ESAT
The Hands-On Training Satellite

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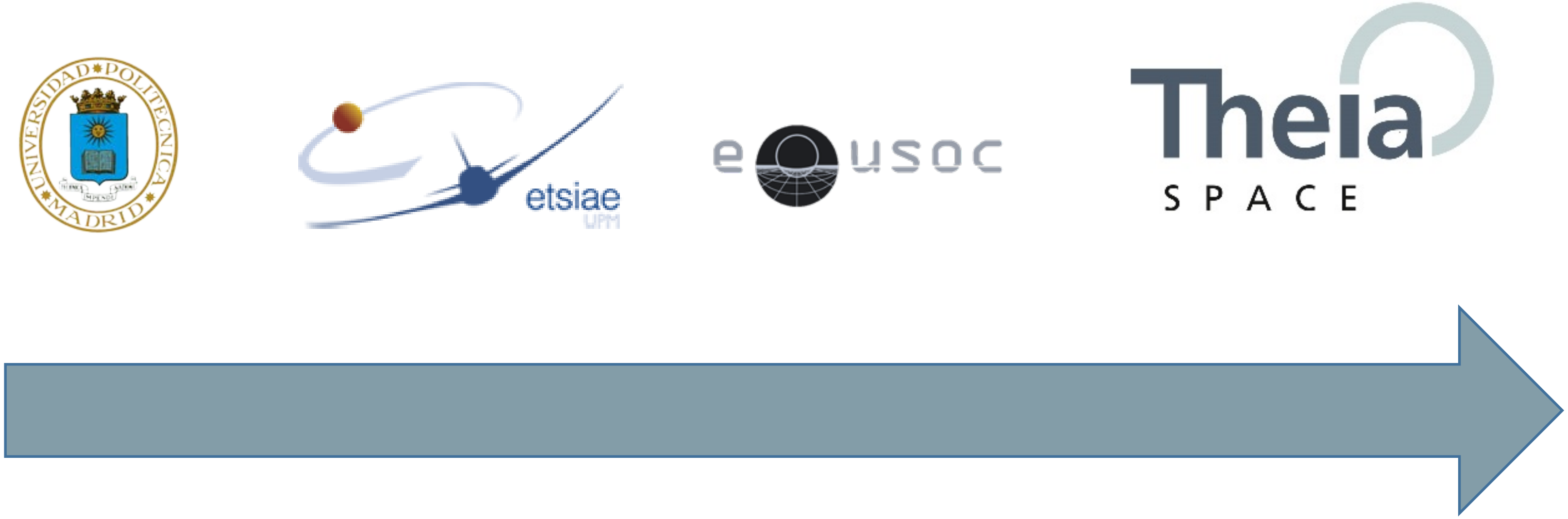
Theia Space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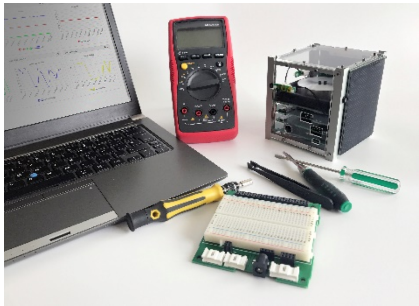
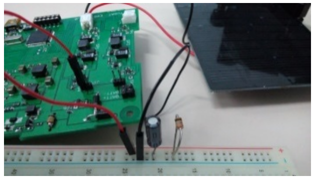
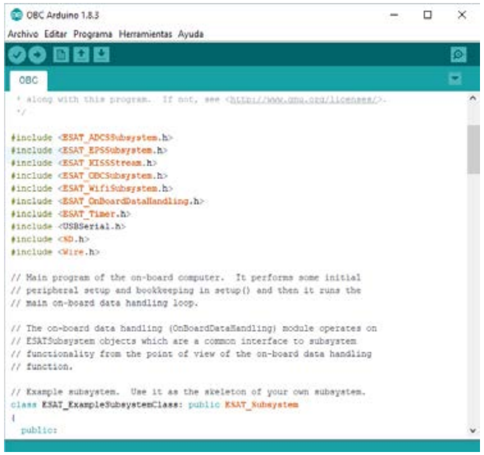
Theia SPACE

ESAT Objectives

- Teach space systems engineering.
- Teach how the different subsystems and architectures work and interact with each other.
- Teach how the integration and validation tests are performed.
- Possibility to work with the subsystems stand-alone or integrated.
- Easy to use and robust.
- Community oriented.
- Easy to build on it:
  - Open Source SW
  - Easy programming interface
  - Serial Interface







```
 * along with this program.  If not, see <http://www.gnu.org/licenses/>.
 */

#include <ESAT_ADCSSubsystem.h>
#include <ESAT_EPSSubsystem.h>
#include <ESAT_KISSStream.h>
#include <ESAT_OBCSubsystem.h>
#include <ESAT_WifiSubsystem.h>
#include <ESAT_OnBoardDataHandling.h>
#include <ESAT_Timer.h>
#include <USBSerial.h>
#include <SD.h>
#include <Wire.h>

// Main program of the on-board computer.  It performs some initial
// peripheral setup and bookkeeping in setup() and then it runs the
// main on-board data handling loop.

// The on-board data handling (OnBoardDataHandling) module operates on
// ESATSubsystem objects which are a common interface to subsystem
// functionality from the point of view of the on-board data handling
// function.

// Example subsystem.  Use it as the skeleton of your own subsystem.
class ESAT_ExampleSubsystemClass: public ESAT_Subsystem
{
  public:
```

