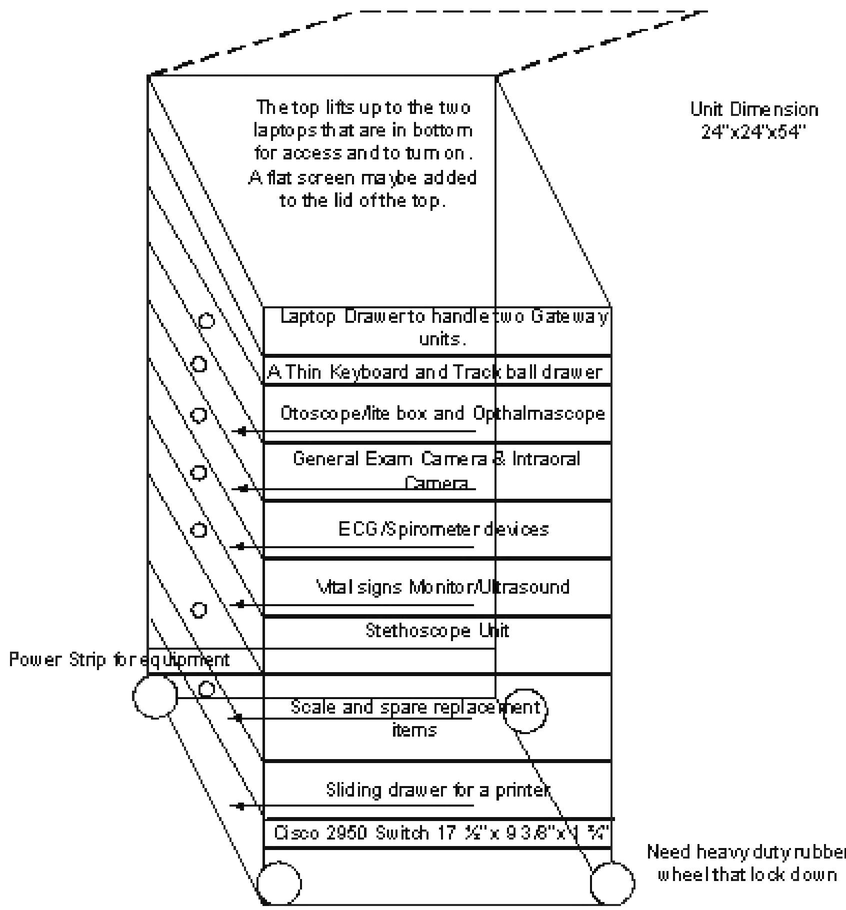
One of the concerns raised by this method of storage and transport centered on the repeated connecting and detaching of the telemedicine equipment each time it was taken out into the field. Concerns were as follows:

- What if clinic personnel do not return all parts of the device into the case
- What if a part of a medical device was lost
- If device were broken, how would it be replaced
- Who was responsible for missing and/or broken devices
- Would the connection pins become worn out from plugging and unplugging of devices
- Would electrical cables become lost or misplaced
- Would the constant wear and tear on the equipment void the manufacturer warranties

These concerns led the team to consider a more comprehensive, yet still modular solution. Based on a medical stand displayed at the 2004 American Telemedicine Conference, it was decided to develop a mobile telemedicine cart. The display cart contained several trays that housed the already connected medical equipment. A monitor was attached to the top of the cart and the wheels locked in place.

Initially, it was proposed to construct the telemedicine cart of metal to accommodate all medical and networking devices; however, this raised questions of mass and heat dissipation when the equipment was in use. A manufacturer was found who was able to fabricate a case made of aluminum reinforced wood, based on the design shown in Figure 11. The entire assembly would be lined with foam to protect the equipment, and the case

Figure 11



Draft telemedicine cart design

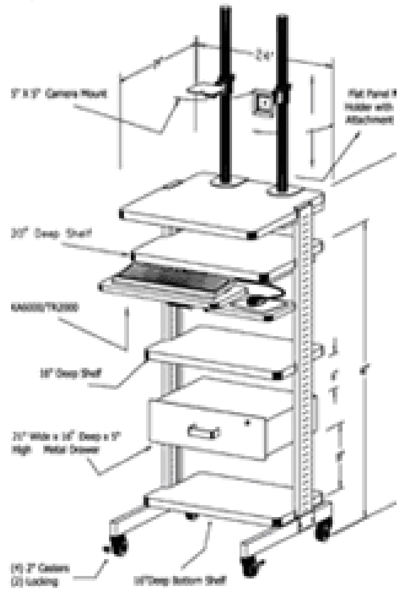
could be outfitted with three inch wheels, a removable top, and side doors. One of the side doors was designed to be utilized as a makeshift patient table or to support additional equipment if needed. This final design cart was selected for the existing telemedicine cart for the following reasons:

- The new cart design was enclosed with locking latches
- All equipment would be encased in the cart
- When doors on new cart are removed, equipment could be seen at first glance

A second cart was designed that would be deployed as a receive station at a clinic or similar location for teleconsulting missions. The receive cart layout is shown in Figure 12, and features video conferencing and related telecommunications equipment designed to utilize the data transmitted from the telemedicine cart via the MCP, as follows:

- Samsung Syncmaster 710 mp monitor
- SmartSteth
- Panasonic ruggedized laptop
- Keyboard and mouse
- Epson 320 color printer
- IQmark software package

Figure 12



Receive site TM cart

The receive site would use existing Internet access allowing consulting medical staff to receive email images from the Nonmydriatic retinal camera, ultrasound images, and reports from the IQmark software, captured scope images, and emails in general.

The Smartsteth software would be loaded on the laptop as well. The audio files could be transmitted via email or done real-time by using Net Meeting with the IP address of the MCP SmartSteth. The SmartSteth hardware and software would work together to facilitate capture and transmission of heart audio files.

For more information:

http://www.amdtelemedicine.com
http://panasonic.com/business/toughbook/home.asp
http://www.midmarkdiagnostics.com/
http://www.welchallyn.com/medical/
http://www.lifesourceonline.com
http://www.samsung.com/
http://www.cisco.com/
http://www.minxray.com/
http://www.topcon.com/
http://www.terason.com/

Task 6: Mobile Communications Platform (MCP) Prototype Implementation and Training - Equipment Installation/Integration

1. Vehicle construction:

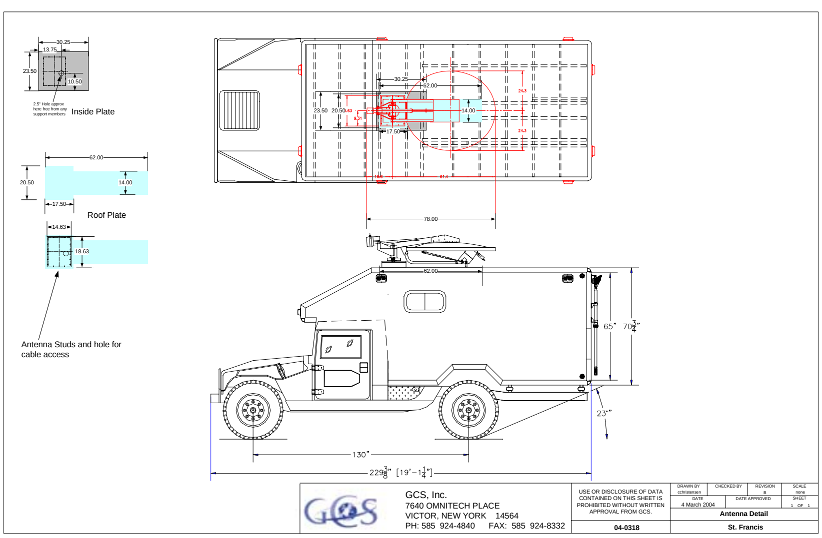
The selection of Danko Emergency Equipment to modify the Hummer and fabricate the communications enclosure has been previously discussed. Final design was contingent on payload form factors, particularly the satellite communications equipment that was to be installed on the enclosure roof. Following the evaluation of satellite communications providers, the decision to utilize a point-to-point solution, and based on a competitive bid, GCS, Inc. of Victor, NY was selected to integrate both fixed-base and mobile satellite communications infrastructures.

The CERMUSA MCP team made the first site visit to GCS on March 3, 2004, to kick off project development work in advance of Hummer vehicle construction. Based on the weight of the mobile satellite system, as well as its location well above the MCP's center of gravity on top of the Hummer's aluminum roof superstructure, coordination between GCS and Danko was required to ensure the structural integrity of the communications enclosure.

The CERMUSA team presented GCS with a package of drawings, diagrams, and specification of the vehicle in progress. While on site, the CERMUSA team interacted with GCS staff, discussing potential design/functional problems and a way to counteract them prior to installation of the equipment.

The team focused on the overall weight of the AvL Technologies 1.2mVSAT dish and the required mounting hardware. A schematic showing the placement of the satellite communications equipment on the MCP is shown in Figure 13. Points of discussion included what type of brackets would be used to mount the entire satellite chassis to the roof and whether or not the Hummer communications body shelter would be able to support the unit. GCS personnel made recommendations on how to reinforce the body shelter braces in the area of the satellite bracket placement. The

Figure 13

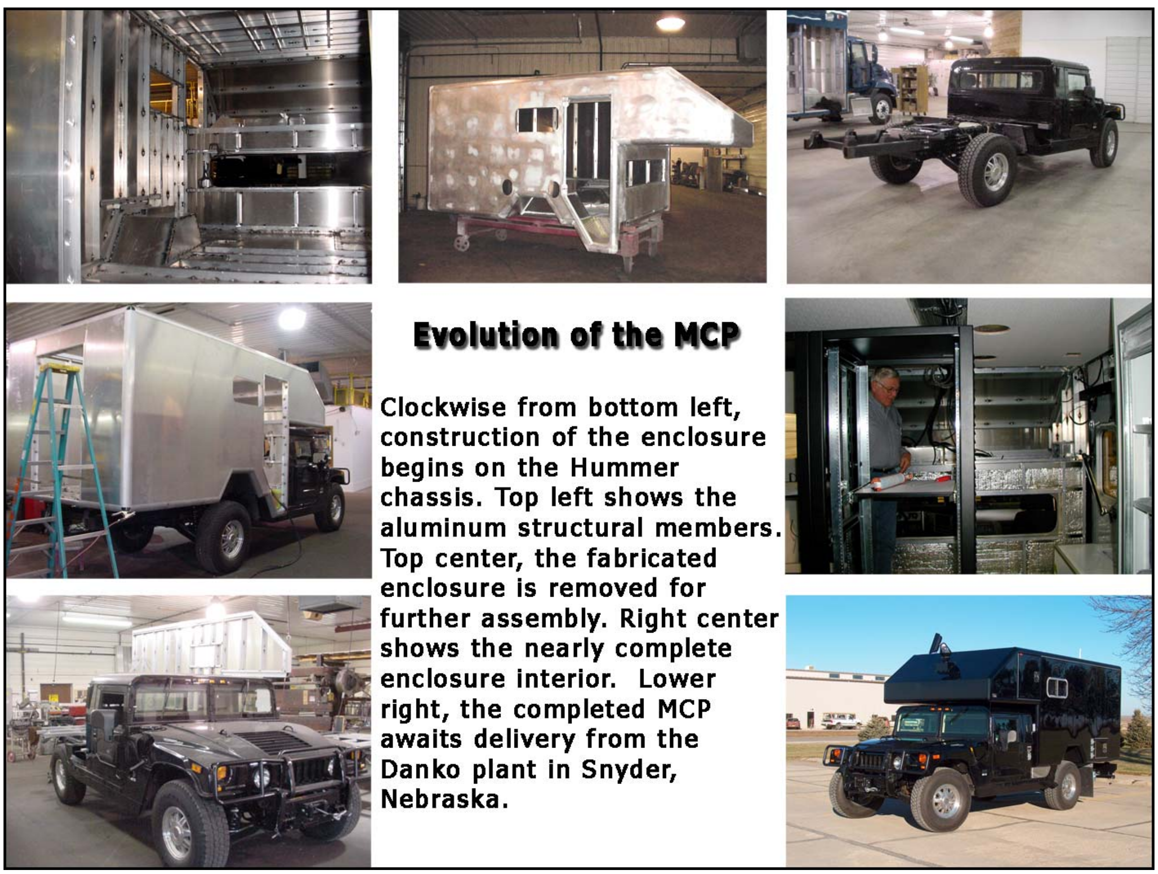


team also discussed the rack layout, the placement of networking components, and the required wiring diagram.

CERMUSA technical staff and the GCS engineers evaluated the roof frame construction of the body shelter. GCS recommended that a box frame construction be used in the area where the antenna dish was to be mounted to provide additional strength. Engineers at Danko were informed of this recommendation and agreed to construct the roof rails of solid boxed aluminum rather than hollow boxed rails. Because the vehicle was currently in the beginning phases of construction, these revisions were predicted to have no bearing on the timeline of the vehicle completion date. The revisions were incorporated into the Danko final design drawing prior to final approval by CERMUSA.

On August 10, 2004, Danko began fabrication of the communications enclosure, a process that extended into mid-December. Figure 14 offers a snapshot view of the progress over that four month period.

