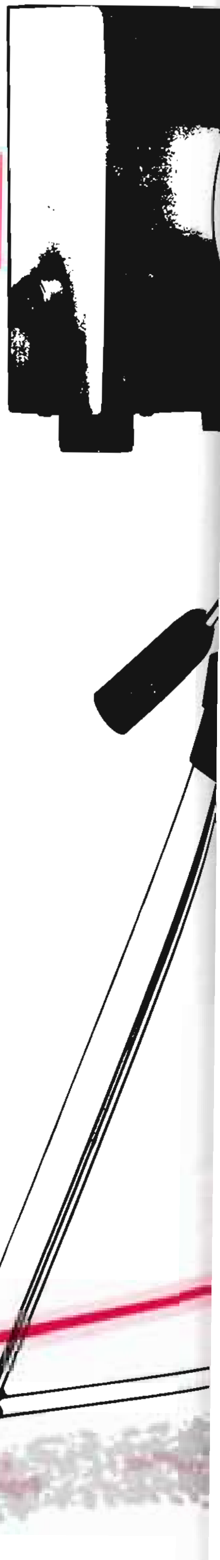
MILLIMETER WAVE RADIO



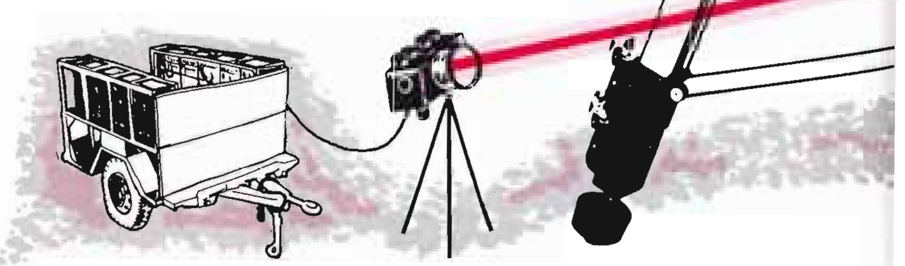
The threat to the survivability of tactical command posts within the division posed by Warsaw Pact electronic warfare capabilities has been well recognized and documented for sometime. To meet this threat, tactical command posts must both remote their electromagnetic signatures caused by communications equipment and maintain a high degree of mobility. Current equipment assets to perform this remoting rapidly and at an effective distance is limited particularly at the division and brigade level tactical command posts. Recent advancements in solid state technology have made it possible to develop a radio system operating in the 15-110 GHz frequency range which may provide a means to remote emitters up to a distance of 8 km rapidly yet provide the necessary degree of ECCM protection to meet the EW threat.

In recent issues of THE ARMY COMMUNICATOR there has been a great deal of interest concerning the vulnerability of tactical command posts and methods of remoting emitters. Maj. Nelson B. Collard, Jr., effectively cited the threat in the Summer '79 issue, and his Fall '79 article (PART II) described in exhaustive detail how the brigade signal officer can remote all electromagnetic emitters with the available WD-1 technology. However, the wire assets needed for the remoting do not exist at the brigade and must be "borrowed" from the Division Signal Battalion. Wiring harnesses must be field fabricated in order to increase installation speed, and remoting range is still limited to approximately one kilometer. Even at this very short remoting range, the amount of 26 pair cable required exceeds the maximum recommended distance according to the Military Transmission Plan by two or threefold and may seriously degrade communications performance. Unfortunately, this is all the signal officer can do for his commander!

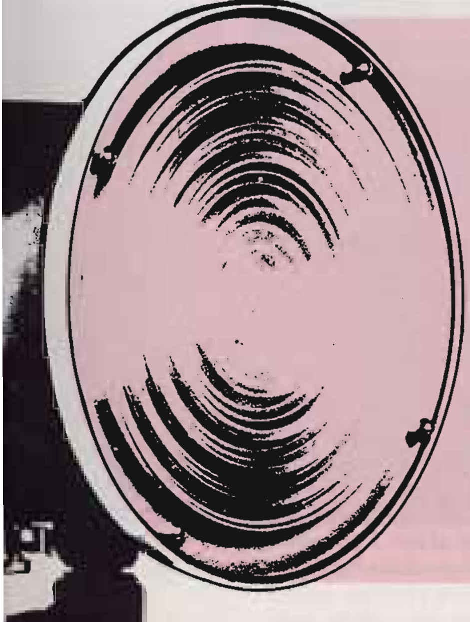
Maj. Steven A. Oliva, (TAC Fall issue) outlined some hope for the future with the use of fiber optic cable. Fiber optic cable is light, secure and EMP immune. In addition, circuits can be multiplexed to give it a very high capacity; however, fiber optic cable is still a cable and subject to all the drawbacks of cable systems. It is still too slow to install and recover. In order to remote a CP a truly effective distance, say 2-5 km, no cable is rapid. Further, all cables suffer the ills of potential damage by vehicles, sabotage, or ordinary theft. What signal officer has never had a part of his tactical cable system damaged by a truck or tank at 2 A.M.? Finally, while the technology of fiber optics is well established, the practical considerations of repair and splicing are far from solved to the extent required by tactical maneuver units.

