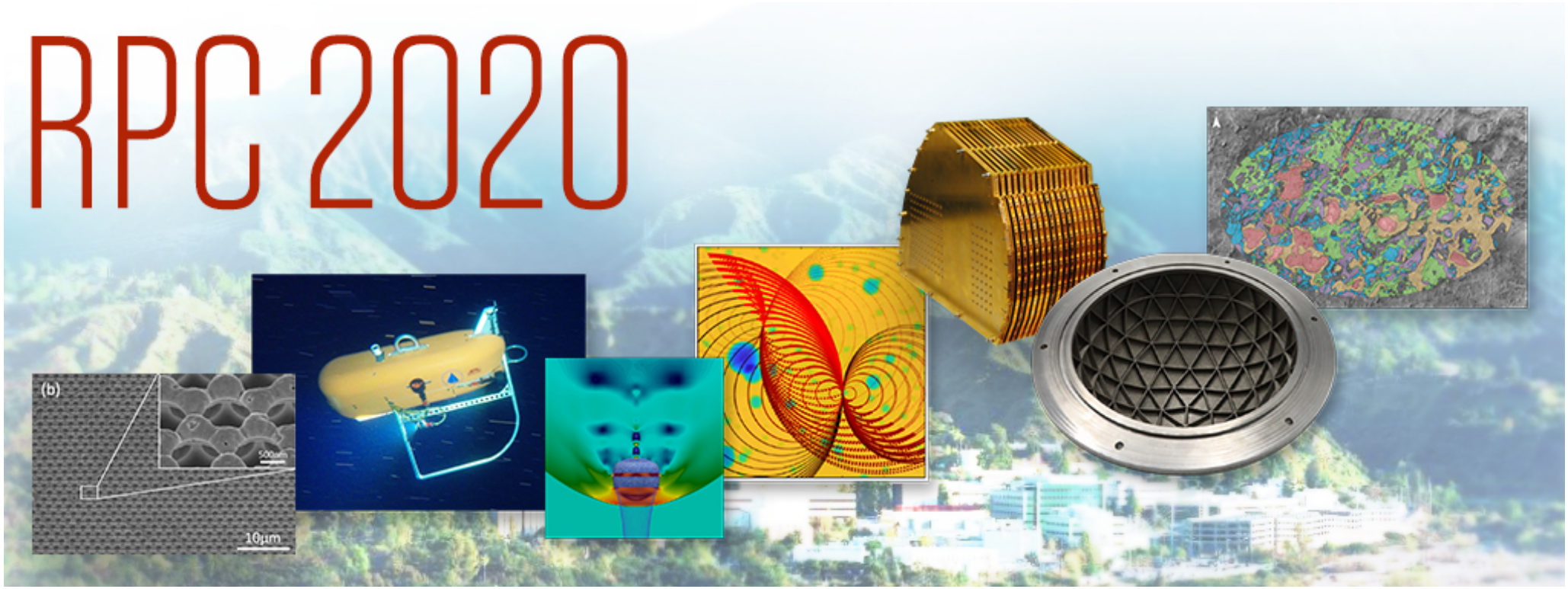


Virtual Research Presentation Conference

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

Principal Investigator: Sidharth Misra, Instrument Electronics And Software Section (386)
Co-Is: Chun Sik Chae, Javier Bosch-Lluis, Mehmet Ogut, Shannon T. Brown, Robert F. Jarnot, King Man Fung, Instrument Electronics And Software Section (386), Richard E. Hodges, Luis R. Amaro, Flight Communications Systems Section (337), Lavanya Periasamy, Matthew D. Lebsock, Earth Science Section (329), Simone Tanelli, Radar Science And Engineering Section (334)
Program: Strategic Initiative