Figure 14



Evolution of the MCP

Clockwise from bottom left, construction of the enclosure begins on the Hummer chassis. Top left shows the aluminum structural members. Top center, the fabricated enclosure is removed for further assembly. Right center shows the nearly complete enclosure interior. Lower right, the completed MCP awaits delivery from the Danko plant in Snyder, Nebraska.

2. Integration of satellite/communications gear

Anticipating a mid-fall to early winter arrival of the modified Hummer, beginning in mid-2004, the MCP team arranged a number of trips to the GCS facility in Victor, New York, to discuss the future satellite and communication installation project. CERMUSA had previous experience working with GCS during development of the First Responder Emergency Communications-Mobile (FREC-M) ambulance. As previously mentioned, GCS had won the contract, based on a competitive bid, to install satellite communications and perform system integration and equipment mounting. All networking and audio-visual gear was either purchased through GCS or provided to their technical staff for installation, although it was later decided to defer the final installation of the audio-video equipment to CERMUSA staff familiar with A/V systems.

The finished Hummer was delivered by Danko to CERMUSA in December 2004. On January 12, 2005, CERMUSA staff drove the Hummer to the GCS staging facility in Victor, NY for the installation of the satellite dish and the integration of the communication equipment into the vehicle. Although GCS was contracted for the majority of technology installations, CERMUSA staff was scheduled to be on-site for all key equipment configurations.

In order to protect the interior, GCS agreed to cover all exposed surfaces with protective plastic sheeting during integration, as shown in the left panel of Figure 15. The right panel shows the beginning phase of equipment installation into the two rack units that make up the core of the electronics infrastructure inside the communications enclosure.

Figure 15

The MCP represents an amalgam of specialized technology, principally IT and television broadcast. Indeed, at first glance, the MCP looks very much like a traditional broadcast television satellite news gathering vehicle. However, CERMUSA's core competency has been and remains IT-based telecommunications; thus, the MCP's design is IT-centric. As a result, the audio and video portion of the MCP's infrastructure must be adapted to the IT architecture. CERMUSA staff have had considerable experience in this area, and so, during the first several visits, CERMUSA technical staff assisted GCS with the wiring of the access panel audio and video connections, including all the audio jacks from access panel to the Ashley 8 input stereo mixer, and video connections to the video switcher in the rack. CERMUSA staff evaluated a comprehensive audio and video wiring diagram of the vehicle with the GCS staff. At this time, CERMUSA staff iterated industry standards for the audio connections, and changed the layout of the exterior access panel. The staff quickly went to work drilling and mounting the new connector configuration and wiring the components permanently into equipment racks, examples of that collaboration are shown in Figure 16. Essentially, all audio was routed through the Ashley mixer whose output was ultimately connected to the Tandberg 6000. The video was also terminated to the same location, with all the inputs feeding the Videotek A/V switcher, and from there being routed into the Tandberg 6000. To monitor the audio connections, CERMUSA staff used a powered speaker with one input monitoring the Tandberg, and another monitoring the Ashley mixer. To monitor the video, staff used one of the three LCD monitors for the Tandberg output, second for the A/V switcher output, and a third auxiliary monitor, currently wired to display the output of the external camera.

Figure 16

By the end of this trip, all audio/video connections were complete and a logical routing mechanism had been designed. Several XLR cable genders at the audio/video interface box were reversed to allow for integration of external audio devices. Additionally, all changes were labeled and documented.

The communications technology integration was not without its setbacks. During GCS's installation of the cables to the exterior front-mounted Pelco motorized camera, it was discovered that during initial installation of the camera at Danko, an improper gasket had been used at the camera mount, vehicle body interface, resulting in water intrusion. The gasket was replaced with a weather tight model. Of more significance, once the camera was connected to the interior control system, it was found the mount would not track properly with the joystick. The camera would only move intermittently, and the camera's image exhibited significant ghosting on the preview monitor in the MCP unit. MCP staff and GCS technicians worked together to trouble-shoot the problem, making calls to the manufacturer's technical support. Following about an hour of troubleshooting, the Pelco technician recommended returning the camera unit to the manufacturer for repairs. GCS staff reinstalled the malfunctioning Pelco camera back on the Hummer front cowl prior to leaving New York, and after CERMUSA staff drove the vehicle back to Loretto, the camera was removed and shipped to the manufacturer for warranty service. As a further precaution, GCS decided to replace the video and control cables running between the camera mount and the equipment rack in the communications enclosure.

The Category 5 (Cat5) patch panel and external access panel design went through several revisions. The patch panel was initially designed to meet standard patch design in which the back of the patch panel was routed to the CAT5, ISDN, and analog phone ports on the external access panel outside the vehicle, as well as to ports designated around the vehicle. The front of the patch panel would go to the Cisco switch for IP data, the NT-1 boxes for ISDN, and the phones for analog voice. The router, server, and other IP-based devices would connect to a Cisco switch directly. The IT integrator at GCS took an unconventional, but in some ways better, approach to the patch panel design by retaining the original architecture for the external access panel, but changing the way the internal devices interconnect. This change was accomplished by connecting the patch panel by hard-wiring the Cat5 cable from the device, such as the AP, Tandberg 6000 VTC Unit, the IP Phone system, etc, to the back of the patch panel top row. The integrator also hardwired all ports from the switch to go directly to the back of the bottom row of the patch panel. This created an opportunity to cross-connect ports from the top row to the bottom row in an incoming and outgoing fashion, all from the convenience of the front of the patch panel, which faces the back of the data rack in an open area. This setup keeps the data cabling in a fastened and untouched manner with little need for manual cable routing during testing and mission-specific reconfiguration. This patch panel solution differs from most data closet standards, but meets the needs for flexibility of the MCP vehicle's infrastructure requirements (and matches well with standard operating procedure in the broadcast video signal routing paradigm.) The only downside to the design is that new team members must be trained on this vehicle-specific configuration in order to operate and troubleshoot quickly and adequately.

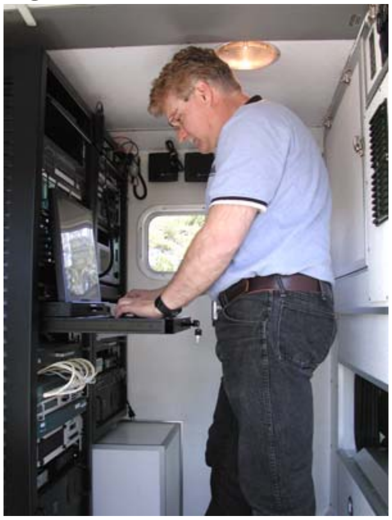
On March 16, 2005, three members of the MCP team traveled to GCS to observe preliminary acceptance testing. Those tests included:

- Testing through a satellite connection into the GCS network
- IP data and video traffic tests
    - These ran well and included brief VTC calls to several CERMUSA destinations; the DLPL session was recorded for evaluation.
- Reprogramming the satellite system to switch connectivity to the CERMUSA IT network
    - Encountered a problem with the Firmware software—it did not function as promised, resulting in a delay of several hours for troubleshooting by CERMUSA and GCS staff
    - Encountered difficulties crossing the firewall for video conferencing; it appeared to be a configuration issue at the CERMUSA firewall
- Manually reprogrammed the satellite system

- Test driving the vehicle
- Training CERMUSA technical staff on system start, system and vehicle security, deploying and stowing the satellite dish, and transferring data

Delivery of the completed MCP was originally scheduled for March 23, 2005, but was extended by one week at the request of GCS due to an unplanned demounting of the auxiliary generator in order to gain access to the front mounted exterior camera in order to make modifications to the camera's cabling. On March 31, 2005, after a final round of acceptance tests, CERMUSA accepted delivery.

Figure 17



Beginning in April 2005, with the vehicle back at the University, CERMUSA staff resumed video and audio systems integration, and began preparing to make the MCP operational. Figure 17 shows a CERMUSA technical specialist logging the details of a test session in early April 2005, using the laptop built into the MCP equipment rack.

Prior to demounting the exterior camera for shipment to Pelco for warranty repairs, additional troubleshooting commenced in an attempt to identify the cause of the video ghosting. This effort involved terminating video outputs on the back of all monitors and changing the control panel switch setting on the camera unit. CERMUSA technical staff began checking video termination to eliminate the variable of radiating RF. Any time a video output of a monitor or video test equipment is left unterminated; it can radiate or leak RF signals causing interference with other video equipment. Upon review, CERMUSA staff found the video connections for preview monitor and video test equipment in the rack were not terminated, and "ghosting" and freezing of video signals were occurring on the monitor. Such symptoms indicated a possible high-impedance signal loop, possibly caused by a change in amplitude of the video signal. MCP technical staff remedied these problems by installing video terminations on all video outputs the entire preview monitors and video test equipment in the rack.

As CERMUSA staff was then conducting research on another vehicular project using the same model Pelco camera, technical staff decided to swap the control units between the two vehicles. Both the camera and the controller worked flawlessly on the other unit. When the control unit from the other project was installed in the MCP, the problem of jerky movement re-appeared, indicating that internal vehicular cabling was to blame. The cable used was a general purpose video cable with no shielding. CERMUSA staff installed a RG59 with a copper braid shield and gold plated center pin for low contact resistances for monitor and camera connection. After replacing the unshielded video cable with a shielded RG59 cable, the Pelco camera tracked correctly with the joystick.

The MCP team was faced with a challenge when connecting the video conferencing equipment at transmission speeds of 384 and 512Kbps. Test calls at these commonly used speeds were plagued by image tiling, break-up and audio delays, which had not been seen during acceptance testing at GCS. CERMUSA contacted GCS technical support and engaged in extensive troubleshooting. Eventually it was found the Tandberg 6000 video conferencing codec had to be set to 100 half duplex, rather than the normal 100 full duplex. Further testing and research led CERMUSA IT staff to determine that the half duplex setting was the result of the IP protocol used for packet handling across the satellite link. The satellite StarWire modem's bandwidth capacity could only be integrated into the videoconferencing at a half duplex transmission setting. Further investigation led CERMUSA staff to examine the StarWire Calypso modems as a possible source of problems or configuration errors. Inside the StarWire modems is a TMC-1000 board, where the Transmission Control Protocol (TCP) is converted to the User Datagram Protocol (UDP) protocol to be sent up to the Intelsat Americas (IA-6) Satellite. Once traversing this link, IP packets are converted back to TCP format at the other StarWire Calypso modem. Additionally, CERMUSA IT suspected that NAT translation might also contribute to the problem. Subsequently, it was decided to experiment by placing the MCP away from the main CERMUSA network and the NAT interface. The MCP network was reassigned to a backup T-1 Internet connection outside of our main Internet link with a completely addressable IP address range. These changes were proven to increase significantly the quality of VTC calls.

CERMUSA staff determined that the audio delay and break-up issues were correctable by confirming identical audio settings (G.722 or G.728) were used at both sides of a video conference. When using the G.722 audio setting, the video conference codec utilizes a compressed wide band of 7 KHz at 64Kbps, while G.728 setting provides a compressed wide band of 3 KHz at 16Kbps. After setting the codec units to G.722, the audio problems were corrected. The Tandberg codec demonstrated no delays or breaking-up of the audio transmission. Disparate audio standard settings between send and receive codecs was found to introduce audio latency and break up. It was concluded that the G.722 64Kbps at 7 KHz format performs better with the wider bandwidth, having no audio delays.

The voice communications configuration of the vehicle has now gone through several iterations as well. The original analog-to-IP voice conversion system, under further evaluation, was determined to be problematic and unreliable. CERMUSA proceeded to identify and evaluate other VoIP phone solutions, including:

- Cisco AVVID
- Avaya
- Altigen
- Pcphoneline.com
- Vonage

The Cisco, Avaya, & Altigen solutions were out of budget for use because of the required equipment overhead. The pcphoneline.com solution did not meet system requirements because it lacked support for multiple phones/lines. As a result, Vonage was the only available solution for the following reasons:

- Minimal equipment was required for purchase (a router and the desired number of standard analog telephones)
- No base station overhead
- System could be configured with a local phone number
- Local and long distance was built into an affordable package
- Service could be easily expanded to more phones/lines by adding low-cost equipment and buying extra packages

The Vonage solution has worked well and already been adjusted to add and remove phones/lines as needed. Standard 900MHz Panasonic analog phones were used with this system. CERMUSA is also currently in process of evaluating several other primarily online-based voice carriers, such as Skype; these and other IM based applications have shown to work very well for voice communications and warrant further investigation.

