The Lack of Interoperability in the 911 Emergency Communications System in Colorado: What Solutions Exist?

Ronak Merchant, Chirag Khandelwal, Mitali Haldankar, Aditya Kamath
Ronak.Merchant@colorado.edu, Chirag.Khandelwal@colorado.edu, Mitali.Haldankar@colorado.edu, Aditya.Kamath@colorado.edu

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1 Introduction

Remember the cop show you watched on TV and in movies when you were a child – in any decade since TV began? Whenever a cop faced an emergency situation, he/she would pick up the radio and ask for help. In no time at all, police vehicles, ambulances or other emergency medical services (EMS), and firefighters would rush to the scene. The seeming flawless response was deceiving because, unless the responders were face-to-face, they generally could not communicate with one another to address the emergency since they used different radio frequencies and communications equipment. What may be even more striking is that the same situation remains in most jurisdictions today, in 2011.

Interoperability among public safety agencies is described as: “The ability of the agencies to communicate with each other by radio on demand and in real-time during a rescue operation” (“Critical issues,” n.d., p. 2). This communication may involve the exchange of voice, data, maps and graphics, including requests for blueprints to guide rescue personnel, additional equipment/manpower, and other pertinent information – especially at night, during storms, or during other adverse conditions where visibility is low and confusion is high (“Next,” 2007, p. 6). During a typical emergency scenario, for example, police officials may need to communicate with the fire department to convey the floor on which a victim is trapped in a fire. Additionally, the EMS may need to have an ambulance and medical staff available at the closest possible location.

The purpose of this paper is threefold: 1) to conduct a technical analysis of the problem, an interim solution, and proposed solution, 2) to discuss the chief legal and economic aspects surrounding the problem, and 3) the requirements for the successful realization of interoperability today. To do these the authors: 1) conducted a literature review of the issue, 2) researched the studies and discussions undertaken by the national E-911 regulators and industry organizations including the Federal Communications Commission (FCC), National Emergency Number Association (NENA) and Associated Public Safety Communications Officers (APCO), 3) developed interview questions and 4) conducted 16 personal interviews with professionals involved with emergency communications in Colorado. The team analyzed and categorized the information obtained from the literature review into five sections history, significance, technical analysis, legal and economic aspects, and two chief issues in this area. The interviews included three firefighters, two officers of the University of Colorado Police Department, three managers of emergency communications technology division, and three independent consultants. Detailed information of interviewees is listed in Appendix A. For the first five interviews, the team used a set of open ended questions it developed to better understand the chief concerns in this area, and for the remaining, the team used a second set of questions to capture the opinions of the interviewees on specific topic areas. The interview responses were tabulated in a question-wise format and analyzed to identify repetitive patterns that helped the team shortlist
two important issues facing interoperable emergency communications: 1) the benefits and drawbacks of using a single vendor as opposed to multiple vendors in a nationwide consistent emergency communications model and 2) an analysis of whether the Federal Government should lead interoperability initiatives.

To present this information, section 2 outlines a brief history of the interoperability issue in emergency communications, while section 3 provides an explanation of the significance of the problem. Section 4 presents a technical analysis of the past, current partial interoperability, and proposed solutions; Section 5 explains the legal and economic overview of this issue; and section 6 describes an analysis of the findings collected from literature review and interview responses.

2 History

The difficulties with interoperability in emergency response communications has a history that dates back many decades, but in 1989 it was identified by the leaders of the public safety communications committee as an important concern in the area for the U.S (Hawkins, 2007, p. 1). To address this issue and standardize digital radio technologies, a $2 Billion initiative, called Project 25, was launched jointly by two national industry groups: 1) the APCO, and 2) the National Association of State Telecommunications Directors (NASTD), and four federal U.S. government agencies including: 1) the National Telecommunications and Information Administration (NTIA), 2) the National Communications System (NCS), 3) the National Security Agency (NSA), and 4) the US Department of Defense (DoD) (“History of,” 2008, p. 4). Project 25 received its name as a result of APCO’s tradition of numbering its initiatives in public safety (Hawkins, 2007, p. 1). While Project 25 accomplished the setting of a digital standard for emergency radio communications that is backward compatible with the traditional systems, it did not from 1989 to 2010, achieve its original goal of interoperability and a U.S. House of Representatives declared the project to be a failure in September, 2010 (“Congressional,” 2010).

