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Radio Propagation Measurements During a Building Collapse: Applications for First Responders

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Abstract
The National Institute of Standards and Technology is involved in a research project to improve wireless communications for first responders (firefighters and police) in large structures (i.e., large apartment and office buildings, supermarkets, sports stadiums, warehouses, convention centers, etc.). Part of this effort involves assessing communication problems in large-scale disaster situations (i.e., collapsed buildings). This work utilizes buildings that are scheduled for implosion. In this paper we present preliminary results of radio-propagation measurements obtained before, during, and after an apartment-building implosion.

INTRODUCTION

When first responders enter large structures (such as apartment and office buildings, sports stadiums, stores, malls, warehouses or convention centers) communication using portable radios to individuals on the outside of these large structures can be problematic [1]. Unreliable communications may occur due to decreased signal strength brought about by losses through structural materials. Reports published on the rescue efforts at the World Trade Center Towers [2, 3] highlighted this difficulty.

The National Institute of Standards and Technology (NIST) is investigating communications problems experienced by first-responders (firefighters and police) in disaster situations (i.e., collapsed buildings). In this effort we are investigating the propagation and coupling of radio-waves into and out of large structures. We are also investigating various schemes for improving detection of radio signals from firefighters and civilians who may have portable radios or cell phones and are trapped in voids in collapsed and partially collapsed buildings [4]. However, understanding propagation issues are the focus of the present paper.

Buildings scheduled for implosions provide the ideal research environment to investigate radio-wave propagation issues in collapsed buildings. We place portable radios similar to those used by first responders in various locations in the building. The radios are tuned to transmit at frequencies near public safety and cell phone bands (approximately 50 MHz, 150 MHz, 250 MHz, 400 MHz, 900 MHz, and 2 GHz). Once the radios are in the building, the building is imploded. We measure the received signals, before, during, and after the building is imploded.

This paper discusses one such set of experiments carried out in a 14-story apartment complex near New Orleans, LA (see Figure 1).

Figure 1: New Orleans apartment building.

EXPERIMENT

Two types of data were collected in the experiment. The first set of data, which is referred to as “radio mapping,” was collected a few days before the building was imploded. This involved carrying radios tuned to various frequencies through the building while recording the received signal from a site located outside the building. Figure 2 shows a typical radio that was used. The radio was placed in a protective case to improve survivability after the implosion.

In the second type of data collection, radios were placed in fixed sites throughout the building. Received signals were collected before, during, and after the implosion. Our receiving sites in this case were both fixed and mobile. The mobile site consisted of a measurement system placed on a cart (see Figure 3). The cart was pulled around the perimeter of the building both before and after the implosion, enabling direct comparison of signal strength through the building and through rubble.

Figure 2: Typical Transmitter.

Figure 3: Mobile receiving cart.

Figures 4 and 5 show typical sets of data collected during the radio-mapping experiments (moving transmitter, fixed receivers). We see that propagation through the building can reduce the radio signal by as much as 50 dB, depending on the location of the transmitter.

Figures 6-8 show typical data collected before, during, and after the implosion. The implosion event can readily be seen in the figures. The results in each figure correspond to receivers at three different locations in the building. Note that at some locations the signal loss increased after the collapse, while at other locations the loss decreased. Figure 9 shows results of signals from the mobile cart obtained before and after the implosion. After the implosion, the radios in this figure had most of the building lying on top of them. From the comparison, we see that the collapsed building caused between 50 to 70 dB reduction of the signals.

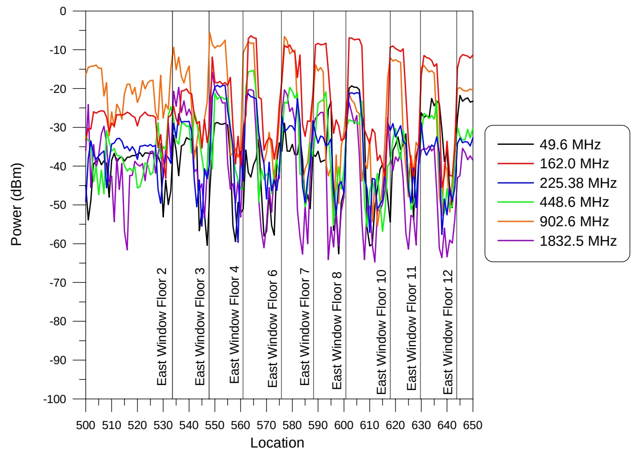

Figure 4: Typical radio-mapping result

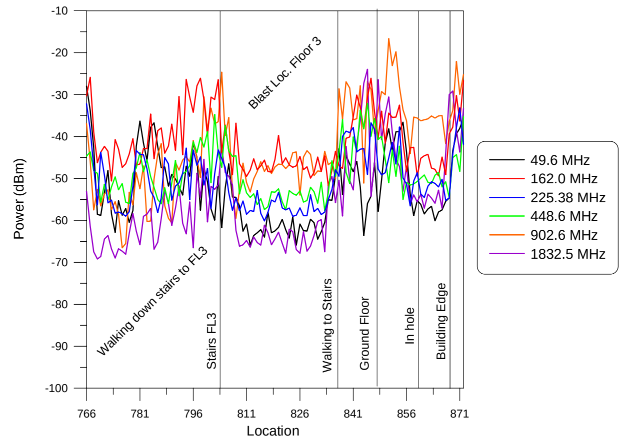

Figure 5: Typical radio-mapping result.