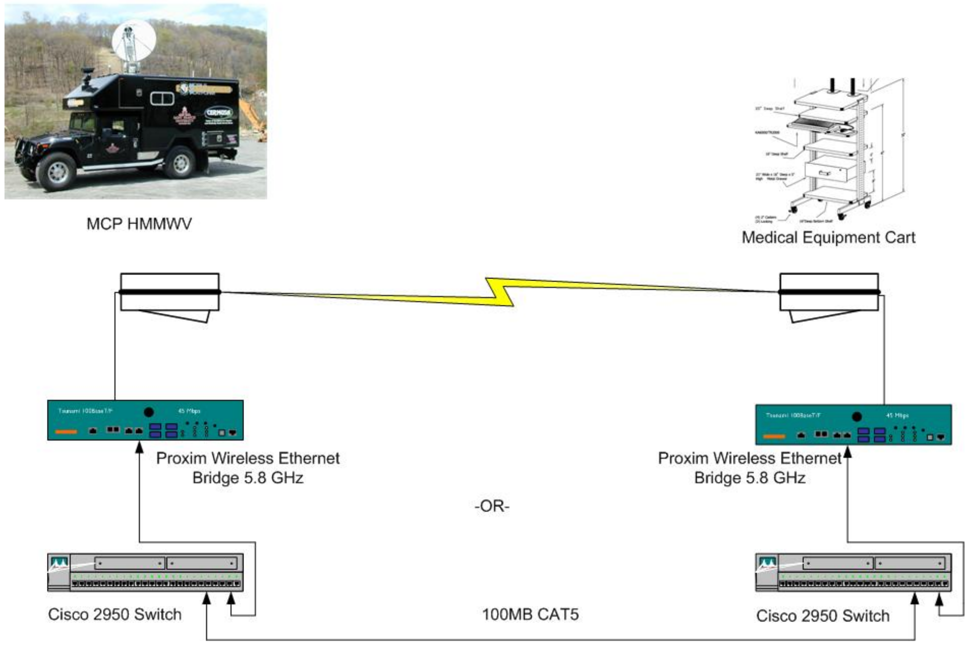
The server design remained consistent with the initial layout because of the forethought of CERMUSA IT staff in creating a diverse platform to support multiple boot operating systems and therefore, a diverse range of services and applications that can be adjusted as any project requires.

Point-to-point wireless was established as a key component of the MCP's tactical function. Based on the original concept, key components of the MCP, including the telemedicine cart and videoconferencing unit, would be offloaded from the vehicle and temporarily installed in a given facility. A point-to-point wireless link would be used to supply network/Internet connectivity between the vehicle and the offloaded components.

CERMUSA IT reconsidered the original choice of Tsunami license-free radios, primarily because of setup complexity, and because they provided far more bandwidth than could be used. Based on previous experience with Tsunami systems, the assessment by the CERFMUSA IT team was that the need for very precise alignment of the paired radios and the requirement to set manually transmit power at each site would be unrealistic in most proposed MCP mission profiles. As a result, a market survey of other viable license-free solutions was undertaken. Based on this survey, the Proxim MP.11 radio was selected. The Proxim MP.11 series of radios and antennas were much smaller and easier to configure and were designed to run at 2.4GHz line-of-site with up to 11Mbps bandwidth, which would be adequate for all proposed MCP applications. The directional yagi antennas had a range of up to several miles in a given direction with clear line-of-site. The MP.11 radios do not require the difficult and time consuming process of alignment and power adjustments, as did the Tsunami radios.

With this link, the MCP could communicate with all offloaded peripherals via secure wireless connection using VPN encryption technology. A Cisco 2950 switch for all Cat5 connections, and a Cisco 1200 AP was installed on the telemedicine cart to serve as an additional repeater within facilities. The MCP Network IP Diagram is shown in Figure 18.

Figure 18



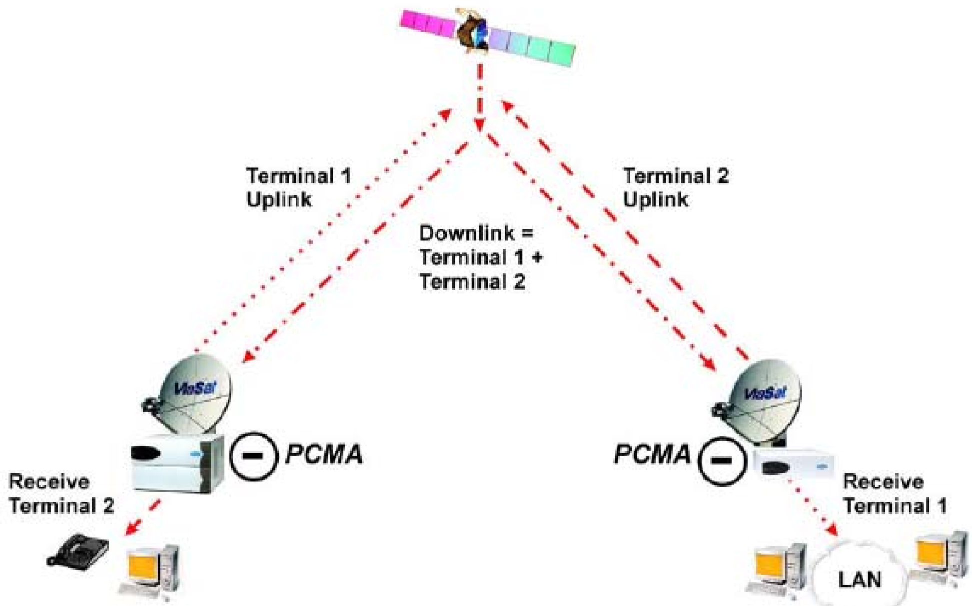
High Speed Data Link

The process of shaking down the MCP was not without challenges. The project encountered delays when an electric heating blanket, required because of severe winter weather conditions in Loretto, was omitted from the original the GCS quote. After requesting a separate quote, CERMUSA staff placed the order in September of 2004 to have a heating blanket ordered for the satellite downlink dish. In September of 2005, a full year after the original purchase order was issued, the heating blanket was finally installed.

In May 2005, point-to-point calls between the MCP vehicle and satellite downlink site became problematic. H.323 video calls were plagued by repeated failures to connect and by poor video quality and intermittent call drops. Preliminary troubleshooting indicated that the problem stemmed from overall signal strength at the CERMUSA base station, which is a fixed antenna dish. CERMUSA contacted the satellite airtime provider, ViaSat Communications, to discuss the RF signal strength. As a result, a ViaSat technician made the necessary adjustments on the stationary satellite modems to increase the total dBw power with respect to the size of ViaSat's satellite dish.
The 2.4 meter dish requires a dBw setting of 87dBw and the 1.2 meter dish requires a setting of 85dBw. A ViaSat technician stated that the smaller dishes require additional power, because of the low gain of the Block Unit Converter (BUC) unit to transmit or receive signals because of the reflection surface area of the dish (the total size of the dish). The larger dishes require less power because they have a higher gain BUC and

more reflective surface area; generally-speaking, larger surface area equates to higher power handling capability, meaning greater transmission capabilities between surface stations and satellites. Figure 19 shows the Energy-per-bit to Noise Density Ratio (E_b/N_o) signal process path, as it transmits and receives on the same frequency to

Figure 19



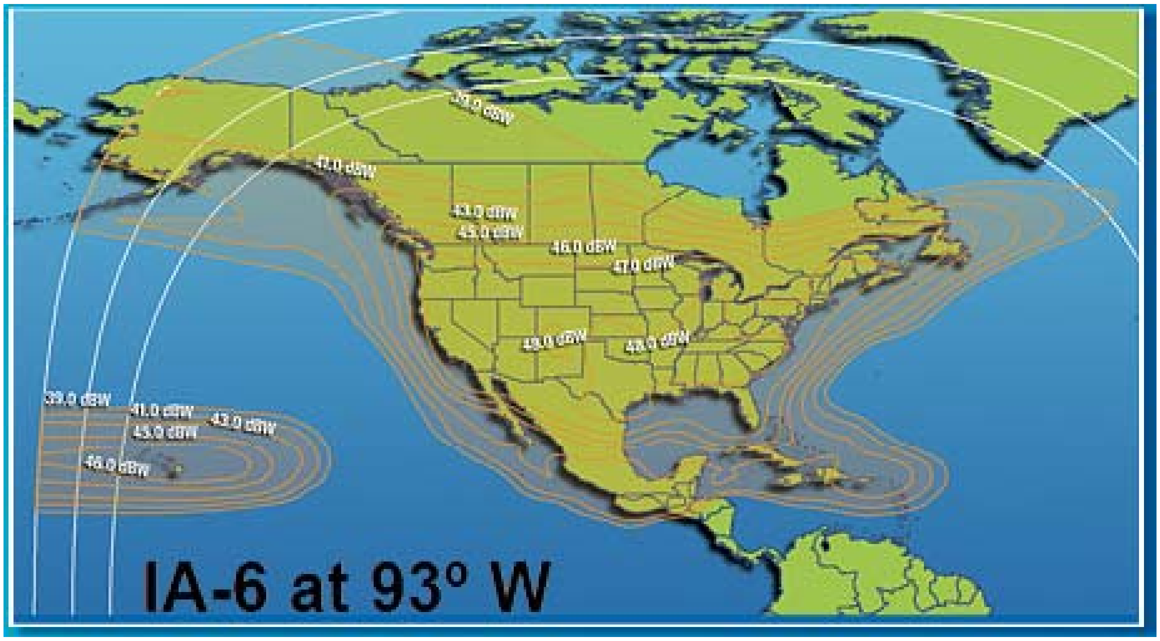
E_b / N_o signal process path

maintain its calibration. The power settings allow both StarWire modems to maintain an E_b/N_o of 8 to 10. E_b/N_o is classically defined as the ratio of Energy per Bit (E_b) to the Spectral Noise Density (N_o); for our purposes, it is the measure of signal to noise ratio (SNR) for a digital communication system. This defines the SNR per bit and is an important measure to evaluate and compare different digital communication systems. The StarWire modem E_b/N_o setting allows the "handshake" timing to be consistent with dishes of varying sizes.

Following these adjustments, ViaSat's RF signal strength was correctly calibrated for the size of antenna dishes that CERMUSA is using; the RF power signal strength to the StarWire modem was increased by 2dBw. Note: Despite these adjustments, the system still requires calibration to peak the E_b/N_o when the Hummer travels over 25 miles from SFU site. This adjustment is required because modem trajectories require the StarWire Modem "handshake" timing to be recalibrated when a mobile system is relocated away more than 25 miles from its home base station . Such recalibration requirements are caused by the longitudinal/latitudinal divisions of the satellite's service footprint, as shown in Figure 20; essentially, the modems must be adjusted to accommodate the additional latency introduced by moving a relocatable system further away from its designated downlink site.

Another challenge was getting adequate signal strength to both StarWire modems. At the

Figure 20



Americas 6 Operational Footprint

start of the testing, the signal strengths were around 6.50 E_b/N_o at the MCP vehicle site and 5.50 E_b/N_o at the CERMUSA site. Both signals needed to be at least 2.50 points higher than the beginning reading. CERMUSA staff contacted the ViaSat technician regarding the problem and subsequently made several calibrations on the StarWire modems and Block Up-Converter(BUC) unit to resolve the problem.

On May 31, 2005, the satellite connection to the stationary CERMUSA site was lost. CERMUSA technical staff performed several tests and contacted ViaSat's communication center. A ViaSat technician tested both the stationary and vehicular systems; MCP vehicle modems appeared to be functioning normally. ViaSat concluded that something on the stationary satellite downlink was not operating correctly, as no RF signal was being received back from this StarWire modem to the ViaSat Network Operations Center (NOC). CERMUSA then contacted GCS for a service call to be placed on the unit. Both GCS and MCP technicians worked on the problem at the CERMUSA site. The technicians traced all wiring and tested the voltages at the BUC (Block Unit Converter), finding no voltage at the BUC unit. The GCS technician placed a service call for another BUC unit to be delivered. Following pick-up of this unit, he installed the BUC, which returned the signal strength up to specifications.

In June 2005, water was discovered to be gathering in a side compartment of the vehicle, creating the potential for immersing an electrical junction box. Further investigation revealed a gap at a junction point between the vehicle body and the equipment shelter, allowing water intrusion into the compartment. A local emergency vehicle supplier was able to seal the gap between the body shelter and the vehicle.

Also in June 2005, while performing audio/video testing, CERMUSA technical personnel found problems in the configuration of video cables from access panel to the Videotek switcher in the communication rack. The cables going from the Videotek switcher were not connected in the proper order, and the MCP technician had to reconfigure them to match the Videotek switcher. Additionally, the output cables from the video switcher to the three monitors were not properly connected and terminated. After the cables were correctly attached, the switching of the video from the input (or output of the access panel) to the switcher and monitor worked properly. Similar cable maintenance had to be performed to the Panasonic Digital Recorder, which was also not properly attached to the vehicle's audio/video routing system.

In addition, the audio cable on the mixer was not correctly connected to the access panel. The audio cable had to be re-wired from the access panel to the Cannon X-series Latch Rubber Gasket (XLR) connectors onto the mixer. This allowed the unit to receive and transmit audio from the MCP vehicle.

In September 2005, the MCP technicians were testing the ISDN connection through the MCP Hummer access panel to Tandberg 6000 Codec. During testing, the technicians could not connect a call to another Codec using ISDN communications lines. The technicians checked all connections from the Hummer communications interface back to the switches in the demarcation point (demarc) room. Every ISDN BRI connection tested positive for local loop connectivity. The technician reconnected the call using a Cat V networking cable (RJ-45 interface, 100mbps-capable) from a wall jack in a CERMUSA facility directly to the vehicle's communications interface. Again, the call failed. A PolyCom FX Codec using 384kbps was connected in lieu of the Tandberg 6000 Codec. The PolyCom FX Codec made several connections out and received incoming connections. CERMUSA staff determined that the Tandberg 6000's firmware was out of date and in need of upgrade. Following a firmware upgrade, CERMUSA technical staff reconfigured all terminal and audio/video settings in the Tandberg codec. At this point, the Tandberg 6000 Codec based in the MCP was capable of connection using the ISDN protocol to other ISDN sites using 384/512kbps.

