

# **Project Write Up**

Document Proposal for a

## **Transportable Voice, Data, and Wireless Communications System**

Developed for the

### **American Red Cross of Greater Columbus**

Version 2.0 Approved

Prepared by



**Jamison Ables  
Paulo Cambraia  
Michael Clark  
F Abrione Donyeau**

*August 22, 2008*

## Table of Contents

|                                                      |           |
|------------------------------------------------------|-----------|
| <b>1. Final Project Summary.....</b>                 | <b>3</b>  |
| 1.1. Background .....                                | 3         |
| 1.2. Business Opportunity.....                       | 4         |
| 1.3. Business Objectives and Success Criteria .....  | 4         |
| 1.4. Customer or Market Needs.....                   | 5         |
| 1.5. Business Risks.....                             | 6         |
| 1.6. Major Features.....                             | 8         |
| 1.7. Limitations and Exclusions.....                 | 8         |
| 1.8. Operating Environment .....                     | 8         |
| 1.9. Human Resources .....                           | 9         |
| 1.10. Team Charter.....                              | 9         |
| 1.11. Technical Skills and Attributes .....          | 10        |
| 1.12. Roles and Responsibilities .....               | 11        |
| 1.13. Educational/Program Outcomes .....             | 11        |
| <b>2. Design Considerations .....</b>                | <b>14</b> |
| 2.1. System Functional Design .....                  | 15        |
| 2.2. Product Selection.....                          | 18        |
| 2.3. Platform Pricing.....                           | 22        |
| 2.4. ARCGC Geographic Areas of Responsibility .....  | 23        |
| 2.5. Demo Router and Access Point Configuration..... | 27        |
| 2.6. Pricing Summary and Recommendations .....       | 38        |
| <b>3. Annotated Bibliography .....</b>               | <b>38</b> |
| <b>4. Appendices.....</b>                            | <b>42</b> |

## **1. Final Project Summary**

### **1.1. Background**

Depending on the size and nature of the event that occurs within its support area, the ARCGC must respond as quickly as possible with the appropriate resources. This can result in a tremendous logistical effort of dozens of volunteers, suppliers, agencies, and so on. Whether arranging for the shipment of needed supplies, directing medical personnel to trouble spots, reporting to the national organization, etc., each event requires communication and coordination in order to be successful. Because of this need, the ARCGC has an internal organization that specifically supports communications.

In 2006, the ARCGC acquired a former television news vehicle and outfitted it with a variety of two-way radio equipment to serve as a mobile communications center during events. While effective at relaying voice communications between responding agencies and entities, it was not designed or equipped to support data, telephony, wireless, and Internet services. Internal voice and data communications amongst local respondent groups, as well as coordination with ARCGC headquarters staff and suppliers, are hampered without these capabilities. While some laptop computers have cellular data cards, there is no effective method for respondents to communicate with each other or share the Internet communications path.

## **1.2. Business Opportunity**

With the improvements in voice/data network technology, and more common availability of cellular and wireless Internet connectivity, an opportunity exists to design and configure an integrated system to significantly enhance the communications capabilities for the ARCGC Communications Vehicle. With these additional capabilities, the ARCGC could more effectively respond to emergencies, and coordinate the logistics effort by better communicating with a host of agencies and authorities.

## **1.3. Business Objectives and Success Criteria**

The primary objective of the proposal is to analyze, design, specify, and estimate pricing for a transportable system to provide shared wired and wireless Internet access at the disaster site via the ARCGC mobile communications vehicle. A secondary business objective is to also include features in the system that will also provide secure voice and data communications at the disaster site itself, thus enhancing communications with chapter, regional, and national Red Cross services. It is important that the proposed system meet the needs of the ARCGC emergency communications team, while allowing for new features and later growth. Success for this project will be measured by the following outcomes:

- Determine specifications for a communications system package that meets the ARCGC need for secure transportable communications platform supporting voice, data, and wireless
- Analysis and comparison of integrated product offerings that meet the communications system specifications

- Determination of EVDO coverage areas by primary providers compared to the ARCGC supported geography
- Configuration details of proposed system
- Parts list and standard pricing of all proposed system components
- Documented deliverables of the system design elements above

Utilizing the resulting documentation package, the ARCGC can determine the feasibility, resources, and costs to provide the enhanced communications functionality in their disaster response in the surrounding Columbus area. If deemed to be a suitable approach, the ARCGC could use the information garnered from the study to justify a funding and/or donation attempt.

#### **1.4. Customer or Market Needs**

The ARCGC is faced with a difficult task—to respond anywhere in their support area and become the focal-point for emergency services. With the systems the ARCGC has today, voice communication via two-way radio and the occasional cellular data equipped laptop provide the means of communicating amongst themselves and for coordinating their response between the various agencies. The ARCGC needs their own integrated system to address their needs.

Virtual Private Networking (VPN), Email, and web access all require a communications path to the Internet. Advances in cellular data technology, specifically, EVDO services are making it possible to communicate digitally at relatively high-speeds. Laptops equipped with these data cards are effective within EVDO coverage areas, but the service is limited to the enabled device and cannot be shared. Often the location of the laptop device is not optimal for cellular reception. Furthermore, cellular-connected laptops cannot use locally connected

resources, such as network printers and drives. Providing a centralized Internet connection via the mobile communications vehicle and redistributing that access via a local wireless LAN network provides the optimal use of the valuable resource. In addition, the placement and telescoping mask features of the vehicle would likely improve the possibility of better signal reception.

Today, ARCGC personnel use existing two-way radio voice channels for internal ARCGC logistics. This may unnecessarily tie-up valuable channels used by other services. In addition, privacy is also an issue with these shared services—particularly given the sensitive nature of Red Cross communications. A dedicated and encrypted local voice communications system using encrypted Voice over IP (VoIP) system would address this need.

Given these needs and potential solution, other Red Cross communications groups may have need for this type of system.

## **1.5. Business Risks**

Communications for the ARCGC has been predominantly accomplished with voice-only, two-way radio systems and the proposed system represents a change to their operational capability. Furthermore, many of the benefits of the proposed system are dependent upon a functional Internet communications path normally provided by a data connection over cellular/PCS services. While prevalent in many areas, service is not available and/or reliable in all locations, which could limit the effectiveness of the proposed system. It is also possible that funding source for the proposed system will not be available regardless of the potential benefits.

Part of the success of the project is dependent on the cooperation and proper functioning of the team. Quattro Consulting has been successfully meeting deadlines with a high-degree of quality since project inception. When scheduling conflicts could impact the completion of important tasks, other team members have taken different roles in the group to assure task completion. Table 1-1 shows the risk profile.

| <b>Risk</b>                                                                  | <b>Severity</b> | <b>Mitigation</b>                                                                                                                                                        |
|------------------------------------------------------------------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Funding for a new communications system may not be available.                | HIGH            | By presenting older and newer technology platform options, older, less-expensive equipment may be able to be substituted, either by purchase or donation.                |
| Cellular data coverage may not be available at every site                    | HIGH            | Platform will be capable of other connectivity options, such as T1 or wireless LAN.<br>Local wireless IP telephony feature will function without cellular data coverage. |
| Wireless LAN system may experience interference                              | Medium          | System designed for multi-frequency and multi-band operation, and configured for auto frequency assignment, reducing the chance of frequency congestion.                 |
| Operators may not fully understand how to configure system features          | Medium          | Pre-configured features will be enabled and documented. The process to reload the feature set from a computer file will be included.                                     |
| Cellular carriers may not share detailed coverage maps for the complete area | Medium          | General maps can be interpolated. The cellular tower database may be used (for a fee).                                                                                   |

**Table 1-1 Project Risks**

## **1.6. Major Features**

The new voice and data system will encompass the following features:

- Portable Access to voice and data services via the Communications Vehicle
- Distributed network connectivity from a cellular network
- Wireless communications at the disaster site
- Local Voice over Internet Protocol (VoIP) communications
- Local site internal communications, regardless of external link availability
- Secure (encrypted) voice and data communications across unsecure links

## **1.7. Limitations and Exclusions**

The solution will provide data access to the ARCGC from a mobile platform. If the service provider doesn't have wireless coverage in the area that the team is deployed communications would be limited. It would also be possible that the team would have wireless access but the speed would limit the amount of communications to the point that it could be unusable.

