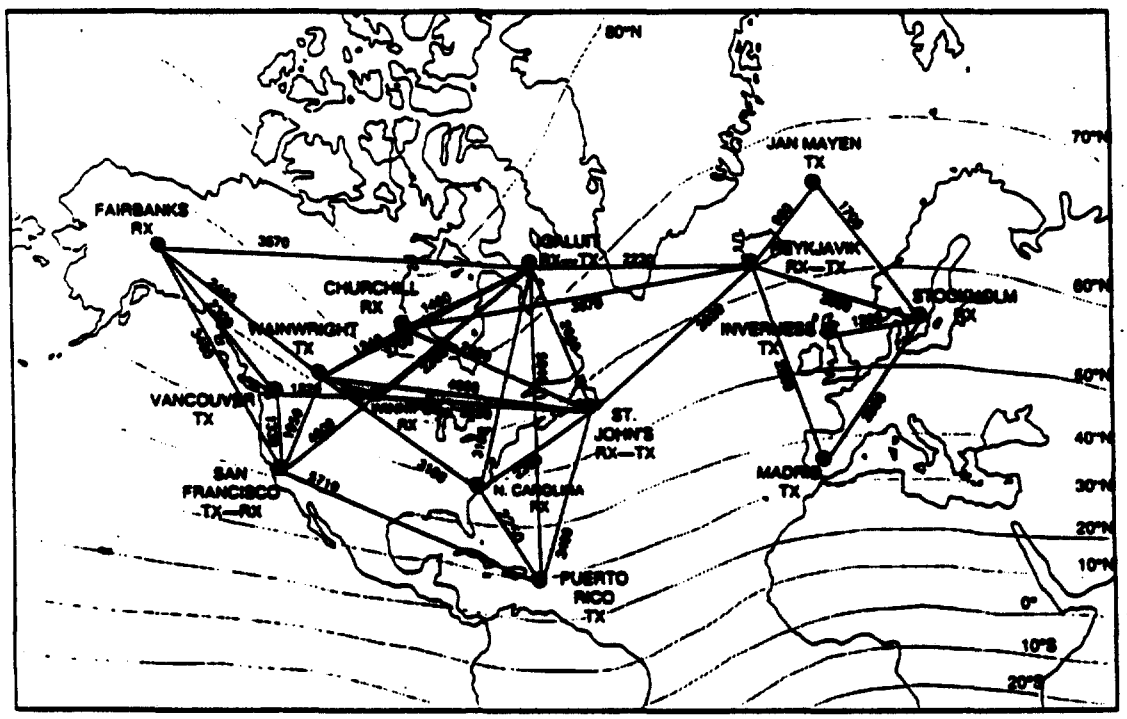
involved. It should be noted that no cluster is characterized by the admixture of paths in a single geophysical regime. This is intentional, since a well-designed system is one for which diversity is to be stressed. Accordingly, Churchill, Iceland, Tors Cove, and North Carolina may represent polar, auroral. trough, and midlatitudes respectively; but association of a specific cluster with a geophysical regime does not imply that all of the paths correspond to that regime, only that the clusterhead is located at a position characterized by that regime.

The average availability is deduced under the following condition. It is asserted that connectivity is established if any one of eleven preselected bands will pass a prescribed SNR test reckoned at the clusterhead for passage of 300 bps messages over any one of the four paths in the star-net or cluster. One is really deducing service availability. Figure 3 is a chart showing the monthly-average availabilities and composite service availability for each of the selected clusters of paths. It is seen that that the least reliable cluster is Churchill (polar) with gradually improving availability arising for Iceland (auroral), Tors Cove (trough), and North Carolina (midlatitude). There are also certain months with low availabilities for selected sites. For example, the lowest value for Churchill is in December 1994, the lowest for Iceland is in May, the lowest value for Tors Cove is in October, and the lowest value for North Carolina is in June. Thus we see little seasonal consistency in the data base.

Despite the fact that there appears to be no seasonal pattern in the data base, it is reassuring to see that the network or cluster-average service availabilities obey a simple rule of monotone improvement with decreasing geomagnetic latitude. Still one might have expected a cluster labeled "auroral" to exhibit somewhat poorer performance than a cluster labeled "polar". A strictly polar communication path should exhibit fairly stable availability despite the generally lower MOFs, except in the presence of polar cap absorption events. However, a major reason that the Churchill cluster has a lower availability than the Iceland cluster is that the former generally consists of three transauroral and 1 polar-polar path whereas the Iceland cluster consists of 2 midlatitude and 2 transauroral paths. The Tors Cove cluster is generally represented by a trough-auroral path, a trough-trough path, a transauroral path and a midlatitude path. The North Carolina cluster is generally represented by 3 midlatitude paths and 1 transauroral path. Again, we must emphasize that the geophysical regime representations depend upon time of day, magnetic activity, and other factors which relate to the dynamic nature of the various circumpolar features.

It is observed that the Churchill cluster never exhibits a month in which the service availability is 100%. Iceland exhibits 3 months out of the 11 analyzed for which the availability is 100%. Tors Cove exhibits 4 months having 100% availability out of 9 analyzed, and North Carolina exhibits 5 months with 100% availability out of 10 analyzed. It is noteworthy that August provided the highest composite availability: 100% for North Carolina, Tors Cove and Iceland, and the highest computed monthly value for Churchill: 0.9993. The overall composite availability for August for all four sites was 0.9998.

