1. The OpenSTEM Labs Concept

Traditional university model: students and teachers co-located in a lab; available during office hours.

The OpenSTEM Labs concept connects students to state-of-the-art instrumentation for practical enquiries over the internet – distance no object and open all hours. Apparatus for experiments and observations is set up at various appropriate locations in labs and at observatories. Students and teachers access the equipment remotely via web-browsers to send control commands, and to receive data downloads and performance monitoring data, including audio and webcams that provide sense of presence. Apparatus can be linked to single user or a group of users as required. Scalability comes through smart reservations and duplicate sets.

2. The Challenges

We have about 19,000 FTE students studying STEM subjects. For many of them practical work is essential for their skills development. The OpenSTEM Labs provide a 21st Century delivery platform for practical skills in STEM: *real data, authentic interfaces, real-time*. We exploit the ubiquity of web-browsers, the versatility of HTML5, the speed of light and imaginative approaches to minimising latency in networks. The delivery challenges for the project relate to engaging multiple stakeholders with disruptive innovation. It was essential to ensure compatibility with existing campus infrastructure and IT requirements, while giving students the best possible user-experience.

Multi-stakeholder engagement

- Estates team (OU) to oversee building work on campus and at remote site (International Astronomical Observatory in Tenerife).
- IT network team (OU) to manage data traffic and high-reliability access to student-facing internet.
- Purchasing team to ensure compliance with OU policy and EU obligations for large-ticket purchases.
- Academic 'ownership' of instruments to ensure alignment with curriculum.

Compatibility with campus infrastructure, remote locations and the Internet

- Real instruments in physical location determined by operational requirements, whether inside fume-hoods or on roof-tops or up mountains or in orbit.
- Secure connectivity through institutional firewalls – allows apparatus to be situated in appropriate digital environments, with low latency connections for real-time control of equipment.
- Adaptation of commercial equipment not originally intended for routine, web-based student-use.

User-experience for students

- Interfaces in HTML5 – ensures compatibility with a range of browsers and the most common internet-enabled communication devices (PCs, laptops, tablets, smart phones).
- Accessibility standards compatible with OU practice.
- Data management system to store and distribute high-resolution image files, and video.

Lab-management

- Software platform to host the Internet of Laboratory Things.
- Instrument and connection status dashboards.
- Integrated booking-system and protocols for remote control instruments.

Capacity for growth

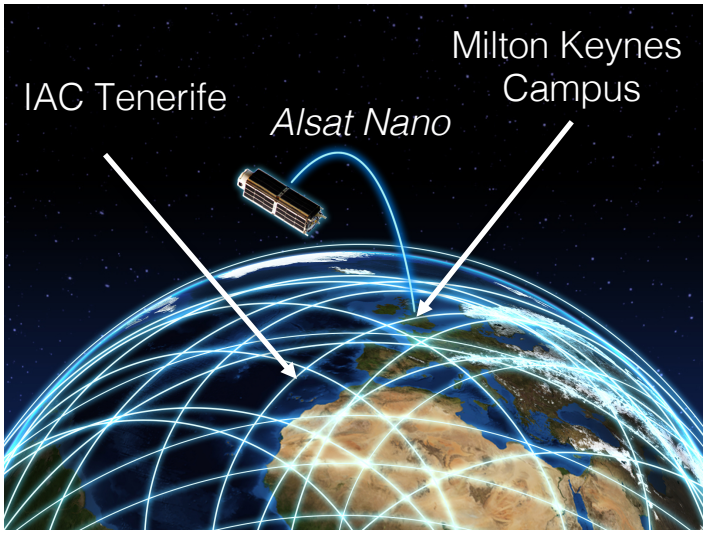
- Re-configurability for specific audiences.
- Third party use (eg other HEIs, secondary education sector…).
- Expandability to accommodate future plans for replication and diversification of our Internet of Laboratory Things.

3. Steering Group and liaison network

The project development was facilitated by ensuring high-level buy-in by the steering group, which comprised senior managers from the key institutional units.

*LTI = Learning Teaching & Innovation

4. Locations, Equipment and Users



The world is now connected to an unprecedented degree. Fibre-optic cables criss-cross the globe. Data packets and control commands can circumnavigate the world in the same time that it takes humans to react to an event occurring right in front of them.

Thus there is now no longer a compelling argument to routinely incur the cost of co-locating people and equipment. Students in a class no longer need to learn in the same time-zone, let alone the same building.

