mation, the bias information from the global solution, and only data from the single receiver to resolve double-differenced phase combinations. It is called "resolved" instead of "fixed" because constraints are introduced into the problem with a finite data weight to better account for possible errors.

A receiver in orbit has much shorter continuous passes of data than a receiver fixed to the Earth. The method has parameters to account for this. In particular, differences in drifting wide-lane values must be handled differently. The first step of the process is automated, using two JPL software sets, Longarc and Gipsy-Oasis. The resulting orbit/clock and bias information files are posted on anonymous ftp for use by any licensed Gipsy-Oasis user. The second step is implemented in the Gipsy-Oasis executable, gd2p.pl, which automates the entire process, including fetching the information from anonymous ftp.

This work was done by William I Bertiger, Bruce J. Haines, Jan P. Weiss, and Nathaniel E. Harvey of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47149.

Ultra-Wideband Angle-of-Arrival Tracking Systems

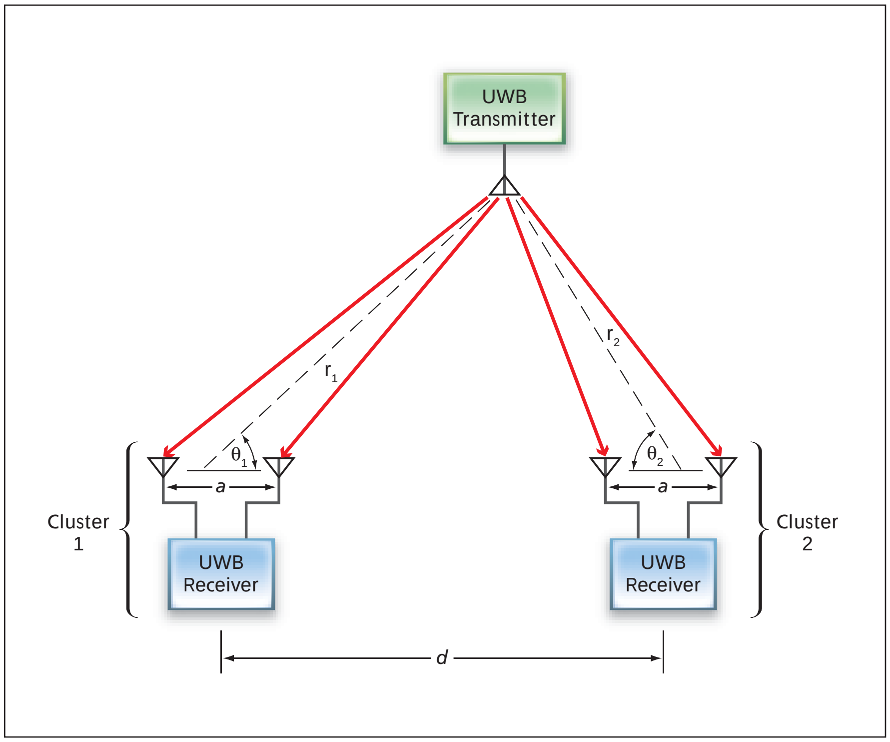
UWB radio pulses afford temporal resolution needed for estimating angles of arrival.

Lyndon B. Johnson Space Center, Houston, Texas

Systems that measure the angles of arrival of ultra-wideband (UWB) radio signals and perform triangulation by use of those angles in order to locate the sources of those signals are undergoing development. These systems were originally intended for use in tracking UWB-transmitter-equipped astronauts and mobile robots on the surfaces of remote planets during early stages of exploration, before satellite-based navigation systems become operational. On Earth, these systems could be adapted to such uses as tracking UWB-transmitter-equipped firefighters inside buildings or in outdoor wildfire areas obscured by smoke.

The same characteristics that have made UWB radio advantageous for fine-resolution ranging, covert communication, and ground-penetrating radar applications in military and law-enforcement settings also contribute to its attractiveness for the present tracking applications. In particular, the waveform shape and the short duration of UWB pulses make it possible to attain the high temporal resolution (of the order of picoseconds) needed to measure angles of arrival with sufficient precision, and the low power spectral density of UWB pulses enables UWB radio communication systems to operate in proximity to other radio communication systems with little or no perceptible mutual interference.