ESAT Subsystems (I)

EPS

- 2 solar panels
- 2 solar panel regulators: MPPT/DET
- Voltage/current telemetry
- 5V, 3.3V DC/DC converters and switches
- Battery management module with overcurrent/overvoltage/undervoltage protection
- Integrated battery charger
- Programmable MCU

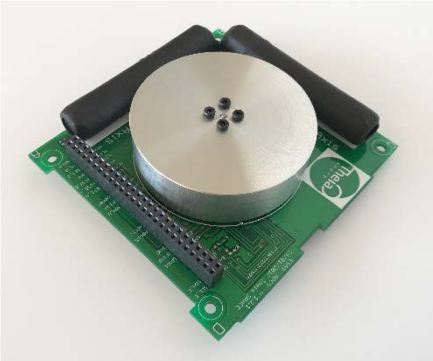
OBC

- Fully programmable unit (preprogrammed with open source base software)
- Micro-SD card
- Real Time clock
- Wireless communication via WiFi module

ESAT Subsystems (II)

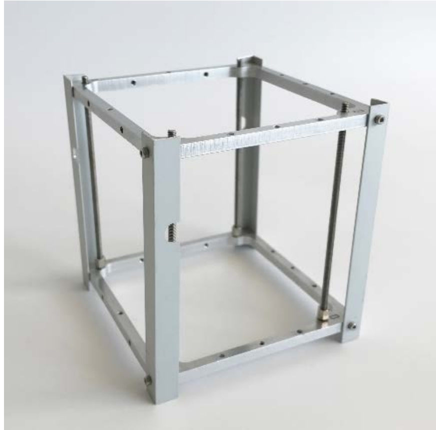
ADCS

- One reaction wheel
- Two magnetorquers
- One IMU with 9 degrees of freedom (3 accelerations, 3 gyros, 3 magnetic axis)
- 4 sun sensors
- Wheel tachometer
- Customizable control algorithms



STR

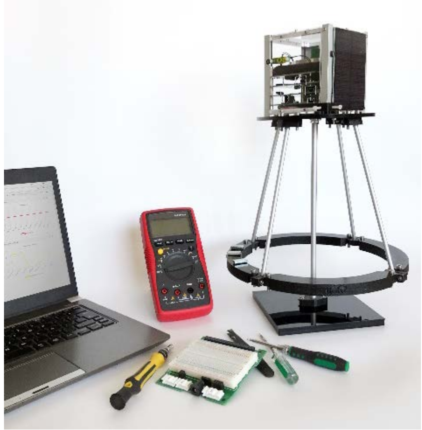
- 2 Aluminium frames
- 4 Aluminium rails
- 4 methacrylate side panels
- 2 Solar panels
- Spacers between the electronic boards



ESAT EGSE and MCS

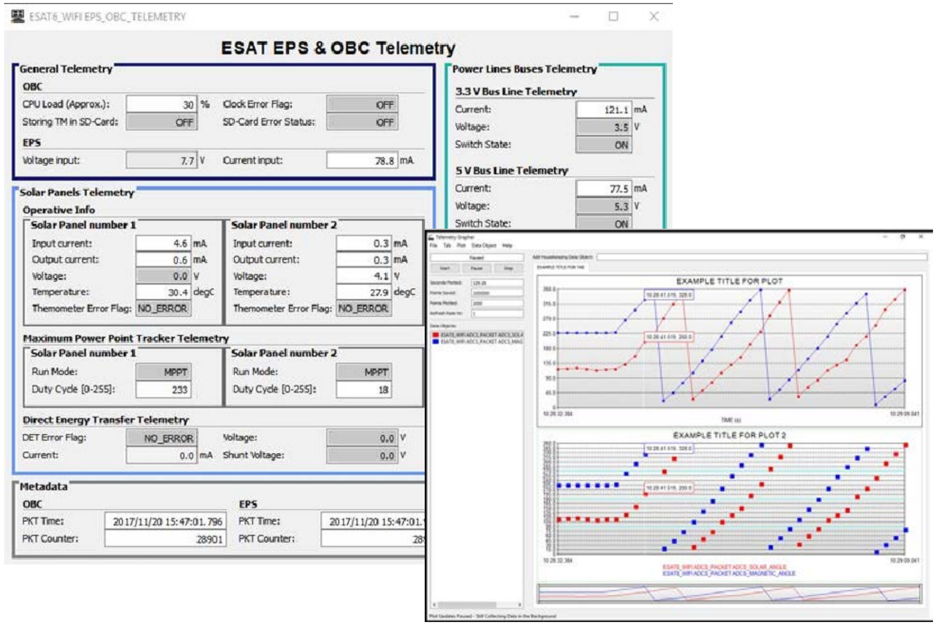
EGSE

- Turning table
- Sun simulator
- Magnets to provide a useful magnetic field



MCS

- COSMOS SW
- Telemetry visualization:
  - Raw
  - Plots
  - Subsystems displays
  - Replay
- Telecommands