During the September 11, 2001 (9/11) attack on the World Trade Center, police helicopters circling the scene issued warnings about the possible collapse of the towers (“Working,” 2003, p. 4). However, due to lack of interoperability among the radios used by the police and fire departments, hundreds of firefighters never received this warning and 343 firefighters lost their lives (“Working,” 2003, p. 4). In contrast, most of the police officers were able to hear the warnings on the police frequencies and to escape in time. Thus their death toll was significantly lower. To address the interoperability issues raised during the 9/11 attacks, Congress allocated sums of money in the form of various grant programs, such as the State Homeland Security Grant Program (“FY 2010,” 2010). Despite this funding, interoperability continues to remain one of the biggest challenges facing emergency communications in the U.S. today.

3 Significance

During the course of this research, the authors identified three main stakeholders in this issue of interoperability: 1) the “First Responders” including law enforcement officials, firefighters, EMS personnel, 2) the government agencies that are responsible for forming and regulating guidelines and budgets in order to achieve interoperability, and 3) researchers and analysts involved with the development of New Generation 911 (NG 911) equipment and capabilities. (“Next,” 2008, p. 3). The first responder agencies, is the group that is most critically affected by the issue of the failure of interoperability. As shown in 9/11, the lives of
law enforcement officials, firefighters, and EMS personnel are ultimately at stake in this debate as the ability to communicate effectively with each other using interoperable communication systems is their lifeline during emergency situations.

The second group of stakeholders is of government agencies and officials that have an important role to play in all interoperability efforts. A governance structure consisting of agencies at the federal, state and local level must be created to specifically oversee progress in the interoperability issue. The third group consists of researchers and analysts involved with NG 911. The technical, legal, and economic analysis completed as part of this research indicates that the NG 911 platform may offer significant options in realizing full interoperability in emergency radio communications. This would include Internet Protocol (IP) - based communications over which a variety of current and evolving radio technologies can operate and thus be immediately interoperable.

4 Technical Analysis

To understand the problems of interoperability, it is helpful to understand how radio communications work, the technical challenges faced to date, and the benefits and shortcomings of the various proposed solutions. Most solutions tried as of today provide only partial interoperability while full interoperability is the sought-after long-term solution.

4.1 Traditional 911 Inter-Agency Communications

Consider the typical communication scenario among different first responder agencies that belong to different jurisdictions: 1) fire fighters from a city or county, 2) police or sheriffs, 3) EMS teams from a city, county, or the state; and in some major events: 4) the Colorado Bureau of Investigation (CBI), 5) the Federal Bureau of Investigation (FBI), and 6) groups such as the National Guard. Figure 1 below considers a scenario in which at least four of these agencies come together to respond to a major event, perhaps like the 2008 National Democratic Convention held in Denver, Colorado.

![Figure 1: Traditional 911 Inter-Agency Communications](image)

First responder agencies use radios as the primary means of on-site communication. All four use radios that operate at different frequencies, using different technologies from various vendors because of fragmentation in the available radio frequencies, funding, and
viability of vendors. As shown in Figure 1, these variations include: 1) the City of Lakewood using the 800 MHz Analog radio system, 2) the State of Colorado using the 800 MHz Digital radio system, 3) the FBI using radios operating in the VHF band; and 4) the National Guard operating in the UHF band (Kabelis, personal communication, March 22, 2011). With each system operating on a different frequency, it is difficult for the diverse radio systems to interoperate successfully. Most “First Responder” agencies must physically exchange radios upon arrival at the crime scene in order to communicate with each other (Nakao et al., n.d.). While this initially appears to be an inexpensive solution, the practice also creates problems including: 1) the cost and trouble of carrying multiple radios and 2) time to train each other in the functionality of each agency’s radio system.

4.2 Interim Solutions to Achieve Interoperability

One solution suggested was to replace the millions of radio handsets and systems used by first responder agencies with a new system that would have the same frequency, protocol, and bandwidth (“Interoperability solved,” 2004, p. 2). This solution was not adopted because of the substantial cost involved with replacing every radio handset.