## **1.8. Operating Environment**

The proposed infrastructure will provide a solution for automating the communications support for Red Cross communications by transferring data, video, and voice over wireless connections, using voice activation commands which allow key personnel to have total hands-

free while performing maintenance. Due to the inherent and antiquated performance issues associated with the current architecture, distributed ground communication architecture ensures reliable, unambiguous, and accurate information distribution, data timeliness, data filtering and speed-of-service for the client. A partially decentralized architecture, with at least one backup server, allows the processing load to be distributed among all the servers creating a completely collaborative structure. Decentralized architecture provides better performance reliability since you will not suffer from a single point of failure. Using a centralized, hierarchical system architecture requires more bandwidth and is susceptible to performance throughput degradation and point of failure problems.

## **1.9. Human Resources**

The Human Resource Strategy for Quattro Consulting, LLC involves defining and understanding the central philosophy or approach to the way in which our group will be managed. The manner, in which this approach translates into best practices, is the development and delivery of human resource policies and how these policies and practices together will support the company, service objectives and strategies.

## **1.10. Team Charter**

### **General Description:**

The members of Quattro Consulting, LLC will create a design and proposal for a transportable voice and data communications infrastructure that can be used to support emergency activities, in support of the American Red Cross of Greater Columbus, Emergency Communications Section.

### Expected Results by Objectives:

- o Secure Data
- o IP Telephony
- o Wireless Functionality
- o Integration with Existing Mobile Platform
- o Integration with Existing Radio Transport Equipment
- o Design Analysis
- o Product Configuration
- o Financial Details required for Funding and/or Donations

### 1.11. Technical Skills and Attributes

The following table exclusively defines the skills and attributes of each team member, their contributions, the manner in which all members will work as one unit, and what the expected outcomes are. Table 1-2 lists the members of the team and their skills and attributes.

| Name             | Skills                                                                                                                                                                                  | Attributes                                                                                                                                                               |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Michael Clark    | <ul style="list-style-type: none"> <li>o Certified CCIE Professional</li> <li>o Certified CISSP</li> <li>o Networking and Security Subject Matter Expert (SME)</li> </ul>               | Able to provide supervision. Consistently demonstrates awareness and responsive to political or interpersonal conflict among other team members within the organization. |
| FAbrione Donyeau | <ul style="list-style-type: none"> <li>o Certified Department of the Army (DOA) Technical Instructor</li> </ul>                                                                         | Ability to negotiate joint tasks, clarifies roles, work collaboratively and resolve conflicts in a respectful manner.                                                    |
| Paulo Cambraia   | <ul style="list-style-type: none"> <li>o Certified admin Professional for the OSI PI Data Capture</li> </ul>                                                                            | Skillful in manufacturing and engineering environments. Skilled in project management reporting.                                                                         |
| Jamison Ables    | <ul style="list-style-type: none"> <li>o Networking</li> <li>o VoIP</li> <li>o Computer Programming</li> <li>o Email, Windows, Linux Servers</li> <li>o MySQL, MSSQL, Oracle</li> </ul> | Familiarity with use of computers including the use of electronic mail networks, and development of organizational databases.                                            |

**Table 1-2 Team Skills Matrix**

## 1.12.Roles and Responsibilities

Collectively, the members of Quattro Consulting, LLC will be responsible for planning and executing the course project. The roles will consist of a Project Manager and Project Team members, who will deliver their tasks according to the project schedule. The table below further defines precise role and responsibilities that are necessary to facilitate company's success. Table 1-3 lists each team member and their roles and responsibilities within the scope of the project.

| Name             | Role        | Responsibilities                                                                                                  |
|------------------|-------------|-------------------------------------------------------------------------------------------------------------------|
| Michael Clark    | Team Lead   | Responsible for maintaining continuity of course project and ensuring tasks are completed and deadlines met.      |
| FAbrione Donyeau | Team Member | Responsible for providing task and technical leadership, and sometimes maintaining a portion of the project plan. |
| Paulo Cambraia   | Team Member | Responsible for providing task and technical leadership, and sometimes maintaining a portion of the project plan. |
| Jamison Ables    | Team Member | Responsible for providing task and technical leadership, and sometimes maintaining a portion of the project plan. |

**Table 1-3 Team Roles & Responsibilities**

## 1.13.Educational/Program Outcomes

This section addresses the questions posted in the Capstone Project assignment in the order they were presented.

This particular information technology problem was chosen because of its originality and usefulness to the general public. By improving its mobile communication system, the American Red Cross of Greater Columbus can better serve the population during emergency situations, when it may be required to keep communications going from remote sites.

During the project proposal and draft, special attention was placed on the flexibility and robustness of the proposed solution. Considering the fact that the Red Cross may be operating under an emergency situation, it is very important that we design a system that can allow the crew to establish reliable connections efficiently under diverse circumstances.

Because of the nature of the proposed design, a wireless connection that utilizes the pre-existing cell phone infrastructure was the optimum solution. However, coming up with a solution that maximizes the coverage to give Red Cross the most reliability was a challenge. A combination of the two major cell phone providers was a good compromise to solve that problem. Depending on the deployment location (easily obtained with the help of a GPS device), the crew can quickly cross reference that location in a predefined chart and find out which provider offers the strongest signal at that location. In addition to the wireless connection to one of the cellular networks, the Red Cross would also have the option to take advantage of existent network connections in near by buildings, provided that they got permission to use it for their emergency response.

During the progress of our project, a few revisions were made to the Vision and Scope document and Status Report 1. Those revisions were mainly to address updates on the schedule (Gantt chart) and other statistics such as effort, man-hours, and current issues. All advices provided by Professor Smith and the business practitioner were implemented. There was no feedback that was not acted upon.

There are always opportunities for improvement in any project, provided that more resources (time, money, and personnel) are available. For example, a pilot test based on a smaller scale setup or proof of concept could have been done, if funds and time had been made

available. Unfortunately, some projects don't allow for a quick test run, so they have to rely on extra effort put into the design phase to assure the success of the implementation.

