Computer Aided Designs of Hyperspectral Microwave Atmospheric Sounder (HyMAS) Scanhead

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Abstract

Recent technology advances have significantly and profoundly changed the landscape of modern radiometry by enabling miniaturized, low-power, and low-noise radio frequency receivers operating at frequencies up to 200 GHz. These advances enable the practical use of receiver arrays to multiplex multiple broad frequency bands into many spectral channels. We use the term "hyperspectral microwave" to refer generically to microwave sounding systems with approximately 50 spectral channels or more. In this project, the co-mentors and I report on the design and analysis by using SolidWorks CAD program to generate a 3-D design of the receivers subsystem (lensed antenna, RF front end electronics, and IF processor module) for the Hyperspectral Microwave Atmospheric Sounder (HyMAS) comprising multiple receivers near the oxygen absorption line at 118.75 GHz and the water vapor absorption line at 183.31 GHz. The hyperspectral microwave receiver system will be integrated into a scan head compatible with the NASA GSFC Conical Scanning Microwave Imaging Radiometer (CoSMIR) airborne system to facilitate demonstration and performance characterization. Four identical radiometers will be used to cover 108-119 GHz.

Introduction

The term "hyperspectral microwave" is used to indicate an all-weather sounding that performs equivalent to hyperspectral infrared sounders in clear air with vertical resolution of approximately 1 km (Blackwell). Hyperspectral microwave is achieved through the use of independent RF antennas that sample the volume of the Earth's atmosphere through various levels of frequencies, therefore produce a set a dense, spaced vertical weighting functions (Blackwell). Furthermore, the simulations proposed for HyMAS 118/183-GHz system should yield surface precipitation rate and water path retrievals for rainwater, graupel (small hail, soft hail, or snow pellets), snow, etc. with accuracies, and with any further improvements in methodology. The HyMAS project is similar to the CoSMIR project. The CoSMIR instrument is packaging concept is re-used on HyMAS to ease the integration features of the scanhead. The HyMAS scanhead will include an ultra-compact Intermediate Processor (IFP) module mounted on the door. The IFP is fabricated with materials made of Low-Temperature Co-fired Ceramic (LTCC) technology integrated with detectors, amplifiers, A/D conversion and data aggregation (Blackwell). Using numerous spectral channels will advance the use of receiver arrays to multiplex broad frequency bands, thereby further demonstrating the benefit of atmospheric sounding systems as an expected spin-off of this work (Blackwell). Another key difference between HyMAS and CoSMIR is HyMAS will be using three antennas using two 118 GHz and one 183 GHz, compared to CoSMIR that has four antennas using 50 GHz, 89 GHz, 150 GHz, and 183 GHz.

