National Aeronautics and Space Administration

Multi-Functional and Scalable Ka-band Active/Passive Digital Array Receiver

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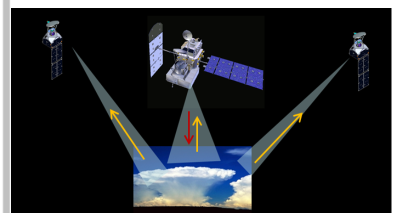
Program: Strategic Research and Technology Development

Project Objective:

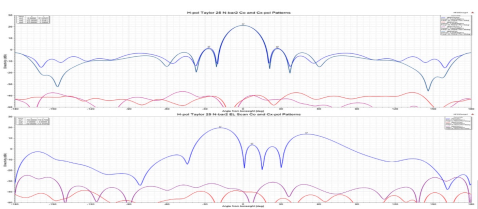
\he **overall goal** of this task is to develop a complete system architecture and advance key technology areas that allow JPL to move forward from single purpose sensors to **fully configurable digital arrays** delivering **multi-purpose** capability required for future decadal survey observations.

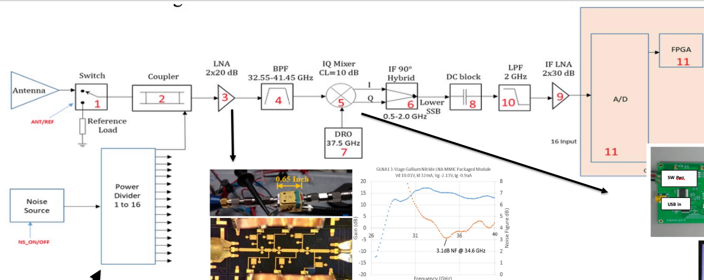
Our **objective** is to demonstrate airborne-ready scalable and multi-functionality **Ka-band (37 GHz) 16 channel combined active/passive RF array** system, with **digitally re-configurable antenna beams** to to enable the next generation of flexible active/passive microwave instruments for a key science observing priority *Clouds, Convection and Precipitation*.

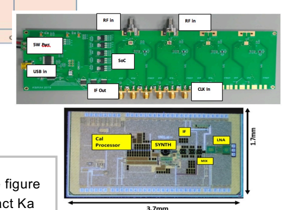


Envisioned digitally steerable concurrent radar and radiometer beams. Higher levels of active/passive integration, reduce cost, mass, power, and volume of the overall system critical for high-temporal observations from small spacecraft

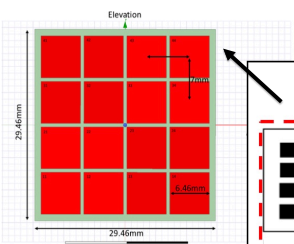
A 4x4 dual polarization wave-guide array antenna was designed for 35.75 GHz with 1 GHz bandwidth, return loss of <15 dB, cross polarization coupling of <20 dB, gain of 20 dB over a 3cmx3cm compact volume. Beam efficiency of more than 90% is still difficult for the beams pointing away from boresight.

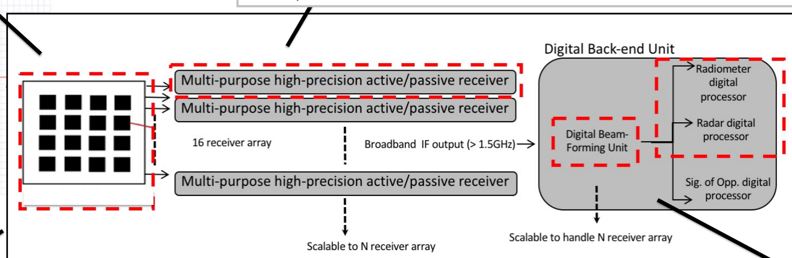


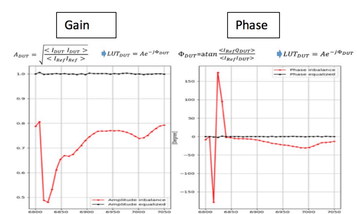


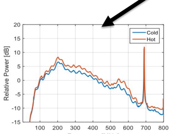


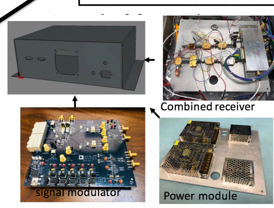
Each individual active/passive array channel shares a common noise source for array gain and phase calibration and equalization, and individual reference load for absolute calibration. The expected noise figure of the array receiver is 4dB, with a receiver gain of ~80 dB. We have also leveraged and tested compact Ka band elements (amplifier shown above – leveraged off ACT 13), and on-chip heterodyne mixers to ensure compactness of the instrument.



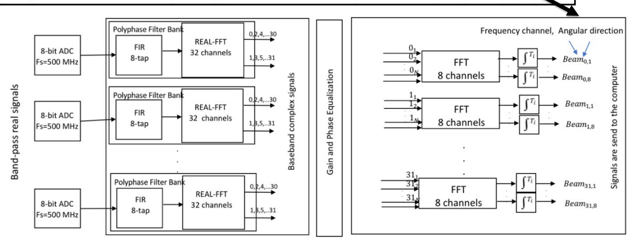






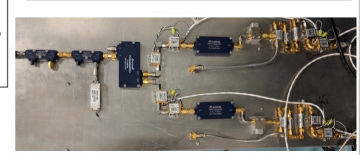


We are also developing a single channel version (led by Dr. Chae) airborne version of the instrument. The active/passive receiver chain has already been developed, with a higher power amplification at 1W. An adaptive phase matching FM demodulation scheme is currently being implemented to compensate for random phase differences between Tx and Rx LO. The instrument is currently being packaged.



The digital signal processing chain includes a front-end 32 channel spectrometer followed by a phase and gain equalization strategy. The technique used for achieving multiple digital beams uses a unique beamforming "spectrometer" design that outputs 8 digitally steered beams concurrently from one end of the scan angle to the other.

A"sand-box" 2 receiver test bed was built at C band to test out the front-end channelization, followed by the unique digital gain/phase equalization algorithm. The above figure shows channelization and, gain and phase equalization achieved via the on-board FPGA system from two receivers.



Benefits to NASA and JPL:

The **2017 National Academy of Sciences Decadal Survey** for Earth Science and Applications has recommended a diverse set of Earth Science Questions to understand the changing Earth and its complex interconnected processes. In particular the committee recommends that the scientific community *pioneer novel approaches* and emphasize *technological innovations to accomplish more with less* that can satisfy multiple science objectives. The following strategic effort aims to satisfy the *Clouds, Convection, and Precipitation* observing system priority from the decadal survey. The payload will also be flexible in partially satisfying cloud dynamics related questions required for *Atmospheric Winds* observing system priority.

The above instrument development combines the functionality of active and passive receivers, while also allowing multiple digitally configurable concurrent spectral beams. The compact system will allow an extremely agile, flexible, and multi-purpose instrument architecture capable of satisfying varying observation needs.

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