Microwave Frequencies Used To Detect Victims "Buried Alive"

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Abstract

In the past, when victims of landslides or collapsed buildings were trapped beneath the earth or concrete, debris or rubble, there was little chance that they would be found. This was due to the fact that search techniques were limited to the use of human sensory detection, optical/seismic devices and animals which specialized in detection of buried victims. If the victim was being crushed or unconscious and could not cry for help, there would be little chance he/she could be heard and found. This was all before microwave techniques were developed to detect life signs (up to nine feet into debris). With the use of two tested frequencies at 450MHz and 1150MHz, recent results seem to indicate that clear and distinct heart beats and respiratory signals can be detected. There seems to still be some factors not yet dealt in too much detail such as liquid / mud barrier and multiple personnel interference (searching in the vicinity).

Introduction

Since the early 1990s' situations have been studied to determine if microwave frequency can be used to help detect survivors in avalanche and collapsed building situations. Initially early in the 90's, microwaves were used to remotely detect life signs from subjects lying on the ground (surface), up to 100feet away or behind a wall. This was initially facilitated through the use of frequencies in the L-band and X-band i.e. 2GHz and 10GHz respectively (Y. Chen, K. Chen, H. Chuang, 1991) . So far results have showed great potential in such systems. Slow, vibratory signals created by the heart and the respiratory systems of a survivor would modulate a reflected microwave signal sent from the surface. This would in turn be Fourier analyzed to see if a heart beat and breathing (of frequencies approximately 1.36 Hz and .3 Hz respectively), is present. Later, test were conducted with combinations of barriers such as wood, cider blocks, conventional bricks, reinforced concrete blocks and fine metallic wire mesh and wet soil (K. Chen, 2000). Because of new microwave technology, it does not mean that using dog and human sensors as detecting agents are futile. Audio recognition and instinct still play a major role in the search for survivors. However if the victim is being pinned down and unable to scream and shout, then the audio factor is non-existent. Seismic detectors too are not obsolete. This is because if and when victims are pinned down and unable to create audio noise, the next instinctive thing to do would be to grab something that can make the noise for them. This often comes in the form of hitting something hard against something solid (like a wall or beam). When this is done, not only is sound created but measurable seismic vibrations, which can be detected by search personnel. However, in situations such as collapsed buildings, often structures are unstable. Unstable structures often create stress noises that are audible and measurable. These sounds/vibrations can be counter-productive to human seismic detection attempts. In addition, hitting something solid against a wall of recently fallen structure is unsafe and may cause further disaster upon the survivor.

So to aid in the detection of surviving humans, once this microwave technique is perfected many more lives may be saved with the additional time that this passive technology will buy for the rescuers.

