DEVELOPMENT OF AN INNOVATIVE PAYLOAD EXPERIMENT CONTROLLER TO BE TRIALLED ON THE CASPA CUBESAT

Karen Holland (1), David Colebrook (1), Steve Maddox(2), Jonathon Winch(3), Clive Rolston(1), Abigail Shaylor(1), David Gopinath(1)

(1)XCAM Ltd., 2 Stone Circle Road, Northampton, NN3 8RF, +44(0)1604 673 700, Karen.Holland@xcam.co.uk

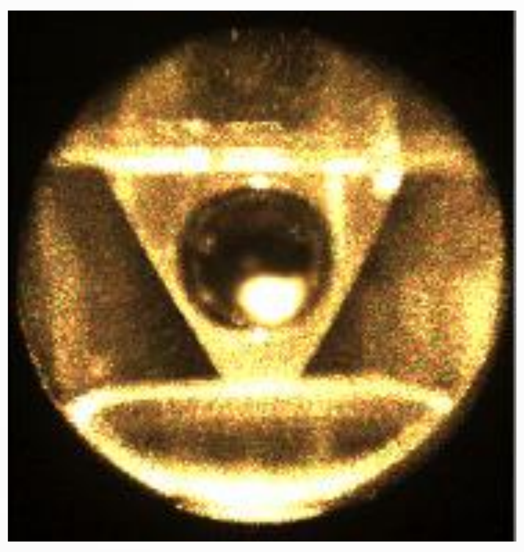
(2) Teledyne e2v, 106 Waterhouse Lane, Chelmsford, Essex, England, CM1 2QU, +44(0)1245 453 178, Steve.Maddox@teledyne-e2v.com

(3)University of Birmingham, Atom Interferometry Midlands Ultracold Atom Research Centre, School of Physics and Astronomy, Birmingham, B15 2TT, +44(0)121 414 8303, J.Winch.1@bham.ac.uk

Introduction

The CASPA (Cold Atom Space PAyload) project is an Innovate UK-funded project to design and develop a prototype 6U satellite carrying a cold atom experiment into space. The project is led by Teledyne e2v Ltd (Teledyne e2v), and involves 6 other consortium members including XCAM Ltd, University of Birmingham, University of Southampton, Covesion, Gooch and Housego, and Clyde Space.

Cold atom sensor technology may have a number of exciting applications in the future, including enabling precise gravity maps of the Earth to be made from the ground or space.



This project aims to prove that operating a miniature cold atom system in space is now a viable possibility and will raise the TRL level of the technology required to a level at which such payloads may be considered for larger satellites which require more mature technology with space heritage.

The image (left) shows an optimised MOT image (courtesy University of Birmingham) taken at an early stage in the project in a laboratory setting using XCAM's existing cubesatellite imager system.