Millimeter wavelength radios, which operate in the 15-110 GHz frequency range, appear to be a viable alternative to cable in this CP remoting role. Radios which operate in this frequency range have some unique features which make them particularly attractive. First, because they are radios, installation is very rapid. Second, because of the frequency characteristics, the needed ECCM protection can be afforded. In order to understand this last point fully, an understanding of the propagation characteristics of millimeter wave length frequencies is essential.

The largest single factor affecting propagation of frequencies in the 15-110 GHz range is absorption by oxygen and water in the atmosphere. The graph at figure one demonstrates this absorption. One notes from the graph that absorption is roughly 100



times greater at 60 GHz than 40 GHz, and the absorption at 40 GHz is roughly 100 times greater than at conventional UHF or VHF frequencies associated with multi-channel communications equipment. It is precisely this severe range limitation which provides the ECCM protection.

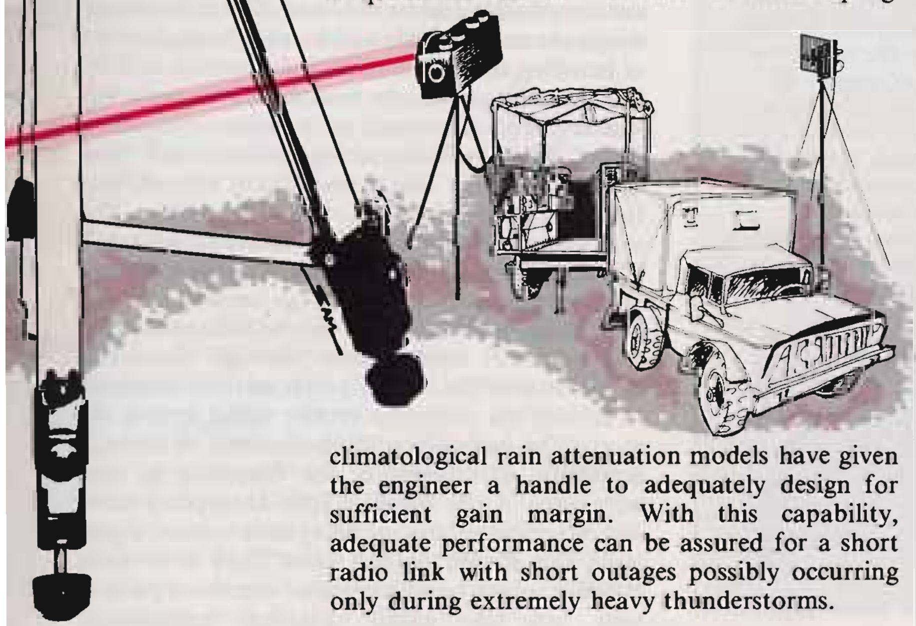


A New Developmental Approach to Command Post Remoting

by Capt. Geoffrey B. Charest

There are other atmospheric phenomena which can effect millimeter wave propagation but generally they are negligible when considering relatively short range tactical applications. Among these phenomena, absorption by atmospheric gases other than oxygen and water, evaporative ducting, beam clearance, multipath fading and reflection from atmospheric layering have been studied and are insignificant for short ranges over land. Scattering by battlefield dust particles, which is a serious problem for optical (laser) systems, also produces negligible effects at millimeter wave lengths.

Rain, however, is another significant contributor to the absorption of millimeter wavelength frequencies and has caused some concern in development of radio systems operating at these frequencies. Recent efforts at developing



climatological rain attenuation models have given the engineer a handle to adequately design for sufficient gain margin. With this capability, adequate performance can be assured for a short radio link with short outages possibly occurring only during extremely heavy thunderstorms.

Figure two demonstrates some predicted worst case link availabilities for a Millimeter Wave Radio with an output power of 100 milliwatts and a frequency of 38 GHz. Figure three depicts areas in Europe and CONUS where predicted link availabilities will be too low for acceptable performance of tactical applications. These diagrams are based on rain data collected over the past thirty years.