In November 2005, some paint blistering was observed on the front overhang of the body shelter. Danko Emergency Equipment was notified of the problem. Danko, in turn, referred the problem to Rescue Vehicles of Iowa, the subcontractor hired to paint the enclosure during fabrication. RVI contacted the paint manufacturer, and after photographic and direct inspection, a representative of DuPont concluded that the cause of the problem was improper surface preparation and instructed RVI to issue a check to CERMUSA to have a local body shop repaint the affected area.

In December 2005, CERMUSA technical staff noticed the Hummer was losing battery charge when it sat for more than two weeks without operation. In researching the problem, technical staff found that the Auto Charger 1200 that charges the batteries was not generating the correct voltage. The lead technician called the manufacturer of the unit to perform troubleshooting, and found the output voltage is supposed to be 13.5volts DC output and the unit in question were only generating 12volts. The staff removed the Auto Charger 1200 and sent it back to manufacturer for repairs. The manufacturer found a malfunctioning Silicon Controlled Rectifier (SCR) Bridge that regulates the voltage to the batteries. The manufacturer replaced the SCR Bridge, which returned the Auto Charge 1200 to proper charging specifications of 13.5 volts. To date, the batteries in the hummer have not discharged since it was fixed.

Additional delays encountered on the satellite completion were due to the installation of the heater blanket for the CERMUSA satellite dish before winter. This heater blanket was a polyurethane cover with heating wires to keep the stationary downlink clear of snow and ice during cold weather. The heating blanket is always on and automatically heats when temperatures go below 32 degrees Fahrenheit. In April 2005, the GCS technicians integrated and installed the stationary satellite downlink on a CERMUSA tower, but did not install the specified heater blanket at that time. The GCS technicians indicated that they would have to order one for the site. It took seven months to complete this process.

3. Integration/configuration of telemedicine scopes and modular cart:

As previously mentioned, CERMUSA chose a Panasonic Toughbook as the primary interface for all PC-based medical peripherals due to its factory ruggedization and the line's long history of quality and durability.

CERMUSA began PC integration efforts by categorizing medical peripherals to be managed using two non-ruggedized laptops. This approach was based on early difficulties in managing operating system internal interrupts, but was ergonomically cluttered and technically inefficient. After resolving the interrupt issue, it was decided to consolidate most devices to a single computer, based on the following criteria:

- All software resides in a single laptop for ease of use and maintenance
- All digital hardware is attached to one laptop
- Ease of troubleshooting software and hardware
- Reduced software costs due to elimination of redundancy
- All medical reports can be generated from a single computer.
- Less maintenance/fewer updates
- Better security: only one laptop to sign onto as opposed to two
- Separation of standard examination tools from elaborate sub-specialty devices for better utilization of one or two larger medical devices (ultrasound, nonmydriatic camera)

Following consolidation, the medical peripherals attached to this laptop are as follows:

- USB Hub 4 port
    - Keyboard
    - Mouse
    - HP printer
    - WelchAllyn Virtual monitor
- USB 2.0 Card
    - IQmark Digital ECG
    - Spirometer
- Wireless card – internal 802.11*b*
- Network connectivity: Cisco switch can connect to various network devices in any clinics.

Following the initial telemedicine cart design, several issues still needed to be addressed:

- There was no room for the printer
- There was no room for the Cisco Access Point
- There was no room for the Cisco Switch
- There was no room for the scale
- No room for medical supplies, (scope covers, gloves, etc.)
- The cables to the equipment were exposed
- Keyboard tray and mouse fell out each time doors taken off
- 4 by 1 switcher kept falling off side of cart

- Requirement for keyboard, video, and mouse (KVM) switch because of the original plan for multiple laptop computers for PC-integrated peripherals
- The equipment was facing one way and the monitor the other
- The Ultrasound laptop was on the bottom of the rack
- The nonmydriatic camera laptop was on the bottom of the rack
- The cart was not user-friendly: CERMUSA technical staff evaluated user friendliness via a verbal survey of non-technical MCP team members

It was decided to reconfigure the cart, retaining the same overall external dimensions. Based on the feedback obtained from non-technical MCP team members, a greater emphasis was to be placed on end-user ergonomics. The new design would be guided by the following findings:

- The scope cables still would have to be plugged in and out at each use
    - Scope cables were too short to reach patient on table since they were located at bottom of cart
- Vertical orientation: People under 5 feet 3 inches tall could not see the images on the monitor
- The nonmydriatic camera laptop housing became cracked from daily movement
- There were not enough laptop USB ports for all devices and medical peripherals
- The ultrasound laptop AC power supply pin failed
    - The laptops were located on the bottom of the cart and, with the consent movement, the attached ultrasound power cables were subject to vibration and contact with the cart housing, causing the pin to break
- A video and audio capture device did not work properly
- User friendliness
    - If the cart was too difficult for clinic personnel to use, it would not be used
- Time savings
    - The set up and use of equipment had to be accomplished in a timely manner
- Patient assessments
    - A system that increased wait time and service delivery time to patients would not be accepted by either patients or providers
- Equipment set up
    - Which tools on the telemedicine cart would be used most often?

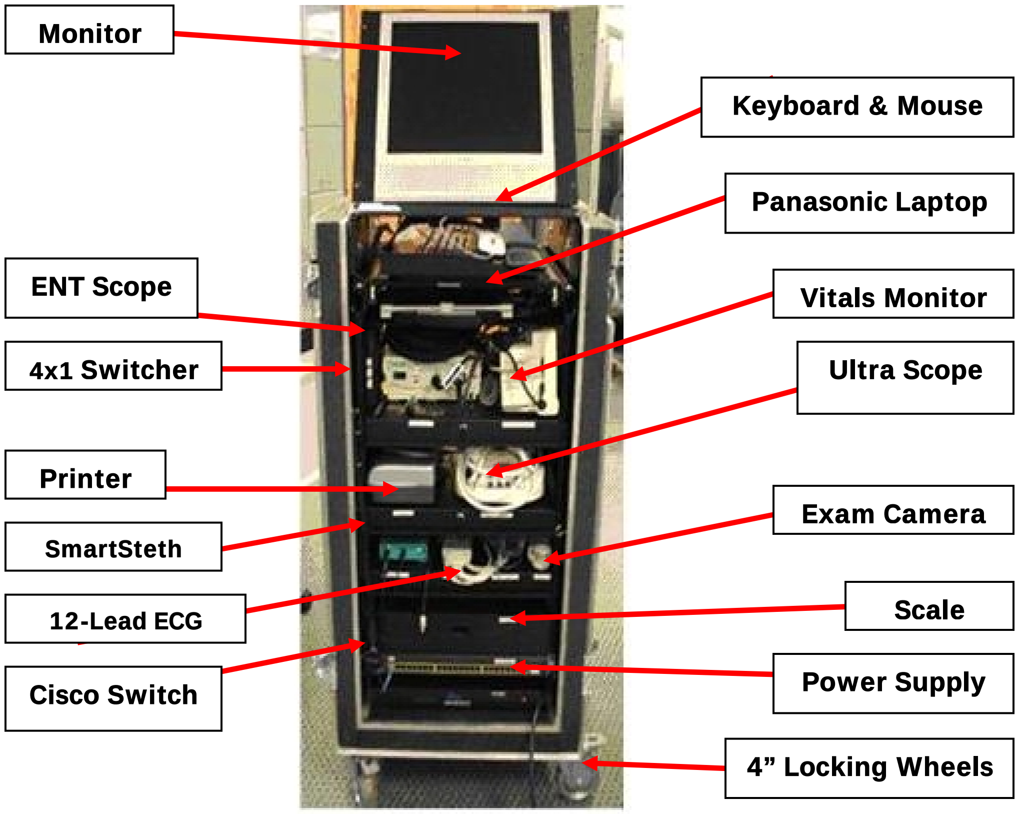
The reconfiguration made the best possible use of existing equipment, focusing mainly on repositioning for efficient accessibility by end-users. The issues addressed were as follows:

- Medical equipment measured for space location on cart
- Specifications on current laptops were readdressed to ensure component interoperability (i.e. adequate number of USB ports, physical cabling, etc.)
- Locking, slide out trays would be deployed in place of the rack shelves
- Locking, drawer would be used for the scale
- Printer to be installed on cart
- Cisco switch would be installed in cart

- Monitor and medical peripherals would all be facing the same direction
- Monitor height would be addressed

The cart was reconfigured as illustrated in Figure 21.

Figure 21



Telemedicine Cart Equipment Layout

Steps taken in order to reconfigure the cart were as follows:

- telemedicine cart was "stripped
  - All equipment had to be taken out of cart before the reconfiguration could start
  - All cables were labeled at both input and output ends
- Laptop options were evaluated
  - Since it was determined that a ruggedized laptop was needed, a Panasonic ruggedized laptop was chosen to replace the two existing laptops
  - Necessary software updates were installed on the Panasonic ruggedized laptop for all medical equipment and Windows operating system
  - Due to the highly-specialized nature of the applications, the nonmydriatic retinal camera and ultrasound device remained on separate laptops in separate cases
- Placement of medical equipment was determined

  - By using a test patient sitting in a chair, CERMUSA staff determined where equipment should be placed on the cart
  - This evaluation was done in order to set the length of the cables attached on the medical equipment
- Placement of locking slide-out shelves was determined
  - By measuring the height of the medical equipment, CERMUSA staff determined how much clearance would be required between shelves
    - One inch of space was left between each shelf for air circulation
- Monitor height issues were determined
  - Ten pound springs were attached to the monitor and the cart's support structure to allow adjustment of the monitor to the end user's sightline

The reconfigured telemedicine cart incorporated the following equipment:

- Monitor
- Keyboard and mouse on pull out tray
- APC uninterruptible power supply (UPS) located at rear of first pull-out tray
- Panasonic rugged laptop on permanent shelf
- First (from top) pull-out shelf
  - 4x1 switch
  - ENT scope
  - Vitals monitor
- Second pull-out shelf
  - Printer
  - Ultra camera
- Third pull-out shelf
  - SmartSteth
  - ECG
  - Exam Camera
  - Spirometer
- Drawer
  - Electronic Scale
- Cart floor
  - Cisco Switch
  - Main power of telemedicine cart

Additional information:

- All equipment was secured in place by using poly-locking, industrial strength Velcro
- All equipment cables were labeled on both input and outputs for ease of identification
- All equipment cables were secured to the cart inner rack by using zip ties and wire conduit
- The two laptops that were being used for the ultrasound and nonmydriatic camera were manually updated on a monthly basis with Microsoft Windows updates and new software versions when available

- Cisco access point can be placed on the back of the cart as needed
- Approximate time frame to reconfigure the cart and create two medical cases: seven days

The telemedicine cart has several metal handles on the side doors to make it easy to pull the cart to different locations. The thick rubber covers on these handles made it difficult to get the telemedicine cart into the MCP doorway. To remedy this situation, the rubber covers where removed from the handles, giving the cart enough allowance to gain access through the doorway of the MCP.

When the telemedicine cart was loaded with all medical devices the stock-equipped 3 inch wheels on the cart would not allow for easy movement over carpet, let alone shale or other possible field conditions. Additionally, the stock wheels did not lock the telemedicine cart in position. When the telemedicine cart was placed on the lift gate, it would roll on the gate causing a potential hazard to individuals holding the telemedicine cart in place as the lift gate was raised off the ground.

CERMUSA staff located four inch wheels with locking features for the telemedicine cart. Measurements where done on the telemedicine cart and the MCP lift gate before modifications were again made to the telemedicine cart. First, a determination of clearance for the door opening of the MCP had to be considered. With the measurements of clearance, the telemedicine cart was measured with all side panels installed. At first, the technicians found that with the additional 1 inch on each wheel, the cart was ½ inch too tall. Upon further inspection, however, CERMUSA staff discovered that a bottom wooden panel could be removed giving the telemedicine cart the required clearance to get through the lift gate door of the MCP. The layer of wood at the bottom of the cart removed and later replaced with a thinner layer of metal bracing to retain structural integrity while lowering the cart's height.

The board was removed and the new four inch wheels were drilled and sealed into place onto the bottom of the telemedicine cart. With the larger wheels in place, the cart was easily moveable by a single individual over carpet and shale. With the additional locking feature of the wheels, the telemedicine cart safely remained in place during transit on the lift gate.