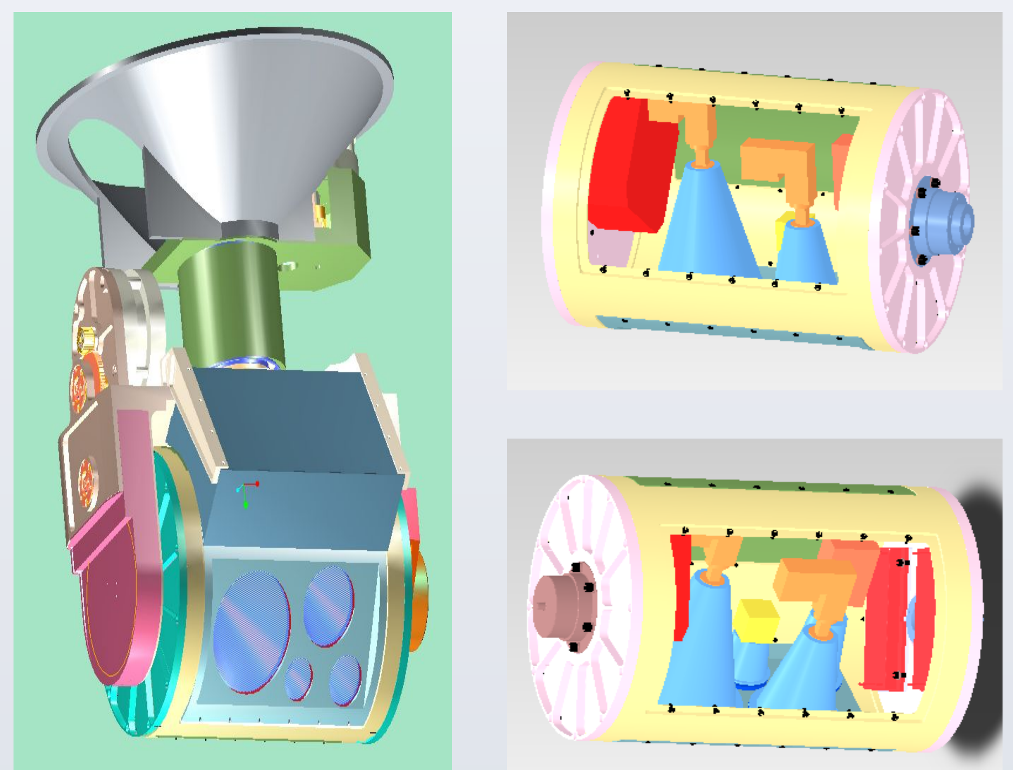
Objectives

- Begin preliminary mechanical design modifying CoSMIR scanhead drum for HyMAS configurations and requirements.
- Modify the CoSMIR scanhead openings frames to accommodate GOA interfaces from the CoSMIR configurations to HyMAS
- Generate preliminary layouts of IF processor and connectors form and fit on the inside of the door of the scanhead drum.

Methods

I used the SolidWorks software to design a computer model of HyMAS. SolidWorks is a 3D commercial computer aided design (CAD) program that is used by numerous engineers and designers for multiple companies worldwide. The methodology of drew from previous work done on CoSMIR. The team decided to engender a new model called HyMAS by using the same volume and space in the drum. Many similar microwave and electronic instruments installed on CoSMIR will be utilized in HyMAS. The components are Gaussian Optic Lens Antenna (GOAs), IF processors, connectors, and faceplate..

CoSMIR



The mechanical configurations and constraints (Interior Envelope), and also the pictures above show the mechanical interface portals for GOA on the faceplate. The existing components from the CoSMIR model were maintained in the HyMAS computer aided design layout. In fact, CoSMIR was successful and is currently being tested experimenting in aircrafts for field testing.