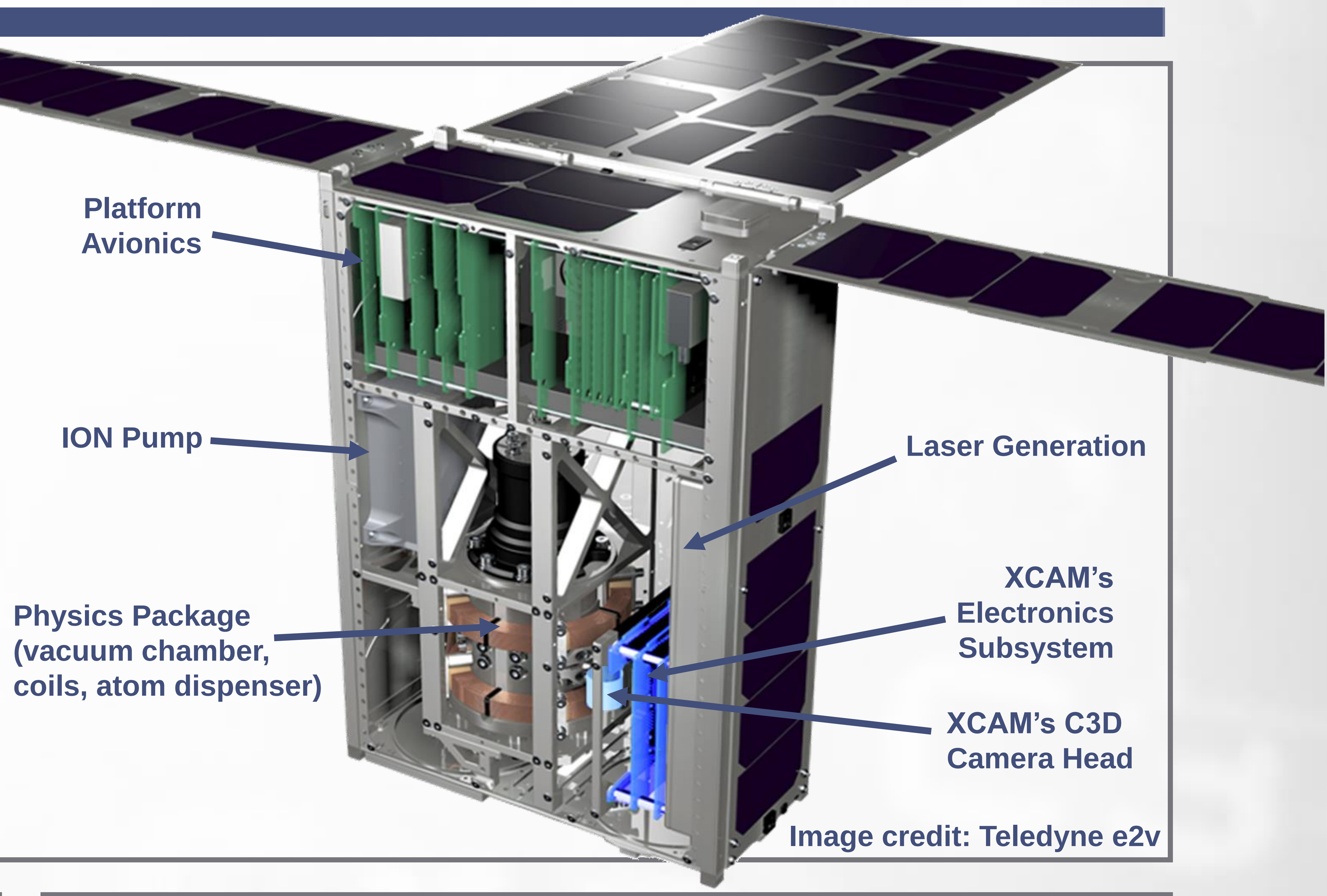
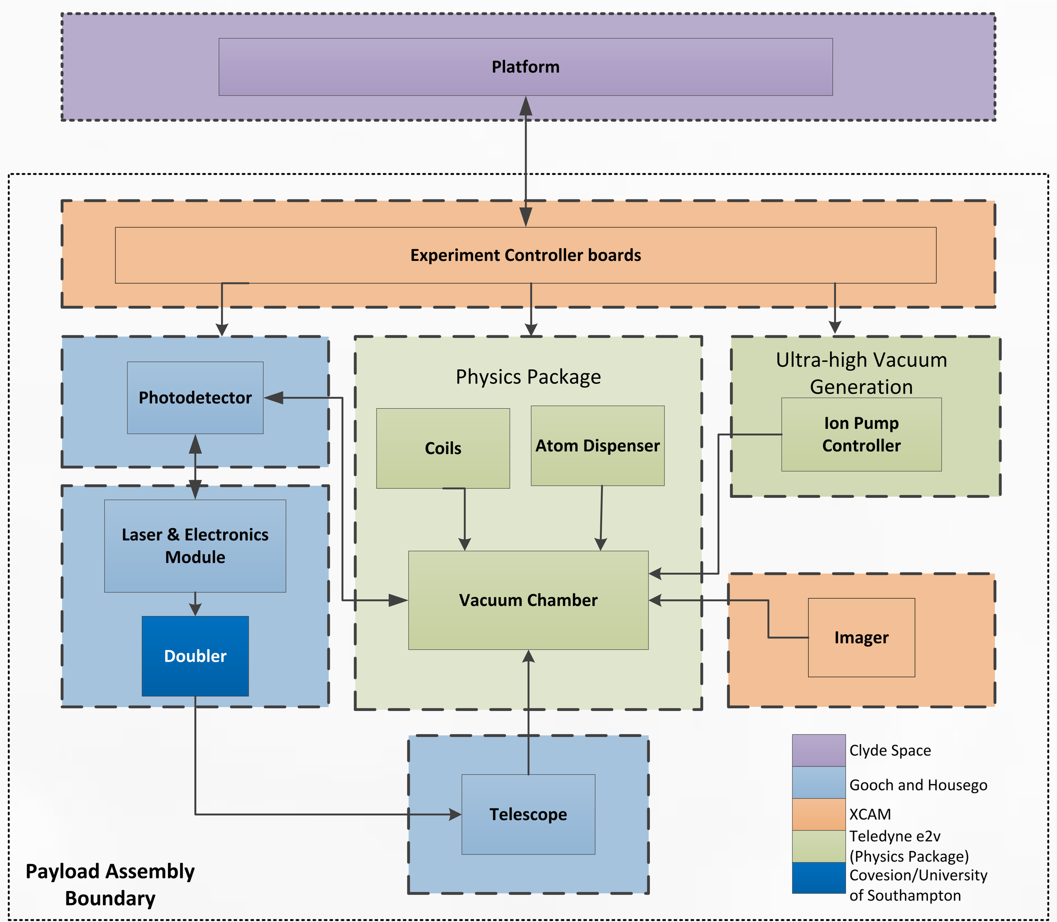


