Research work on Astrobee

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1 Introduction

From July to August 2019, an exchange program between UCLouvain and MIT gave me the opportunity to do a research work in the Space Systems Laboratory at the Massachusetts Institute of Technology.

We worked in team to give MIT its own copy of Astrobee. Designed by NASA, these are robotic teammates to work alongside astronauts on the International Space Station as they help to advance research. They help astronauts reduce time they spend on routine duties, leaving them to focus more on the things that only humans can do [1]. As a Master's student in Electromechanics, my work consisted to build the avionics of Astrobee.

2 Research work

The project began a few weeks before my arrival, I have thus worked on the first steps of the design.

Avionics diagram

With the schematics and assembly files of the boards given by NASA, I created an avionics diagram that highlights the connections between all the boards and sensors.

Schematics analysis

I analyzed and wrote details in the schematics files of the boards, it is useful during the boards tests in case of malfunction after soldering.

Ordering of the electronic components

I ordered most of the electronic components, mainly available at DigiKey but also looking for some replacements in other websites. For small orders with specific companies, I could notice the important tradeoff between the unit price and the shipping cost. I also sorted the components, first by board and then by number inside each board. This methodical step spared a lot of time during the PCB soldering. The status of each component is documented in an Excel sheet.

Test of the development boards and sensors

I manipulated three development boards to replicate the three real processors in the robot. This enabled me to test the board-to-board communication (USB, Ethernet and WiFi) as well as the sensors data. The boards are:

- the Inforce 6601 as the High Level Processor,
- the Inforce 6640 as the Middle Level Processor,

- and the Wandboard WB-IMX6Q-BW as the Low Level Processor.

I tested and validated some sensors:

- a color camera (DFM 42BUC03-ML),
- a 3D camera (CamBoard pico flexx),
- and an IMU (VectorNav VN-100).

PCB soldering

In the EDS[1], I achieved the soldering of three among the five most important boards of Astrobee (see Figure 1).

Figure 1: Soldering session in the EDS

The vast majority of the components are in SMD packaging, and the smaller ones do not exceed a length and width of 1.0 mm and 0.5 mm respectively. I also soldered some Quad Flat Package chips and Dual In-line Package chips.

I handled a microscope, solder paste and hot air gun for the smallest components. For the tallest ones, I could use a solder iron and a flux tube.

The Low Level Processor board is available in Figure 2.

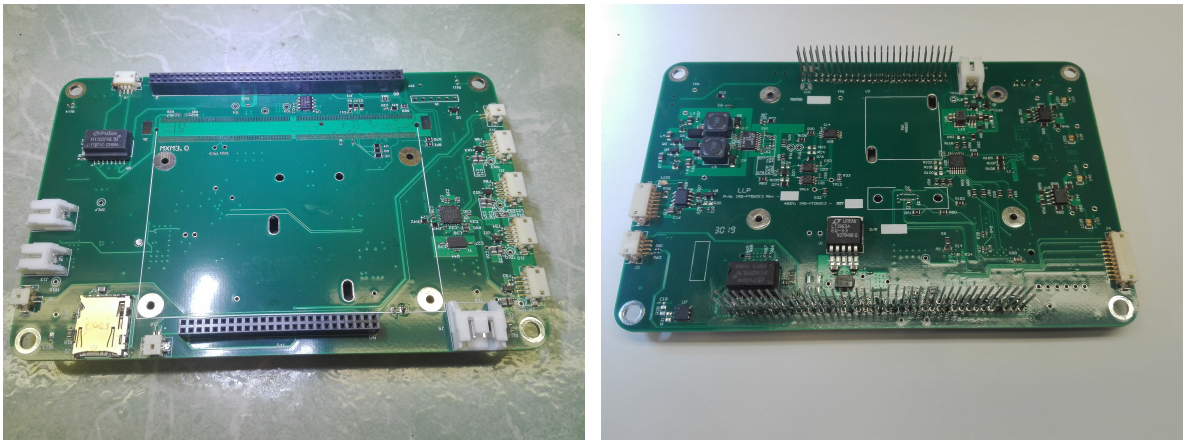

Figure 2: Soldering of the LLP board

[1]Engineering Design Studio, is part of the EECS Department at MIT.

The Middle and High Level Processor board has four 100-pin connectors for the System on Module and four antenna connectors (see Figure 3).

