National Aeronautics and Space Administration

Simultaneous X- and Ka-Band Receiver for Astrometry and Navigation

Principal Investigator: Lorene Samoska (386)
Dan Hoppe (333), Jacob Kooi (386), Andy Fung (386), James Bowen (333) Raju Manthena (333), Walter Brisken (VLBA Scientist, NRAO)

Program: Strategic Initiative

Project Objective: The objectives of this work are to develop a wideband cryogenic monolithic microwave integrated circuit (MMIC)-based receiver, to cover 8-36 GHz, simultaneously covering X and Ka band, for potential use in developing an X-Ka reference frame for astrometry and navigation. The receivers are needed to provide reference frames to navigate, including determining positions of quasars for navigation beacons, measuring station locations, and measuring earth orientation to the nanoradian level or better. The measurements of X and Ka band simultaneously allows for calibrations of both the Earth's ionosphere and solar plasma at the exact time and direction of the observations. The acquisition of data in the 8-36 GHz range will, in principle, consolidate several receiver systems (X, Ku, K, and Ka) into one receiver package, which can save space and power, and allow for additional receivers in VLBI systems.

FY19 Results: In Year 1, we have worked to design and build an X-Ka band receiver. The receiver will include a wideband feed, low noise amplifiers and downconverters, where the LNAs will be cryogenically cooled (with the feedhorn) in a dewar, whose size will be compatible with an unused receiver slot in the Very Long Baseline Array feed circle. **Feed:** A feed design that is simultaneously compatible with the 25 meter Cassegrain VLBA optics as well as meets the 8-36 GHz frequency requirements has been performed. The feed design is a Quad-Ridge-Flare Horn (QRFH). The simulated aperture efficiencies are in the 70-80% range for the full bandwidth. The feed and cryostat are being machined in Fall, 2019. **LNAs:** We have evaluated multiple JPL designs in NGC's process and Ommic's processes. The best performing LNA is shown below. In addition, we have designed new, optimized LNA MMICs in Ommic's process and expect chips fabricated by the end of 2019. **Receiver:** A balanced configuration using cryogenic coaxial hybrids is being investigated. Initial results are promising and a possible configuration including the dewar is shown below.

Benefits to NASA and JPL (or significance of results):
The specific focus of this Task is to design and develop a prototype receiving system that can be used in the Very Long Baseline Array (VLBA). The VLBA has played and continues to play a significant role in the development of celestial reference frames, providing many of the measurements for the legacy S-X reference frame. Further, as an imaging array, it has provided structural information on current and candidate reference frame sources, which is then used in assessing their suitability and stability as defining reference frame sources. Improved precision navigation of deep space spacecraft is a goal of this work. In addition, new science on radio source structure can be obtained with a simultaneous multi-wavelength receiver.

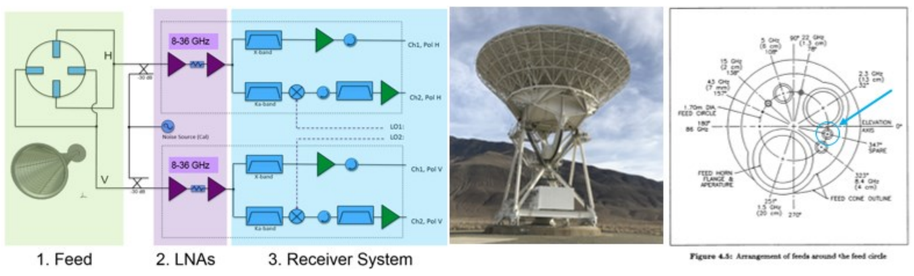

Fig. 1. Schematic diagram of the new simultaneous X-Ka Band receiver (left) for this proposal, for eventual testing on the Very Long Baseline Array (center) in the feed slot indicated (blue, right, from Napier, 1995).

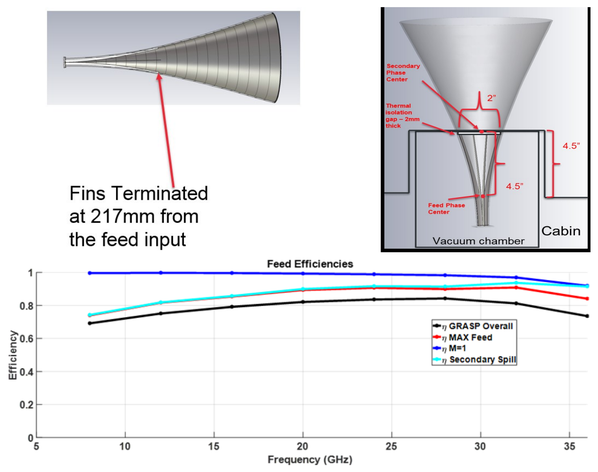

Fig. 2. Upper: Placement of vacuum window and feed, and chamber within the VLBA cabin. Bottom: Simulated feed efficiencies are 70-80%