HyMAS Block Diagram

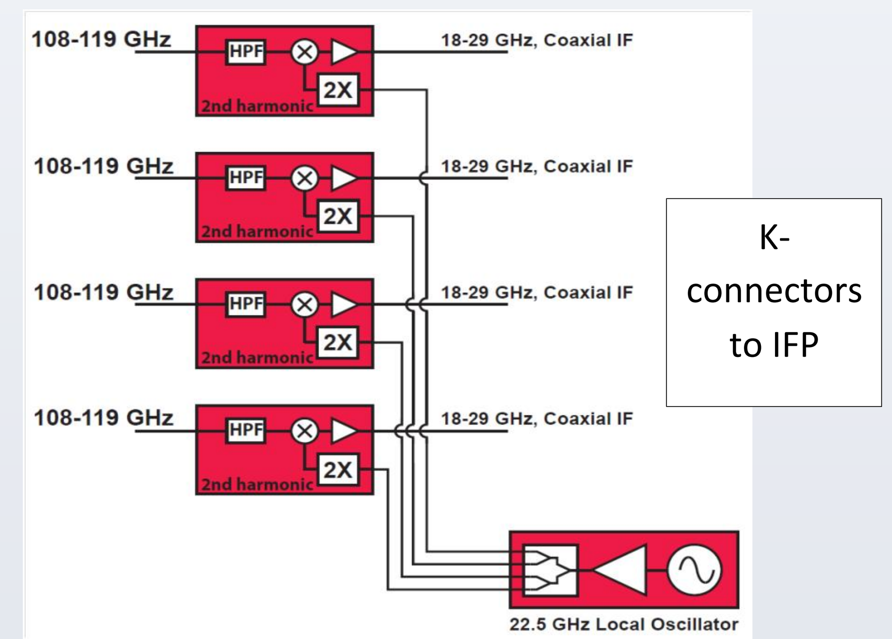


Fig. 1: The four118 GHz Radiometers

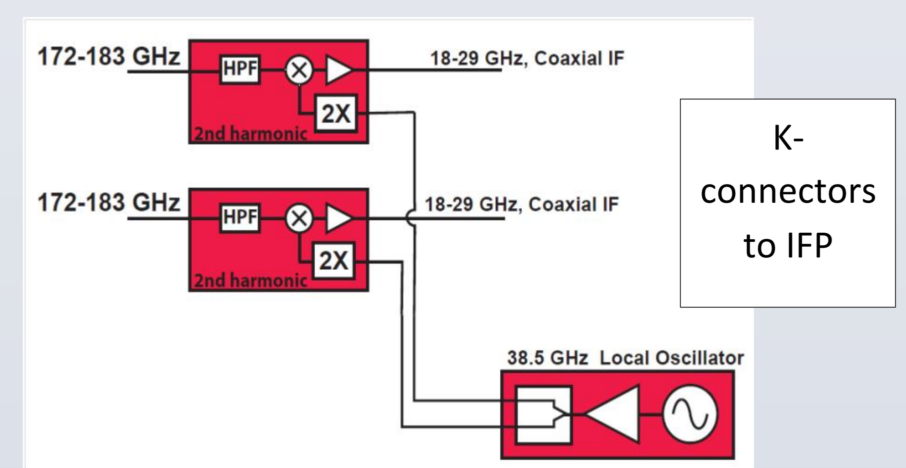


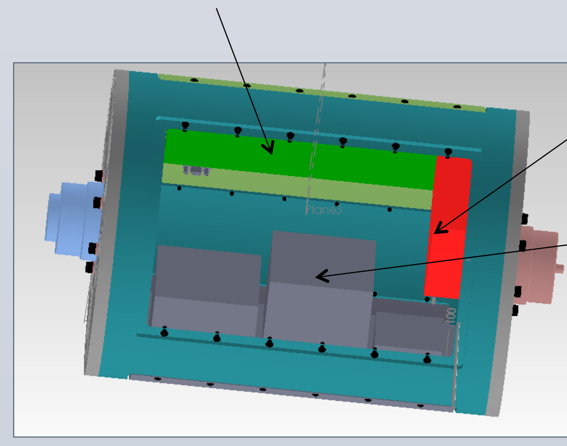
Fig. 2: The two 183 GHz Receivers

In Figure 1 there are 4 signal chains of 118 GHz components, and in Figure 2 there are 2 signal chains of 183 GHz receivers. All 6 **must** fit within an existing drum and share volume with the data system and three dual-pol lens antennas.

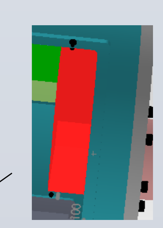
Mechanical Configuration Trades

- GOA orientation and placement within the scandrum
- IF Processor board configurations (size and connector locations)
- Evaluating clearance between components