Image credit: Teledyne e2v

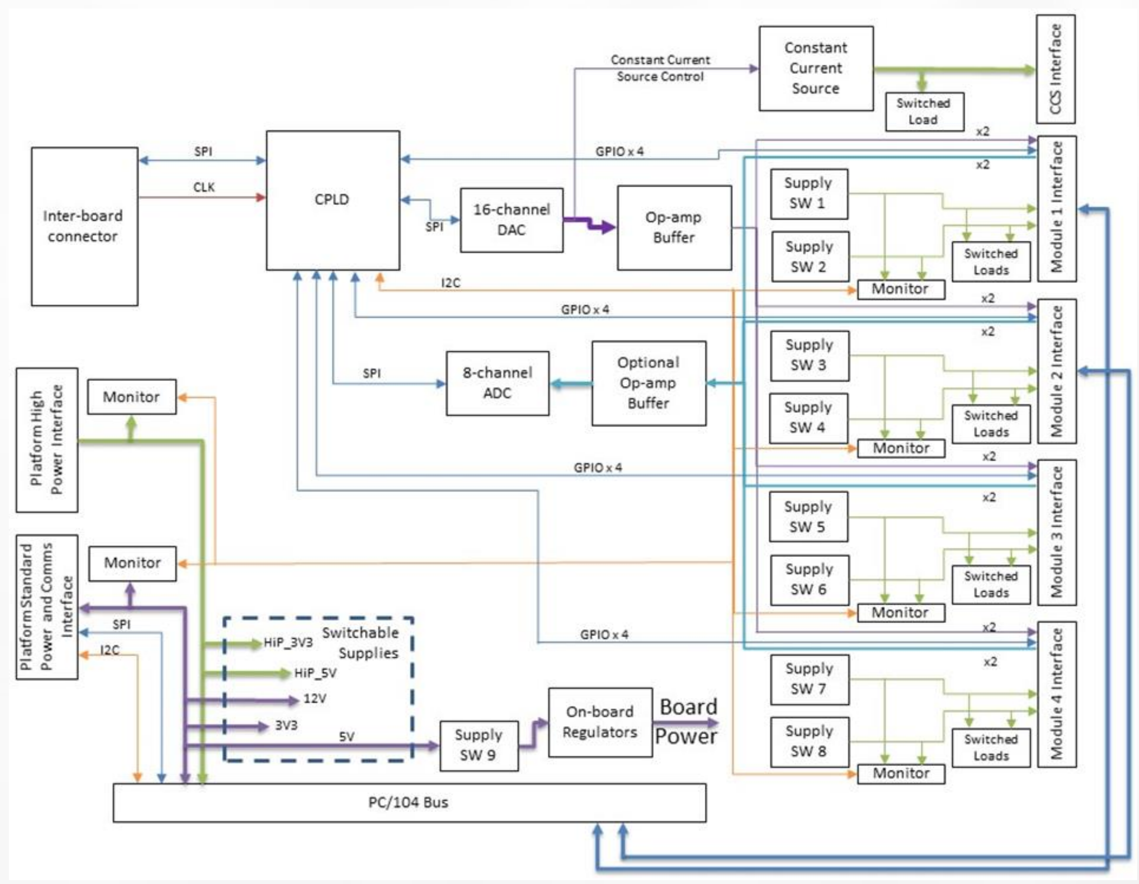
CASPA System



The Payload Assembly can be split into 3 subsystems; Electronics Subsystem (XCAM), Optical Subsystem (Gooch & Housego with Covesion and University of Southampton PPLN incorporated) and the Vacuum Subsystem or Physics Package (Teledyne e2v).

The Electronics Subsystem will provide the interface between the Platform Assembly and the rest of the cold atom experiment. It manages all communication with the Platform's on-board computer (OBC), controls the functions of the other subsystems in order to produce a cold atom cloud, and then images the cold atom cloud once it has been formed.