Another suggested solution was implemented by the Denver Police Department (DPD) in December 2004 (“Software,” 2006, p. 9). The solution, called “NetworkFirst”, was developed by the company M/A-COM. “It is a software platform that acts as a Voice over Internet Protocol (VoIP) switch” (Careless, n.d.). As a part of this solution, “talkgroups” or channels were defined and each “talkgroup” was allocated to each first responder system. As shown in Figure 2, each radio system sends audio to a NetworkFirst voice-communications gateway. The gateway converts the audio into Internet Protocol (IP) data packets, and transmits and receives packetized digital voice (“Interoperability gateway,” 2006, p. 1). These packets are then routed to a NetworkFirst Switching Center over a private and secure Wide Area Network (WAN) using IP protocol. The switching center then moves the IP packets to the appropriate radio network by identifying each NetworkFirst Gateway’s IP address, and creating and managing talkgroups (“NetworkFirst,” n.d., p. 5). Network switching centers in nearby locations are interconnected to cover larger areas. Beyond the gateways and switching centers, NetworkFirst provides backup for existing dispatch consoles and the ability to replay the last conversation among first responders (Nakao et al., n.d.).
Although NetworkFirst serves as an effective initial solution, it has two major disadvantages, specifically: 1) the maximum number of 12 “talkgroups” supported by NetworkFirst has been exhausted (Kabelis, personal communication, March 24, 2011; Stephenson, 2006, p. 35), and 2) it requires an IP Wide Area Network that is relatively difficult to deploy and maintain (Hrapchak & Leger, 2003).

4.3 Proposed Long Term Solution

A third proposed solution is use of the NG 911 platform. As shown in Figure 3, this solution encourages the conversion of most radio communications into IP packets and the management of communications networks to allow for the flow of the packets. This solution uses Radio over IP (RoIP) technology and Radio Interface Units (RIU) to convert the radio communication into IP packets, providing an interface between the first responders and the IP network. A group of networks, collectively called the Emergency Services IP network (ESInet), is shared by the various agencies responding to emergencies and typically managed by a county (“NENA functional,” 2007, p. 18). These county-wide ESInets are then connected to one other to form a nationwide network and thus would provide full interoperability.

![Figure 3: NG 911 IP based Interoperability Solution (“NENA functional,” 2007, p. 25)](image)

The advantage of the NG 911 platform is full interoperability among emergency systems despite different frequency bands, vendors, and protocols, plus an unlimited number of “talk groups”. It thus overcomes the limitations of the previous proposed solutions and provides a long-term solution to the interoperability problem. However, this solution also raises several concerns including: 1) security issues with IP, 2) prioritization of emergency communications traffic (Quality of Service) over the public Internet, and 3) development of a backup system that could be used in the event of a catastrophe. The authors of this paper acknowledge these problems but limit the scope of this paper to the proposed solutions of the interoperability problem.
5 Legal and Economics Aspects

In the U.S., all three levels of government, federal, state, and local, address the issue of interoperability through laws, and their implementing regulations, agencies and programs. These three levels are also an important part of the economic aspects of this discussion on interoperability.

5.1 Federal Efforts

The efforts by the Federal U.S. Government toward achieving interoperability have been directed through two chief agencies: 1) the FCC, and 2) the Department of Homeland Security (DHS). In its National Broadband Plan (NBP), submitted to the Congress on March 16 2010, the FCC recommended reauthorizing the Implementation Coordination Office (ICO) to ensure the deployment of NG 911 in an interoperable radio fashion (Moore, 2010, p. 16). Consistent with the Department of Homeland Security Appropriations Act, 2007 (P.L. 109-295), the DHS is the agency promoting interoperability through the formation of Regional Emergency Communications Coordination (RECC) Working Groups. These groups are tasked with ensuring interoperable emergency communications across a variety of agencies and jurisdictions (Moore, 2010, p. 14; “Regional,” 2008).