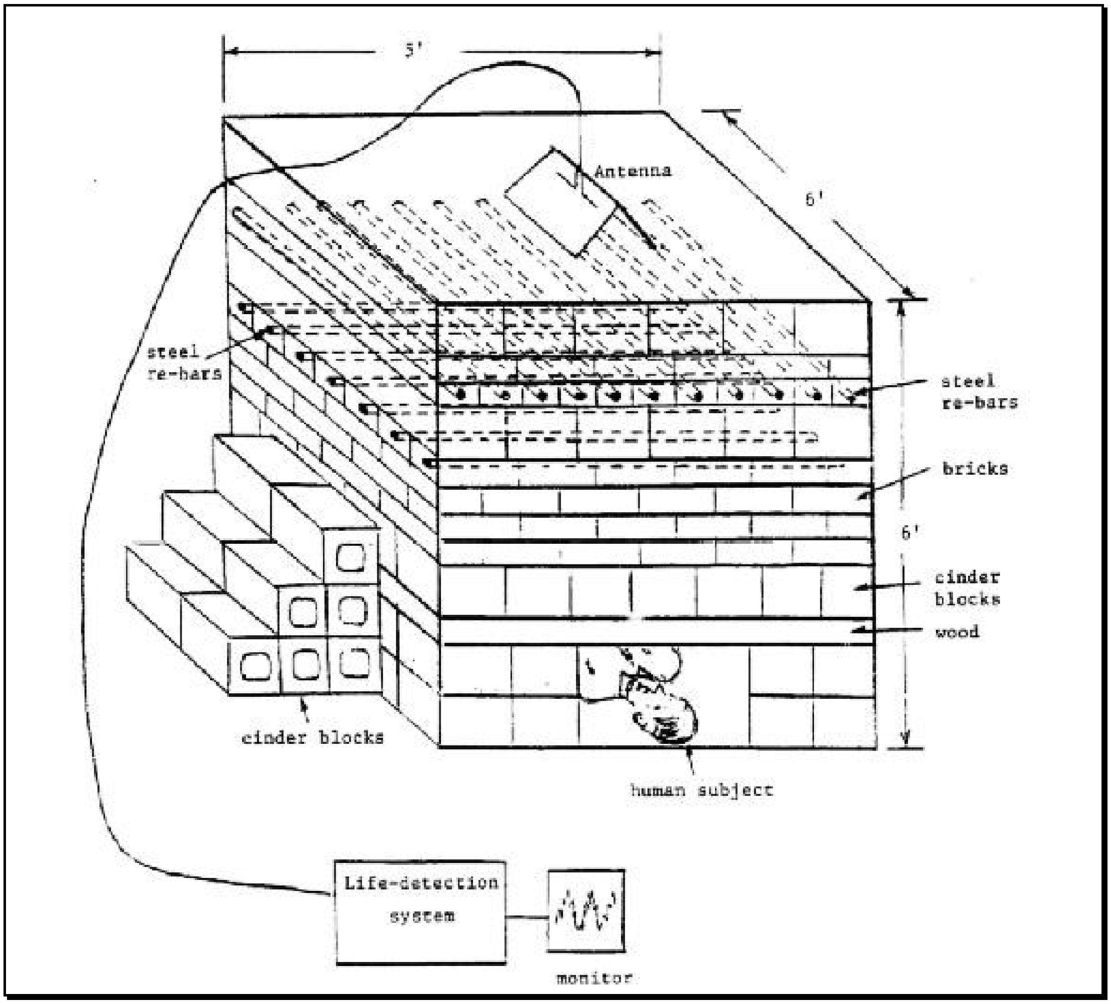

Fig. 1

The diagram above shows experiments being conducted using a reflector antennae. The simulated victim lies approximately 6 feet below combinations of steel re-enforced blocks, wood, cider blocks and normal bricks.

Microwave System.

The idea and principal of the detection is quite simple. The method is this: firstly, microwaves are propagated via a particular method (elaborated on later) and sent though the rubble to detect any signs of life. Microwaves having the property of being able to penetrate though seemingly solid barriers would reflect back signals from certain objects and items in its path. These objects includes humans. When the propagating wave hits a body, the signal is altered and reflected back with an additional modulation created by the movement of the heart and of the lungs. All this is true provided that the reflected signal form false stationary objects can be filtered out and only the movement of the human is present.

It was determined early in 1991 that lower frequencies had better penetrating capabilities then that of higher ones. From recent and present literature, 2 effective frequencies have been experimented with. With the extent that these experiments have been conducted, it would be safe to say that a pattern can be seen. It would seem that though higher frequencies have the ability to penetrate through rubble which consist of layers of reinforced concrete with imbedded metallic wire, the lower frequency have the ability to penetrate deeper and more effectively when metallic wire is not embedded in the concrete.

To generally describe the systems, it must first be initially said that both frequencies were tested on the same situation to see how each faired. Power of 400mW or 25.6Dbm is generated and projected from a phase-locked oscillator generator and subsequently fed into a 10dB directional coupler and circulator, from there it flows into the RF switch and finally to the antenna.

Regarding the antennae, three different types have since been developed; the reflector, the patch and the probe. On a functional and performance perspective the reflector and the patch antennae are very similar. Both radiate and receive microwaves from the same plate and from the surface. The differences being that the reflector can be folded and has an adjust able dipole antennae as its main driving component. This particular situation essentially forms a half wave length electric dipole antennae.