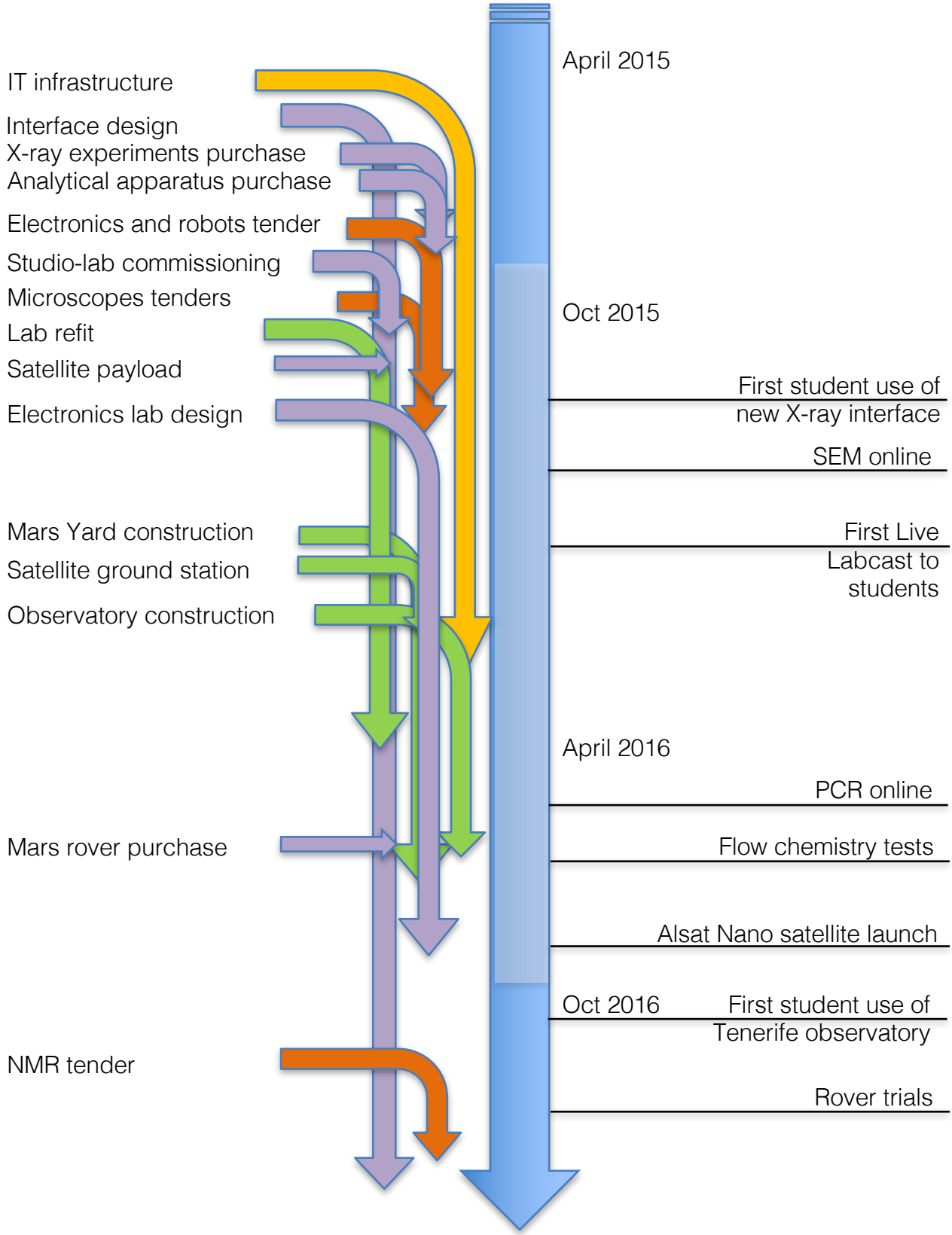
To make the most of this opportunity we have constructed an Internet of Laboratory Things – aka the OpenSTEM Labs

In this initial phase of establishing the OpenSTEM Labs we have added the following to our Internet of Laboratory Things:

- 80 x electronics work-stations featuring
- 7 x programmable, collaborative robots
- 7 x analytical-chemistry tools (FTIR, PCR, UV-vis spectrophotometry, HPLC, GCMS, auto-titrator, NMR)
- 2 x scanning electron microscopes
- 2 x optical microscopes
- 2 x relocation and reconfiguration of optical telescopes in new domes (at the Instituto de Astrofísica de Canarias on Tenerife) plus new telescope operating systems
- 1 x enclosed ‘Mars landscape’ and remote-controlled, multi-user, Mars rover
- 1 x cloud chamber
- 1 x flow-chemistry reactor
- 1 x satellite ground-station and a component of satellite payload (on board Algerian-UK cube-sat, *Alsat Nano*)
- 1 x studio-lab for livestreaming of experiments

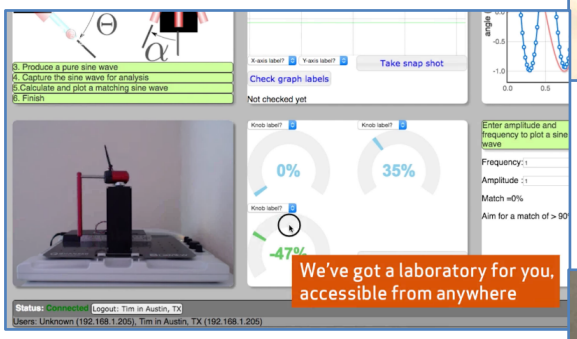
5. Indicative Time-line

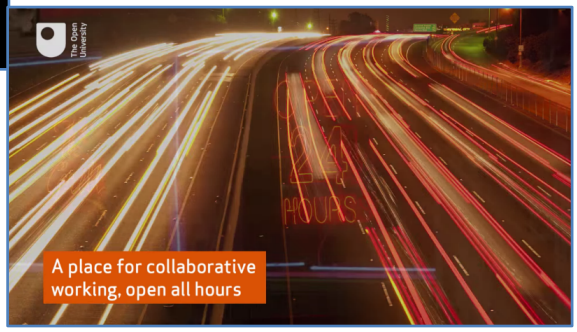
For clarity, this time-line features only a representative set of acquisitions, commissioning etc.



6. The Open STEM Labs:

An Internet of Laboratory Things





Frames extracted from a short promotional video aimed at OU students, showcasing the potential of the OpenSTEM Labs.