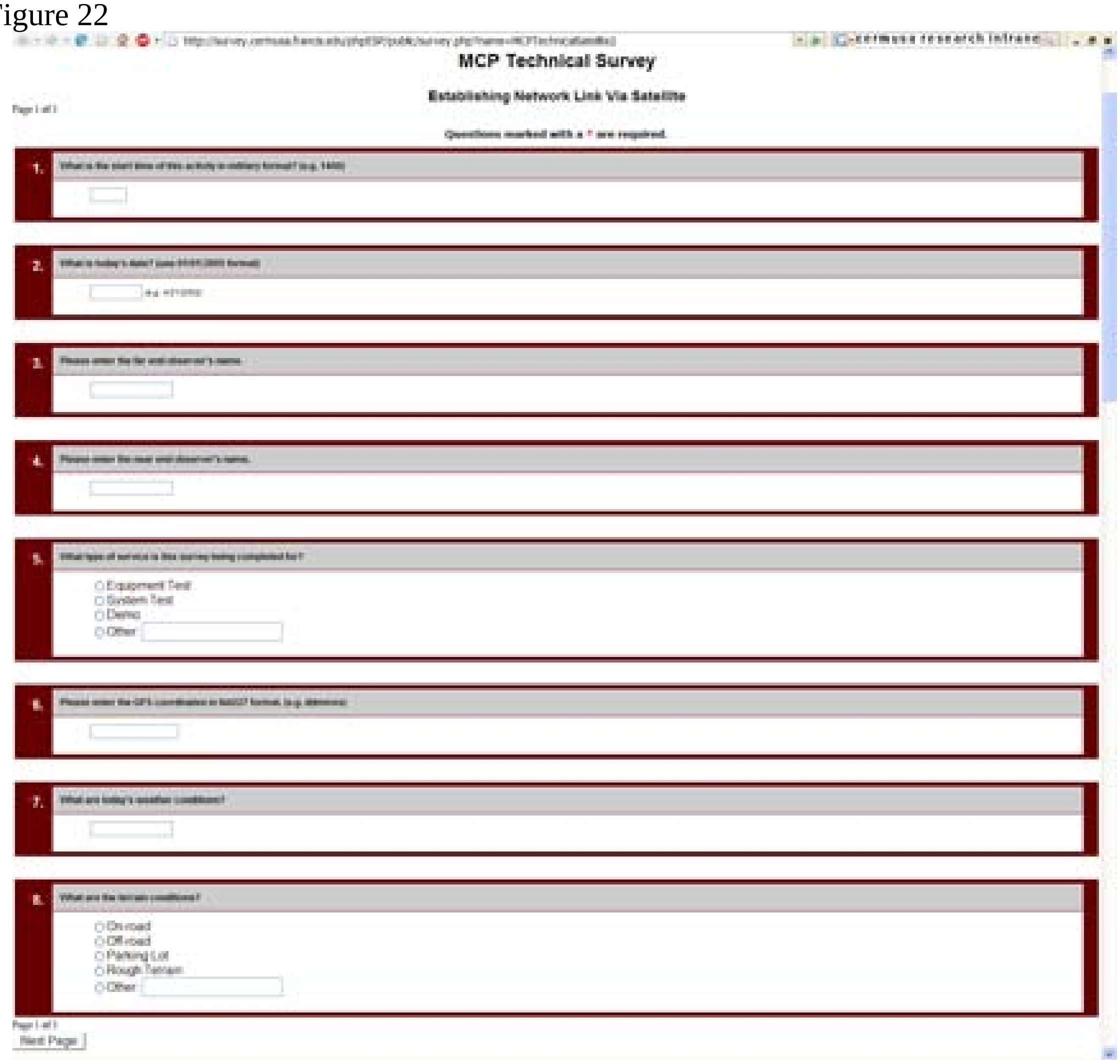
Task 7: Mobile Communications Platform (MCP) Prototype Operational Sustainment and Research Findings

a. Operational sustainment

Task 7, the operational sustainment phase, like the previous two tasks was evolutionary: it began as a necessary component of a previous task. Prior to final delivery of the Hummer from Danko, planning had already begun on training of CERMUSA staff to operate the vehicle and its functional payload.

The MCP returned to the Saint Francis University campus on March 31, 2005. As final audio and video infrastructure integration was completed, the first operational tests of the system commenced. During this time, all major operational metrics were recorded manually in a journal, since development of the test plan and the data acquisition form were still in process. It was hoped this initial data would provide a baseline for the eventual data collection. The data collection form was a web-based form, which allowed the data to be recorded in real or near real- time and instantly be fed into a database, as shown in the screenshot in Figure 22. A text version of the data collection form is

Figure 22



Screen capture: MCP data entry web-based form

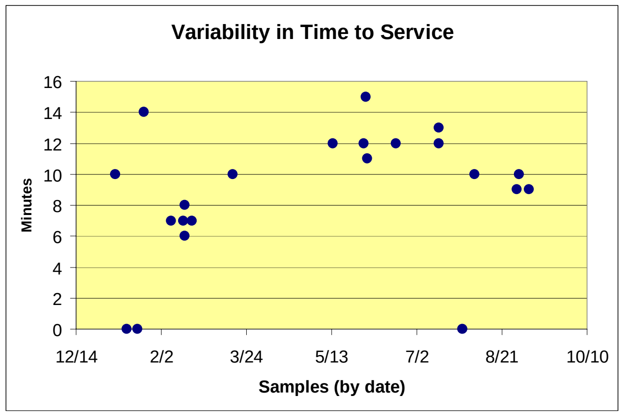
appended as Attachment A. The test plan called for operational data to be recorded each time the MCP was used.

b. Research findings

The stated goal of Task 7 is operational sustainment. Since the terms of contract DAMD17-02-2-0029 proscribe any human use data, the test plan was limited to measuring technical performance metrics.

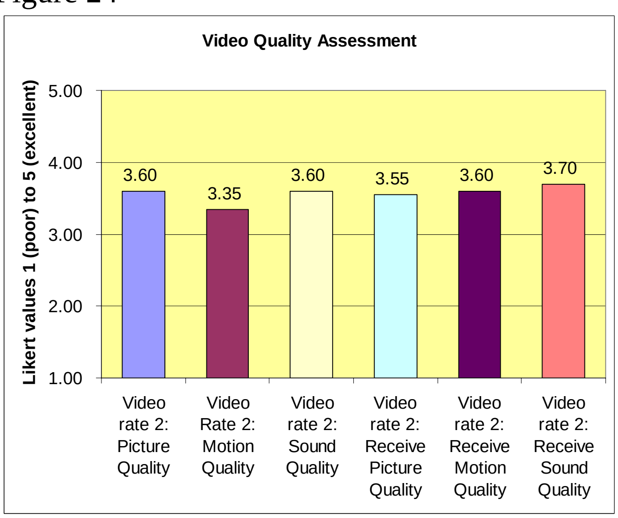
The researchers collected a range of environmental, temporal, and performance data each time the vehicle was used and the satellite dish deployed. The performance data were optimized delineate quality of service dimensions. The most fundamental of questions centered on the length of time needed to make the MCP capable of providing telecommunications services once on site. As noted in Figure 23, time to service varied considerably early in the testing phase, likely due to operators unfamiliarity with the StarWire system. In the beginning, it took on average between ten and twelve minutes to initiate the satellite dish tracking and lock onto the appropriate communications satellite. The range of duration was six to fifteen minutes. In three tests, no attempt was made to establish a satellite connection; instead, Internet connectivity was obtained via hardwire connection to an existing IT infrastructure. For purposes of this analysis, those tests were not included. By the end of active data collection in October 2006, the average duration had leveled out at just less than eight minutes.

Figure 23



Because the MCP is optimized to support transmission of video (both cameras and visually-based telemetry), the test plan incorporated several measures of video quality of service, illustrated in the bar chart in Figure 24. Both quantitative and qualitative metrics were incorporated into the test plan. The video metrics reflected in Figure 24 are subjective in nature, and so a Likert-type scale was developed to convert the

Figure 24



qualitative assessments into qualitative values. Twenty two tests were conducted for this analysis, of which video tests were done in twenty, providing a sample *n=20*. An ANOVA single factor analysis yields an *F* value of .62 and a *p* value of .68, as shown in Figure 25, offering little confidence that these questions are of some statistical significance, at least on a graduated scale. In practice, video and audio performance tends to be gauged on a far narrower range of acceptable or not acceptable. The freeform comments entered into the survey form (see Attachment C) by the MCP team technicians appear to support this notion.

Figure 25

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video: Picture Quality	20	72	3.6	**0.357894737**
Video: Motion Quality	20	67	3.35	**0.660526316**
Video: Sound Quality	20	72	3.6	**0.568421053**
Video: Receive Picture Quality	20	71	3.55	**0.365789474**
Video: Receive Motion Quality	20	72	3.6	**0.252631579**
Video: Receive Sound Quality	20	74	3.7	**0.431578947**

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	**1.366667**	**5**	**0.273333**	**0.621956088**	**0.683309402**	**2.293911156**
Within Groups	**50.1**	**114**	**0.439474**			
Total	51.46667	119				

Environmental factors such as weather conditions and time of day appeared to have no significant impact on quality of service. Terrain is essentially a binary factor; there is either a clear view, or not, of the southern sky. Based on experience, the MCP operator tends to self select locations that provide an operational window to the Americas 6 communications satellite. As a result, these dimensions have not been subject to statistical analysis.

c. Noteworthy demonstrations

The MCP and REMeD-D have been demonstrated to a wide variety of interest groups including the emergency response community, government representatives, the general public, educators, fellow technology researchers, and the mass media as follows:

CERMUSA Rural Homeland Security Technology Expo, (2004, October 20-22). Johnstown, PA: CERMUSA.

Mainhart, R. (Program Manager (MCP & REMED-D). (2005, April 17-20). *Mobile Communications Platform (MCP)*. American Telemedicine Association Conference, Denver, CO: CERMUSA.

Mainhart, R. (Program Manager (MCP & REMED-D)), Bender, T. (Communications Platform Technology Manager), & Litzinger, G. (Telehealth Development Specialist). (2005, May 4). *Mobile Communications Platform (MCP) Presentation*. Health & Wellness Fair, Johnstown, PA: CERMUSA.

Mainhart, R. (Program Manager (MCP & REMED-D)) & Bender, T. (Communications Platform Technology Manager). (2005, May 14-15). *Mobile Communications Platform* (*MCP) Demonstration*. EMS Appreciation Day, Altoona, PA: CERMUSA.

Mainhart, R. (Program Manager/MCP & REMED-D), & Litzinger, G. (Telehealth Development Specialist). (2006, May 25). *CERMSUA Telehealth Experiences & MCP and REMeD-D Overview*. Internet2 Presentation to MAGPI Virtual Forum: Healthcare and Medicine: CERMUSA.

Mainhart, R. (Program Manager), Cronin, G. (Instructional Designer), Litzinger, G. (Telehealth Development Specialist) (2005, August 5). *CERMUSA's Mobile Communications Platform (MCP).* Internet2 Gigaconference Videoconferencing Event, Loretto, PA: CERMUSA.

Mainhart, R. (Program Manager (MCP & REMED-D). (2005, September 27). *Automated Casualty Care – Integrating Multiple Systems/Multiple Vendors into a Successful Project*. Pittsburgh Robotics Conference, Pittsburgh, PA: CERMUSA.

Mainhart, R. (Program Manager), Bender, T. (Communications Platform Technology Manager), &Bickford, S. (Telemedicine Handheld Computing Specialist). (2005, November 15). *Mobile Communications Platform (MCP) Presentation*. JARI-PA Careerlink-National Telehealth Career Week assembly at Ferndale Middle School, Johnstown, PA, and Greater Johnstown Junior High School, Johnstown, PA: CERMUSA

Mainhart, R. (Program Manager), Bender, T. (Communications Platform Technology Manager), &Bickford, S. (Telemedicine Handheld Computing Specialist). (2005, November 18). *Mobile Communications Platform (MCP) Presentation*. JARI-PA Careerlink-National Telehealth Career Week assembly at Westmont Middle School, Johnstown, PA: CERMUSA

Mainhart, R. (Program Manager (MCP & REMED-D) & Bickford, S. (Telemedicine Handheld Computing Specialist). (2005, November 22). *Robots to the Rescue: Development of Life-saving Robots*. Science Day 2005 Presentation, Loretto, PA: CERMUSA.

Mainhart, R. (Program Manager/MCP & REMED-D). (2006, January 19). *Mobile Communications Platform (MCP) & Robotic Emergency Medicine and Danger-Detection.(ReMed-D).* Videoteleconference Presentation/Demonstration for University of Scranton I2 Event. Loretto, PA: CERMUSA.

Roberts, J. (Director) & Tonkin, K. (Assistant Director for Information Technology). (2006, February 21). *Mobile Communication Platform (MCP) for Hill Briefing.* Communications & Information Technology Tools for Biosurveillance & Disaster

Preparedness: Lessons Learned From Recent Natural Disasters and Global Monitoring Systems to Detect and Warn of Public Health Emergencies: Steering Committee on Telehealth and Healthcare Informatics. Capitol Hill, DC: CERMUSA.

Mainhart, R. (Program Manager), Bender, T. (Communications Platform Technology Manager), & Knee, D. (Technology Coordinator). (2006, March 17). *MCP and REMeD-D Overview*. Penn Cambria High School. Cresson, PA: CERMUSA.