ESAT6_WIFI EPS_OBC_TELEMETRY

ESAT EPS & OBC Telemetry

General Telemetry

OBC

CPU Load (Approx.): 30 %

Clock Error Flag: OFF

Storing TM in SD-Card: OFF

SD-Card Error Status: OFF

EPS

Voltage input: 7.7 V

Current input: 78.8 mA

Solar Panels Telemetry

Operative Info

Solar Panel number 1

Input current: 4.6 mA

Output current: 0.6 mA

Voltage: 0.0 V

Temperature: 30.4 degC

Themometer Error Flag: NO_ERROR

Solar Panel number 2

Input current: 0.3 mA

Output current: 0.3 mA

Voltage: 4.1 V

Temperature: 27.9 degC

Themometer Error Flag: NO_ERROR

Maximum Power Point Tracker Telemetry

Solar Panel number 1

Run Mode: MPPT

Duty Cycle [0-255]: 233

Solar Panel number 2

Run Mode: MPPT

Duty Cycle [0-255]: 18

Direct Energy Transfer Telemetry

DET Error Flag: NO_ERROR

Voltage: 0.0 V

Current: 0.0 mA

Shunt Voltage: 0.0 V

Metadata

OBC

PKT Time: 2017/11/20 15:47:01.796

PKT Counter: 28901

EPS

PKT Time: 2017/11/20 15:47:01.

PKT Counter: 28

Power Lines Buses Telemetry

3.3 V Bus Line Telemetry

Current: 121.1 mA

Voltage: 3.5 V

Switch State: ON

5 V Bus Line Telemetry

Current: 77.5 mA

Voltage: 5.3 V

Switch State: ON

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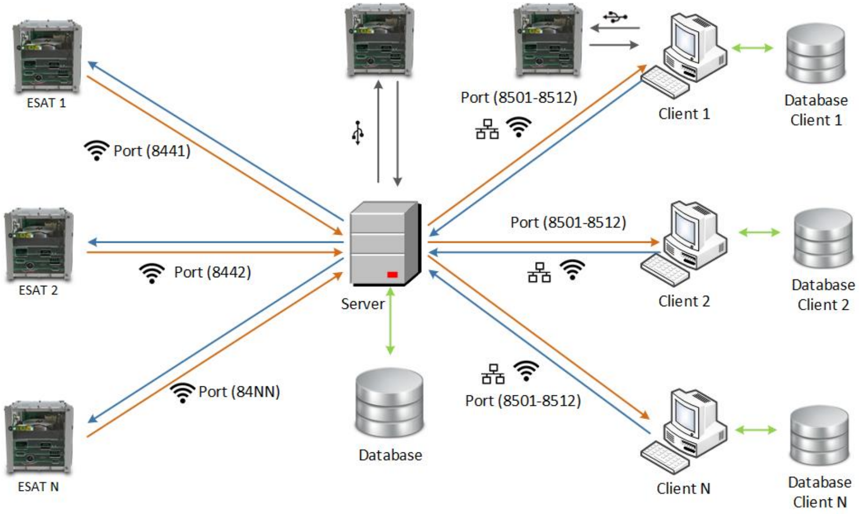
ESAT Data Management

- CCSDS and XTCE standards implemented
- A central server handles the TM sent by all the satellites and broadcasts it to the corresponding connected users (clients).
- The server forwards commands from the users to the corresponding satellites.
- The client interface helps the user interpreting the TM and sending TCs.
- Open-source code.



ESAT On-Board Software (I)

- Free/Libre/Open-Source Software, so users are welcome to:
  - Run the programs as they wish.
  - Study and modify the programs.
  - Share the programs (as they received them) with others.
  - Share the programs (as they modified them) with others.
- Available on GitHub:
  - Currently, the most popular software development platform.
  - Check our repositories at https://github.com/TheiaSpace
- Leverages the Arduino platform:
  - Popular among artists, hobbyists, students and educators.
  - Well-established community.
  - Lots of learning resources.
  - Quick, easy and simple setup.
  - Also Free/Libre/Open-Source Software.

ESAT On-Board Software (II)

- Designed with user-extensibility and user-modifiability in mind.
- Common utility library:
  - CCSDS Space Packets.
  - CCSDS-over-I2C transfer protocol.
  - Data conversions.
  - Timekeeping.
- Per-subsystem libraries/programs:
  - Subsystem programs are Arduino example programs/sketches.
  - Low-level details are handled by the libraries.
  - Plug-in architecture: the user can add new functionality (including low-level functionality) directly from the Arduino sketch.

Potential Users

- STEM education
- Universities
- Space Companies
- Space Agencies

- Training
- Fast prototyping
- Satellite programmes
- Outreach activities
- First step towards a real satellite

- We provide courses

Thank you!

Jose Miguel Ezquerro Navarro

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