A final characteristic of millimeter wave radio systems which further enhances ECCM protection is the ability to design extremely narrow beam width antennas. Beam widths of three degrees with highly suppressed side lobes are easily obtainable.

Physically, the size of a "typical" millimeter wave radio for tactical applications is very small. This further enhances mobility and can significantly reduce the visual signature of a CP even to the point of being superior to cable. Prototype millimeter wave radios with complete antenna systems weigh about 15 pounds and can fit into a box one foot square.

The major drawback to effective employment of millimeter wave radio systems is the extreme line-of-sight nature of the transmission path with limited foliage penetration. While terrain characteristics may impose employment limitations, this line-of-sight feature coupled with narrow beam width and suppressed side lobes is again part of the ECCM advantage. The radio waves do have some foliage penetration ability but appear to be affected by dense vegetation. A search of literature has failed to yield any definitive studies of foliage penetration at these frequencies. While some preliminary work has been done, further research is needed.

To further refine millimeter wave radio system capabilities and requirements, ten exploratory development models were obtained in 1979 by the US Army Communications Research and

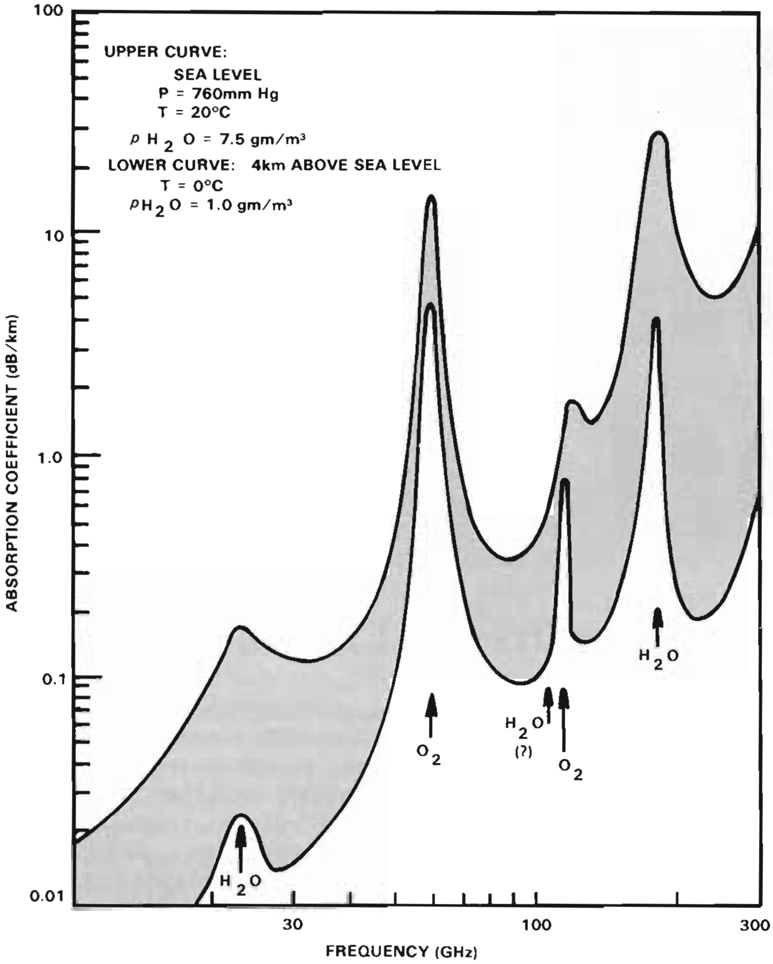
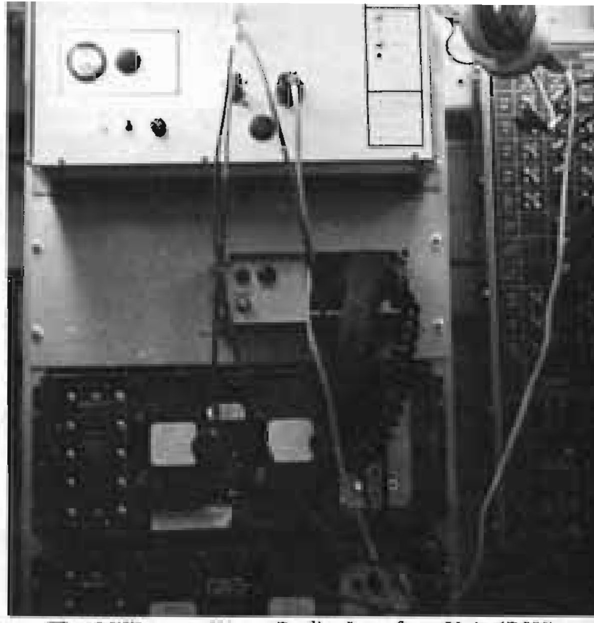


Figure 1. Horizontal absorption due to oxygen and water vapor.