## **2. Design Considerations**

Quattro Consulting conducted interviews with key emergency communications services personnel at the ARCGC to determine the required features and functions for the proposed Transportable Voice, Data, and Wireless Communications System. The main three goals were considered to be critical to achieve:

- Provide best-effort Internet data access to the ARCGC communications vehicle regardless of event location
- Distribute Internet data access at the event site to ARCGC personnel over a secure medium
- Enable private, secure voice communications to ARCGC personnel at an event location

In addition, regardless of the equipment or technology selected to accomplish these goals, the following design constraints were deemed as operationally important to the intended ARCGC use of the system:

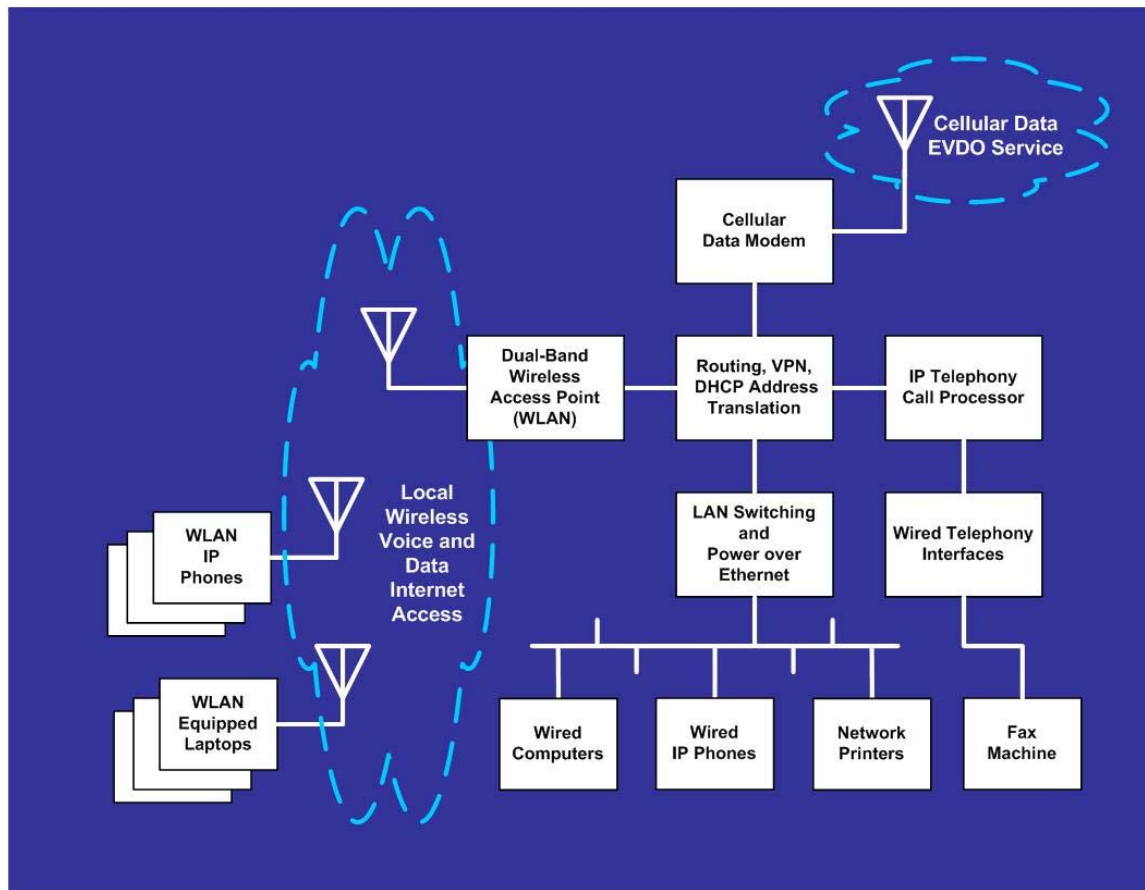
- Device(s) must have small physical size
- Device(s) should consume the lowest power consumption that is practical
- Configurations must be easy to create, store, and reconfigure in the field
- Cellular services must be compatible with Sprint and Verizon
- Up to eight simultaneous wired data users/devices must be supported
- Up to eight simultaneous telephone users must be supported
- System must be expandable to meet future needs and technology options

- System must be cost effective

Based on the design criteria outlined by the ARCGC, Quattro Consulting, LLC has selected several key technologies for the integration of the required functions. At a high-level, the system design will include a cellular Internet access capability which will allow ARCGC to access email, instant messaging, web-based services while deployed. Internet Protocol (IP) telephony will provide the required local secure voice communications service. Wireless LAN will provide a means to distribute the cellular-based Internet access locally to a variety of computers without the purchase of individual cellular data cards. The wireless LAN component will also create a connection path for wireless IP telephone instruments. Integrated switch technology provides the connectivity for local network devices without the additional hardware complexity.

## **2.1. System Functional Design**

Quattro Consulting, LLC has designed a system for the American Red Cross of Greater Columbus (ARCGC) which will provide mobile data access at remote locations. This functionality presents a whole new range of possibilities for new applications and services. At the heart of the system is the integration of cellular data service that connects to the 3<sup>rd</sup> Generation (3G) wireless network of cellular companies, allowing the ARCGC to communicate in new ways that are much more efficient than the current methods. Routing, switching, cellular, wireless LAN, and telephony functions are included in the design. Figure 2-1 shows the function block diagram of the system.



**Figure 2-1 – System Functional Block Diagram**

The router device will be specially configured for a number of common router tasks including Internet Protocol (IP) routing, Virtual Private Networking (VPN), Dynamic Host Control Protocol (DHCP) and Network Address Translation (NAT). In this application, the router device will act as a VPN server that will allow secure voice and data transmissions between the remote site and the home base of the Red Cross. DHCP will be used to automatically configure network clients, including IP phones on the network. Address translation will provide internet connectivity to client computers since would be unable to access the Internet with local private addresses.

For Wide Area Network (WAN) connectivity, the router device has been specified with an integrated cellular modem. With the availability of high-speed data services over the cellular network, this modem can provide Internet access to the communications vehicle and the router can be used to share this connectivity and bandwidth to a variety of users at the site, both as wired connections within the vehicle and via wireless LAN (WLAN/WiFi) connections to mobile laptops within range. If 3G cellular coverage is deemed inadequate, or if other higher-speed WAN services, such as T1 circuits or direct-connected Ethernet are available, the router configuration is flexible enough to accommodate other connection types.

In addition to the basic router functions, the proposed routers have also been equipped with integrated Power over Ethernet (PoE) LAN switches that provide power to devices on the network. The advantage to PoE is that each end device, such as an IP telephone or wireless access point, does not require a separate power adapters, but rather, receives their power from the same Ethernet connection used for the data transfer. This arrangement allows for simplified installation and support. This same LAN switch also provides data access for any other wired network devices necessary, such as desktops, laptops, and network printers.

The final important function of the integrated router is to provide telephony services using the IP protocol. These IP telephone instruments will allow users at the remote site to communicate with each other at the event site using standard telephone-style instruments—both directly wired within the communications vehicle and wirelessly within WLAN range of the vehicle. With additional interface cards for the router other telephony devices can be connected to the platform, such as, fax machines. The local IP telephony voice functionality will substantially reduce the need for using two-way radio communication channels for Red Cross

business and logistics functions. In addition, the technology used for the IP telephones are encrypted, ensuring that conversations cannot be intercepted by other parties. This feature is particularly useful when addressing privacy concerns regarding victims and other issues during an emergency event.

As cellular bandwidth continues to improve and the service offering mature, it will become possible for calls at the event site to be routed through the 3G data service to provide voice communications to the Red Cross home base and then out to the public telephone network. Any authorized user within wireless range of the truck would then remotely be able to dial any extension or phone number, and conversely, calls from ARCGC headquarters could directly dial extensions to mobile users at the event site.