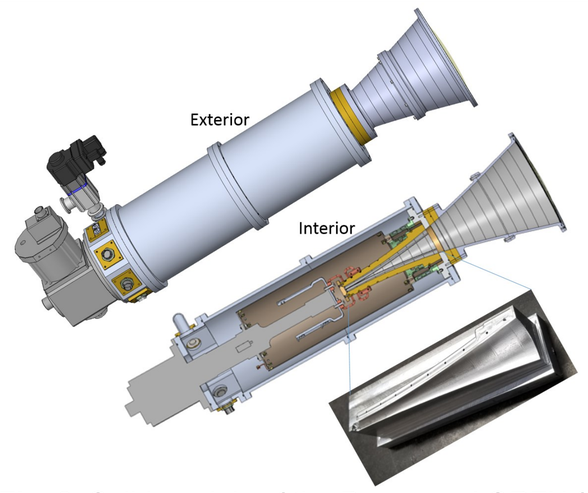

Fig. 3. Solid models of the Dewar and QRFH feed, which were designed for this task and are in fabrication. Blowup shows a quarter of the feed partially fabricated.

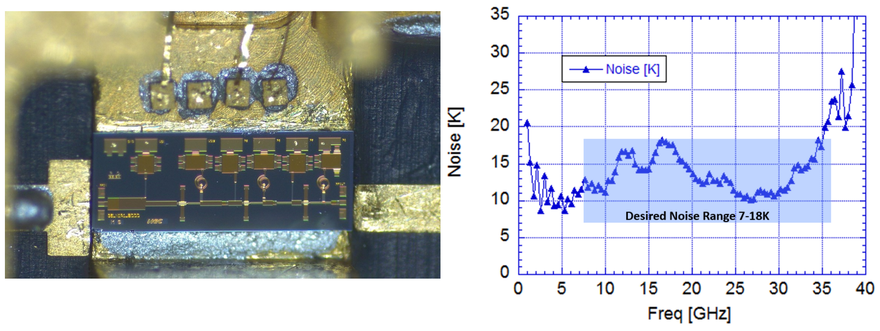

Fig. 4. Example of the best LNA design covering 8-36 GHz, using NGC's InP 35 nm MMIC process, and designed and measured at JPL. Desired noise is 7-18K.

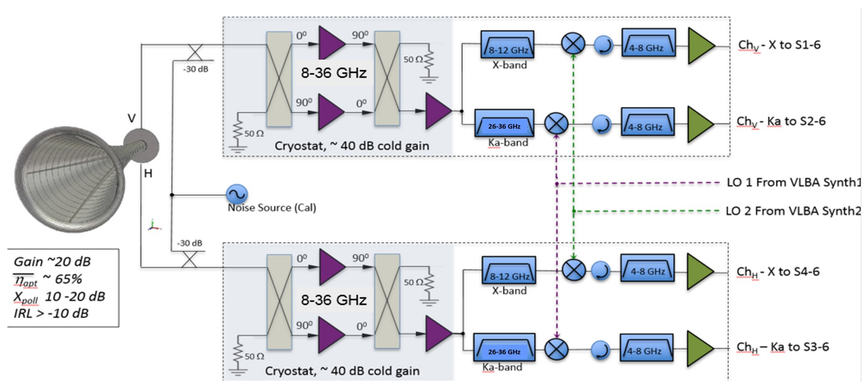

Fig. 5. Left: Schematic of balanced receiver design for X-Ka receiver. Right: Potential Balanced LNA concept using cooled coaxial hybrid couplers (blue) being investigated for best match to quad-ridge flare horn.

Acknowledgments
We would like to acknowledge the contributions of Mr. John Sosnowski and Mr. John Huleis of JPL for mechanical design and drawing expertise. We would also like to acknowledge Drs. Richard Lai and Michael Barsky of NGC, for InP MMIC development and fabrication. Also we would like to acknowledge helpful discussions with Dr. Wes Grammer of NRAO.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Publications:

L. Samoska, M. Soriano, J. Bowen, A. Fung, D. Hoppe, C. Jacobs, J. Kooi, J. Lazio, R. Manthena, "Simultaneous X- and Ka-Band Receiver for Astrometry and Navigation," to appear in *Proceedings of the US VLBA Navigation and Reference Frame Workshop*, Albuquerque, NM, Nov., 2019.

PI/Task Mgr. Contact Information: Lorene Samoska
Phone 818-354-0849, Email lsamoska@jpl.nasa.gov

Poster No. RPC-110