The difference with the patch antennae is that it is connected to an aluminum ground plane, which is fed by a coaxial cable. The patch (plate) itself is insulated from the ground.

The probe antennae, however, is slightly different. Physically it is not on the surface but is lowered down via a bore-drilled hole or through naturally prevalent fissures. It consists of 2 half-wavelength dipoles separated by an inductor in the center. And a slightly shorter piece of wire, called the parasitic element, is placed next to the 2 dipoles purely for the reason of increasing the bandwidth. A diagram of a probe antennae is shown below.

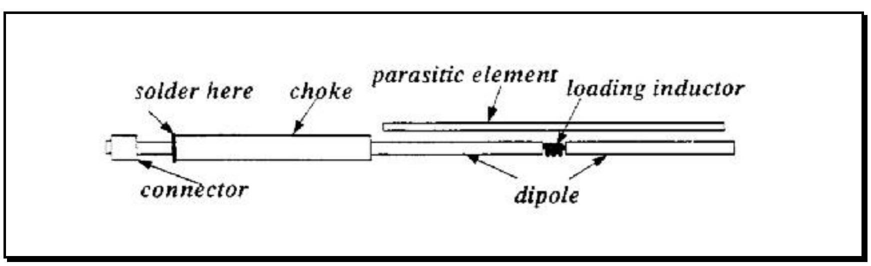

Fig. 2 (Probe Antennae)

Situational Results and Readings.

As it was stated early in 1991, that lower frequencies exhibited better capabilities to penetrate homogenous barriers. In addition to this in the same article written by Chen, experiments were elaborated on where he included moisture laddened bricks. Here too lower frequencies showed signs of greater penetration and resistance to the elements. Higher frequencies seemed to be severely effected, and penetration was greatly mitigated.

Then recently experiments were conducted where an increasing distance and thickness of barriers were placed between the human signal and that of the microwave transceiver. In addition to this thickness, three sub-situations were incorporated. The test subject acted normal, she held her breath and finally was removed completely from the test site. Of the first and second case, a distinct heart beat and breathing signal was detected. However on in the third situation (where the test human was not present) the received signal was very small but still picked up life signs. It is believed that these are the signals of the operator taking the measurement. Physical results are shown below :

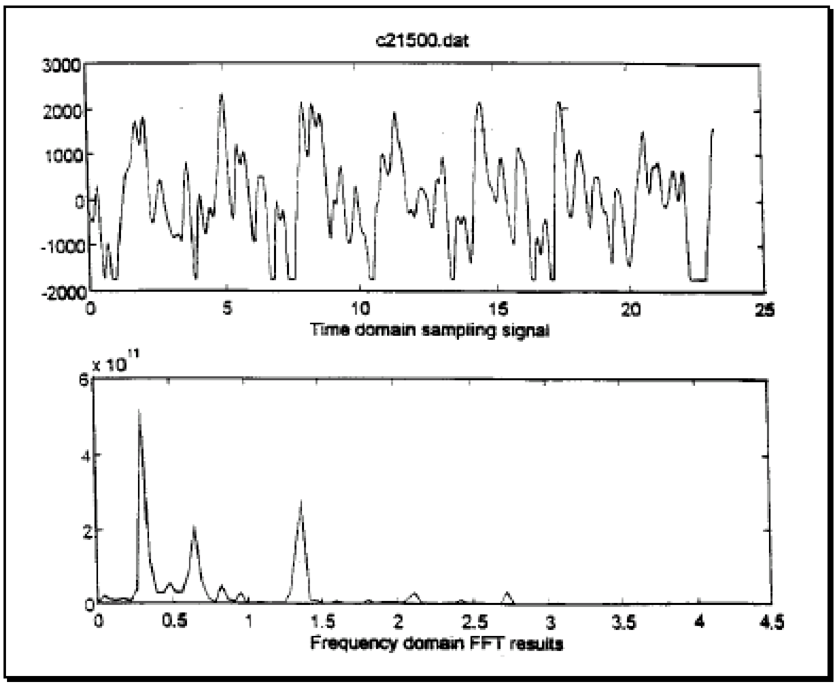

Fig. 3 : **Breathing and heartbeat signals** of a female human subject under simulated rubble. A reflector antenna was placed on on top of the rubble. Radiated power was about 300mW. The 450-MHz life detection system was used.