## 2.2. Product Selection

In response to the integration requirements for the design, only manufacturers of both voice and data hardware were considered for possible suitable products. In addition, it was important to focus on market leaders in networking technology in order to ensure long-term availability and expandability for products. With these criteria, three networking equipment suppliers were considered:

- Avaya
- Cisco Systems
- Nortel Networks

Although each company offered both voice and data products, the resulting research determined that only Cisco Systems supplied the single platform product types required by the ARCGC design criteria. Several variations of Cisco System products were considered

depending on capacity, built-in features, and module compatibility. Based on the design criteria, the following Integrated Services Router (ISR<sup>®</sup>) platforms, as were evaluated:

- 1800-series ISR
- 2800-series ISR
- 3800-series ISR
- 3700-series MAR

The 3800-series platform was eliminated from consideration based due to its very high cost—a limiting factor dictated by the design criteria. As an alternative, the lower-cost, but less integrated 3700-series was also considered for comparison purposes and its potential availability on the used or refurbished market. Figure 2-2 shows the feature comparison between the various Cisco Systems platforms.

| Feature Comparison of Cisco Routers |         |      |     |                         |             |           |                                 |
|-------------------------------------|---------|------|-----|-------------------------|-------------|-----------|---------------------------------|
|                                     | Routing | DHCP | VPN | Celluar Internet Access | Wireless AP | Telephony | Switching w/Power over Ethernet |
| Cisco 1861                          | ●       | ●    | ●   | ●                       |             | ●         | ●                               |
| Cisco 2811                          | ●       | ●    | ●   | ●                       | ●           | ●         | ●                               |
| Cisco 3745                          | ●       | ●    | ●   |                         |             | ●         | ●                               |

**Legend**

- Modular
- Built-in

Figure 2-2 – Integrated Router Feature Comparison

Each of the platforms evaluated had unique advantages and disadvantages. One specific model was chosen from each class based on the best match to the design criteria resulting in three specific models: Cisco 1861 ISR, Cisco 2811 ISR, and Cisco 3745 Multi-service Access Router.

The ISR-based routers are Cisco's latest products featuring a wide range of services that can be integrated into the router, an important attribute that insures a smaller footprint and lower power consumption while remaining cost effective. The 3745 is a generation older router that is unable to support some of the features internally, but can be lower-priced on the used market.

### Cisco 1861 ISR

The Cisco 1861 ISR is an entry level, fixed function-specific routers that includes many features. The 1861 is the lowest model to support Cisco Unified Communications Manager Express, which provides call processing for IP Phones. The router also supports the new 3G data access cards that fit into its one modular High-Speed WAN Interface Card (HWIC) Slot. Some of the extra features included standard on this model include Cisco Unity Express which provides voicemail support, an 8 port PoE switch, and 8 voice ports for connection phone lines and end user device like fax machines. Figure 2-3 shows the advantages and disadvantages of the Cisco 1861 platform.

| <b>Advantages</b>                                                                                                                                                                                       | <b>Disadvantages</b>                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>♦ Highly-integrated</li> <li>♦ Includes Voicemail</li> <li>♦ Supports 3G HWIC</li> <li>♦ Has 8 voice ports (4FXO, 4FXS)</li> <li>♦ Lowest power usage</li> </ul> | <ul style="list-style-type: none"> <li>♦ Supports only 8 telephony users (only 15 max with upgrade)</li> <li>♦ Not available with built-in wireless</li> <li>♦ Only 1 HWIC slot</li> <li>♦ Non-standard (1.5 RU) size</li> </ul> |

**Figure 2-3 – Cisco 1861 Advantages & Disadvantages**

## Cisco 2811 ISR

The mid range Cisco ISR chosen was the 2811. This model features a maximum of HWIC slots (4) in the smallest physical size. The 2811 also supports Cisco Unified Communications Manager Express (IP telephony engine), but the only includes two Fast Ethernet ports for external connectivity. While many features are not built-in or preconfigured, the 2811 has several modular slots to support the needed functions. The 2811 allows many services to be integrated into a very small vertical space, but at the expense of depth. The ARCGC vehicle can accommodate the depth of the 2811 ISR. Figure 2-4 shows the advantages and disadvantages of the Cisco 2811 platform.

| Advantages                                                                                                                                                                    | Disadvantages                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Standard 1 RU height</li> <li>• 4 HWIC and 1 NME slot</li> <li>• Supports 3G HWIC</li> <li>• 25-user IP telephony license</li> </ul> | <ul style="list-style-type: none"> <li>• 10" deeper than the 1861</li> <li>• Does not include voicemail (supported as module)</li> <li>• No built-in FXO/FXS ports (supported as module)</li> <li>• No built-in LAN switch (supported as module)</li> </ul> |

**Figure 2-4 – Cisco 2811 Advantages & Disadvantages**

The remaining option considered is the Cisco 3745 Multi-service Access Router. While this product represents an older design lacks some of the functionality of the newer ISR routers, it may be available for a lower cost as a used or potentially donated source.

The main disadvantage of the 3745 is the inability to support any 3G HWIC modules, so an external 3G modem will be required. Figure 2-5 shows the advantages and disadvantages of the Cisco 3745 platform.

| Advantages                                                                                                                | Disadvantages                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>♦ Lower cost</li> <li>♦ Potentially available used or donated equipment</li> </ul> | <ul style="list-style-type: none"> <li>♦ 4 RU high</li> <li>♦ Deeper than the 1861</li> <li>♦ Does not include voicemail (supported as module)</li> <li>♦ No built-in LAN switch (supported as module)</li> <li>♦ Platform considered End of Life (EOL), but still supported by Cisco</li> </ul> |

Figure 2-5 – Cisco 3745 Advantages & Disadvantages

## 2.3. Platform Pricing

Each modular platform contains one or more chassis and individual modules that provide various features. Figure 2-6 shows the parts list and pricing for each of the three platforms: Cisco 1861, 2811, and 3745.

| Solution #1 Cisco 1861 Router |                   |                        |          |              |
|-------------------------------|-------------------|------------------------|----------|--------------|
| Cisco Model #                 | Cisco Part #      | Description            | Quantity | Street Price |
| 1861                          | C1861-UC-4FXO-K9  | Router with Voice      | 1        | \$3,300      |
| 3G HWIC                       | HWIC-3G-CDMA-V=   | Wireless Internet Card | 1        | \$600        |
| Aironet 1240AG                | AIR-AP1242AG-N-K9 | Wireless AP            | 1        | \$650        |
|                               |                   |                        | Total    | \$4,550      |
| Solution #2 Cisco 2811 Router |                   |                        |          |              |
| Cisco Model #                 | Cisco Part #      | Description            | Quantity | Street Price |
| 2811                          | CISCO2811-CCME/K9 | Router with Voice      | 1        | \$2,200      |
| 3G HWIC                       | HWIC-3G-CDMA-V=   | Wireless Internet Card | 1        | \$600        |
| 9 Port Module                 | HWIC-D-9ESW-POE=  | 9 Port Powered Switch  | 1        | \$750        |
| AP HWIC                       | HWIC-AP-G-A=      | Wireless AP Card       | 1        | \$350        |
| Power Supply                  | PWR-2811-AC-IP=   | Upgraded Power Supply  | 1        | \$250        |
|                               |                   |                        | Total    | \$4,150      |
| Solution #3 Cisco 3745 Router |                   |                        |          |              |
| Cisco Model #                 | Cisco Part #      | Description            | Quantity | Street Price |
| 3745                          | C3745-            | Router                 | 1        | \$1,800.00   |
| 3G Modem                      | WRT54G3G-VN       | Linksys External Modem | 1        | \$150        |
| 16 Port Module                | NM-16ESW-PWR      | 16 Port Powered Switch | 1        | \$750        |
| Aironet 1240AG                | AIR-AP1242AG-N-K9 | Wireless AP            | 1        | \$650        |
| Power Supply                  | ?                 | Upgraded Power Supply  | 1        | \$75         |
|                               |                   |                        | Total    | \$3,425      |