Assigned Presentation RPC-145

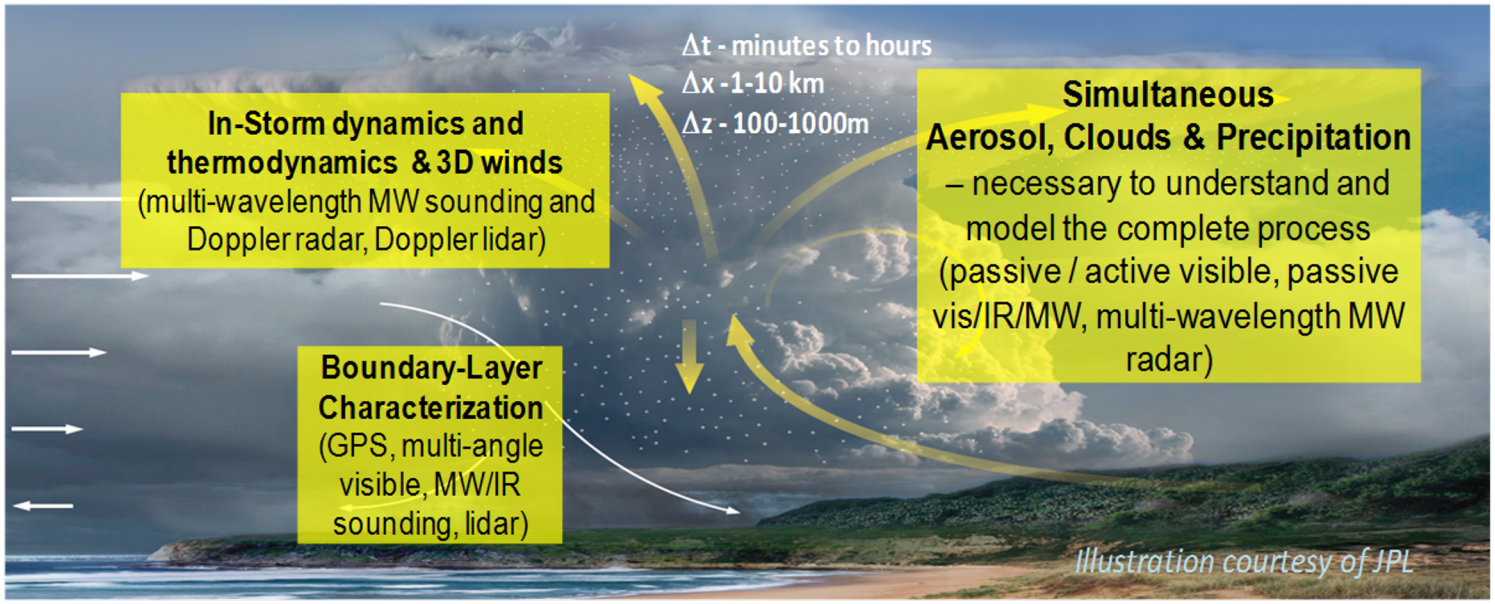
Jet Propulsion Laboratory
California Institute of Technology

Introduction

The National Academies Decadal Survey committee recommends that the scientific community ***pioneer novel approaches*** **and emphasize** ***technological innovations to accomplish more with less***. This requires future science observatories that are designed to be agile, flexible and multi-disciplinary supporting multiple scientific priorities."

The following work aims to satisfy the ***Clouds, Convection, and Precipitation*** observing system priority.

