

## CHAPTER II: METHODOLOGY

The project was divided into two primary tasks: to identify fire service communication problems and solutions and to research and analyze the potential solutions to the technical RF issues involved in resolving and improving these communications problems. From the outset, the project was further refined to focus on communications problems within as well as to and from structures, to include high-rise buildings, tunnels, basements, underground parking garages, and subway systems.

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### *Determination of Critical Areas of Interest*

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To begin the project, the team members compiled a comprehensive set of communications issues that affect radio communications in the fire service from several sources – an initial literature survey, knowledge of the project team members, and discussions with fire service leaders, NIOSH project team, engineers, and others. Team members refined this comprehensive set of issues with NIOSH project personnel to identify critical issues that could be addressed by improvements in radio communications. A prioritized list of communication and personnel location problem areas was developed. In general, the primary focus was clarified to be the identification, status, and research recommendations for technologies that could improve communications or provide firefighter location within structures. The list of the high priority topics is shown in Table 3 below. The full list of ranked topics is attached as Appendix A with ‘10’ being a highly ranked problem and ‘1’ the lowest.

TABLE 3: PRIORITY TECHNICAL AREAS AND RELATED TOPICS ADDRESSED IN STUDY

Ranking	Area	Example Issues
10	Accountability (Integrating Personal Accountability Systems (PAS) with Communications)	<ul style="list-style-type: none"> <li>• Integrating PAS with communications</li> <li>• Electronic accountability</li> <li>• Automatic vehicle location</li> <li>• Electronic command boards</li> </ul>
10	Communication Planning and Coordination	<ul style="list-style-type: none"> <li>• Through building (into/out of)</li> <li>• Underground</li> <li>• In building</li> </ul>
10	Monitoring Firefighter Welfare and Location On-Scene	<ul style="list-style-type: none"> <li>• Role/responsibility of dispatchers.</li> <li>• Use of field communications units and communications coordinators</li> <li>• Remote monitoring</li> <li>• Vital signs</li> <li>• Location</li> </ul>
10	Reliability	<ul style="list-style-type: none"> <li>• Line-of-sight limitations</li> <li>• Underground (subways, parking garages)</li> <li>• Confined space rescue</li> <li>• Communication into and out of buildings (especially high rises)</li> <li>• Intermittence</li> <li>• Communication coverage/dead spots</li> </ul>

Ranking	Area	Example Issues
10	Interference	<ul style="list-style-type: none"> <li>• Building construction and materials (such as concrete, metal, and Lexan)</li> <li>• Radio propagation through fire, heat, and smoke</li> <li>• Cell phone towers (e.g., Nextel)</li> <li>• Terrain</li> </ul>
10	Unsuitable Equipment	<ul style="list-style-type: none"> <li>• Frequency band unsuitable for structure/ground penetration</li> </ul>

Information on and about grants to pursue these technology areas was originally ranked as one of the priority issues. Because grants are not within the scope of the technical nature of this project, this topic was not pursued. Grants, however, are available through the United States Fire Administration (USFA), National Institute of Standards and Technology (NIST), and other sources as well. The USFA, through its Assistance to Firefighters Grant Program, has awarded funds to many fire departments to purchase communications systems and other equipment. Money is also available from NIST for research and development.

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### *Literature Review*

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Based on this prioritized set of topics, the study team conducted a comprehensive literature review to research the radio communication technology in use by firefighters, what problems exist with communications, and on relevant research/evaluations of existing or proposed technology. The team searched a variety of bibliographic databases including the following:

*Engineering Index* – The Engineering Index contains abstracted information from the worldwide significant engineering and technological literature. It covers approximately 4,100 journals and selected government reports and books from 1970 to the present. Over 480,000 records of significant published proceedings of engineering and technical information are also included.

*INSPEC* – INSPEC is a database containing bibliographic citations to items in *Physics Abstracts*, *Electrical and Electronic Abstracts*, and *Computing and Control Abstracts*. Over 4,100 journals and serials are scanned from 1969 to the present. Included are papers, journal articles, conference proceedings, books, reports, and dissertations.

*PubMed* – PubMed is the National Library of Medicine's (NLM) search service that provides access to over 11 million citations in MEDLINE, PreMEDLINE, and other related sources journals. MEDLINE is NLM's premier bibliographic database and contains over 12 million citations from the mid 1960s to the present. PreMEDLINE is the in-process database for MEDLINE, containing details of very recently published articles. The journals primarily fall within the general science and chemistry field. MEDLINE contains bibliographic citations and author abstracts

from more than 4,600 biomedical journals published in the United States and 70 other countries.