Figure 2-6 – Platform Pricing Estimates

## Other Components

In addition to the routing/switching/call processing platform, actual telephone instruments will be required for the system. Per the design specification, two (2) wired IP telephones for the communications vehicle and six (6) wireless IP telephones for the field staff have been included. Figure 2-7 shows the parts list and pricing for the telephone components.

| Telephones     |                    |                       |          |              |             |
|----------------|--------------------|-----------------------|----------|--------------|-------------|
| Cisco Model #  | Cisco Part #       | Description           | Quantity | Street Price | Total Price |
| 7941           | CP-7941G-CH1       | Console Phone         | 2        | \$400        | \$800       |
| 7921           | CP-7921G-A-K9=     | Wireless Phone        | 2        | \$350        | \$700       |
| 7921 Charger   | CP-DSKCH-7921G-BUN | 7921 Cradle           | 6        | \$150        | \$900       |
| 7921 Batteries | CP-BATT-7921G-EXT= | 7921 Extended Battery | 6        | \$75         | \$450       |
|                |                    |                       |          | Total        | \$2,850     |

Figure 2-7 – Telephone Instrument Pricing Estimates

## 2.4. ARCGC Geographic Areas of Responsibility

The areas of ARCGC responsibilities are delineated by Ohio county boundaries, in three separate tiers.

The primary area includes Fayette, Franklin, Madison, and Pickaway Counties. The secondary area includes the 22 counties of Athens, Coshocton, Crawford, Delaware, Fairfield, Gallia, Guernsey, Hocking, Knox, Licking, Marion, Meigs, Morgan, Muskingum, Noble, Perry, Ross, Union, Vinton, Washington, and Wyandot. The remaining 62 counties in Ohio make up the tertiary area of ARCGC responsibility.

Figure 2-8 shows the primary (red) and secondary (blue) areas in detail.



Figure 2-8 – ARCGC Counties of Responsibility

In order for the Internet connectivity to the mobile center to be operational, data services must be established. The system is designed to utilize Evolution Voice Data Optimized (EVDO) data services from either Sprint or Verizon. Depending on the area, each cellular data carrier has differing coverage and speeds. They also have different names for their data services. Table 2-1 shows a comparison of Sprint and Verizon service definitions.

| <b>Sprint</b>             | <b>Verizon</b>         | <b>Download</b> | <b>Upload</b> |
|---------------------------|------------------------|-----------------|---------------|
| Sprint Mobile Broadband   | Broadband and Vcast    | 600k-1.4Mbps    | 250-500kbps   |
| Nationwide Sprint Network | Enhanced Services      | 50-70 kbps      | 50-70 kbps    |
| Data Roaming              | Ext. Enhanced Services | 50-70 kbps      | 50-70 kbps    |
| Mobile Broadband Roam     |                        | 600k-1.4Mbps    | 250-500kbps   |

Table 2-1 – Sprint and Verizon Data Service Definitions

Data coverage for the first and second tier ARCGC responsibility areas are shown in Tables 2-2 and 2-3 below.

| Ohio County Number, County Name,<br>and County Seat City Name | Resp.<br>Level | Verizon<br>Coverage | Sprint<br>Coverage |
|---------------------------------------------------------------|----------------|---------------------|--------------------|
| 24. Fayette County - (Washington Courthouse)                  | 1              | Enhanced            | Broadband          |
| 25. Franklin County - (Columbus)                              | 1              | Broadband           | Broadband          |
| 49. Madison County - (London)                                 | 1              | Mixed EN/BR         | Broadband          |
| 65. Pickaway County - (Circleville)                           | 1              | Broadband           | Broadband          |

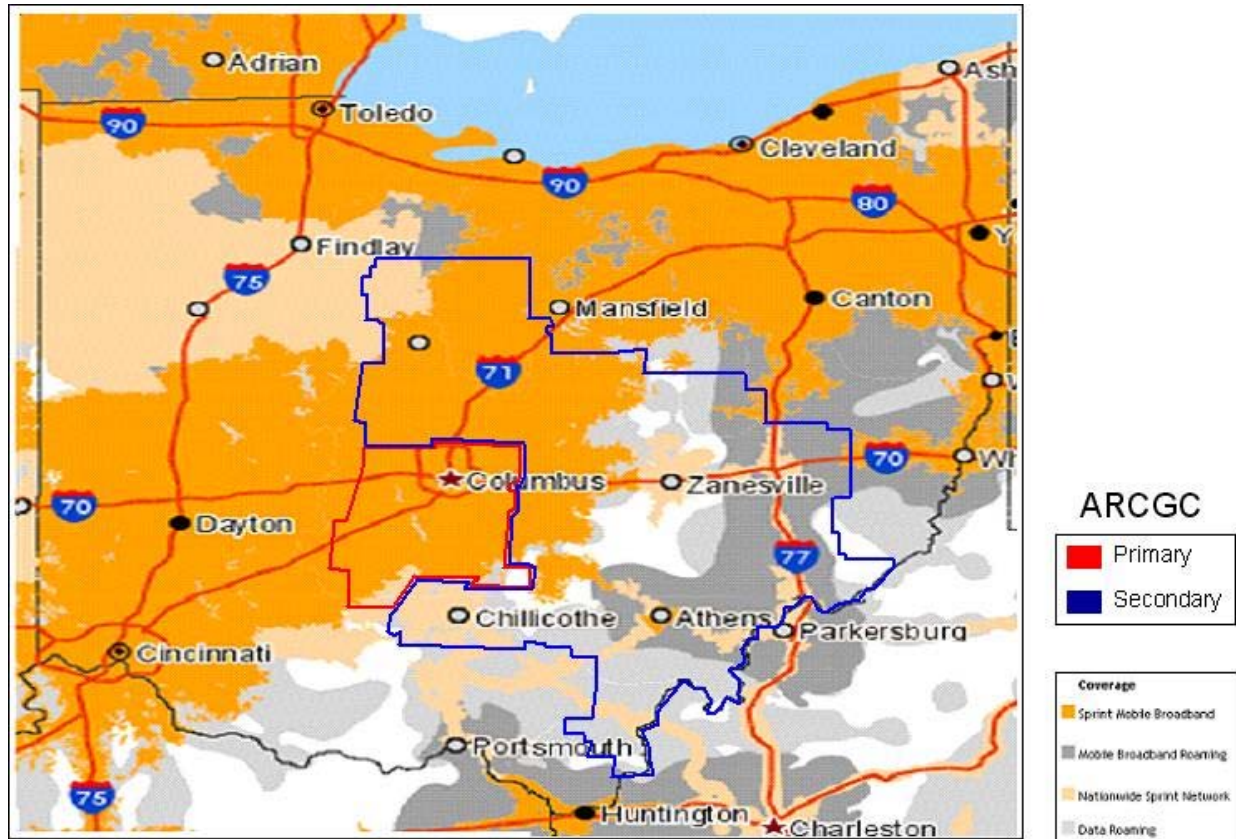
**Table 2-2 – ARCGC Primary Responsibility Counties Coverage**