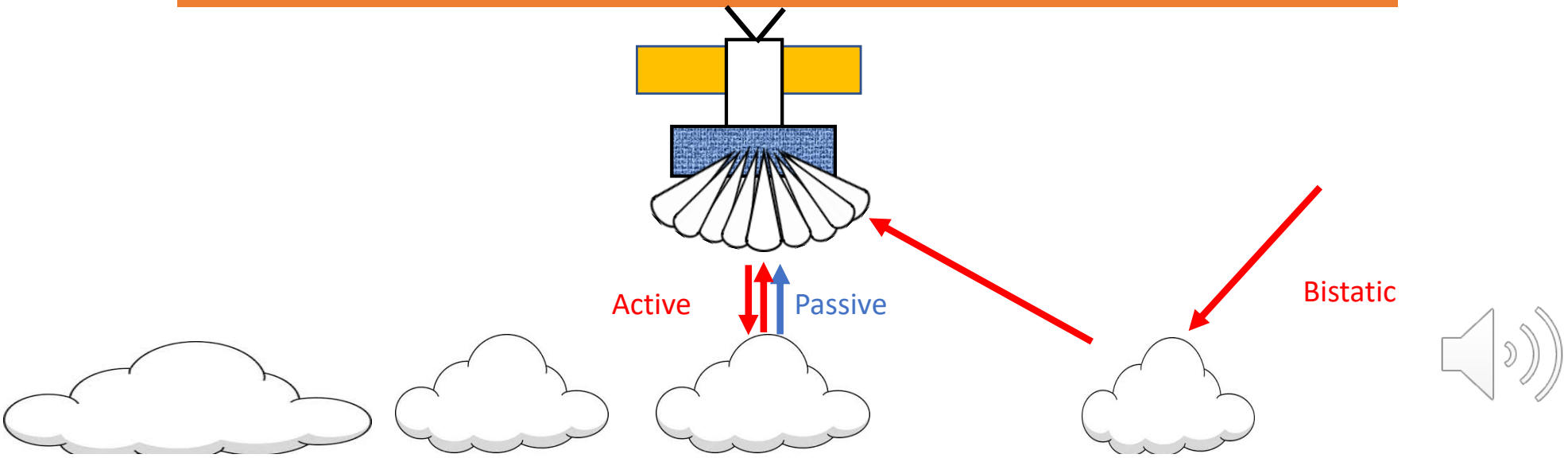
A key part of an observatory focused on weather processes will be **combined active/passive microwave sensors** to provide a detailed characterization of in-storm dynamics, precipitation processes and thermodynamics, with unique sampling requirements to **continuously observe the scene** to identify temporal signatures.



Objectives and Challenges

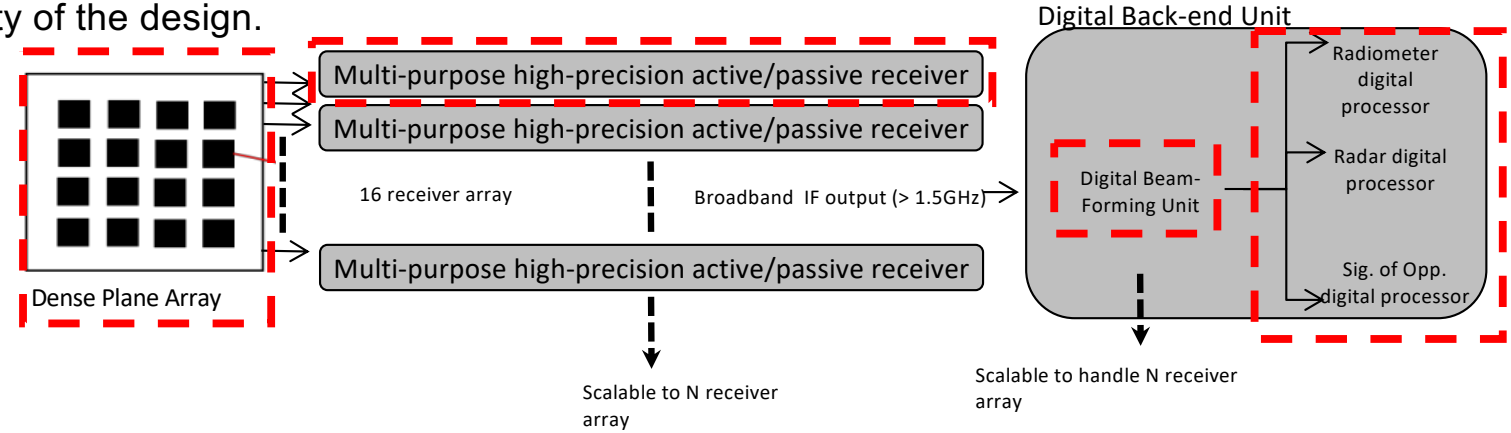
The overall goal of this task is to develop a digitally configurable multi-function Ka-band receiver array for future cognizant satellite constellations.