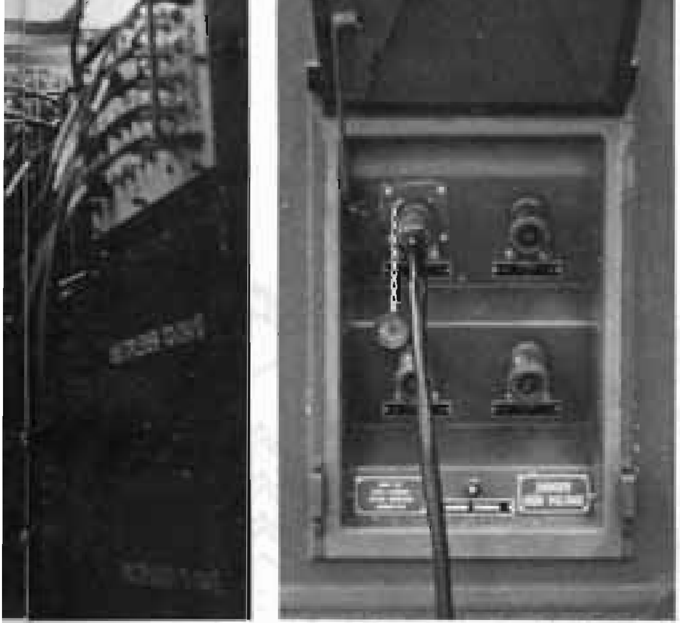
The Millimeter Wave Radio Interface Unit (RIU) and orderwire installed in the AN/TCC-65's.

Development Command (CORADCOM). Concept testing of these radios under direction of the Communications-Electronics Board has taken place, during the last six months of 1979. Initial results from this concept evaluation and testing have been very encouraging - further concept evaluation is scheduled to take place in 1980. Efforts to build an engineering development model of a millimeter wave radio system are being developed by CORADCOM.

A millimeter wave radio system which can be built today is envisioned to operate in the 40 GHz region using a selection of one of five preset frequency pairs. Other than this selection feature, the radio will have one other control: an on/off switch. A built-in test feature can be installed to self-check all components to insure proper operation. With an output power of 100 milliwatts, a range of 8 km line-of-sight can be obtained. The radio should weigh about 15 pounds and be wide band, capable of handling up to 48 multiplexed channels. A radio interface unit can also be built so that the radio will interface with all current multichannel equipment, future TRI-TAC digital equipment, and fiber optics. The radio can be installed in virtually any current shelter or vehicle.

At greater development risk, it has been proposed that the Millimeter Wave Radio be further designed to incorporate an adaptive design feature to further limit signal overshoot. This may be accomplished in one of two ways: either through automatic adjustment of the output power of the transmitter to achieve the minimum receive signal level at the receiver to maintain communications, or through automatic adjustment of the frequency to take advantage of the sharp oxygen absorption curve and maintain minimum acceptable receive signal level. This second method would likely be the most effective from a minimum signal overshoot point of view but may entail spectrum management

The exploratory development model of this Millimeter Wave Radio and its antenna are mounted on the tripod. With this configuration of the antenna and radio built in one unit, the need for wave guide is eliminated. Not shown is a cable which connects the radio to the Radio Interface Unit (RIU) which interfaces the radio with the multiplex equipment. The radio operates at a fixed frequency of roughly 38 GHz. A further development of this radio is currently envisioned to have five pairs of RF channels to select from, to handle 12/24/48 channels, to be further miniaturized and militerized, and to contain a built-in test function to self check all circuitry. The RIU will interface with all current multiplex equipment, projected TRI-TAC equipment (TD 1065/TD 1069) and fiber optics.



The cable connecting the RIU to the radio was routed through the video entrance panel by replacing one of the coax connectors.