| Ohio County Number, County Name,<br>and County Seat City Name | Resp.<br>Level | Verizon<br>Coverage | Sprint<br>Coverage |
|---------------------------------------------------------------|----------------|---------------------|--------------------|
| 5. Athens County - (Jefferson)                                | 2              | Broadband           | Nationwide         |
| 16. Coshocton County - (Coshocton)                            | 2              | Broadband           | Roaming only       |
| 17. Crawford County - (Bucyrus)                               | 2              | Broadband           | Mixed NW/BR        |
| 21. Delaware County - (Delaware)                              | 2              | Broadband           | Mixed NW/BR        |
| 23. Fairfield County - (Lancaster)                            | 2              | Broadband           | Mixed BR/Roam      |
| 27. Gallia County - (Gallipolis)                              | 2              | ExtEn               | Mixed Roam/NW      |
| 30. Guernsey County - (Cambridge)                             | 2              | Broadband           | Mixed Roam/NW      |
| 37. Hocking County - (Logan)                                  | 2              | Enhanced            | Some Broadband     |
| 42. Knox County - (Mt. Vernon)                                | 2              | Enhanced            | Mixed BR/Roam      |
| 45. Licking County - (Newark)                                 | 2              | Mixed EN/BR         | Mixed BR/Roam      |
| 51. Marion County - (Marion)                                  | 2              | Broadband           | Mixed NW/BR        |
| 53. Meigs County - (Pomeroy)                                  | 2              | Mixed EN/Roam       | Roaming only       |
| 58. Morgan County - (McConnelsville)                          | 2              | ExtEn               | Some Roaming       |
| 59. Morrow County - (Mt. Gilead)                              | 2              | Enhanced            | Mixed NW/BR        |
| 60. Muskingum County - (Zanesville)                           | 2              | Broadband           | Some NW            |
| 61. Noble County - (Caldwell)                                 | 2              | Mixed EN/BR         | Roaming only       |
| 64. Perry County - (New Lexington)                            | 2              | Some Broadband      | None               |
| 71. Ross County - (Chillicothe)                               | 2              | Enhanced            | Mixed Roam/NW      |
| 80. Union County - (Marysville)                               | 2              | Broadband           | Broadband          |
| 82. Vinton County - (McArthur)                                | 2              | Mixed EN/Roam       | Roaming only       |
| 84. Washington County - (Marietta)                            | 2              | ExtEn               | Mixed Roam/NW      |
| 88. Wyandot County - (Upper Sandusky)                         | 2              | Mixed EN/BR         | Nationwide         |

**Table 2-3 – ARCGC Secondary Responsibility Counties Coverage**

The third tier ARCGC responsibility area is comprised of the remaining 62 counties within the state of Ohio. Many rural areas, particularly away from major highways, have very limited coverage. Figure 2-9 shows the Sprint data coverage map for Ohio with the ARCGC

primary and secondary responsibility areas in overlay. The corresponding Verizon data coverage map is shown in Figure 2-10.



**Figure 2-9 – Sprint Cellular Data Coverage in Ohio with ARCGC Responsibility Areas Overlay**

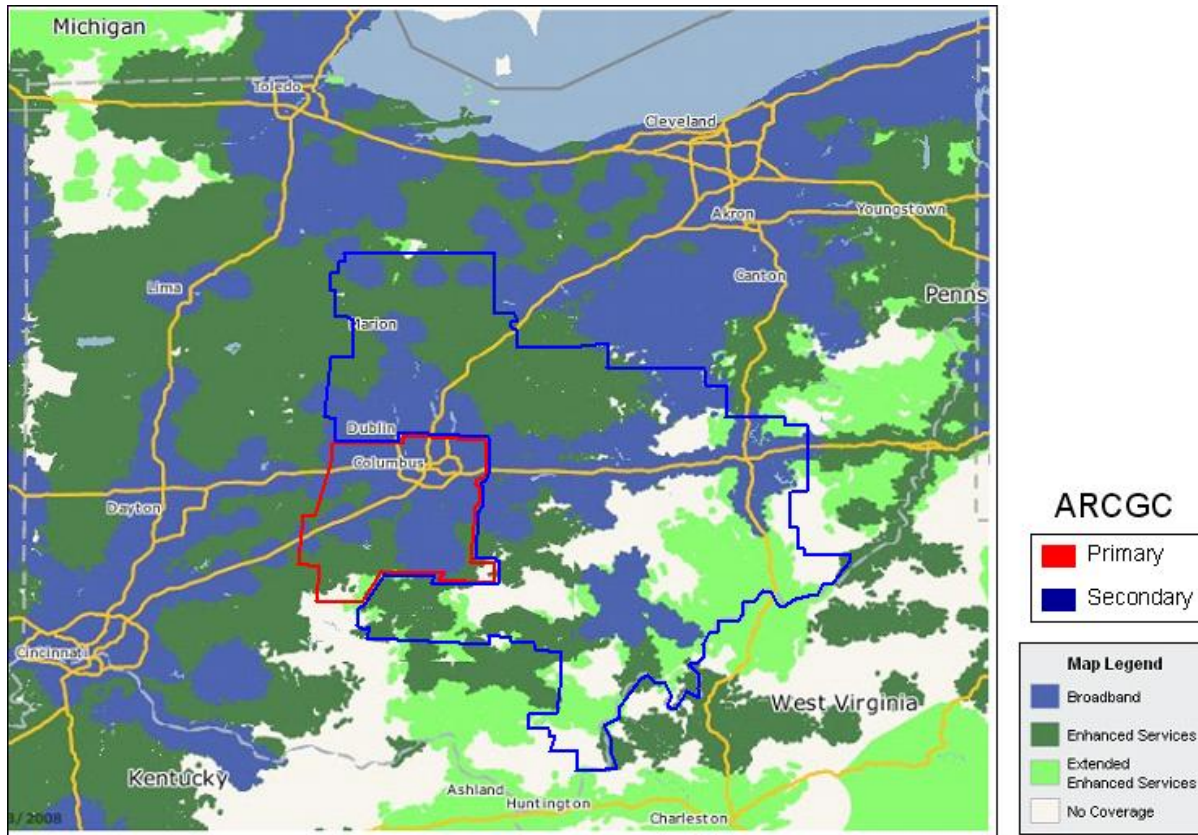


Figure 2-10 – Verizon Cellular Data Coverage in Ohio with ARCGC Responsibility Areas Overlay

## 2.5. Demo Router and Access Point Configuration

The system demonstrated to the ARCGC on August 22, 2008 consisted of a Cisco 2811 router, Cisco 1232 wireless access point, Cisco 7920, 7921, and 7960 IP phones. The following shows the working configuration files for the router and access point.