IFP (10x20x1cm) version

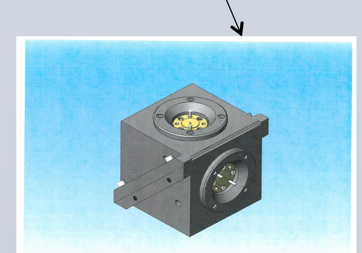


Scan head computer

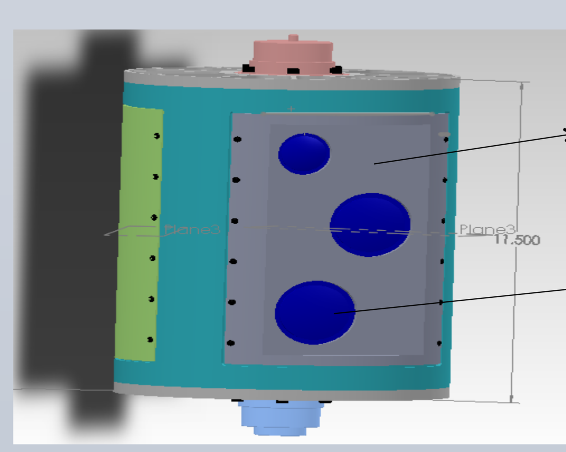


3 GOAs

Fig. 3



Faceplate

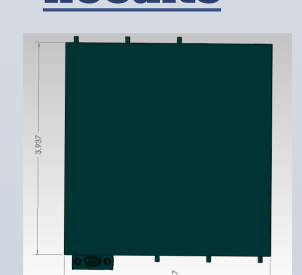


Lens

Fig.4

The figures show the current HyMAS CAD model of the scanhead.

Results



3 K-connectors On each side

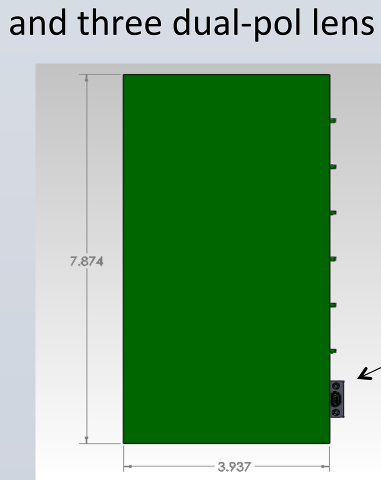
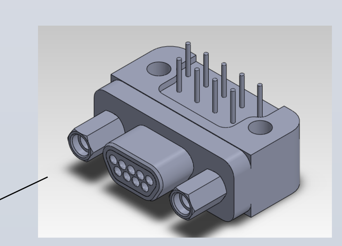


Fig.5



D-connector

In figure 5, these are two possible IF processor board configurations. Starting from left to right the sizes are 10x10x1cm, and 10x20x1cm. The "D" connector is used to connect between the scan head computer, and the IFP. The K-connectors connect the 6 front ends to the IFP.

Even though, several major components of the HyMAS scanhead envelope are configured, and the full assessment is currently on-going. The team is going to refined the layout of the 3-D CAD model HyMAS. After completing the layout and constraints of the drum, we are going to finalize the components in the scan drum. Building a prototype of the HyMAS is will require extra funds so for now the CAD model will help the HyMAS team consider how to route and attach the cables between the components. In addition, the HyMAS team can edit the design or change components, as needed.

Conclusion

Based on the similarity of the existing CoSMIR instrument design to the still developing HyMAS instrument criteria, the HyMAS team began preliminary layout work inside the new drum. Thereby avoiding creating a scanhead drum assembly from scratch. Through the internship I was able to import and re-use models of the shell, the scan head computer, and the slip rings developed for CoSMIR. I was able to import connector models that were under consideration for the IFP, and I was able to modify the antenna faceplate to accommodate the dimensions of the GOA assemblies being procured. Two mechanical concepts for the core technology, a hyperspectral intermediate frequency electronics processor (IFP), were captured in a design tradeoff.

This effort is part of efforts to advance all-weather atmospheric sounding being enabled by recent advances in microwave devices technology. Deploying the HyMAS drum with the existing CoSMIR supporting Earth Science facility gives us a good jump start to all-weather sounding.

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