The figure schematically depicts a simple system of this type engaged in tracking a single UWB transmitter on a plane. The system includes two UWB-receiver assemblies, denoted clusters, separated by a known length *d*. Within each cluster is a UWB receiver connected to two antennas that are separated by a length *a* that is much shorter than the aforementioned length *d*. The signals received by the two antennas in each cluster are subjected to a process of cross-correlation plus peak detection to measure differences between their times of arrival. It is assumed that the distances (r_1 and r_2) between the clusters and the transmitter are much greater than *a*, as would usually be the case in most practical applications. Then the angles of arrival of the signals at the clusters are given by $\theta_1 \approx \arccos(c\tau_1/a)$ and $\theta_2 \approx \arccos(c\tau_2/a)$; where θ_1 and θ_2 are as shown in the figure; *c* is the speed of light; τ_1 is the difference between the times of arrival of a pulse at the antennas in cluster 1; and τ_2 is the difference between the times of arrival of a pulse at the antennas in cluster 2. Then using θ_1 and θ_2, the two-dimensional location of the transmitter, relative to the known locations of the clusters, is calculated straightforwardly by use of the triangulation equations.



Angles θ_1 and θ_2 Are Estimated from differences between the times of arrival of UWB radio pulses at the antennas in each cluster. Then using these angles, the relative position of the transmitter is calculated by triangulation.

The processing of signals to determine the differences between their times of arrival, and the subsequent processing to determine the angles of arrival and the position of the transmitter, is done in a computer external to the clusters. For this purpose, the received waveforms are digitized in the receivers, and the waveform data are sent to the computer via a hub. Even though no attempt is made to synchronize operation of the two receivers, the data from the receivers are quasi-synchronized by means of interface software that effects parallel socket communication with data segmentation, summarized as follows: Waveform data are collected from each receiver in segments, whenever they become available and the computer is ready to collect them. The segments from each receiver are labeled as having come from that receiver and, in the collection process, are interleaved with those from the other receiver in chronological order of collection. Within the computer, the segments from each receiver are stored in a separate buffer. Thus, the contents of the buffers are representations of the same UWB pulse waveform arriving at the two receivers at approximately the same time. When the buffers for both receivers contain complete representations of a UWB pulse waveform, the data from that buffer are copied into an array for use in the calculations described above.

This work was done by G. Dickey Arndt, Phong H. Ngo, Chau T. Phan, and Julia Gross of Johnson Space Center; Jianjun Ni NRC fellow; and John Dusl of Jacobs Sverdrup. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-1003. Refer to MSC-24184-1.

Update on Waveguide-Embedded Differential MMIC Amplifiers

NASA's Jet Propulsion Laboratory, Pasadena, California

There is an update on the subject matter of "Differential InP HEMT MMIC Amplifiers Embedded in Waveguides" (NPO-42857) *NASA Tech Briefs,* Vol. 33, No. 9 (September 2009), page 35. To recapitulate: Monolithic microwave integrated-circuit (MMIC) amplifiers of a type now being developed for operation at frequencies of hundreds of gigahertz contain InP high-electron-mobility transistors (HEMTs) in a differential configuration. The MMICs are designed integrally with, and embedded in, waveguide packages. The instant work does not mention InP HEMTs but otherwise reiterates part of the subject matter of the cited prior article, with emphasis on the following salient points:

- An MMIC is mounted in the electric-field plane ("E-plane") of a waveguide and includes a finline transition to each differential-amplifier stage.
- The differential configuration creates a virtual ground within each pair of transistor-gate fingers, eliminating the need for external radio-frequency grounding.

This work concludes by describing a single-stage differential submillimeter-wave amplifier packaged in a rectangular waveguide and summarizing results of tests of this amplifier at frequencies of 220 and 305 GHz.

This work was done by Pekka Kangaslahti and Erich Schlecht of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-44401, volume and number of this NASA Tech Briefs *issue, and the page number.*