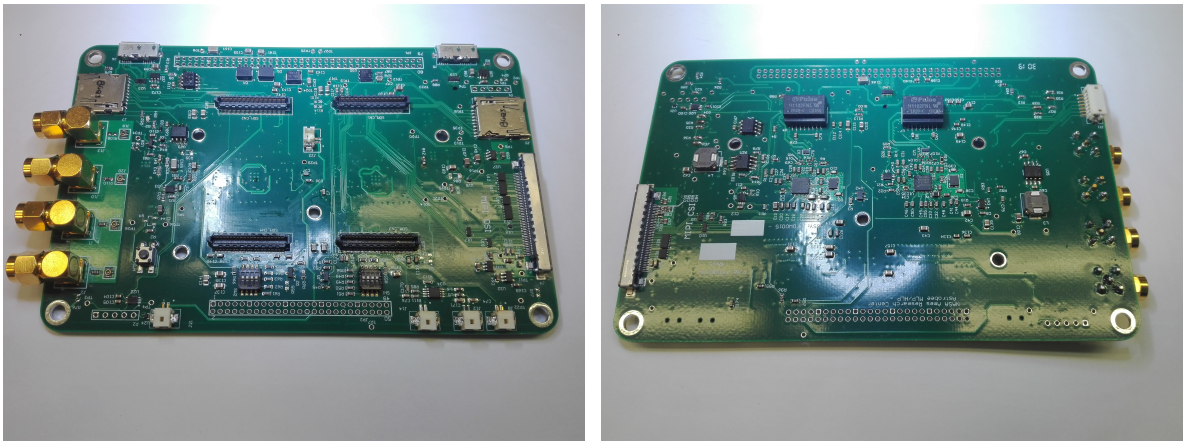

Figure 3: Soldering of the MLP/HLP board

The Electrical Power System board is shown in Figure 4.

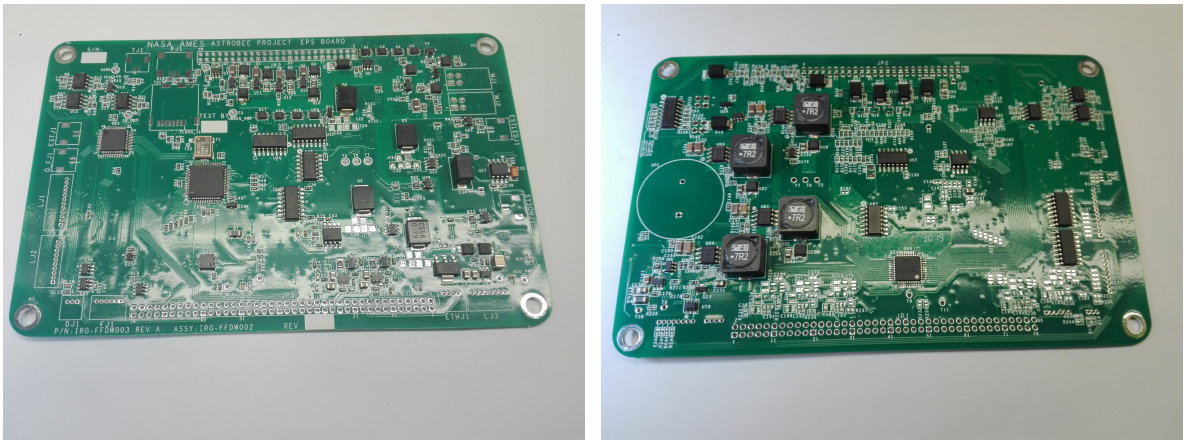

Figure 4: Soldering of the EPS board

Finally, the Astrobee Pogo board and Dock Pogo board enable Astrobee to be docked and charged via its docking station (see Figure 5).

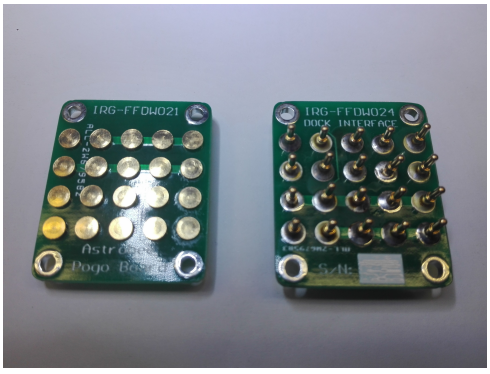

Figure 5: Soldering of the Astrobee Pogo board and Dock Pogo board

3 Conclusion

This research work gave me a strong interest for the space systems, and more generally the electronics of diverse robots. Working on the communication between the boards and the sensors also improved my research skills. The flat hierarchy among the undergraduate and graduate students in the team brought a lot of interesting viewpoints and enhanced my team working and management skills. Finally these discussions have improved my fluency in English.

The next work on Astrobee will be finishing the soldering of the remaining boards and separately validating the boards with the tests procedures. The electronics stack of the five main boards will then be assembled and linked to the other boards and sensors.

The building of Astrobee at MIT is expected to be finished in the end of 2019, in order to start experimentation in the beginning of 2020.

References

[1] Simeon Kanis. What is Astrobee? `https://www.nasa.gov/astrobee`, 2019. [Online; accessed 29-August-2019].