*Nerac* –Nerac began operating in 1966 as the New England Research Application Center, an experimental collaboration between the University of Connecticut and the National Aeronautics and Space Administration (NASA). Nerac provides peer-reviewed literature from a collection of over 250 million abstracts, citations and full-text articles. Nerac locates published articles from international resources to bring information that is typically unavailable through Web-based search engines. Its databases include information on journal articles, patents, conference papers, theses, business and financial reports, manuscripts, and government regulations. Nerac searches can be applied to 128 separate databases of which 57 are in the engineering fields. The databases that were accessed most heavily for this project were:

- Aerospace Database
- DTIC – Defense Technical Information
- Inspec – Electronics and Physics
- Dissertation Abstracts
- Inside Conferences
- Conference Papers Index
- U.S. Patent Applications

*CiteSeer (Research Index)* – CiteSeer is a scientific literature digital library that indexes Postscript and PDF research articles on the Web. Developed by NEC (formerly Nippon Electric Company), it allows the user to quickly track how research has been used and what recent developments have occurred in the research area. The automated indexing system not only indexes research articles by crawling journal websites on a regular basis, but will also index each article's citations, which can be viewed in the context of the article. This context enables the reader to judge the links between studies and the citations noted in the research.

*National Technical Information Service(NTIS)* – NTIS is a database of the U.S. government agencies containing only unclassified literature, some state and local governments, and some non-U.S. governments. Coverage is from 1964 to the present; included are reports, bibliographies, conferences, symposia, government documents, journal articles, patents, standards, and translations.

*Firedoc* – Database of the National Institute of Standards and Technology's Building and Fire Research Laboratory (BFRL). It contains publications from the BFRL staff, its contractors and grantees from the early 20<sup>th</sup> century. Over 60,000 bibliographic records and indexing are in English from the BFRL staff and for fire research and fire engineering organizations and fire departments worldwide regardless of language. Reports, journal articles, conference proceedings, contractor and grantee reports, and audio-visual materials are included.

*USFA/FEMA Online Catalog* – This online catalogue is a database of the U.S. Fire Administration/ Federal Emergency Management Agency. It contains bibliographic citations (and abstracts Executive Management Institute’s papers) to over 100,000 books, reports, periodicals, and audio-visual materials on their collection.

*InfoTrac OneFile* – InfoTrac OneFile provides access to periodical and news information on a diverse set of topics, including humanities, education, business, science, current events, art, politics, economics, social science, law, health care, computers, technology, environmental issues, and general interest topics. InfoTrac OneFile has access to nearly 32 million articles in a wide variety of periodicals.

In addition, the team searched for information from other federal agencies, such as the National Aeronautical and Space Administration and the Federal Communications Commission. Private industry sources were also explored, from the National Fire Protection Association to the Association of Public-Safety Communications Professionals, among others. The Internet was used to access current trends and products.

The results of the literature review included a variety of published materials, including technical reports, trade journals, academic research papers, CD-ROM collections, government reports, open-source material available on the Internet, media reports, international studies/reports, and manufacturer/vendor literature.

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### *Fire Department Communication Issues Review*

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Once the technical literature review was well underway, the study team gathered and reviewed fire service communications literature and studies. The information was gathered from a variety of sources: much of the information comes from fire department management studies previously undertaken by TriData Corporation. Some information comes from individual fire department annual reports, websites, or other fire department literature. Wherever possible, the information from these studies was verified with the fire department to ensure that the most current data was reflected in this report. The reviews focused on actual communications problems experienced by various jurisdictions and the solutions implemented to mitigate them.

The technical literature review yielded a number of promising technology areas. During the course of this research, the study team contacted experts in these areas to determine whether the new products and research had potential to improve firefighter communications. These contacts were conducted primarily by telephone and email.

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### *Knowledge Gaps Analysis*

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Based on the information collected through the literature search and discussions, a review was conducted of the available knowledge and research related to radio communication systems. We identified the gaps between what current technology yields for firefighter radio communication and what would be necessary to address the firefighter location issues and more effective communications within structures. We also determined what technologies and solutions are available bridge these gaps; and addressed future

technologies or products that could improve overall firefighter communication and safety.

The analysis approached the knowledge gap problem from three angles. First, we examined the gap between the current technical knowledge of the problems and current proposed solutions. Second, we assessed the gap between available published material and the material actually needed to fully address the issue. Finally, we considered the gap between the available technology and the implementation of that technology in the fire service.

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### *Recommendations*

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The final step in the study process was to develop a series of recommendations for areas of future research to improve firefighter communications. Where possible, specific vendors, agencies, and other resources are identified as avenues to complete this research.