formance is related to strong spatial variations in phase, including phase wraps (phase variations in excess of 360°).

By arranging small reflectarrays in a piecewise-planar approximation of a parabola, instead of constructing one large reflectarray on a single planar surface, one minimizes the number of phase wraps per panel and reduces the angle of incidence at each reflectarray patch. This makes it possible to simultaneously maximize the vertical- and horizontal-polarization gains, to improve the radiation pattern, and reduce sensitivity to fabrication and adjustment errors.a

This work was done by Richard Hodges and Mark Zawadzki of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.
NPO-40889

Reducing Interference in ATC Voice Communication

Digital signal processing would be used to suppress unwanted signals.

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Three methods have been proposed to be developed to enable reduction of the types of interference that often occur among voice-communication radio signals involved in air-traffic control (ATC). For historical reasons and for compatibility with some navigation systems, control towers and aircraft use amplitude modulation (AM) for voice communication. In the presence of two simultaneous AM transmissions in the same frequency channel, what is heard through a receiver includes not only the audio portions of both transmissions but also an audio heterodyne signal at the difference between the carrier frequencies of the transmissions (as a practical matter, the carrier frequencies almost always differ somewhat). The situation is further complicated by multiple heterodyne signals in the presence of more than two simultaneous transmissions. Even if one of the transmissions does not include AM because of a transmitter malfunction or because a transmitter was inadvertently turned on or left on, the heterodyne signal makes it difficult to understand the audio of the other transmission. The proposed methods would utilize digital signal processing to counteract this type of interference.

In the first of the three methods, a post-detection audio digital signal processor (DSP) in a receiver would reduce the level of the heterodyne signal significantly. The DSP would be a self-contained unit that would be connected between (1) the output terminal of the ATC receiver audio circuitry and (2) a loudspeaker and/or headphones. The DSP would use a well-understood least-mean-square (LMS) algorithm to automatically adjust the coefficients of a finite-impulse-response filter in order to minimize the amplitude of such highly correlated signals as sine waves (including audio heterodyne signals). The DSP would operate without intervention by the human operator.

In the event that the first method as described thus far did not reduce interference sufficiently, it could be supplanted or augmented by a variant in which a DSP would be added to the last intermediate-frequency (IF) stage of the receiver, where it would be possible to effect improvements through increased dynamic range and linearity and the opportunity to shape the IF pass band for optimum rejection of other types of interference.

The second method, involving independent sideband reception, could be used alone or in combination with the first method. This method would exploit the fact that (1) the two simultaneously transmitted signals would not have the same carrier frequency and (2) the upper sideband would yield a higher signal-to-noise ratio (SNR) for the higher-carrier-frequency signal while the lower sideband would yield a higher SNR for the lower-carrier-frequency signal. Some development would be necessary to determine the best way to make use of the two signals.

In the third method, multiple antennas would be used for reception and their outputs would be combined by an adaptive beam former that would use the same LMS algorithm as that of the first method. In this case, the weighting between the antennas would be adjusted to minimize the coherent component of the received signal. A method equivalent to this one has been used in microwave data communication.

This work was done by John O. Battle of Caltech for NASA's Jet Propulsion Laboratory.

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