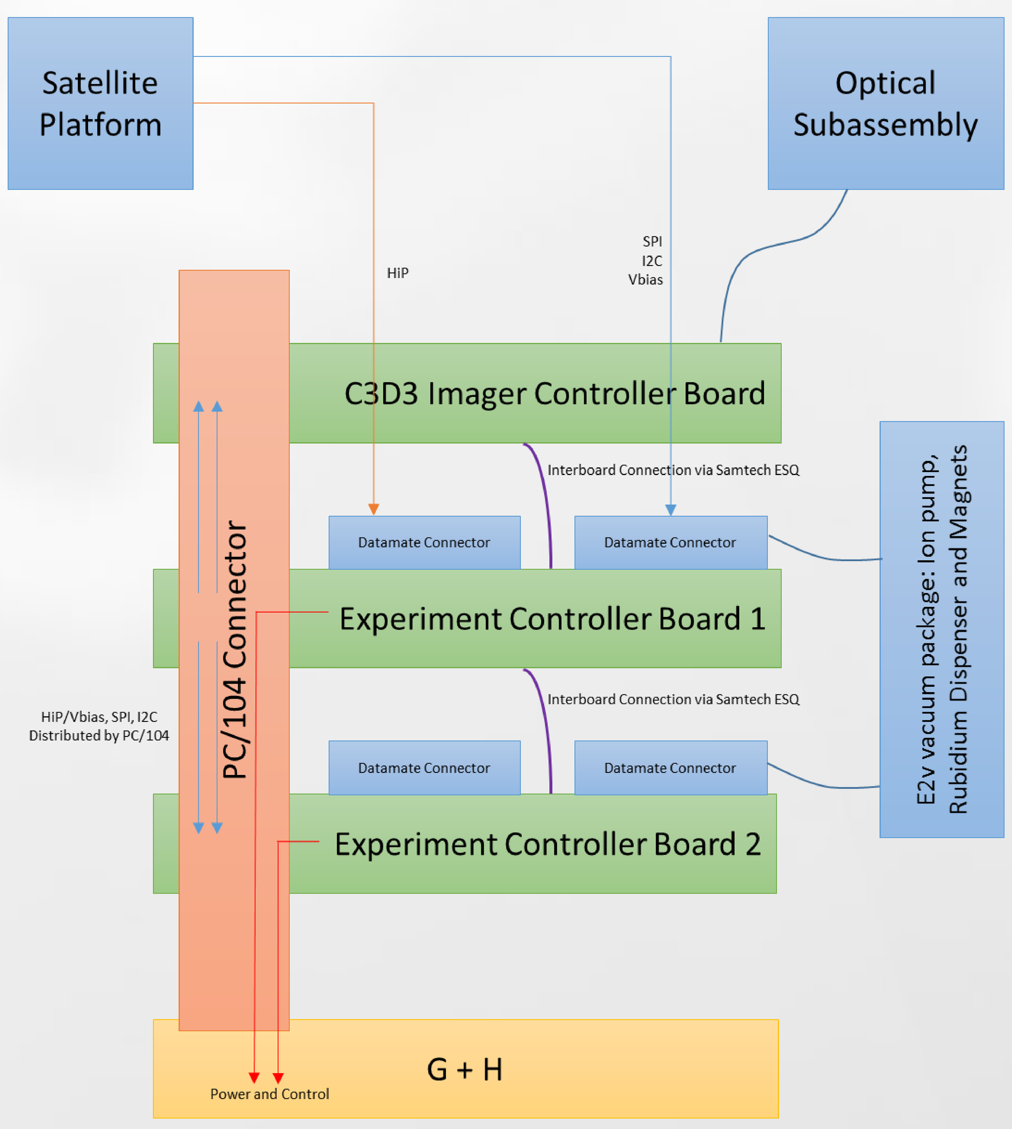
Experiment Controller



The Experiment Controllers provide the hardware to switch power rails to various parts of the Optical and Vacuum Subsystems and each has a constant current source circuit which supplies currents to parts of the Vacuum Subsystem.

The Experiment Controllers can also be used to output analogue signals, receive analogue signals and control GPIO lines to configure interfaces such as SPI. In the CASPA system, analogue inputs are received from the Vacuum Subsystem which monitors the pressure within the vacuum chamber. There are also six GPIO lines connected to the Optical Subsystem which are configured as SPI with three chip selects to communicate and control the laser.

The Electronics Subsystem



The Electronics Subsystem is at the heart of the CASPA system where it acts as the interface between the platform and the experiment, managing the command, control and power interface to the spacecraft platform, and controlling the cold atom experiment.