Given the low values for unavailability (i.e., 1-A), individual outages have been examined. Almost all the outages were in the 0500 to 1300 LMT sector (reckoned at the clusterhead). In fact there were only 5 outages in all of the data collection interval for the period 0500-1300 LMT. The availability in the 16-hour period 1300 to 0500 is approximately 0.99993 based upon the number of possibilities for failure during this temporal epoch. On the other hand, the composite average availability for the 8-hour period from 0500-1300 LMT is reduced to about 0.988. Clearly this will have important implications for frequency management for the ultimate HF data communication system.



(DISTANCES IN KILOMETERS)

Fig.1: Geometry of the Propagation Experiments

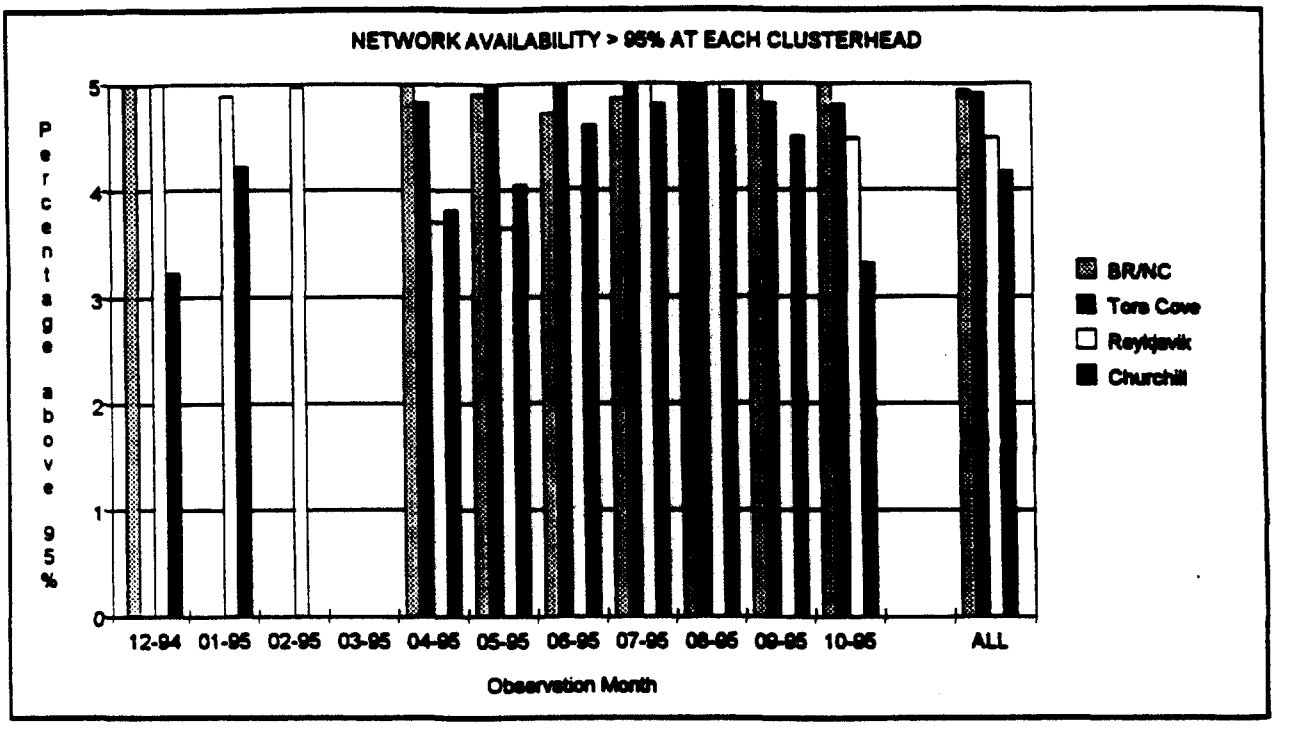


Fig. 3: Graphs of the link cluster availabilities for the Northern Experiment. The clusterheads may represent aircraft, ship, or fixed site positions, but in fact are locations of Chirpsounder® receivers. At these locations, we obtain data from four paths representing HF communication links. The clusterheads we have considered in this study are: (1) a site in northeastern North Carolina (BR/NC), (2) a site near St. Johns, Newfoundland (Tors Cove), (3) a site at Reykjavik, Iceland, and (4) a site located at Churchill, Canada. The links to each clusterhead may be determined from Figure 1. Churchill is connected to Iqaluit, Wainwright, St. Johns, and Reykjavik. Reykjavik is connected to Jan Mayen, Iqaluit, St. Johns, and Churchill. St. Johns is connected to Iqaluit, Reykjavik, Puerto Rico, and Wainwright. BR/NC is connected to Puerto Rico, St. Johns, Wainwright, and Iqaluit. Other possible clusterheads include: Iqaluit, Stockholm, San Francisco, and Fairbanks, but these four have not been considered in the current study. We have selected Churchill, Reykjavik, St. Johns, and BR/NC respectively as clusterheads for non-redundant representation of polar, auroral, trough, and midlatitude regimes, where these terms are based upon climatological average (i.e., not precise) positions. The "ALL" corresponds to a composite average availability for the entire period of observation for each cluster of links. The reader should note that the plotted availability must be added to 95% to get the total value. Thus a plotted value of 4% corresponds to 95 + 4 or 99%.