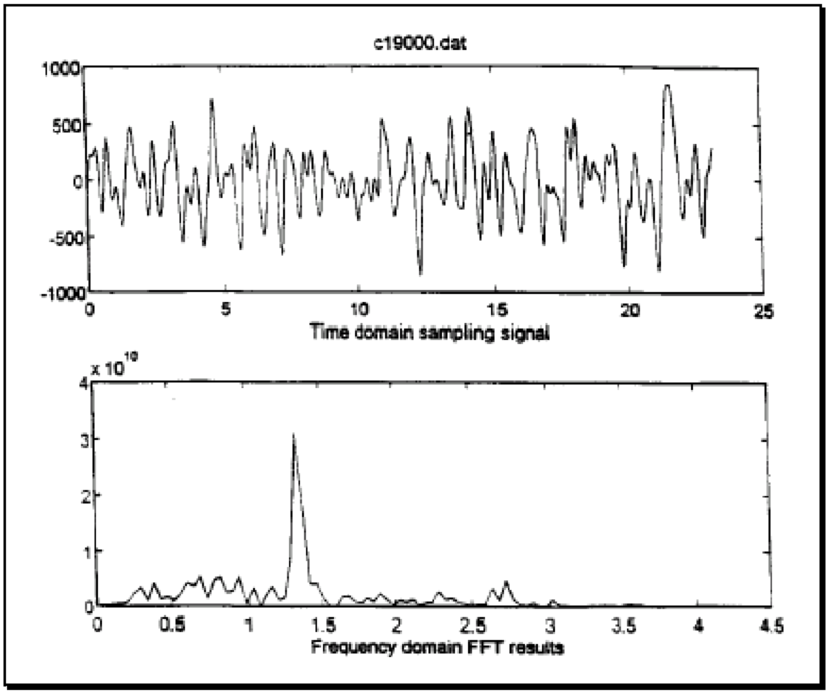

Fig. 4 : Heartbeat signal of a human female under simulated rubble. Again the reflector antenna was placed on top of the rubble. While the subject was in the ruble cavity, **she was holding her breath**. The 450 MHz life detection system was used.

