National Aeronautics and Space Administration

Compact Radar for Measurements of Clouds, Convection and Precipitation

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Program: FY21 R&TD Strategic Initiative **Strategic Focus Area: Decadal Survey Instruments**

Project Objective:

Develop a multi-frequency millimeter-wave (Ka-, W- and G-band) radar system using an architecture that will result in small mass, power and size. The instrument will facilitate a low-cost Clouds, Convection and Precipitation (CCP) mission concept compatible with a small and low-cost spacecraft platform. We will demonstrate and validate the performance of the multi-frequency operation of the radar system, by carrying out measurements of the different subsystems and the instrument as a whole. We will provide an airborne prototype radar that will be able to demonstrate the instrument capability.

On Year 2, we got the notification that our IIP proposal based on this SRTD technology was selected and hence, the technical objectives and funding changed. The new technical objective included only the airborne demonstration of the W-band breadboard.

Benefits to NASA and JPL:

Compact and affordable radar instruments facilitate the deployment of constellations of identical instruments flying in Low Earth Orbit (LEO). Low cost constellations can fly in formation to observe the evolution of weather processes with high-vertical resolution profiling capabilities or in diverse orbits to increase sampling across the diurnal cycle. This work will facilitate proposals to the upcoming EVM and EVI instrument calls, as well as offer competitive and timely "out of the box" candidate solutions for the implementation of specific aspects of the CCP Designated Observable and PBL Targeted Observables. Successful completion of the current task will permit a variety of mission architectures including any combination of the Ka/W/G band channels on a small satellite platform.

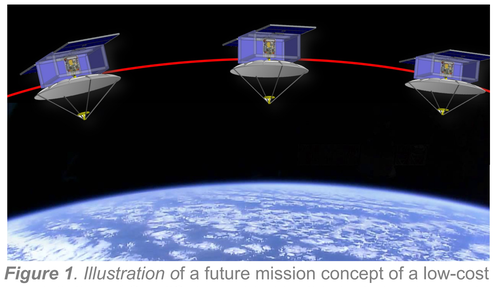

Figure 1. *Illustration* of a future mission concept of a low-cost constellation of SmallSats enabled by this task development.

Approach:

The instrument developed under this task, is composed of mature solid-state components integrated in a compact architecture, analogous to RainCubes', where the baseband signal will be directly upconverted to the RF band without any addition of intermediate frequencies or further multiplication scheme. This novel architecture provides a simple and effective solution while achieving the required performance and robustness of an airborne or space flight radar instrument.

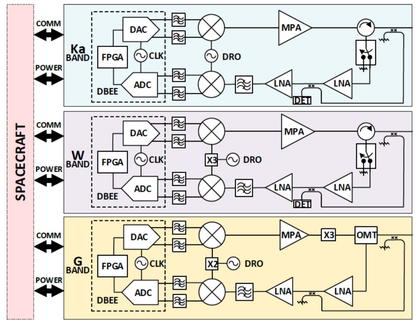

Figure 2. *Simplified radar block diagram, including the three frequency RF modules.*

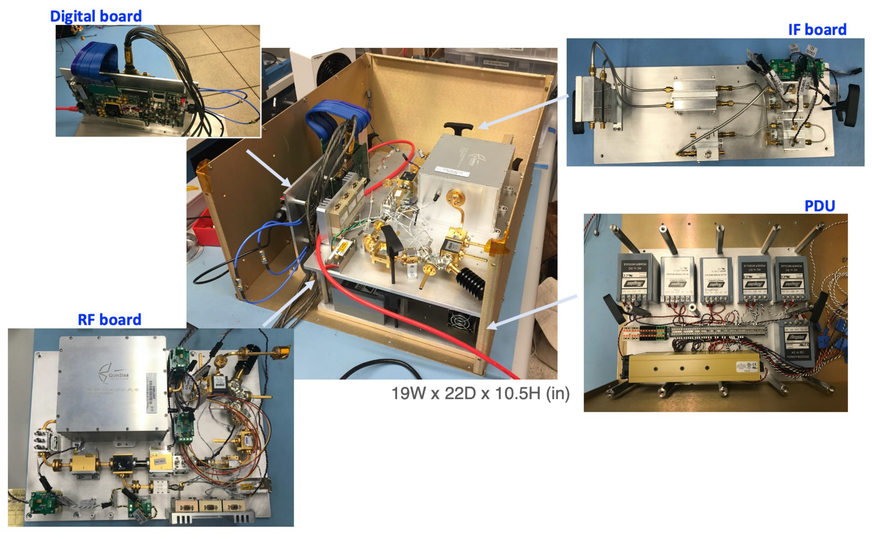

Figure 3. W-band breadboard rack-mounted chassis. The chassis contains the RF electronics, the power distribution unit (PDU) and the digital system (FPGA, DAC, ADCs boards).

