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{A Review of Working Group 2 (Advanced Terrestrial Systems) of the COST 296 Action}

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This paper deals with the research undertaken during the COST 296 Action in Working Group 2 on Advanced Terrestrial Systems. The Working Group comprised three work packages covering various topics: Radar and Radiolocation, HF/MF Communications, and Spectrum Management. Results from this Working Group are presented in this paper, and may be summarised as follows.

Aspects of HF propagation

The propagation characteristics of radio signals are important parameters to consider when designing and operating radio systems. From the point of view Working Group 2 of the COST-296 Action, interest lies with effects associated with propagation via the ionosphere of signals within the HF band. Several aspects were covered:

1. The directions of arrival and times of flight of signals received over a path oriented along the trough have been examined and several types of propagation effects identified. Of particular note, combining the HF observations with satellite measurements has identified the presence of irregularities within the floor of the trough that result in propagation displaced from the great circle direction. An understanding of the propagation effects that result in deviations of the signal path from the great circle direction are of particular relevance to the operation of HF radiolocation systems.
2. Inclusion of the results from the above mentioned measurements into a propagation model of the northerly ionosphere (i.e. those regions of the ionosphere located poleward of, and including, the mid-latitude trough) and the use of this model to predict the coverage expected from transmitters where the signals impinge on the northerly ionosphere.
3. Development of inversion techniques enabling backscatter ionograms obtained by an HF radar to be used to estimate the ionospheric electron density profile. This development facilitates the operation of over the horizon HF radars by enhancing the frequency management aspects of the systems.
4. Various propagation prediction techniques have been tested against measurements made over the trough path mentioned above, and also over a long-range path between Cyprus and the UK.
5. The effect of changes in the levels of ionospheric disturbances on the operational availability at various data throughput rates has been examined for the trough path mentioned earlier.

Utilization of antenna arrays in HF systems

Various radio systems are based on arrays of antennas and associated signal processing techniques. Classically, radio direction finding operates with a multi-channel receiving system connected to an array of receiving antennas. More recently, MIMO architectures have been proposed to increase the capacity of radio links by the use of antenna arrays at both the transmitter and receiver ends of the link. Several aspects were covered within COST-296:

1. Experimental work carried out to characterise the HF channel from the point of view of HF-MIMO systems. Considering various array geometries and a diversity of the transmitting antennas, the correlation coefficients of the different transmitter-receiver paths were estimated to investigate the effectiveness of a MIMO structure for HF radio links.

2. The dependence of the inter element correlation relatively to the sensors spacing within MIMO systems. Simulations were carried out with a model of the HF channel.

3. Sensitivity analysis of different structures of antenna array for direction finding applications. Better robustness of heterogeneous arrays to model errors by comparison to classical homogeneous structures was demonstrated.

4. Computation of antenna array weighting factors to reduce the sidelobe levels and to create nulls in the direction of interfering signals.

HF Spectrum Management

A long-term joint UK–Swedish–German project has previously been undertaken on the measurement and analysis of HF spectral occupancy over northern Europe. The results from that research were shared at COST 296 with research focussed in four areas:

1. Procedures for measuring and modelling spectral occupancy, with final stable-day and stable-nighttime models for northern Europe, when using calibrated monopole antennas.

2. Preliminary investigation into the possible application of artificial neural networks to predict spectral occupancy in the HF spectrum. In particular, a study of the development of a single ITU allocation model for the diurnal variation of HF spectral occupancy over Linköping, Sweden was undertaken.

3. Application of Neural Networks as a means of optimising the reliability of HF groundwave communication systems by predicting the detrimental effect of interference from other users.

4. Application of Neural Networks as a means of optimising the reliability of HF communication systems by predicting the detrimental effect of interference from other users and its variability due to the ionosphere. In particular, the development of a long-term interference prediction model for the HF spectrum was developed.