WORST CASE LINK AVAILABILITIES FOR THE MILLIMETER WAVE CPR		
LOCATION	8 KM RANGE	5 KM RANGE
WEST GERMANY	99.92%	99.96%
NEWARK, N.J.	99.88%	99.94%
*MILAN, ITALY	99.87%	99.94%
WASHINGTON, D.C.	99.82%	99.91%
FORT GORDON, GA	99.74%	99.87%
TALLAHASSEE, FL	99.56%	99.97%
HAWAIIAN ISLANDS	99.55%	99.78%
(MAUI, LANNI, MALOKAI)	(99.97%)	(99.99%)
**MIAMI, FL	99.42%	99.70%

*WORST CASE: WESTERN EUROPE **WORST CASE: UNITED STATES
CPR = COMMAND POST RADIO

OUTAGE TIME FOR GIVEN LINK AVAILABILITY		
LINK AVAILABILITIY	HOURS OF OUTAGE/YEAR	MINUTES OF OUTAGE/DAY
99.99%	0.88	0.14
99.95%	4.38	0.72
99.90%	4.38	0.72
99.90%	8.76	1.44
99.85%	23.14	2.16
99.88%	17.52	2.88

Figure 2. Link availabilities for millimeter wave radio.

difficulties. Another possible improved development feature is incorporation of a fiber optic cable capability. This feature would likely decrease terrain limitations of a purely radio remoting system. How such a system of millimeter wave radio/fiber optics can be employed and effectively packaged needs to be addressed in greater detail.

While these and other CP remoting system design features are potentially attractive, one must weigh the development risk, the length of time needed to develop and field the system, and the urgency to field an effective CP remoting system. Is a Millimeter Wave Radio System without further limiting signal overshoot or incorporation of fiber optic cable "good enough" to fill the role, or are these features essential?

There is an urgent need to remote the electromagnetic signature away from highly mobile tactical command posts in order for them to survive on the modern battlefield. Current equipment to perform this vital role is woefully ineffective, and when made to work, is just too slow. Millimeter wave length radios seem an excellent candidate to perform this CP remoting role. Initial evaluation and testing of this concept is positive, and it is likely that an effective millimeter wave radio system can be built.

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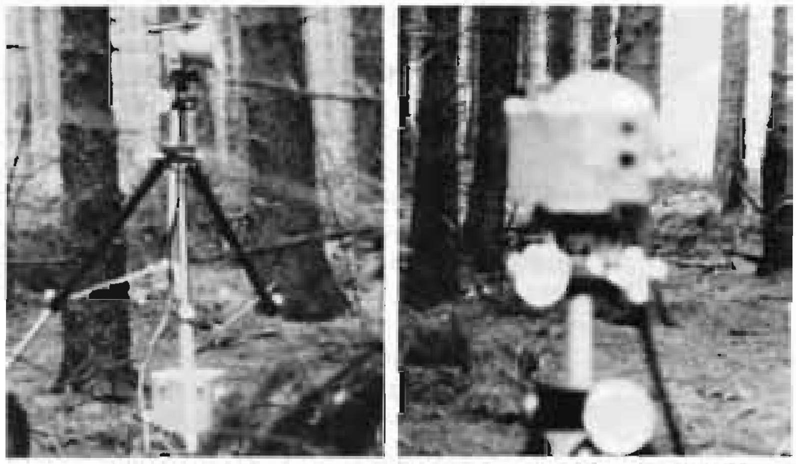

While foliage penetration is limited, some foliage penetration capability can be achieved particularly if some imagination is used during employment. This antenna set-up was used in Germany with the shot oriented through a narrow break in the trees in extremely dense vegetation.

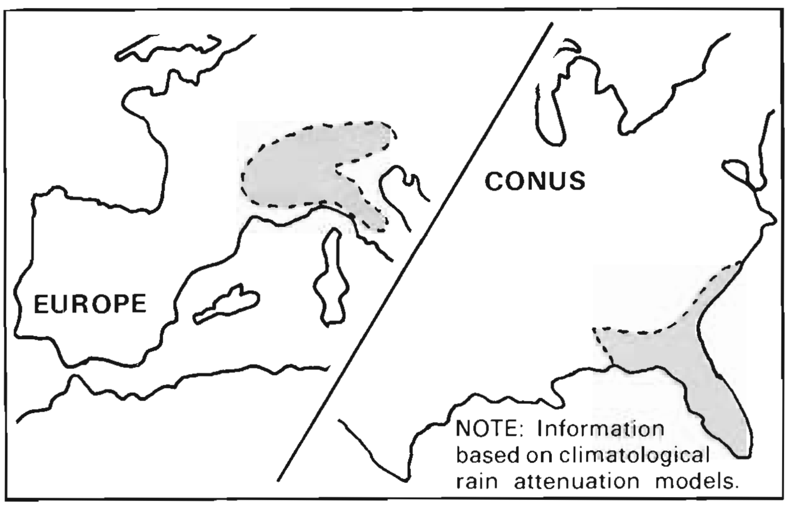

Figure 3. Shaded areas are probably unsuitable for tactical millimeter wave radios.