5.1.1 Laws Addressing the Current Emergency Communications System

To address the radio interoperability issues in the current emergency communications system the US Congress enacted the “2004 Intelligence Reform and Terrorism Prevention Act (IRTPA)” (“Intelligence,” 2004). The IRTPA: 1) highlighted the importance of having a nationwide approach toward achieving interoperability coordinating communications systems at the Federal, State and Local levels, 2) established the Federal SAFECOM Program to oversee the nationwide interoperability initiatives, and 3) directed both the FCC and the DHS to “act promptly on a set of high level goals including, but not limited to, the development of a comprehensive national approach for achieving interoperability, encouraging open architecture and commercial products, and developing a set of best practices” (Faulhaber, 2006, p. 499). The SAFECOM program is an emergency communications program aimed at public safety and managed by the Office of Emergency Communications and the Office of Interoperability and Compatibility (“About Safecom,” n.d.). Its notable efforts include the creation of a Grant Guidance document and a National Interoperability Baseline survey (“Interoperability,” n.d.). The Grant Guidance document is used by agencies like Federal Emergency Management Agency (FEMA) to promote efforts for interoperability (“Interoperability,” n.d.). The National Interoperability Baseline survey was used as a tool to assess the communications interoperability capacity of various first responder agencies (“Interoperability,” n.d.).

5.1.2 Laws Addressing the Emerging Emergency Communications System

To achieve a national IP-enabled emergency system with full interoperability, the US Congress enacted two specific laws: 1) The Ensuring Needed Help Arrives Near Callers Employing (ENHANCE) 911 Act of 2004 (P.L. 108-494) and 2) The New and Emerging Technologies (NET) 911 Improvement Act of 2008 (P.L. 110-283) (Moore, 2010, p. 3). Dale N. Hatfield who was a Telecommunications Consultant in 2002, prepared a report called the Hatfield Report. This report was submitted to the FCC on October 15, 2002 and indicated the antiquated nature of 911 system for both wireless and wire-line calls (Moore, 2010, p. 6).
response to the Hatfield report, the FCC passed the ENHANCE 911 Act of 2004. The purposes of this Act are: 1) to coordinate 911 services and E–911 services, at the Federal, State, and local levels and 2) to ensure that funds collected on telecommunications bills for enhancing emergency 911 services are used only for the purposes for which the funds are being collected (Moore, 2010, p. 6). In the mid 2000’s, a new technology, Voice over Internet Protocol (VoIP) phones became popular. However, their callers generally could not call 911. In 2008, Congress passed the New and Emerging Technologies (NET) 911 Improvement Act of 2008 (P.L. 110-283) to ensure access to 911 call centers for VoIP users (Moore, 2010, p. 7). Primarily, this Act required building VoIP support for 911 services and annual reports from the FCC to track the progress of each VoIP company in doing so (Moore, 2010, p. 6).

5.1.3 800 MHz Band Reassignment

The radio spectrum frequency allocation process in the U.S. places both the public safety radio communications system and the Commercial Mobile Radio Services (CMRS) providers in the 800 MHz Frequency Band (FCC, 2004, p. 1). On July 8, 2004, the FCC issued an Order (04-168) to reconfigure the 800 MHz bands to distinctly separate the frequency band used for public safety radio communications from the band used by the CMRS providers (FCC, 2004, p. 3; “800MHz,” n.d.). CMRS providers, such as Nextel, were required to relocate to two other bands that ranged from 1910–1915 MHz and 1990-1995 MHz (FCC, 2004, p. 2). As a result of this reconfiguration, ten additional channels were assigned to public safety and critical infrastructure interoperability (FCC, 2004, p. 2).

5.1.4 Funding Efforts at the Federal Level

The Federal Government plays a major role in the economic analysis. One of the chief functions of the Federal Government is to support interoperability initiatives by allotting grants to the States. The Interoperable Emergency Communications Grant Program (IECGP) is one such grant program focused on the issue of interoperability (“2010 Interoperable,” 2009, p. 2). The State of Colorado received and distributed IECGP funds on the basis of a formula that included population, population density, number of law enforcement and fire responders serving the population and a base training allocation for each region (“2010 Interoperable,” 2009, p. 4). This funding is focused on the development of operational protocols, defining crucial leadership and conducting appropriate training exercises (“2010 Interoperable,” 2009, p. 2).