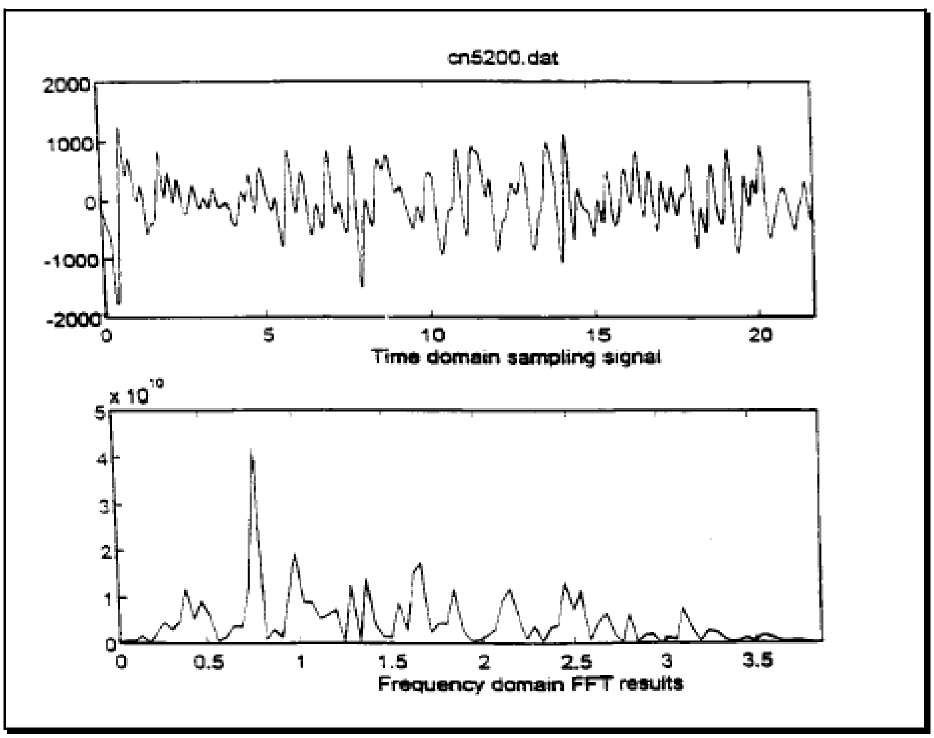

Fig. 5 : Background noise of simulated rubble when no human subject was present. The seeming life sign may be from the person implementing the test.

Further more experiment have been done where instead of using one type of antennae for receiving and transmitting, a combinations of different antennas are used. For a specific experiment the combination consisted of a reflector antennae and a probe antennae (which was in side the rubble some where). The results of each were then taken and cross-correlated. Another similar experiment was done where the signals of two reflector antennas were cross-correlated. The second of the 2 experiments yielded results that were not as clean and clear to that of the experiment done with the probe antennae. In fact when two reflector antennas were used, it was even prone to picking up stray signals created by a person walking near by. Examples and results of the antennas are shown below :

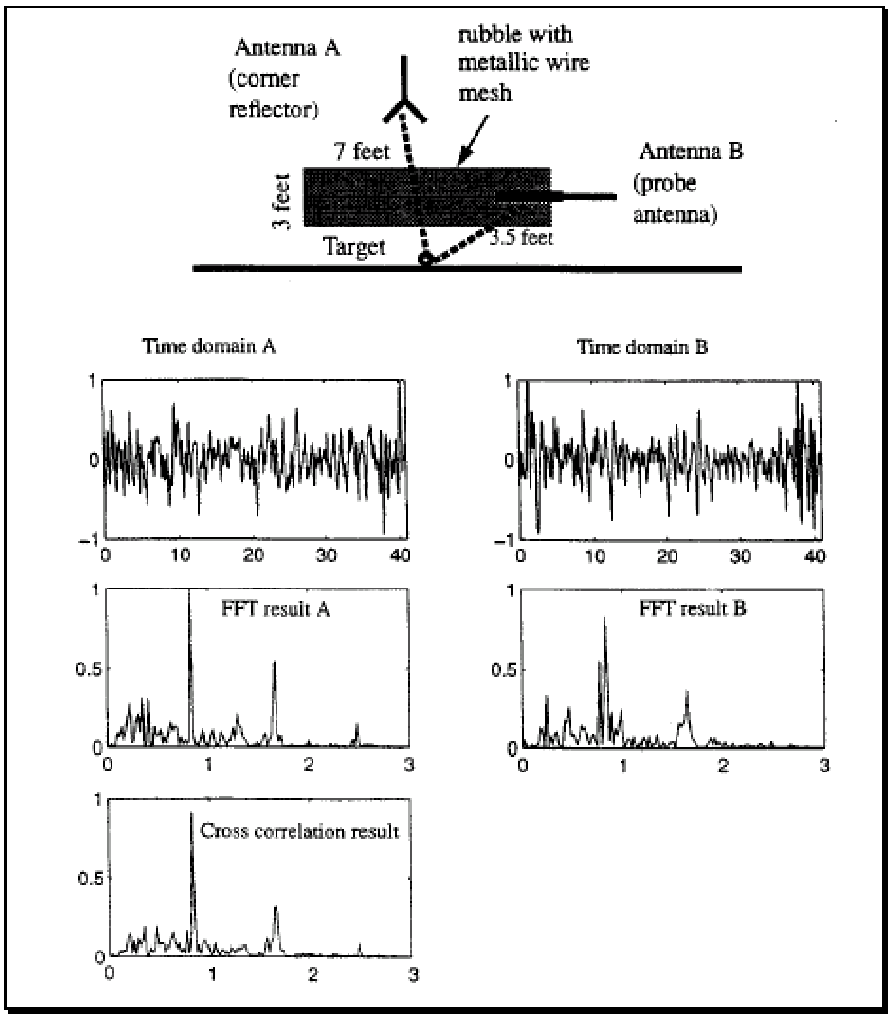

Fig. 6: Heartbeat signals measured by a reflector / probe antenna combination. Both time domain and FFT results are shown. The cross-correlation results of the two sets of results shows the heartbeat frequency and its second harmonic. The 1150 MHz life detection system was used.