\*\*\*\*\* ROUTER \*\*\*\*\*

```
arcgc#sh run
Building configuration...
```

```
Current configuration : 5964 bytes
```

```
!
```

```
! Last configuration change at 14:38:09 UTC Thu Aug 21 2008
```

```
! NVRAM config last updated at 14:52:03 UTC Thu Aug 21 2008
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname arcgc
!
boot-start-marker
boot system flash flash:c2800nm-ipvoicek9-mz.124-20.T.bin
boot-end-marker
!
logging message-counter syslog
enable secret 5 $1$rH0k$zZwj5qvbUNWkjbXe92TmK.
!
no aaa new-model
!
dot11 syslog
no ip source-route
!
!
ip cef
ip dhcp excluded-address 192.168.1.1 192.168.1.199
ip dhcp excluded-address 192.168.1.241 192.168.1.255
ip dhcp excluded-address 192.168.2.1 192.168.2.199
ip dhcp excluded-address 192.168.2.241 192.168.2.255
!
ip dhcp pool voice
    network 192.168.2.0 255.255.255.0
    default-router 192.168.2.1
    dns-server 38.9.222.2
    option 150 ip 192.168.100.1
!
ip dhcp pool data
    network 192.168.1.0 255.255.255.0
    dns-server 38.9.222.2
    default-router 192.168.1.1
    option 150 ip 192.168.100.1
!
!
no ip domain lookup
multilink bundle-name authenticated
!
```

```
!  
!  
chat-script gsm "" "ATDT*99*1#" TIMEOUT 60 "CONNECT"  
!  
!  
voice-card 0  
no dspfarm  
!  
!  
username arcgc privilege 15 password 0 arcgc  
archive  
log config  
hidekeys  
!  
!  
interface Loopback0  
ip address 192.168.100.1 255.255.255.0  
!  
interface FastEthernet0/0  
no ip address  
duplex auto  
speed auto  
!  
interface FastEthernet0/1  
no ip address  
duplex auto  
speed auto  
!  
interface Cellular0/2/0  
description ARCGC  
ip address negotiated  
no ip redirects  
no ip unreachableables  
no ip proxy-arp  
ip nat outside  
ip virtual-reassembly  
encapsulation ppp  
dialer in-band  
dialer idle-timeout 0  
dialer string gsm  
dialer-group 1  
async mode interactive  
ppp chap hostname trial228@INTERNETTRIAL  
ppp chap password 0 trialpass228
```

```
ppp ipcp dns request
!
interface FastEthernet1/0
description Wireless AP
switchport access vlan 10
switchport trunk native vlan 10
switchport mode trunk
switchport voice vlan 20
duplex half
spanning-tree portfast
!
interface FastEthernet1/1
description CommVeh Phone
switchport access vlan 10
switchport trunk native vlan 10
switchport mode trunk
switchport voice vlan 20
duplex half
speed 100
spanning-tree portfast
!
interface FastEthernet1/2
description Guest Phone
switchport access vlan 10
switchport trunk native vlan 10
switchport mode trunk
switchport voice vlan 20
duplex full
speed 100
spanning-tree portfast
!
interface FastEthernet1/3
switchport access vlan 10
switchport trunk native vlan 10
switchport mode trunk
switchport voice vlan 20
spanning-tree portfast
!
interface FastEthernet1/4
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/5
switchport access vlan 10
```

```
spanning-tree portfast
!
interface FastEthernet1/6
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/7
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/8
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/9
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/10
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/11
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/12
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/13
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/14
switchport access vlan 10
spanning-tree portfast
!
interface FastEthernet1/15
description IP Camera
switchport access vlan 10
duplex half
speed 10
spanning-tree portfast
```

```
!  
interface Vlan1  
  no ip address  
!  
interface Vlan10  
  ip address 192.168.1.1 255.255.255.0  
  ip nat inside  
  ip virtual-reassembly  
!  
interface Vlan20  
  ip address 192.168.2.1 255.255.255.0  
  ip nat inside  
  ip virtual-reassembly  
!  
ip default-gateway 166.136.146.1  
ip forward-protocol nd  
ip route 0.0.0.0 0.0.0.0 Cellular0/2/0  
!  
ip http server  
no ip http secure-server  
!  
ip nat inside source list 1 interface Cellular0/2/0 overload  
!  
access-list 1 permit any  
dialer-list 1 protocol ip list 1  
!  
!  
!  
control-plane  
!  
!  
telephony-service  
  load 7960-7940 P00303020214  
  max-ephones 10  
  max-dn 30  
  ip source-address 192.168.100.1 port 2000  
  system message ARCGC Emergency Comm  
  time-zone 12  
  max-conferences 2 gain -6  
  moh music-on-hold.au  
  transfer-system full-consult  
  create cnf-files version-stamp Jan 01 2002 00:00:00  
!  
!
```

```
ephone-dn 1
number 4001
label CommVehicle
description CommVeh 4001
name CommVehicle
!
!
ephone-dn 2
number 4002
label Guest
description Guest 4002
name Guest
!
!
ephone-dn 3
number 4003
label Logistics
description Logistics1 4003
name Logistics1
!
!
ephone-dn 4
number 4004
label Logistics 2
description Logistics2 4004
name Logistics2
!
!
ephone-dn 5
number 4001
label CommVehicle-IPC
description CommVeh 4001-IPC
name CommVehicle-IPC
!
!
ephone 1
mac-address 000D.ED40.9C19
speed-dial 1 4003 label "Logistics 1"
speed-dial 2 4004 label "Logistics 2"
speed-dial 3 4002 label "Guest"
type 7960
button 1:1
!
!
```

```
!  
ephone 2  
  mac-address 000D.ED6C.3D82  
  speed-dial 1 4001 label "CommVehicle"  
  speed-dial 2 4003 label "Logistics 1"  
  speed-dial 3 4004 label "Logistics 2"  
  type 7960  
  button 1:2  
!  
!  
!  
ephone 3  
  mac-address 000D.288E.30D9  
  max-calls-per-button 2  
  type 7920  
  button 1:4 2:2 3:3  
!  
!  
!  
ephone 4  
  mac-address 001B.D458.9670  
  max-calls-per-button 4  
  speed-dial 1 4001 label "CommVehicle"  
  speed-dial 2 4002 label "Guest"  
  type 7921  
  button 1:3  
!  
!  
!  
ephone 5  
  mac-address 0012.3F07.C3B1  
  speed-dial 1 4003 label "Logistics 1"  
  speed-dial 2 4004 label "Logistics 2"  
  speed-dial 3 4002 label "Guest"  
  type CIPC  
!  
!  
banner login ^CCisco Configuration Professional Version:1.0 Date:08/08/2008^C  
!  
line con 0  
line aux 0  
line 0/2/0  
  exec-timeout 0 0  
  script dialer gsm
```

```
login
modem InOut
no exec
speed 384000
line vty 0 4
login local
!
scheduler allocate 20000 1000
end
```

```
arcgc#
```

```
***** AP *****
```

```
arcgc-ap#sh run
Building configuration...
```

```
Current configuration : 2275 bytes
!
version 12.3
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname arcgc-ap
!
enable secret 5 $1$bRJN$ajdBCbwbGHEZIYH.8uKVF/
!
ip subnet-zero
no ip domain lookup
ip name-server 192.168.1.100
!
!
no aaa new-model
!
dot11 ssid arcgc-data
    vlan 10
    authentication open
!
dot11 ssid arcgc-voice
    vlan 20
    authentication open
```

```
!  
!  
!  
username Cisco password 7 047802150C2E  
username arcgc password 7 020716580C05  
!  
bridge irb  
!  
!  
interface Dot11Radio0  
no ip address  
no ip route-cache  
!  
encryption vlan 10 key 1 size 128bit 7 A3C2590B73A0953EF85B4E630D8E transmit-key  
encryption vlan 10 mode wep mandatory  
!  
encryption vlan 20 key 1 size 128bit 7 CE6B241F059DADC0DC132074A185 transmit-key  
encryption vlan 20 mode wep mandatory  
!  
ssid arcgc-data  
!  
ssid arcgc-voice  
!  
speed basic-1.0 basic-2.0 basic-5.5 basic-11.0  
power local 5  
no power client local  
power client 5  
station-role root  
!  
interface Dot11Radio0.10  
encapsulation dot1Q 10 native  
no ip route-cache  
bridge-group 1  
bridge-group 1 subscriber-loop-control  
bridge-group 1 block-unknown-source  
no bridge-group 1 source-learning  
no bridge-group 1 unicast-flooding  
bridge-group 1 spanning-disabled  
!  
interface Dot11Radio0.20  
encapsulation dot1Q 20  
no ip route-cache  
bridge-group 20  
bridge-group 20 subscriber-loop-control
```

```
bridge-group 20 block-unknown-source
no bridge-group 20 source-learning
no bridge-group 20 unicast-flooding
bridge-group 20 spanning-disabled
!
interface FastEthernet0
no ip address
no ip route-cache
duplex auto
speed auto
hold-queue 160 in
!
interface FastEthernet0.10
encapsulation dot1Q 10 native
no ip route-cache
bridge-group 1
no bridge-group 1 source-learning
bridge-group 1 spanning-disabled
!
interface FastEthernet0.20
encapsulation dot1Q 20
no ip route-cache
bridge-group 20
no bridge-group 20 source-learning
bridge-group 20 spanning-disabled
!
interface BVI1
ip address 192.168.1.10 255.255.255.0
no ip route-cache
!
ip default-gateway 192.168.1.1
ip http server
no ip http secure-server
ip http help-path http://www.cisco.com/warp/public/779/smbiz/prodconfig/help/eag
!
!
control-plane
!
bridge 1 route ip
!
!
!
line con 0
line vty 0 4
```

```
login local
!
end
```

```
arcgc-ap#
```