The overall objective of the proposal is to build an airborne-ready scalable and multi-functional Ka-band digital beam-forming receiver array to enable the next generation of flexible active/passive microwave instruments for a key science observing priority *Clouds, Convection and Precipitation*.



Objectives and Challenges

- We will design, fabricate and test a prototype for an active/passive reconfigurable and scalable digital Ka-band plane array.
- The objective of the prototype will be to demonstrate the multi-mode functionality of the array that includes scalability of the design.



1. Test 16 channel radiometer receiver system
2. Develop multi-channel scalable digital backend system
3. Develop single-channel active/passive airborne ready system
4. Leverage industry development on beamforming

Ka-band RF receiver

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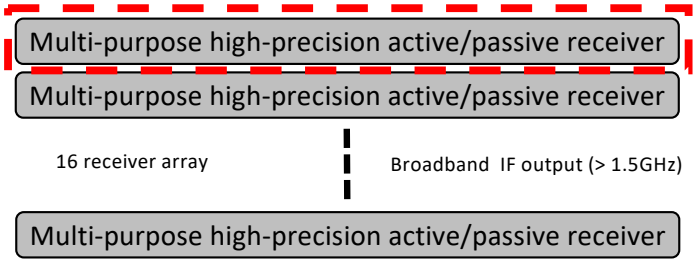
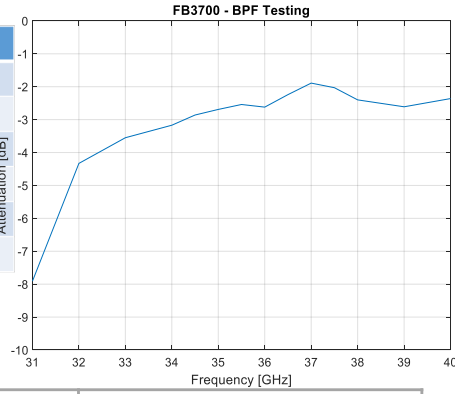
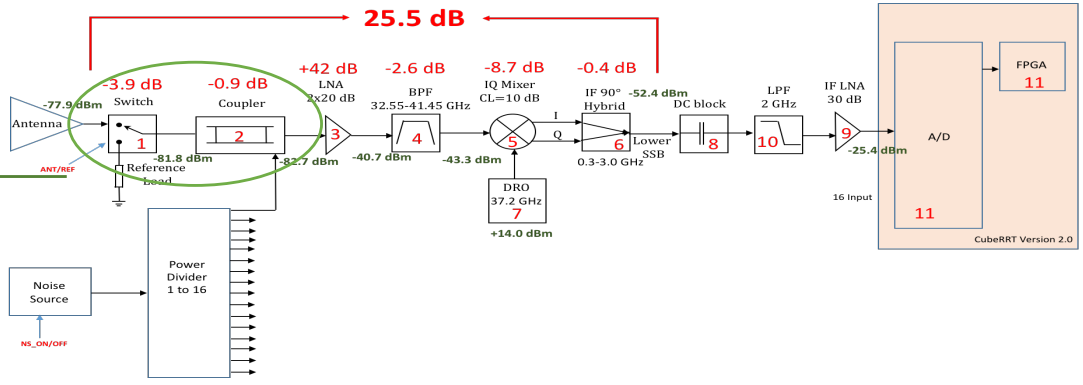
- Designed and tested a receiver that can take the dynamic range of a radar yet be as precise as a radiometer
- Noise was an issue
- To get around the noise issue by taking advantage of digital beamforming for calibration and remove noisy switch and coupler up front.