Pepon, B. (Diabetes Research Analyst) & Mainhart, R. (Program Manager). (2006, March 28). *The Basics of Diabetes.* MCP Presentation to the Johnstown Senior Center. Johnstown, PA: CERMUSA.

Roberts, J. (Director), Tonkin, K. (Assistant Director for Information Technology), Mainhart, R. (Program M*anager/MCP & REMED-D), & Litzinger, G. (Telehealth Development Specialist). (2006, April 19-21). Military Communications in Catastrophes: Tsunami to Flu via Katrina.* 9th Annual Distributed Medical Intelligence Conference: Disaster Response and Preparedness: From Hurricanes to Infectious Disease. New Orleans, LA: CERMUSA.

Roberts, J. (Director) & Tonkin, K. (Assistant Director for Information Technology). (2006, May 31). *Mobile Communication Platform (MCP) Federal Government Health Information Technology Transfer Opportunities: Working with State and Local Governments Towards Multi Use Technologies in Support of Disaster Preparedness, Mitigation and Response*: Steering Committee on Telehealth and Healthcare Informatics. Pasquerilla Center, Johnstown, PA: CERMUSA

Mainhart, R. (Program Manager), Bender, T (Communications Platform Technology Manager), & Bickford, S. (Telemedicine Handheld Computing Specialist). (2006, June 20-21). *Integration of Multiple Autonomous Agile Robots into a Casualty Care System.* ROBO Business Conference & Expo. Pittsburgh, PA: CERMUSA

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d. Plan for testing and deployment in real world settings

Because it is based on robust, mature technologies, the MCP project has focused on the packaging of those technologies and their related capabilities into a relatively compact form factor. Communications vehicles with similar capabilities have been developed and deployed in a variety of military and civil environments, but most of these have been designed around considerably larger vehicles that not only house the technology but also provide work space for multiple users. The MCP's compact design is based on the notion that this form factor is far better able to negotiate terrain denied to larger over-the-road vehicles, thus increasing its potential field of operations; and that once the communications capabilities are brought to wherever needed, working space can be borrowed or provisioned through any number of commonly available means. It is anticipated that the MCP's mobility and modular mission specific payload capability can be further demonstrated in support of ongoing and future CERMUSA research efforts.

The MCP would prove useful in several existing and proposed CERMUSA projects, as follows:

The National Bioterrorism Civilian Medical Response Center (CiMeRC) is developing a prototype training program, Tactical Communications Network for First Responders (TaCNet), in which the MCP would be used as a mobile command and control center for a simulated police response to school shooting and/or hostage incident

It is proposed to employ the MCP in the Wireless Test Bed project, for delivery of the hardware to the scene, providing remote situational awareness, and communications support for ongoing *ad hoc* mesh network research.

CERMUSA is currently participating in a Pennsylvania state government economic development initiative, the Keystone Innovation Zone (KIZ) program. The potential of offering MCP communications services in commercial applications is one of the items under study. Informal enquiries about the MCP's availability for the provision of communications services have been received from both private and government sector entities.

CERMUSA and Monmouth University are in the early stages of developing a collaborative program to enhance the collection and distribution of vital information to the emergency response community. It is anticipated that the MCP could play a significant role in such an endeavor.

CERMUSA is also in discussions with the Indiana University of Pennsylvania Research Institute (IUPRI) to consider a joint program for development of a civilian application of IUPRI's National Guard Civil Support Team Information Management System (CIMS). A demonstration of this possible collaboration was conducted on August 18, 2006 for our congressional sponsor at the Armtech Showcase for Technology in Kittanning, Pennsylvania. In such a joint program, the MCP would serve as a command and control center, and communications hub for a civilian emergency management organization.

As other projects are developed at CERMUSA, the MCP will be considered as a potential asset whenever mobile, temporary telecommunications capabilities are required.

B. Robotic Emergency Medicine and Danger-Detection (REMeD-D)

a. Discussion and background

Together, the MCP program and the associated REMeD-D project form the nucleus of a technology driven emergency response infrastructure. While each system can operate independently of the other, this project's principle question centered on the amalgamation of hardware and software in the areas of communications, sensing, and mobility; in short, could these various technologies be combined to form a system that could potentially be integrated into existing emergency response environments. The question was multiplied in the REMeD-D project by having a number of preexisting products that were required components of the final working model.

Although more than five years have passed, the terrorist attacks of September 11, 2001, remain on the minds of most Americans. The potential threat of terrorist actions in the United States is generally accepted as real, as does the need to improve the ability to respond appropriately to emergencies resulting from terrorist actions. The results of studies conducted since 2001 suggest that robotics and communications technologies can be utilized to provide medical treatment to victims of bioterrorist attacks, and, when necessary, transport these victims from the site of the attack to a secure area.

In an effort to improve the civilian and military response to WMD attacks in rural areas, CERMUSA is conducting a research study to evaluate the role of robotics and advanced telecommunications technologies to existing emergency management and response authorities. The Robotic Emergency Medicine and Danger-Detection (REMeD-D) research project is a system of interoperable robots designed to remotely detect biological, chemical, or nuclear agents, locate victims, assess their physical condition, and then extract them to a safe location for medical intervention.

While urban areas remain terrorists' most likely targets, the risk of a WMD attack on a rural population remains possible. Moreover, any WMD attack, even in an urban population, can be widespread, affecting not only the immediate area but the surrounding rural communities. Therefore, when preparing for a WMD incident, rural areas must be able to assess their strengths and weaknesses in order to develop a rational, sustainable response plan. The unique social, political, and environmental characteristics of rural communities create management and implementation obstacles that differ from the challenges that urban areas face when developing a system to deal with the threat of WMD. As a result, the REMeD-D project offers a model to follow when developing a system to prepare for and manage emergencies resulting from a terrorist attack implemented using weapons of mass destruction.

The REMeD-D project successfully demonstrated a fusion of differing technology platforms operated by a common software architecture; however, significant questions remain regarding the potential practicability of such a system for automated patient extraction, either in battle space, or in civilian environments. On a positive note, the REMeD-D system does show considerable promise as a tool for far forward

reconnaissance and situational awareness through its ability to deliver and manage a wide variety of environmental sensors – in short, a robotic equivalent of hearing, sight, smell, taste, and touch. TATRC has identified just such a research effort to which the majority of the REMeD-D system may be employed. Additionally, CERMUSA has identified an opportunity to use one portion of the REMeD-D system, an iRobot Packbot as a teleoperated or autonomous delivery system for the nodes that make up an ad hoc mesh network.
The REMeD-D project is effectively an extension of MCP Tasks 6 and 7. Of the five tasks identified under the REMeD-D program, this report will focus primarily on Task 4, but will encompass the project in its entirety, particularly from a technical perspective.

b. Task 4 Integration of remote control, guidance, and patient extraction systems

The REMeD-D prototype was developed through a collaborative effort involving CERMUSA and several vendors. These vendors provided a diverse, but vital role in developing the functional prototype. Collaborators on this project were as follows:

- Applied Perception Inc. was responsible for developing and programming the computing software that would allow remote operation wireless communication between the REMeD-D prototype vehicle and the base unit. Additional duties included the programming and integration of biological and chemical sensors onto an iRobot PackBot payload to detect a WMD attack.
- Foster Miller was responsible for development of the Patient Extraction Unit (PEU). This device moves a patient onto a stretcher by using a mechanical roller system. The patient can be rolled on to a standard stretcher, which can then be removed and transferred manually.
- RoPro Design subcontracted with Applied Perception to design and fabricate the interface between the Foster Miller PEU unit and the modified Gator vehicle. This integration included hydraulic lifts to elevate the PEU from the ground to a height of about three feet.
- iRobot was responsible for supplying the PackBots that are to be used for housing the biological and chemical sensors used to identify any WMD attack and for acting as "forward observers" to locate and assess casualties. Future possible payloads for the PackBot include physiological sensors for determining casualty health.

CERMUSA was the primary lead in the design and integration of all of the various vendors included in the prototype. CERMUSA integrated all of the various vendors' concepts and ideas, and encouraged collaboration among the vendors when appropriate. However, all critical decisions in developing a final working prototype were made by CERMUSA directors and managers. Following all design and construction tasks, CERMUSA initiated prototype testing and reporting the results.

To control the robotic functions of the REMeD-D prototype remotely, several wireless technologies were investigated. The most practical and efficient wireless technology was the 802.11 family of WiFi standards. These standards offered the highest data exchange and range when compared to other wireless technologies.

The 802.11 family currently includes six over-the-air modulation techniques all using the same protocol, the most popular techniques being those defined by the b, a, and g standards. 802.11b and 802.11g standards use the 2.4 gigahertz RF band. Operating in the 2.4 gigahertz frequency band, 802.11b and 802.11g equipment can incur interference from microwave ovens, cordless phones, Bluetooth devices, and other appliances using the same 2.4 GHz band.

802.11b is usually used in a point-to-multipoint configuration, wherein an access point communicates via an omni directional antenna with one or more clients that are located in a coverage area around the access point. Typical indoor range is 30 meters at 11 Mbps. 802.11b and 802.11g divide the spectrum into 14 overlapping, staggered channels whose center frequencies are 5 megahertz apart. Channels 1, 6, and 11 are usually used to minimize interference. If transmitters are closer together than channels 1, 6, and 11, overlap between the channels will probably cause unacceptable degradation of signal quality and throughput.

The Global Positioning System (GPS) can be used for determining one's precise location and providing a highly accurate time reference almost anywhere on Earth. The accuracy of the GPS signal itself is about five meters. Using differential GPS and other error-correcting techniques, the accuracy can be improved to about one centimeter over short distances. The GPS system is made up of a satellite constellation of at least 24 satellites. Each satellite circles the Earth twice every day at an altitude of 12,600 miles.

A GPS receiver compares time signal transmissions from four or more satellites to calculate the precise time and its current position. The receiver computes the distance to each of the four satellites and then determines the latitude, longitude, and elevation relative to the various satellites.

These two technologies were incorporated into the REMeD-D Gator system to enable semi-autonomous control (Figure 26). The 802.11b wireless signal was amplified through a directional antenna from the control station. This amplified system enabled increased range over the normal 30 meters. The increased range is essential for reliable control and monitoring of the robotic unit from the base station.

Figure 26

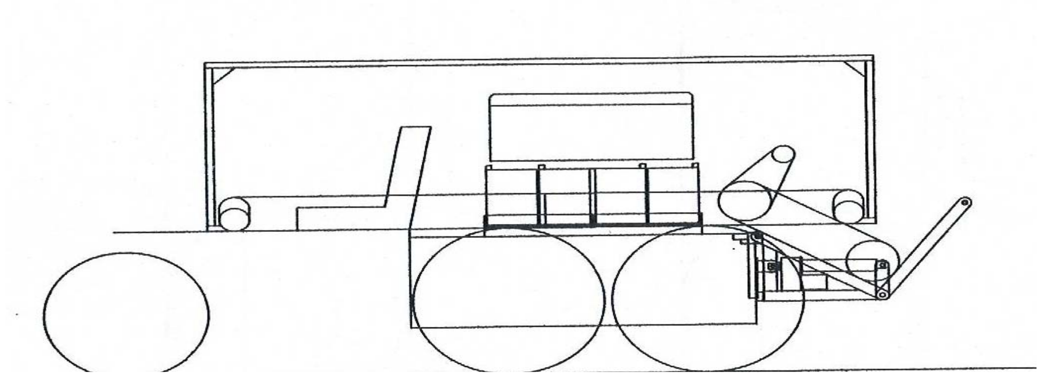
The GPS coordinates are acquired on the Gator vehicle. These coordinates establish where the vehicle is located. These coordinates are also transmitted back to the base station from the wireless antenna. The base station can use the GPS system to create a path on a computer station map, which will be followed on the Gator autonomously.

Foster Miller was contracted as a vendor for this project because TATRC already had an agreement in place for them to build an extraction unit with Applied Perception and Foster Miller. Foster Miller designed and created the PEU extraction unit independently and without much collaboration with the other vendors in this project. Because of this situation, integration with the Gator had to be performed by another vendor.

RoPro was contracted to design the connection interface between the Foster Miller PEU and the John Deere Gator, while still maintaining the function of autonomously driving the vehicle and still being able to pick up casualties. There were three ideas on how to mount the PEU device, which included:

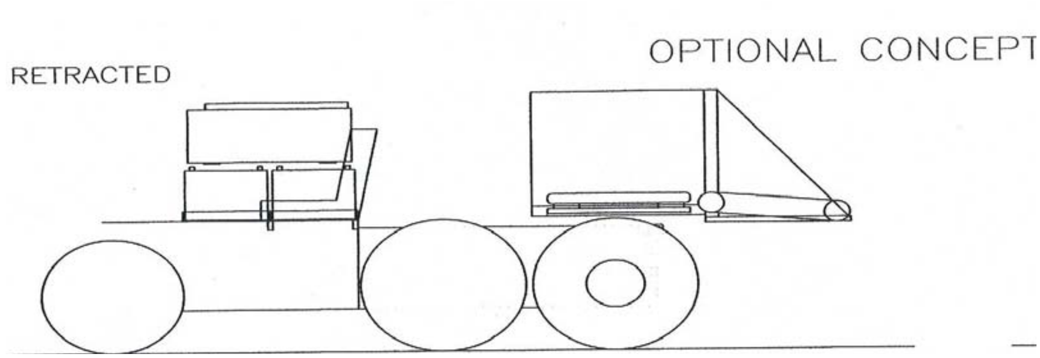
- Side Mount (Figure 27)**:** In this option, the conveyer lies on the side of the gator. The advantages to this approach were that it required the fewest modifications to the gator. The risk of injury to the patient was minimized, since the gator only approached the causality laterally.