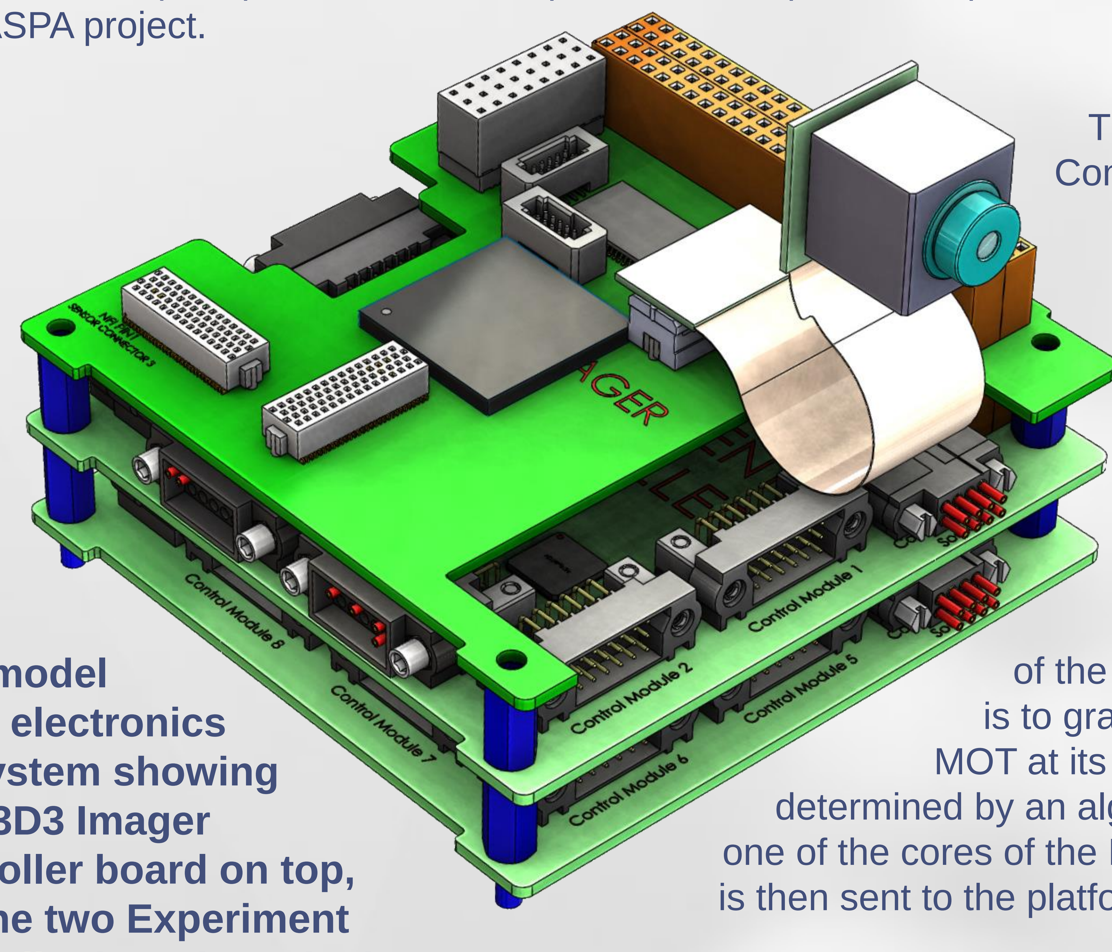
Communication is via I2C and SPI, with high-speed LVDS over SPI designed into the hardware for later development. A USB2 link is provided on the imager controller board for ease of ground-based testing and a Bluetooth chip has been added for later development and use.

Whilst these components have been developed with CASPA in mind, they have been designed to be as modular and flexible as possible. All types of board can be used in combination or individually, to enable their use in many other application types covering a broad range of experiments envisaged for the CubeSat or a small satellite platform.

C3D3 Imager Controller

The C3D3 Imager Controller not only controls the Camera which will take the magneto-optical trap (MOT) Image, but effectively controls the whole experiment. It does this using three processor cores embedded within its FPGA:

- Communications Processor – handles all communications between the platform and the other two processor cores.
- Data Processor – handles the interface to the Camera and grabs images under the control of the Communications Processor.
- Experiment (User) Processor – this processor will perform experimental control for the CASPA project.



CAD model of the electronics subsystem showing the C3D3 Imager Controller board on top, and the two Experiment Controller boards at the bottom.

The software in the Communications and Data Processors has already been proven on C3D and C3D2 missions and will be largely unchanged.

The ultimate goal of the Imager Controller is to grab an image of the MOT at its optimum moment determined by an algorithm running in one of the cores of the FPGA. The image is then sent to the platform.