During Year 3 of this task, the W-band brassboard radar has been reconfigured into a rack-mounted interface compatible with the DC-8 airplane configuration. The radar electronics have been assembled within a 10U rack-mounted chassis. The chassis contains the RF electronics, the power distribution unit (PDU) and the digital system (FPGA, DAC, ADCs boards). The PDU design includes 5 Acopians and a several regulator boards. The digital system consisted using RainCube's EGSE unit and modify the firmware to be able to stream filtered, range compressed and floating-point packets continuously. The compact design into a single 10U chassis facilitated the radar's tests, transportation and installation.

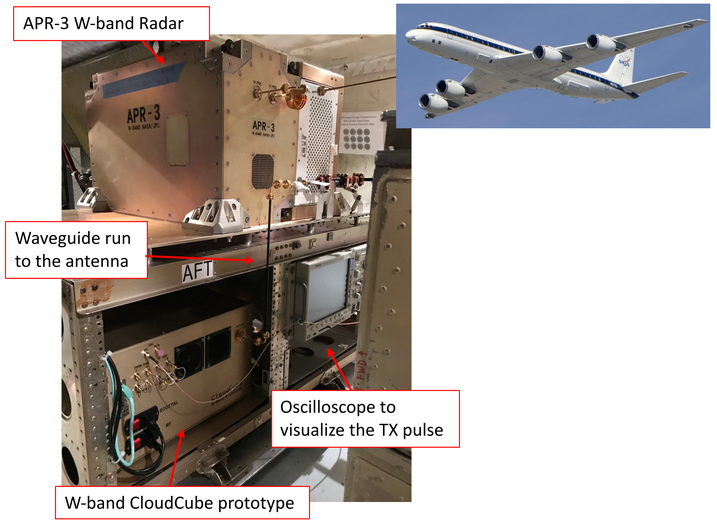

Figure 4. W-band breadboard installed into the NASA DC-8 airborne together with APR3 (Airborne Third Generation Precipitation Radar).

CloudCube's W-band prototype was successfully integrated into NASA's DC-8 Airborne, on August 2nd, together with the APR-3 (Airborne Third Generation Precipitation Radar) and is currently participating, as a technology demonstration instrument, in the Convective Processes Experiment- Aerosol & Winds (CPEX-AW) field campaign in St. Croix, US Virgin Islands.

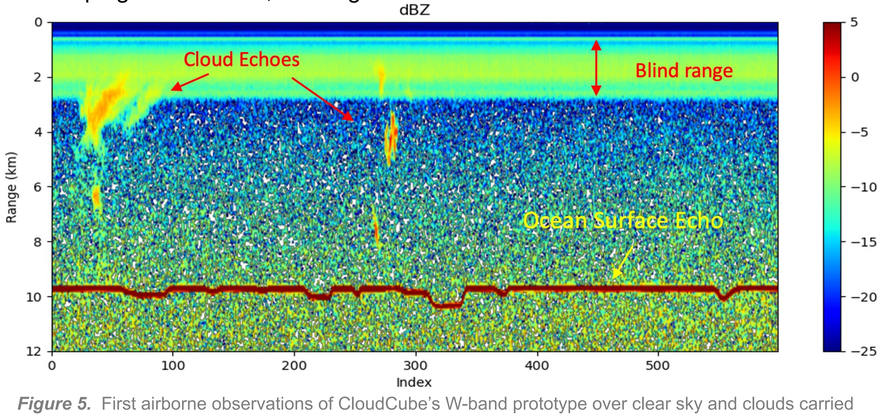

Figure 5. First airborne observations of CloudCube's W-band prototype over clear sky and clouds carried out during the science flight, on August 20th.

During the science flight, on August 20th, the CloudCube/APR-3 team was able to carry on the first airborne observations of CloudCube's W-band prototype over clear sky and clouds.

CloudCube thus demonstrates for the first time, the direct up/down-conversion radar architecture with pulse compression at W-band from an airborne platform, with the successful detection of ocean surface echo and clouds.

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