Determining Communications Distances and Footprint Areas of Air-Mobile Relay Stations

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The concept and use of an air-mobile communication relay station is not new. CAP communicators have proposed and used variations of this concept (known as "High Bird") for some time, but the concept has never been formalized into policy, regulation or into written guidelines. This short paper examines the communications distances possible using air-mobile relay stations, and the scope of their geographical footprints. The analysis should aid in better understanding the potential role of air-mobile relay stations and to facilitate the communications planning process in scenarios involving their use.

Introduction

The air-mobile communication relay station (AMCRS) is defined in this paper as an aircraft, which because of its altitude, is used to relay radio traffic over extended distances. The relay may be mechanical (i.e., automatic, through the use of an air-mobile repeater), or by manual message handling by a crewmember. Because we will examine the characteristics of circuit distances and the geographical coverage (footprint) of the station, the actual method of relay is irrelevant to our discussion and will be ignored.

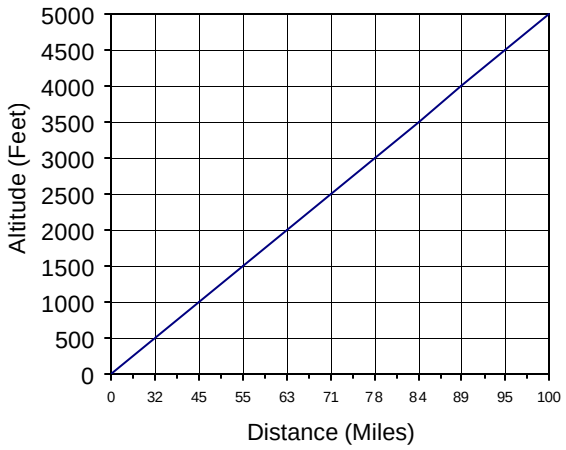
Air-mobile communications relay sorties are primarily used for the relay of VHF-FM communications on one or more frequencies authorized for use by CAP[1]. Under normal circumstances, these frequencies are considered just slightly better than line-of-sight[2]; that is, the radio waves are not particularly good at bending too far beyond the curve of the earth (radio horizon) when compared to other bands. Although solar or atmospheric conditions and phenomena may occasionally extend the range of these communications, such conditions cannot be reliably forecast or expected to exist during operations.

Determinants of Communication Range

A number of factors influence the range of radio communications, including power output, receiver sensitivity, antenna efficiency, and antenna elevation. With the exception of antenna elevation, few of these factors are under the control of aircrews flying relay sorties.

In determining the relationship of elevation (or altitude) to communications range, we can use a formula[3]

Figure 1 - RADIO HORIZON



that approximates the radio horizon to be one-third greater than the actual optical "line-of-sight distance":

$$d = 1.415\sqrt{h}$$

Where,

d = Distance to radio horizon in miles;
h = Height of antenna in feet

and the formula assumes that the earth is smooth to the horizon.

From this formula we can determine, for example, that the radio horizon for an antenna transmitting at 1,000 feet AGL is 44.7 miles, *to a receiving antenna situated on the ground*. Figure 1 graphs this relationship of altitude vs. radio horizon.

If the receiving antenna were located on a structure, or otherwise elevated, we could determine its radio horizon independent of the transmitting station.

For example, using the stated formula, we determine the radio horizon of an antenna located on a 50-foot tower to be approximately 10 miles. We can then sum the radio horizons of the two stations in the communications link to obtain an overall communications distance of 60 miles[4] ($d_1 + d_2$).

Geographical Footprint

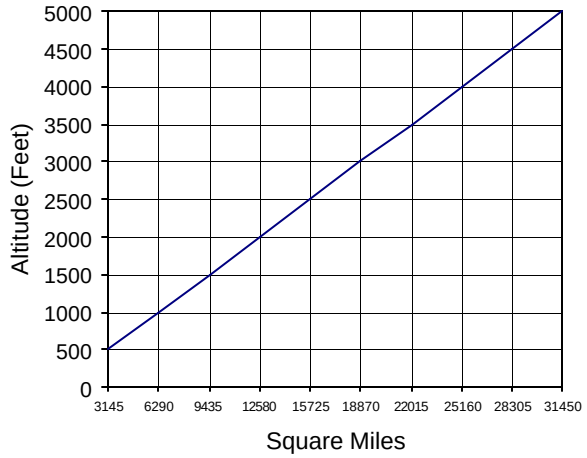
After having determined the distance to the radio horizon (d) for our air-mobile station, we can use that figure as the radius of a circle defining the footprint of that station on the ground. With a range of almost 50 miles to the radio horizon, we determine, using $a = pr^2$, that our station has a footprint area encompassing some 7,854 square miles[5].

Considering the vast footprints and the potential for interference inherent in air-mobile relays, great care should be taken to ensure the minimum altitude possible is used when conducting operations. A prudent approach would be to determine the minimum radio horizon required for reliable relay and use the appropriate altitude to achieve this coverage. The formula may be adapted, in this case, to determine the required altitude for a given radio horizon:

$$h = (d / 1.415)^2$$

We can calculate, therefore, that for a desired radio circuit distance of 70 miles, we should consider the minimum altitude of 2,447 feet AGL.

Figure 2 - FOOTPRINT



In many cases we assume the air-mobile station to be keeping station above working or rolling ground teams, generally given their relatively low-powered mobile or portable radio equipment and the uneven terrain they often encounter on searches. When ground teams work flat terrain, the air-mobile may choose to station itself between the ground teams and the base station it serves, thereby reducing its radio range requirement and using a lower altitude[6].

References and Notes

[1] Potential frequencies to be used in any given application are the 143.750 and 143.900 MHz repeater input frequencies, and their paired output frequencies of 148.125 and 148.150 MHz (also used as simplex channels), and simplex frequencies 148.1375 and 149.5375 MHz.

[2] The ARRL Antenna Book, 15th Edition, Page 23-5.

[3] The ARRL Antenna Book, 15th Edition, Page 23-5.

[4] Again, this assumes a relatively flat surface. Variations exist, and should be considered when using the formula to assist in planning. It is recommended as a guide only.

[5] This formula and process for determining area of coverage is valid for repeater planning as well, since we are working with an elevated antenna, and whether it is fixed or air-mobile is irrelevant.

[6] In all probability, a minimum altitude will be assigned which will be safe for flying repetitive patterns (station keeping), and may be higher that the minimum altitude required for maintaining reliable communications.