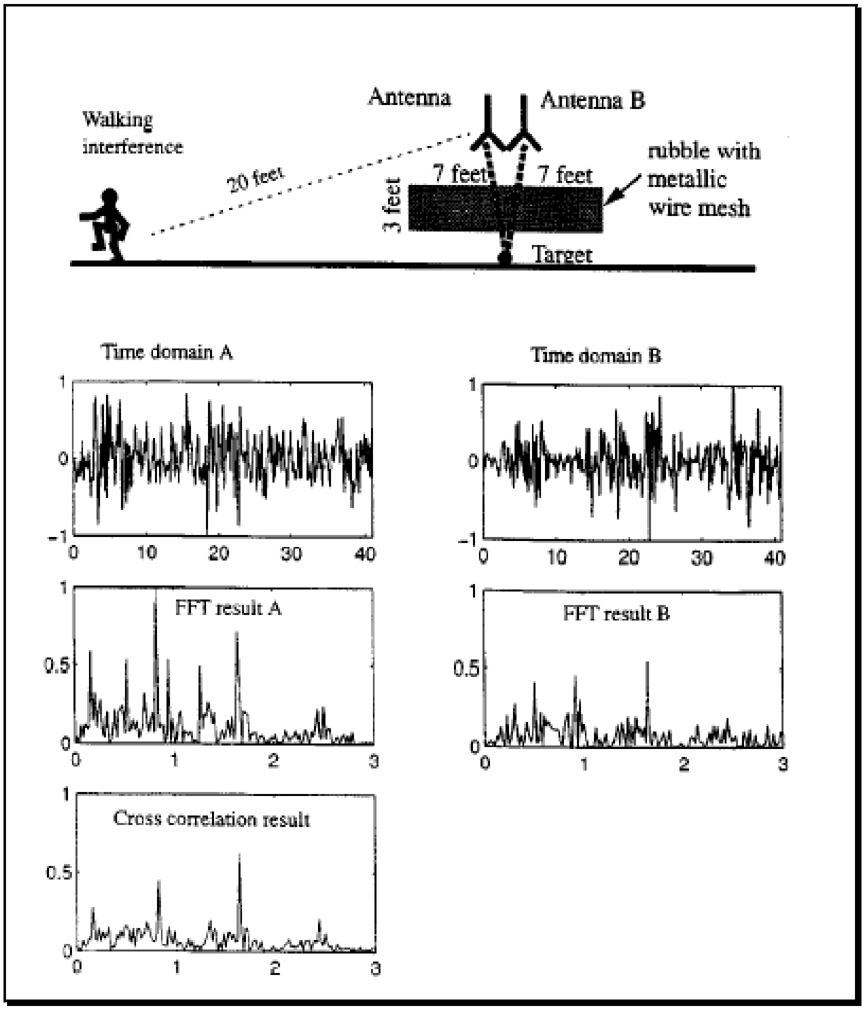

Fig.7 : The heartbeat signals measured by two reflector antennas while a human operator was walking near the rubble. Both time domain and FFT results are shown. The cross-correlation results of the two sets of results shows the heartbeat frequency and its harmonic, while the interference signal created by the operator nearly disappears. The 1150 MHz life detection system was used

Discussion

If one were to take and overview of the research being done, it would seem that this is technology that is bettering and aiding in the preservation of human life. This is a noble cause and thus it is ethically hard to criticize such work on these grounds. But if we were to see it as an aid and not as criticism then perhaps it would be viewed in a different light. This is what the following section is about.