## 2.6. Pricing Summary and Recommendations

With all three high-level options, IP telephone instruments will also be required. Initially, two (2) Cisco 7941 wired IP phones and six (6) wireless Cisco 7921 phones are recommended. Figure 2-11 shows the pricing summary including the IP telephones.

| Solution #1 - Cisco 1861 |                | Solution #2 - Cisco 2811 |                | Solution #3 - Cisco 3745 |                |
|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|
| Router and Misc          | \$4,550        | Router and Misc          | \$4,150        | Router and Misc          | \$3,425        |
| Telephones               | \$2,850        | Telephones               | \$2,850        | Telephones               | \$2,850        |
| <b>Total</b>             | <b>\$7,400</b> | <b>Total</b>             | <b>\$7,000</b> | <b>Total</b>             | <b>\$6,275</b> |

**Figure 2-11 – System Pricing Summary Estimates**

Based on the price, performance, and features offered in the three product platforms, Quattro Consulting, LLC recommends the Cisco 2811 ISR system shown in Section 3. Although the Cisco 2811 is more expensive than the Cisco 3745 option, it is a more integrated product that will continue to be supported in the future. The Cisco 1861 has some size and power advantages, but they are offset by limited flexibility because of the additional modules available with the Cisco 2811 ISR.

## 3. Annotated Bibliography

Airvana. (2008). *EV-DO Rev A – VoIP*. Retrieved May 24, 2008, from

[http://www.airvana.com/technology/technology\\_voip.htm](http://www.airvana.com/technology/technology_voip.htm)

This article provides information on EVDO Revision A which is important if you want to use VoIP over an EVDO connection. The article explains some of the enhancements from Rev 0 to Rev A and why these are important for VoIP. One of the major changes between the revisions was the increased uplink communications which will increase the number of calls possible on the link.

Barnes, S, & Scornavacca, E (2006). *Unwired business* [electronic resource]: *cases in mobile business*. Hershey PA: IRM Press.

This book is a compilation of practical uses of the current mobile technology. Although Internet and mobile communication technologies are developing along two separate paths, they've come closer to each other as technology progresses. Wireless applications such as person-to-person messaging, e-mail, banking, news, games, music, shopping, information feeds, and others are just a few of the examples addressed by the authors. It's a good reference for a broad view of what mobile applications are currently available, and what's possible in the near future.

Bhushan, N, Lott, C, Black, P, Attar, R, Yu-Cheun, J, Fan, M & Au, J (2006). EV-DO revision a: a physical layer and MAC layer overview. *IEEE Communications Magazine*. 44 Issue 2, 37-49.

This journal article describes the technical merits of Revision "A" over the previous Revision "0" versions of the CDMA/EVDO service adopted by Verizon and Sprint. Specifically, the article covers the improvements in latency, Quality of Service (QoS) queuing, and system gain afforded by the new technology. The

Rev. "A" version of the EVDO technology is required for delay and bandwidth-sensitive Voice over IP (VoIP) services.

Curtis R. Carlson, William W. Wilmot. *Innovation: The Five Disciplines for Creating What Customers Want*. Publisher: Crown Business Date: Aug. 8, 2006

The book cites dozens of examples of innovative ideas brought to fruition by innovators from Thomas Edison to Steve Jobs. It outlines, in workbook fashion, the critical decision-making process--the Five Disciplines of Innovation--required to think innovatively along with the quantitative tools that one needs to become an innovator, regardless of one's profession.

Deal, R (2006). *The complete Cisco VPN configuration guide* [electronic resource] /

Richard Deal. Indianapolis, IN: Cisco Press.

This book, written by Richard Deal (20 years experience in computing and networking industry, BS in mathematics, and trainer for several Cisco certification courses), is basically a "how-to" book that describes the implementation of Virtual Private Networks (VPNs) on Cisco products. The book makes some assumptions as far as the reader's initial knowledge as far as Cisco routers, Operating Systems, and command-line interfaces. The idea behind this book is to aid engineers and network administrators in their every day duties setting up secure network connections through VPNs. This is relevant to Quattro Consulting research due to the security aspects of the proposed system.

EVDOinfo.com. (2005). *Using VOIP over EVDO - Testing Vonage over EV-DO*.

Retrieved May 24, 2008, from <http://www.evdoinfo.com/content/view/138/63/>

The basic premise for the article examines how to use VoIP technologies over a wireless EVDO connection. The hardware the author used is far different than the solution that Quattro Consulting will likely propose, but the article does provide some good background information. The most important part of the article is the information on how well it works. If the connection is using the old 1xRTT connection then VoIP won't work, but over EVDO it does work.

Shneyderman, A (2003). *Mobile VPN* [electronic resource]: *delivering advanced services in next generation wireless systems*. Indianapolis, IN: John Wiley & Sons.

In this book, the authors address the wonders and challenges of the mobile Internet. They explain technologies such as Mobile IP and Virtual Private Networks (VPNs) and how these technologies can restructure the Internet as we know it today. Advancements in securing connections and increased bandwidth have allowed mobile devices to become a more prominent tool for on-line communication and work collaboration.

Wireless Communications Interoperability. Retrieved May 25, 2008 from:  
<http://www.nascio.org/advocacy/washwatch/issues/nascio-wirelessinteroperability.pdf>

This article illustrates how the lives of American citizens (and the public servants charged with keeping them safe) are jeopardized as a result of problems associated with wireless communications interoperability. NASCIO is a 501c(3)h non-profit association whose mission is to foster government excellence through quality business practices, information management, and technology policy.

## 4. Appendices

The following documents can be found in the “artifacts” folder:

- **Revised Vision and Scope document**  
Version 3 of Vision and Scope document with updated information such as updated Gantt chart to reflect current project status.
- **Feedbacks from instructor**  
Feedback on the version 1 and 2 of our Status Reports document as well as the feedback on the Vision and Scope document.
- **Gantt chart**  
Updated chart to reflect new and updated tasks and milestones.
- **Earned Value Management spreadsheet**  
Spreadsheet with calculation and charts to show our progress in man hours and dollars.
- **Recordings from team meetings**  
The recordings can be found at <http://freud.franklin.edu/ables04/recordings/>
- **Price List**  
List of prices for hardware/software necessary for each of the three provided scenarios.

- **Feature Matrix**  
Feature Comparison of Cisco Routers.
- **Func Block Diagram**  
Functional Block Diagram of the system (Visio).
- **Detailed Coverage Maps and Tables**  
Coverage Maps for Sprint and Verizon with Primary area detail (PowerPoint).
- **ARCGC County Responsibilities and Coverage**  
Written and graphics section on ARCGC Responsibility Areas and Corresponding Coverage (Word).
- **Presentation slides**  
Screenshots of the slides created for the project presentation