Figure 27



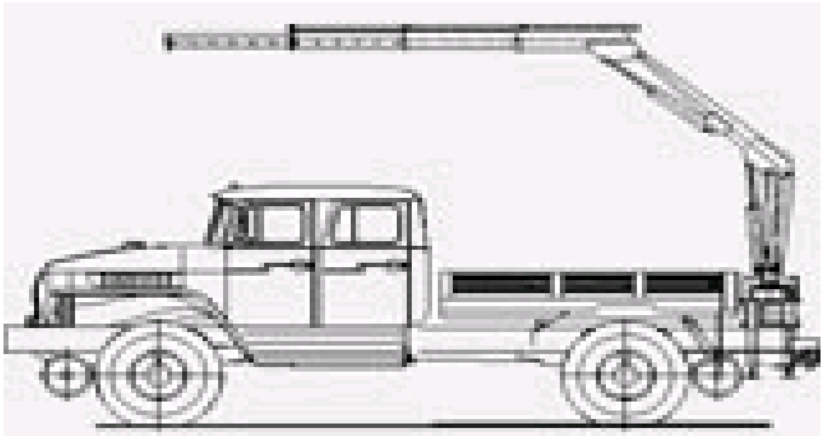
- Rear Mount (Figure 28)**:** This option reduced the risk of static and dynamic instability. However, this option would have required relocating the battery cage and computing box. This option also aided in moving the PEU into a better position for picking up casualties.

Figure 28



- Boom Mount (Figure 29)**:** For this option, if an appropriately sized boom were to be mounted on the gator, with the conveyer on top capable of swiveling, then the boom could be extended out, the PEU lowered down, and then fine-controlled to pull the casualty aboard the conveyor. This option also would have required major modification of the Gator as well, though. More control options would have also resulted in a more difficult machine to operate.

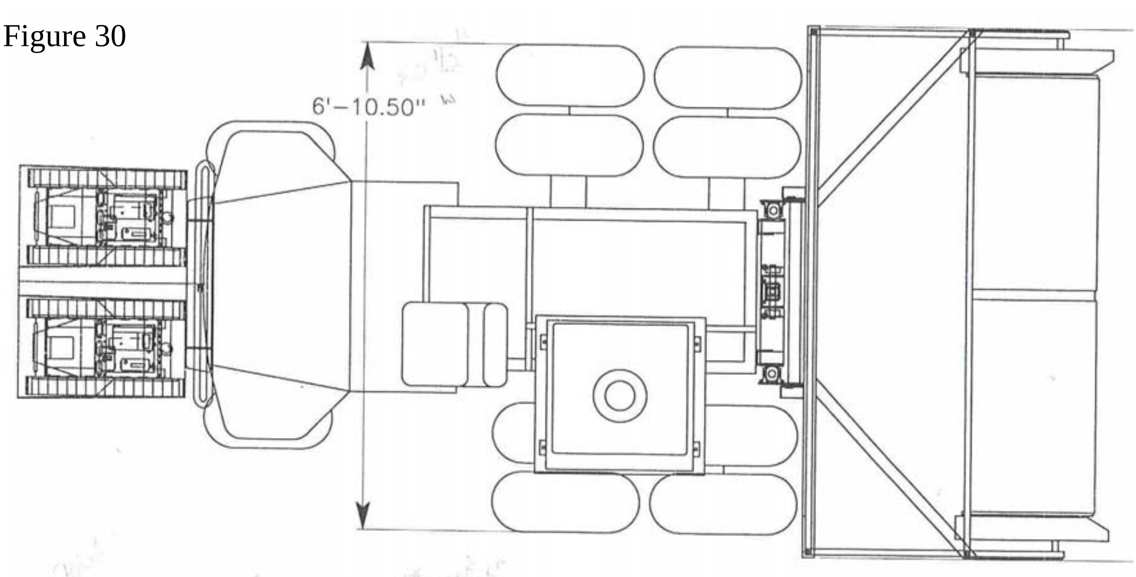
Figure 29



The rear mount option was selected, due to the initial placement of the battery box to a more forward position by Applied Perceptions. This option was also chosen because of the ability of the gator to be driven forward and backward to assist in picking up the casualty.

After the mounting decision was made, the next step was to decide how to remove the PEU from its framework and assemble the PEU onto the Gator. A hydraulic lift design, similar to a forklift, was decided upon. This design allowed for a compact, heavy-duty method of lifting the conveyor mechanism and payload. This design also was able to move and pivot on both a horizontal and vertical axis. This method had the added advantage of significantly reducing the electrical demand on the battery system, since the Gator comes equipped with a hydraulic system of sufficient lifting capacity.

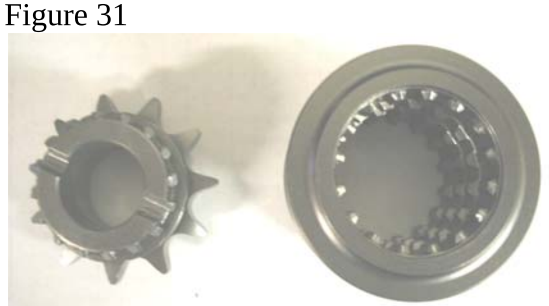
Figure 30



When the PEU unit was assembled with the Gator vehicle by RoPro, another issue was encountered. The additional weight of the unit plus a casualty weight created a need for four additional tires in the rear of the Gator to be added for load distribution and to widen the vehicle's center of gravity. The four extra tires also created more stability on the Gator vehicle (Figure 30).

During testing by RoPro, the Gator transmission gearbox failed. It was determined the failure resulted from an inability to smoothly transfer from forward to reverse during remote control operation. A bigger transmission with a better gearbox ratio (Figure 31) was ordered to replace the broken one and ensure that this problem would not occur again.

Figure 31



Replacement gearbox parts

During initial API testing, the Gator was found to blow exhaust fumes and kick up dirt onto the stretcher unit on the PEU. This would cause irritation and discomfort to any casualties that would be rolled onto the stretcher. This problem was fixed by placing white Plexiglas sheets in between the back of the Gator unit and the PEU device.

After the REMeD-D vehicle was handed over from API to CERMUSA and initial testing began, two major problems were discovered. The first was that the PackBot deployment winch was not working. After tracing the wiring back to the Gator battery, it was discovered that the two fuses that were in line with the winch were blown. These two fuses were replaced, and no more issues with the fuses blowing have occurred.

The second problem was that the e-stop mechanism was not turning off to enable remote operation of the vehicle. After tracing the wiring back to the main control box, the cause was narrowed down to a faulty wire or relay. A technician from API came to do further testing and replace the faulty item. It was determined that a wire from the main control box to the vehicle battery was broken. Due to the fact that the wiring was placed in a position under the vehicle that it could not be replaced, another wire was run between the box and the battery in its place. Connecting the new wire solved the e-stop problem, and the vehicle operated suitably again.

After resolving these problems, some other minor issues occurred. These issues included:

- The white Plexiglas sheets that were added to the back of the gator hindered the visibility of the Gator driver while going in reverse. This issue was resolved by replacing the white Plexiglas with clear Plexiglas panels.
- The bolts in the front of the PackBot deployment bay were shaking loose from the Gator. This was resolved by replacing the regular bolts with nylon locking bolts.
- A PackBot that was being updated with a firmware upgrade was found to have a hole that could cause an electrical malfunction if it was placed near water. This unit was never handed over from API and a direct cause of this hole was not determined. iRobot is in the process of fixing this problem.
- Due to the dimensions of the Gator vehicle and the PEU unit, a custom transport hauler was required. A modified automotive hauler (typically used in stock car racing) was obtained from Gale Trailer Sales through a competitive bidding process.

The REMeD-D project was developed as an add-on to the MCP project, in part, because it was envisioned that the MCP’s communications and transport capabilities would complement possible REMeD-D missions. Further, inasmuch as proposed missions for the REMeD-D would be multidimensional, the MCP or a close analogue would be a useful augment to the response effort. The ability to integrate REMeD-D through the MCP is a logical step in the evolution of the future emergency responder’s technological toolkit, reshaping the overall structure and process of emergency management first response.

Due to limited testing opportunities, a full integrated MCP/REMeD-D test mission was not attempted; however, the technological infrastructures of the two systems are fully compatible.

c. Results/Lessons Learned

A technical test plan (see Attachment B) similar in scope to the one developed for the MCP was developed; however, due to the numerous software and hardware issues the REMeD-D team confronted, there was insufficient time for formal implementation. Since the REMeD-D system is a discrete collection of components, it was possible to conduct limited testing of portions of the whole, and this was done.

The entire system was functional for several demonstrations. Due to the nature of such demonstrations, no research data was collected under the test plan, although these demonstrations provided opportunities for learning. One such example was the previously discussed discovery of ground debris and vehicle exhaust flowing into the patient transport area of the PEU. The initial installation of several sheets of Plexiglas established a sufficient level of protection, but it was later discovered that the opaque sheets also hindered remote navigation by obscuring crucial sightlines, especially during patient extraction. Replacing the offending opaque panels with transparent ones solved the problem.

The blending of several platforms from different manufacturers, on a relatively modest budget, decreased the odds of achieving a mature, fully functional, and ready to be deployed tool. However, the REMeD-D system does show the potential for operating multiple autonomous vehicles using a single user interface. The Joint Architecture for Unmanned Systems (JAUS) software and the user interface designed by Applied Perception ties the various components together in a manner that appears ready to fit into existing operational standards for emergency responders.

Based on limited testing using a simulated patient, it appears the ability to perform autonomous extraction safely and effectively remains an unmet research goal. The REMeD-D can remotely recover the patient, but the time from deployment to rescue is a concern. A larger concern from the civilian first responder community (and a topic of some discussion within CERMUSA) is the inability to provide any type of neck or cervical spine support by using this method of extraction.

On a positive note, the REMeD-D system does show considerable promise as a tool for far forward reconnaissance and situational awareness. Its ability to deliver and manage a wide variety of environmental sensors – in short, a robotic equivalent of hearing, sight, smell, taste, and touch into mass casualty or other dangerous scenes, may well be considered its greatest strength. TATRC has proposed transferring the primary REMeD-D system to another research project focused on remote sensing, that would entail minimal modifications to the Gator (essentially replacing the PEU with a similarly sized sensor.) Additionally, CERMUSA has identified an opportunity to use one portion of the REMeD-D system, an iRobot Packbot as a teleoperated or autonomous delivery system for the nodes that make up an ad hoc mesh network.

Funding for the MCP and REMeD-D projects has been expended.

MCP Technical Survey
Establishing Network Link via Satellite
Page 1 of 3
Questions marked with a * are required.

*1. What is the start time of this activity in military format? (e.g. 1400)

*2. What is today's date? (use 01/01/2005 format)
(e.g. 4/21/2002)

*3. Please enter the far end observer's name.

*4. Please enter the near end observer's name.

*5. What type of service is this survey being completed for?
Equipment Test
System Test
Demo
Other:

*6. Please enter the GPS coordinates in NAD27 format. (e.g. ddmmss)

*7. What are today's weather conditions?

*8. What are the terrain conditions?
On-road
Off-road
Parking Lot
Rough Terrain
Other:

*9. Does the satellite terminal automatically track on to satellite?
Yes
No

*10. What is the time from power-up of satellite modems to receipt of Ku-Band transponder? (in whole minutes)

*11. What is the latency from satellite uplink to website (www.cermusa.francis.edu) and back? (in milliseconds)

*12. What is the latency from satellite uplink to website (www.yahoo.com) to the internet and back? (in milliseconds)

*13. Can Website (http://www.pcpitstop.com/internet/default.asp) be reached?

Yes
No

14. What is the upload speed from pcpitstop.com (in kbit/s)?

15. What is the download speed from www.pcpitstop.com (in kbit/s)?

*16. Are two-way video calls from site to CERMUSA successful at the following rates? (check if successful)
128
256
384
512

*17. Are there any quality issues?
No Issues Encountered
Frozen Video
Tiling
Other:

18. Video quality (please rate on a scale of 1=poor to 5=excellent)
1 2 3 4 5
Picture quality
Motion quality
Sound quality
Receive picture quality
Receive motion quality
Receive sound quality

*26. How long does it take to upload specified test file to CERMUSA network? (in seconds)

*27. How long does it take to download specified test file to CERMUSA network? (in seconds)

*28. Are two-way video calls from site to CERMUSA successful at the following rates? (check if successful)
128
256
384
512

*29. Are there any quality issues?
No Issues Encountered
Frozen Video
Tiling

Other:

30. Video quality (please rate on a scale of 1=poor to 5=excellent
1 2 3 4 5
Picture quality
Motion quality
Sound quality
Receive picture quality
Receive motion quality
Receive sound quality

31. Please check all devices that can successfully transmit medical data back to CERMUSA receive site.
General Exam Camera
Ultrasound
Dental Camera
ENT scope
Vital Signs/Blood Pressure/Weight

32. Use this area to explain responses to specific questions and to provide an overall summary of this event.

What is today's date?
Please Enter the vehicle operator's name
What type of service is this survey being completed for?