RF Frequency	IF Freqeuncy	IF Power
35.6 GHz	1.9 GHz	-58.4 dBm
36.2 GHz	1.3 GHz	-56.7 dBm
36.5 GHz	1.0 GHz	-57.2 dBm
37.0 GHz	0.5 GHz	-56.6 dBm
38.0 GHz	0.5 GHz	-76.3 dBm
38.5 GHz	1.0 GHz	-78.8 dBm





LNA Testing	**Measured Gain ~21dB, NF = 1.6dB**
Switch Testing	**Insertion Loss: 3.9dB, Isolation=60dB**
Coupler	**Insertion Loss: 0.9dB**
Filter testing	**See figure**
Hybrid testing	**See table**

Ka-band RF receiver

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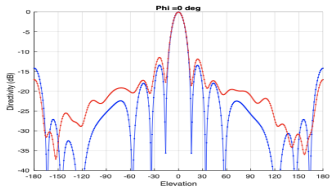
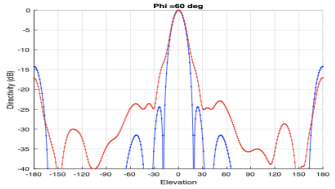
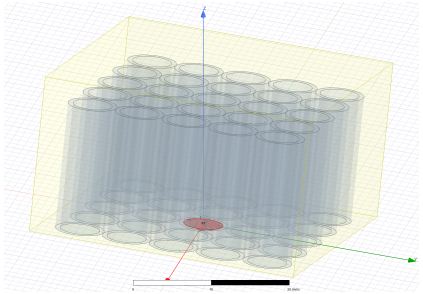






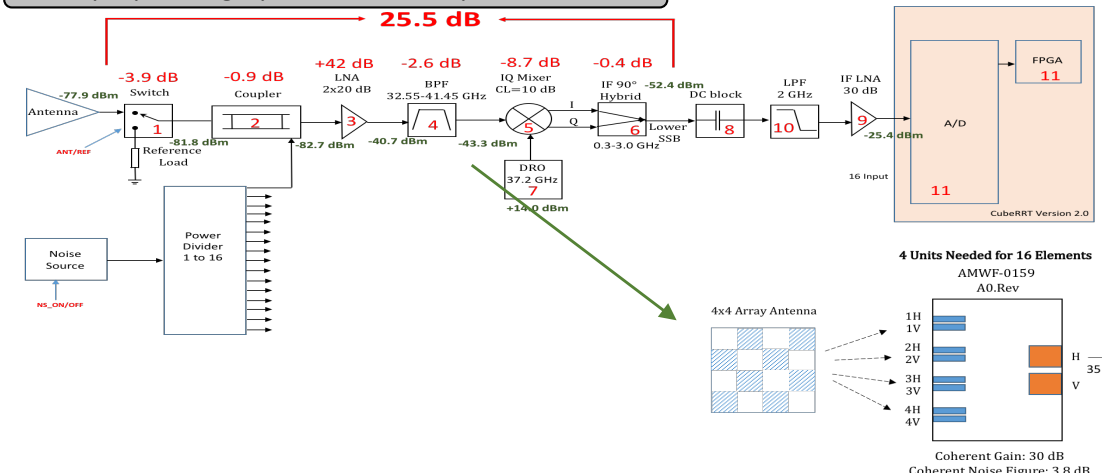
Multi-purpose high-precision active/passive receiver

Multi-purpose high-precision active/passive receiver

16 receiver array

Broadband IF output (> 1.5GHz)

Multi-purpose high-precision active/passive receiver



- In addition to designing our own RF and antenna, we asked the question can 5G be leveraged?
- The team is still assessing several commercial options that can be directly utilize din our RF design

Digital back-end

The overall goal of this task is to develop a **digitally configurable** multi-function **Ka-band receiver array** for future cognizant satellite constellations.