5.2 State and Local Efforts

The role played by the State of Colorado and its local agencies in ensuring interoperable emergency communications is very important. Two noteworthy efforts by the State and its local agencies are described below:

5.2.1 Development of Digital Trunked Radio System (DTRS) and Consolidated Communications Network of Colorado (CCNC)

The State of Colorado is in the process of achieving statewide interoperability through a Digital Trunked Radio System (DTRS). Started in 1991 by a users group, the development of the DTRS technology was tasked with the development of an operational “requirements plan” (“Colorado’s,” n.d.). The DTRS system is basically a wireless system used throughout the State that allows for interoperable communications between first responder agencies
This system is the radio backbone that contains equipment owned by different user agencies and is based on Project 25 (P25) technology (“Frequently,” 2011). The CCNC is “a non-profit organization that is made up of participating agencies that use the DTRS system. It governs the DTRS system and is a partnership between local, county, state, federal, and tribal agencies across the State of Colorado” (“Frequently,” 2011).

5.2.2 9-1-1 Surcharge

Apart from Federal funds, every phone bill in the State of Colorado includes a monthly 911 surcharge collected by the phone service providers and submitted to the State Treasurer. The sixty-two counties in Colorado receive a share of these funds, based on each county’s population, (primarily for the portion of the system that connects callers to the 911 call centers or “Public Switching Answering Points”) (“Texting,” 2010, p. 11). The funds do not necessarily provide funds for the radio interoperability of the responders. When they do, these funds provide important resources for the more populated, urban counties, but the less populated, generally rural counties struggle to afford equipment upgrades, complicating their ability to participate in the interoperability efforts (“Texting,” 2010, p. 11).

6 Analysis and Findings

During the interviews conducted, several issues were raised including the impact of interoperability on the cost, security and innovation of the 911 operations. Two chief issues were identified by the interviewees as crucial to all interoperability efforts: 1) a nationwide emergency communications model via the involvement of a single or multiple vendors, and 2) the leading role played by the Federal or State/Local governments in interoperability initiatives. An analysis of these two issues is presented below.

6.1 Analysis of Issue 1

During the course of the interviews conducted for this research, the idea of developing a nationwide emergency communications system was raised on numerous occasions. This research identified eleven important criteria, listed in Table 1, in the development of such an emergency communications system and compared the impact on each of these criteria using equipment from a single vendor versus from multiple vendors. In Table 1, the green portions indicate the level of benefit to the overall emergency system interoperability efforts, while the red portions indicate problems or issues for the interoperability efforts. Each level represents intensity of benefit or loss with lowest being most intense.

<table>
<thead>
<tr>
<th>S.R. NO.</th>
<th>CRITERIA FOR COMPARISON</th>
<th>SINGLE VENDOR</th>
<th>MULTIPLE VENDORS</th>
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<tbody>
<tr>
<td>1.</td>
<td>Co-ordination in management / upgrades</td>
<td><img src="green.png" alt="Green" /></td>
<td><img src="red.png" alt="Red" /></td>
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<tr>
<td>2.</td>
<td>Consistency in devices</td>
<td><img src="green.png" alt="Green" /></td>
<td><img src="red.png" alt="Red" /></td>
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<td></td>
<td>Ability to interconnect systems</td>
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<tr>
<td>4.</td>
<td>Dependency on single vendor</td>
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<td>5.</td>
<td>Monopolistic behavior</td>
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<td>6.</td>
<td>Innovation</td>
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<td>7.</td>
<td>Inventory in stock for catastrophe</td>
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<td>8.</td>
<td>Prices</td>
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<td>9.</td>
<td>Establishment of Single point of failure</td>
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<tr>
<td>10.</td>
<td>Security Threat</td>
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<tr>
<td>11.</td>
<td>Corruption</td>
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</table>

### 6.2 Findings for Issue 1

Based on the comparison between single and multiple vendors as shown in Table 1, this research suggests the involvement of multiple vendors. A committee must be established within the government to oversee the co-ordination among vendors. This body must comprise of experienced professionals with past experiences in vendor companies, government regulatory bodies and emergency communication experts. The participation of such professionals will help to increase the pace of interoperability initiatives.