- Equipment test
- Demo
- Other

What are today's weather conditions?

- Sunny
- Partly Cloudy
- Cloudy
- Precipitation

What are the terrain conditions?

- On-Road
- Off-Road
- Parking Lot
- Rough Terrain
- Other

Did the laptop turn on properly?
    If no, what issues were encountered?
Did the Gator turn on properly?
    If no, what issues were encountered?
Did the Packbots turn on properly?
    If no, what issues were encountered?
Was the laptop able to detect the Gator and Packbots?
    If no, what issues were encountered?

Do all the Gator camera views work correctly?
    If no, what issues were encountered?
Does the Packbot ramp work correctly?
    If no, what issues were encountered?
Does the PPU unit work correctly?
    If no, what issues were encountered?
Does the Gator Teleop Mission work correctly?
    If no, what issues were encountered?
Does the Gator Train/Follow Path Mission work correctly?
    If no, what issues were encountered?
Does the Gator Goto Mission work correctly?
    If no, what issues were encountered?

Does the Packbot camera view work correctly?
    If no, what issues were encountered?
Does the Packbot CHARS Payload work correctly?
    If no, what issues were encountered?
Does the Packbot Teleop Mission work correctly?
    If no, what issues were encountered?
Does the Packbot Vector Drive Mission work correctly?
    If no, what issues were encountered?
Does the Packbot Goto Mission work correctly?
    If no, what issues were encountered?

Please enter a summary of the event and any remarks or concerns here

How many minutes did it take to setup the Gator and accompanying gear?
How many minutes was the gator and accompanying gear tested for?
How many minutes did it take to teardown the Gator and accompanying gear?

On a scale of 1-5 (1 being lowest & 5 being highest) please rate the following:

- Ease of setting up the Gator equipment
- Ease of use of the Gator software
- Ease of remotely driving the Gator
- Effectiveness of the PPU
- Ease of tearing down the Gator equipment
- Overall experience using the Gator and software

RESPONSE	SUBMITTED [yyyymmddhhmmss]	USERNAME	TIME	DATE	FAR OBSERVER	NEAR OBSERVER	SERVICE
299	20060109085635	10.1.10.68	1400	1/6/2006	Steve	Tom	Equipment Test
300	20060109144502	10.1.11.17	1330	9/6/2001	Steve	Tom	Equipment Test
302	20060111145817	10.1.10.68	1400	3/16/2006	Jim Makin	Tom	Equipment Test
303	20060111152846	10.1.10.68	1330	6/1/2006	Dawne	Tom	Demo
304	20060111153338	10.1.10.68	1700	6/2/2006	Dawna	Tom	Demo
305	20060111153634	10.1.10.68	800	6/3/2006	Dawna	Tom	Equipment Test
306	20060111154814	10.1.10.68	1200	5/14/2005	none	Tom	Demo
307	20060111155732	10.1.10.68	1400	7/29/2005	Kent	Tom	Demo
308	20060112084745	10.1.10.68	1000	7/15/2005	Steve	Tom	Equipment Test
309	20060112090551	10.1.10.68	1130	7/15/2005	Dawna	Tom	Equipment Test
310	20060112091147	10.1.10.68	1230	8/5/2005	Person I-2	Tom	Demo
311	20060112092109	10.1.10.68	800	8/30/2005	Dawna	Tom	Demo
312	20060112092905	10.1.10.68	900	8/31/2005	Dawna	Tom	Demo
313	20060120091331	10.1.10.68	1300	1/19/2006	Dana	Tom	Equipment Test
314	20060120092505	10.1.10.68	1330	1/13/2006	Steve	Tom	Equipment Test
315	20060124141135	10.1.10.68	1330	1/23/2006	Steve	Tom	Equipment Test
316	20060215124117	10.1.10.68	1406	6/20/2002	Dawna	Tom	Equipment Test
318	20060215130029	10.1.10.68	915	2/8/2006	none	Tom	Equipment Test

319	20060216143016	10.1.10.68	1429	2/15/2006	Dawna	Tom	Equipment Test
320	20060216144132	10.1.10.68	1040	2/16/2006	Dana	Tom	Equipment Test
321	20060216145239	10.1.10.68	1122	2/16/2006	Dana	Tom	Equipment Test
322	20060220155930	10.1.10.68	1241	2/20/2005	James	Tom/Bob	Equipment Test

GPS COORDINATES	WEATHER	TERRAIN	TRACK	TIME2 [minutes]	PING1 [ms]	PING2 [ms]	CONNECTIVITY	UPLOAD [ms]
N48 30' 01" W78 38' 20" Wireless Blding	Cloudy, Windy, Cold	Parking Lot	Yes	10	368ms	538ms	Yes	313ms
N48 30' 01" W78' 39 21" Wireless Blding	Windy, Sunny Temp.	On-road	Yes	9	555	654	Yes	235
N42 52' 20" W77 26' 50" Victor, NY	Cloudy	On-road	Yes	10	523	624	Yes	236
N40 30' 30" W78 38' 20" Christian Hall	Sunny	On-road	Yes	12	N/A	N/A	Yes	198
N40 30' 30" W78 38' 20" Christian Hall	Sunny	On-road	Yes	15	N/A	N/A	Yes	421
N40 30' 30" W78 38' 20"	Rainy	On-road	Yes	11	N/A	N/A	No	N/A
N40 28' 10" W78 23' 24" Altoona Curve Staduim	Sunny	On-road	Yes	12	N/A	N/A	Yes	243
N40 28' 10" W78 38' 34" St Francis Univ	Sunny	On-road	Yes	N/A	N/A	N/A	Yes	368
N48 28' 10" W78 38' 24" Wireless Blding testing 1.2mb connection	Partly cloudy	On-road	Yes	13	N/A	N/A	No	N/A
N40 29' 34" W78 46' 25" Revloc Park for testing of 1.2mb	Sunny	On-road	Yes	12	N/A	N/A	Yes	435
N40 28' 10" W78 23' 24"	Cloudy and lite rain	On-road	Yes	10	N/A	N/A	No	N/A
N39 26' 32" W77 25' 17" TATRAC Site for a Demo	Sunny Hot and Humid	Off-road	Yes	9	N/A	N/A	Yes	352
N39 25' 19" W77 19' 26" WoodCliff Lodges for demo.	Cloudy and light rain	On-road	Yes	10	N/A	N/A	No	N/A
N48 30' 27" W78 45" 01" Wireless blding	Sunny	On-road	Yes	N/A	N/A	N/A	No	N/A
N48 30' 27" W78 38' 45" Wireless blding	Sunny	On-road	Yes	N/A	N/A	N/A	No	N/A
N40 31' 08" W78 38' 13" ISO Container off campus	Heavy cloud cover, foggy, icy and a lite drizzly rain.	On-road	Yes	14	575	620	Yes	241
N40 31' 57" W78 38' 43 ISO site	Windy and cloudy	On-road	Yes	12	512	593	Yes	196
N40 19' 43" W78 54' 20" Jntw Senior Center	Sunny	On-road	Yes	7	594	498	Yes	295

N48 30' 01" W78 38' 01" Wireless Blding	Sunny	On-road	Yes	7	629	730	Yes	191
N40 25' 35" W79 34' 46" Valero RV Site	Very Rainy and Cloudy condition	On-road	Yes	6	570	611	Yes	310
N40 26' 00" W79 34' 27' Shopping mall Delmont, PA	Rainy and rain hard at times	On-road	Yes	8	575	609	Yes	155
N40 19' 40" W78 54' 56" Senior Center	Sunny	On-road	Yes	7	567	667	Yes	196

DOWNLOAD [ms]	TESTFILE [seconds]	TESTFILE2 [seconds]	VIDEORATING2	VIDEOQUALITY2	VIDEORATE2_PICTURE_QUALITY	VIDEORATE2_MOTION_QUALITY	VIDEORATE2_SOUND_QUALITY	VIDEORATE2_RECEIVE_PICTURE_QUAL	VIDEORATE2_RECEIVE_MOTION_QUALI	VIDEORATE2_RECEIVE_SOUND_QUALI	MEDICALDATA
					3.60	3.35	3.60	3.55	3.60	3.70	
226ms	296sec	213sec	384,384	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	General Exam Camera,General Exam Camera
352	120	150	384,384	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	
321	132	145	512,512	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	
267	N/A	N/A	384,384	Frozen Video,Frozen Video	2	2	4	2	4	4	
239	N/A	N/A	384,384	No Issues Encountered,No Issues Encountered	4	3	4	3	3	4	
N/A	N/A	N/A	384,384	No Issues Encountered,No Issues Encountered	4	4	4	4	3	4	
325	N/A	N/A	384,384	Other: No video sent							
265	N/A	N/A	512,512	No Issues Encountered,No Issues Encountered	4	4	5	4	4	5	
N/A	N/A	N/A	512,512	Frozen Video,Frozen Video	3	2	3	3	3	3	
356	N/A	N/A	512,512	Frozen Video,Frozen Video	3	2	3	3	3	3	
N/A	N/A	N/A	512,512	No Issues Encountered,No Issues Encountered	3	3	3	3	3	3	General Exam Camera,General Exam Camera,ENT
224	N/A	N/A	384,384	No Issues Encountered,No Issues Encountered	4	4	4	3	3	4	
N/A	N/A	N/A	384,384	No Issues Encountered,No Issues Encountered	4	3	4	4	4	4	
N/A	N/A	N/A	512,512	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	
N/A	N/A	N/A	512,512	No Issues Encountered,No Issues Encountered	3	3	3	4	4	4	
185	240	285	384,384	Frozen Video,Frozen Video	3	2	2	3	3	3	
279	254	293	384,384	No Issues Encountered,No Issues Encountered	3	3	3	3	3	3	
201	238	289	128,128	Other: Did not test Tandberg							

153	266	289	384,384	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	General Exam Camera,General Exam Camera
227	258	242	384,384	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	
225	261	253	512,512	No Issues Encountered,No Issues Encountered	4	4	2	4	4	2	
199	248	239	384,384	No Issues Encountered,No Issues Encountered	4	4	4	4	4	4	General Exam Camera,General Exam Camera,ENT

COMMENTS
The VTC in the Wireless conference room must be set at 100 half and the audio must be the same. Like G.722 or G728. The weather was some snow showeres and temp about 34 degree that day. Use that Access panel to conect the Monitor, Camera and audio to.
Not switching good enough between the main camera and doc.
Did a couple of test calls from GCS in Victor Ny, when we went to pick up the MCP
The fields with the 99999 in the are not valid one we were not doing those test at the time.
The audio on these test were set at G728 and the codec ip network setting was at a half 100.
That day it rained all day for the showcase demo.
This was demo down at the Altoona Curve Staduim.
This was for the Alumi weekend demo
This was doing testing for the I2 Gigaconference coming up. The far unit was not set to half 100 network connection at the time.
This test was at Revloc Park in Revloc. Testing for I2 Gigaconference at a rate of 1.2mb.
This was the day of the Demo for the I2 Gigaconference. The General Exam Camera working great, and the Ent scope also work great. Did call at 1.2mb call went thru with no problems.
Doing a demo at TATRAC test grounds all day. This day was very Hot and Humid.
This was a demo site at the WoodCliff Lodges for the TATRAC review board to look at the equipment.
We were doing a Demo connection to the Scranton University with I2 thru a bridge from the MCP unit. We connected from the Wireless building to the hummer via RJ-45 cable hardware. Ever thing went good no problem with our connection. We used the outsi
Did a test of 768k and 1.425mb for the demo of I2 for Scranton University. The Hummer was connected to the wireless building via a RJ-45 cable. Did a test call to the Wireless building were Steve viewed the video. There was no Satelitte connection or c
It was a very cloudy, foggy, icy condition, and rainy. The temp was 38 degree the wind were from the W at 6 MPH and humidity was 94%. The call from the ISO off campus. Had a hard time keeping the ping going in this weather. Made a call to the NOC in C
It was pretty windy that day the temp was 28d winds from the WSW Humidity 56% and pressure 29.85.
Did not do any video testing with the Tandberg in Johnstown. Just testing the sat connection for a site survey at the Senior Center.

The QoS from the Download site was 74% and roundtrip was 553ms. Tested the medical cart connection and sent images from the exam camera.
Check the operation of the Vonage phones system working ok. Weather condition 50degree, 10mph SW winds Rainy, Hum 64%, Press 3020. QoS 90% and Round Trip 547ms
Note that the codec at the 2nd floor was not set at 100half the one in the vehicle was at 100half. Roundtrip 549ms QoS 90%. MCP FOW 66.50 and EbNo 8.25 and at CERMUSA side FOW 68.00 EbNo 9.25. The video look good no major tiling the audio was somewhat
The roundtrip time 566ms and QoS 72%. Everything just great.