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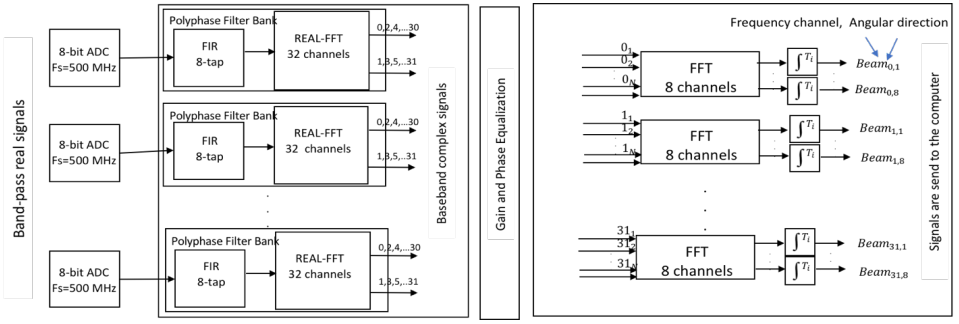
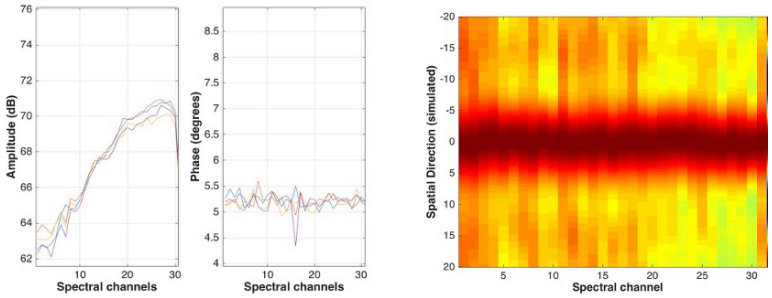
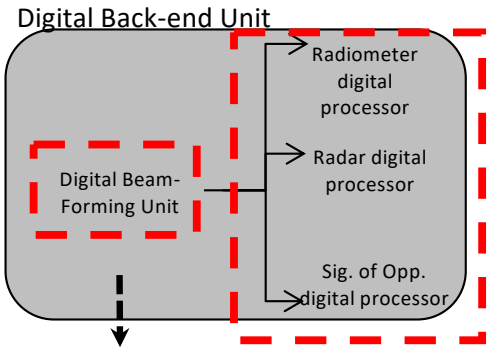
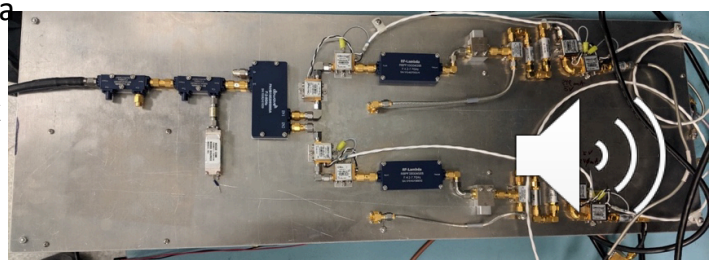




- Implemented DBF system that concurrently looks at multiple angles at the same time digitally
- Successfully tested DBF on a 4 receiver system with simulated injected noise, with gain and phase equalization on a "sand box" test set up
- Design ported to Xilinx ultrascale



Scalable to handle N receiver array



Airborne Active/Passive Single Receiver

The overall goal of this task is to develop a **digitally configurable** multi-function **Ka-band receiver array** for future cognizant satellite constellations.