For the experiment done in 1991, microwave absorbers were used to line the inside of brick structure simulating rubble. This was done in an attempt to minimize and hopefully prevent microwave scattering through the pile. The basic flaw is this is that a collapsed building or any type of rubble for that matter will never have such uniform layering and structure as that of the brick structure constructed over the test subject. And as a result will almost always result in microwave scattering. So why do research and study on a case scenarios that was practically be unlikely to occur? Logic would seem to indicate that the best way to create a detection device, would be to create the worst case scenario, (i.e. random rubble in all shapes and sizes, reflective material and external interference), and see if the human is still detectable.

Another mystery is: why in both experiments done is 1991 and 2000, were the subjects lying in known positions and locations? The core of this experiment is to detect life signs, not measure life signs (there is a fundamental difference between the two). It was already determined a while years ago that lower frequencies penetrate uniform barriers better and that higher frequencies penetrate metallic barriers easier. So with this knowledge why, instead was an experiment not done to determine whether a human in an unknown position would in fact be able to be detected?

Further more, in a situation where a building or structure has collapsed and a rescue attempt is in progress, there will definitely be many people walking around. For this reason, the fact that the double reflector antennae was able to pick up the signal of a passer-by makes the signal detection of a trapped victim harder to find. To begin with the victim may be further then 9 feet below the surface, and if this were the case then the life signs would be small and hard to detect. That fact coupled with a person walking near by would create a false signal. From the experiment in Jan. 2000 the person was detected approximately 20 feet away. In a real case scenario there would not only be one person but multiple rescue personnel all working and walking in a vicinity much closer then 20 feet, creating great noise and interference.

Another factor that was only slightly dealt upon was the fact that in a collapsed building scenario, there will almost always be water and waste pipes that are punctured and broken. When large amounts of moisture is present (in cases such as mud / land slides and avalanches) great interference is created. If the experiments were to be repeated, perhaps it would be beneficial to include a barrier of encased water, this would simulate the factor of moisture obstruction and interference.

Conclusion

When one thinks of the aspect of survivor rescuing, safety would be high on any and all lists. A know fact is that once a structure / building or land has collapsed, the area and its surroundings are very unstable. This poses a great threat not only to the rescuers but the survivors buried below the ruble. If an unstable structure gives way while there is a person below, the survivor may end up crushed, or if a rescuer is on top of an unstable he may end up falling within and become a buried victim himself. Before rescuers are allowed onto the site, it must first be made sure beyond a shadow of a doubt that their movements on the surface would not cause any unnecessary and additional seismic complications which may result in further death. Before this safety can be determined, precious time must be spent, time which may decide the fate of countless lives. I have though of a method to remedy this. A suggested title for this new technology would be the "Detection Net". This net or blanket would be placed over the surface or area of interest. Perhaps consisting of an area of 10 meters by 10 meters. Within this area would be a grid of microwave transceivers linked to a processor that would be able to analyze the readings for each position on the gird. Having this would have at least a two fold benefit. Firstly it would only require at most two people to walk onto and place the blanket on the target area, and secondly for a 10 meter squared area there would be no human / animal rescuer creating a "false" signals. However this is not without its down side. As touched on previously, there would be microwave scattering. This would result in certain grid sensors picking up stray signals from different transmitters.

Future

Perhaps in the future microwave detection equipment would no longer be necessary, for seismic predictions would be accurate to such a degree that warnings would be prevalent long before the occurrence. But in the near future perhaps detection equipment would not necessarily be manually taken in but flown in via miniature helicopters. Thus reducing the need for fragile stress bearing structures to further support the weight of the rescuers. Or perhaps in the future mobile flying units (MFU) would be able to run the grid and scan and search for survivors instead of having humans trod all over the potentially hazardous site. Although this is still not yet reality but it is a foreseeable progression form our current status.

References

1. Chen KM, Huang Y, Zhang JP, Norman A, "**Microwave life-detection systems for searching human subjects under earthquake rubble or behind barrier**", IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, Pages 105-114, JAN 2000

2. Chuang HR, Chen YF, Chen KM, "Automatic clutter-canceler for microwave life-detection systems", IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, Pages 747-750, AUG 1991

3. Chen Kim, Misra D, Wang H, Chuang HR, Postow E, "**An X-Band Microwave Life Detection System**", IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING Pages 697-701, JUL 1986