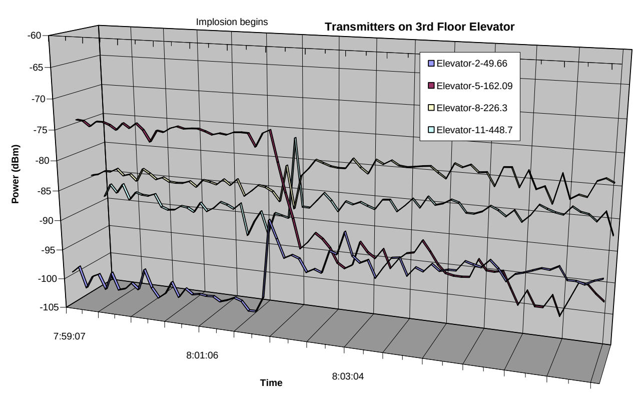

Figure 6: Radios located in elevator.

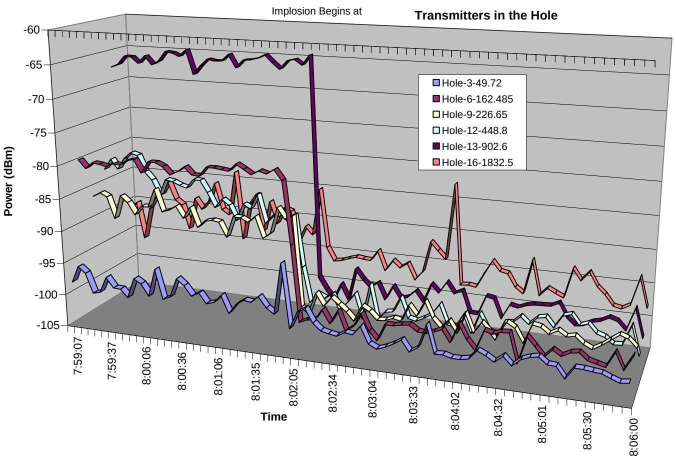

Figure 7: Radios located at bottom of building.

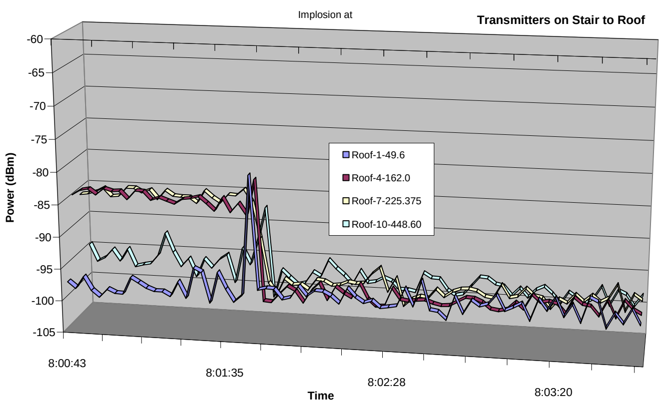

Figure 8: Radios located at top of building.

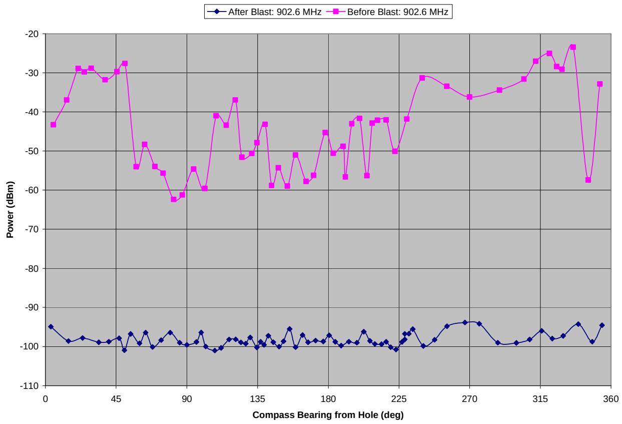

Figure 9: Mobile cart measurements: both before and after the implosion. Radios located at bottom of building.

CONCLUSIONS AND DISCUSSION

In this paper we presented selected results of radio propagation data collected before, during and after the implosion of a 14-story apartment building near New Orleans, LA. The preliminary results of this experiment show that this type of building can reduce the radio signal by as much as 50 dB by just entering the building. Once the building collapsed, attenuation can increase much more than this. This type of data helps us understand the communication problems with which first responders are confronted when they enter large structures, and the changes in propagation that occur when a building collapses.

We have carried out similar sets of experiments during the implosion of a large sports stadium and a convention center. The initial findings in these data sets are very similar, that is, attenuation by as much as 70 dB may be encountered when communicating in these large structures. Details of these additional experiments will be published later.

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