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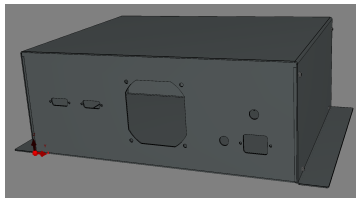
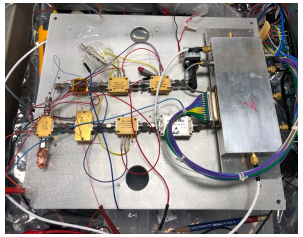
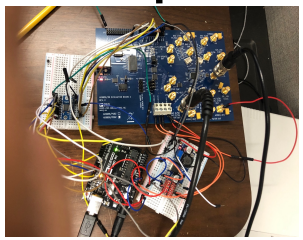
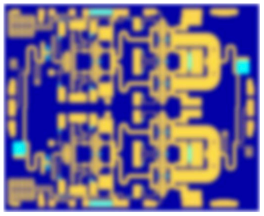




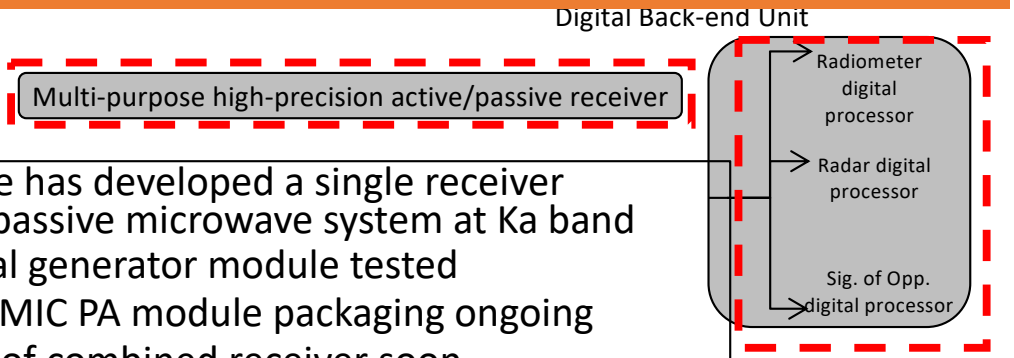
Combined receiver



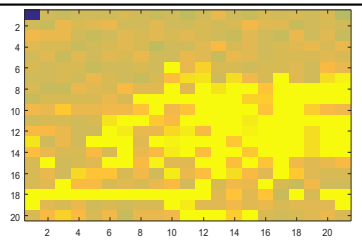
IQ generation signal modulator

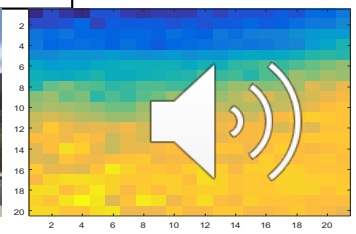


10 W Tx power amplifier



- Dr. Chae has developed a single receiver active/passive microwave system at Ka band
- IQ signal generator module tested
- 10W MMIC PA module packaging ongoing
- Testing of combined receiver soon.
- In addition, an instrument simulator for rain-rate detection using an active/passive receiver has been developed





Milestones, Goals, and Next Steps

Design and package Ka-band receiver chip 16 channel array to work in-system -

End-to-end one channel receiver system test completed.

16 channel development delayed to Q1 Y3 to assess feasibility of 5G chips.

Complete development with packaging of single receiver Ka-band active/passive receiver system at 5-10W output

Combined single channel active/passive receiver built. PA upgraded to 10W.

Packaging still ongoing to enable airborne implementation.

Develop array antenna system and test antenna -

Antenna design updated for JPL 3D printing manufacturing options.

Testing will have to be done in Q2 year 3.

Develop phased array calibration network –

Baseline calibration strategy had to be redesigned due to front-end noise from switch and coupler network.

Taking advantage of digital beam forming will be used.

Upgrade firm-ware design to introduce scalability and test multi-FPGA unit -

Beam forming functionality had been tested in year 2 and designed to be scalable.

Design ported to Xilinx RFSoC unit for multi input system.

FPGA to Chip path development

The work identified has a lot of potential to leverage industry 5G development.

Once individual sub-systems identified a chip based design will be made