### 6.3 Analysis of Issue 2

When the Federal Government leads the effort and provides the states and local agencies with appropriate funding in the form of grants or allocation of spectrum to follow the Federal guidelines, a consistent national model evolves that is relatively easy to implement across the jurisdictions of state and local agencies. On the other hand, when the State governments and local agencies lead, the needs of the individual jurisdictional areas guide the efforts and thereby receive more local support. They also allow for faster implementation – but are much more varied and thus more confusing and difficult to comply with in large operations.
6.4 Findings for Issue 2

This research suggests a solution that allows the capture of the main benefits of both scenarios. The State governments and Local agencies must be allowed to submit their suggestions on schemes to improve interoperability to a body within the Federal Government. This body must have the authority to decide on the most viable initiative and then allocate spectrum and funds accordingly. This research acknowledges that efforts towards such a solution are in progress.

7 Conclusion

As outlined by incidents such as the Columbine shooting, interoperability among first responder agencies is a large concern for emergency communications. Although efforts such as the use of NetworkFirst architecture serve as a good interim solution, the IP based NG 911 platform offers the best long term technical solution. This is because the NG 911 platform is an IP based open standard that provides full interoperability by allowing the use of different frequency bands, vendors, and protocols. In spite of numerous initiatives, interoperability continues to remain one of the biggest issues in emergency communications. During the course of interviews, this research identified the two main reasons for this continued lack of interoperability: 1) the lack of a committed and unified approach on behalf of the Federal Government, State Government and local agencies to back interoperability initiatives, and 2) the unwillingness of first responder agencies to give up their legacy systems. This research recommends immediate attention to solving both these problems, coupled with the deployment of NG 911 to achieve full interoperability.

Appendix A: LIST OF INTERVIEWEES

1. Alan Rubin  
   Independent Consultant  
   Owner, Useful-knowledge  
   Interviewed on February 16, 2011

2. Martin Saint  
   Fire Fighter  
   Student, University of Colorado at Boulder  
   Interviewed on February 25, 2011

3. Professor Dale Hatfield  
   Independent Consultant  
   Former Chief Officer of Engineering & Technology, Federal Communication & Commission  
   Adjunct Professor, University of Colorado at Boulder  
   Interviewed on March 10, 2011

4. Kevin Epperson  
   Volunteer Firefighter  
   Louisville Fire Department  
   Interviewed on March 11, 2011
5. **Gary Arai**  
   Sergeant 985  
   University of Colorado Police Department (CUPD)  
   Interviewed on March 13, 2011

6. **Kevin Thelen**  
   Director, Department of Public Safety  
   Police Operations Division, CUPD  
   Interviewed on March 14, 2011

7. **Tim Parker**  
   Fire Chief  
   Louisville Fire Department  
   Interviewed on March 16, 2011

8. **Steve Kabelis**  
   Division Manager  
   Information Technology Department  
   City of Lakewood  
   Interviewed on March 24, 2011

9. **Scott Rose**  
   Supervisor- Communication Section  
   Lakewood Police Department  
   City of Lakewood  
   Interviewed on March 24, 2011

10. **Myron Kissinger**  
    IT Administrator I – Technology Services, Electronic Engineering Bureau  
    City and County of Denver  
    Interviewed on March 29, 2011

11. **Daryl Branson**  
    MPA ENP  
    Director, Colorado 9-1-1 Resource Center  
    Interviewed on March 29, 2011

12. **Brad Bernthal**  
    Associate Clinical Professor of Law  
    University of Colorado at Boulder  
    Interviewed on March 30, 2011

13. **Gabe Steele**  
    Arvada Information Technology  
    Police Systems Technician  
    Interviewed on March 30, 2011
14. **Mark Krapf**  
Division Chief – Communications  
West Metro Fire Department  
Interviewed on April 2, 2011

15. **Ebere Ibegbu**  
Student (Alumni), University of Colorado at Boulder  
Interviewed on April 3, 2011

16. **Molly Bosley**  
University of Colorado Police Department (CUPD)  
Interviewed on April 11, 2011

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