

Cubesats for Innovation, Science and Education Dr Chris Castelli Technology, Science and Exploration



7th Appleton Space Conference

What are CubeSats?

In 2000 Bob Twiggs invents "CubeSat" concept: a 1kg, 10cm x 10cm x 10cm cube.

- affordable satellites for University programmes using standardised parts.
- 2U and 3U versions give satellites commercial as well as academic research utility.
- Development on tractable timescales
 <18months
- Standard launch adapter (P-POD) greatly simplifies getting access to space









Pictures of CubeSats inside their deployment systems attached to various launch adapters

Indian PSLV (left) and a Russian Dneper (top)



ESA's VEGA rocket will carry 9 CubeSats on its maiden flight in Jan 2012

Benefits of a National CubeSat Programme

- Cost effective, fast access to space for a wider range of potential space users
- Barriers to entry are lower providing opportunities for SMEs
- An enabling technology with countless applications still to be imagined – putting innovation into action
- The ability to foster more industry & academia partnerships and knowledge exchange
- Try out new and ambitious ideas in space for less
- Help prepare our future spacecraft engineers, underpinning growth by having a skilled workforce
- Schools and universities can get involved through specific experiments
- A perfect fit for the Space Innovation and Growth Strategy











UKube-1

Advanced Mission Concepts

A 3U CubeSat being built in the UK by ClydeSpace Ltd

UKube-1 will carry 4 payloads and demonstrate new technology and science as well as flying educational packages directed at STEM education

Launch Q3 2012 on Dneper

Outcome of feasibility study funded by the TSB 'Innovation in Space' programme

~1m resolution imaging platform for disaster monitoring, EO applications and security. Constellations for global coverage for very low cost

'LIVE' Google Earth

'Live maps' could be the next evolution of online satellite EO images

- Constellation of cubesats could provide images every 20-30 mins
- Starting with medium resolution imagery ~20 m/pixel
- Deployable optics could provide hi-res imagery in 2-3 year timeframe
- Fraction of the cost of current systems





myPocketQub 442

OpenSpace365

Arduino with sensors allowing 365+ school pupils, university students and hobbyists to develop and fly virtual software payloads on-orbit for a day OpenSpace run you

Imaging payload to capture 360 degree panoramas From multiple points on-orbit to allow anyone to 'look out of the window' of UKube-1

Qubduino

Arduino with Field Programmable Gate Array (FPGA) to space qualify GBP 10 FPGA, test self Repairing algorithms and host advanced virtual payloads

SuperLab

Physics experiment to characterise thin film superconductor materials

SuperSprite

Satellite on a chip proof-of-concept with solar cells, energy storage, micro-controller and transceiver



codebase

NATIONAL INSTRUMENTS

@esa

S SOLIDWORKS



MathWorks^{*}

VEGA





TOPCAT, Topside Ionosphere and Plasmasphere Computer Assisted Tomography

Cathryn Mitchell, Robert Watson, Talini Pinto Jayawardena and Julian Rose, University of Bath



The TOPCAT payload consists of a specialised dualfrequency GPS receiver.

It will be used to study space weather through tomography, by observing the upper ionosphere and the plasmasphere.

This could validate the technique for a future constellation mission to provide real space weather maps



University of Bath PhD student Talini Pinto Jayawardena testing TOPCAT

> The ionosphere, part of the Earth's upper atmosphere

C3D – Compact CMOS Camera Demonstrator

Instrument Goals

1. TRL



- 1. Provide a technology demonstrator to improve the Technology Readiness Level of new CMOS¹ sensors 2. Correlate the effects of space radiation with ground based testing (primarily Single Event Effects and dark current increase)
 - 3. Capture images of the Earth (wide + narrow fields)

Experiment Controller



2.Radiation



3. Imaging



Uses 3 CMOS sensors, Power <1W, Mass 200g





Wide Field Imager Earth Observation

Colour CMOS sensor



¹CMOS = Complimentary Metal Oxide Semiconductor



Astrium Technology Payload

Demonstrate true random number generation for high data rate applications e.g. SAR

- Enabling technology which can be leveraged for future missions (Telecom, EOS, or Crypto)
- The main objective of this proposal is to demonstrate the feasibility of Astrium Patent 20090316898 - Random Number Generation in Orbit (Inventors: Dr Omar Eman, Peter Bennie and James Stuart Glanfield)
- Secondary objective to gather statistics on the radiation performance of an SRAM based FPGA

Conclusions

- CubeSats have revolutionised space education at University level but there are growing commercial applications.
- For the first time, real space missions are within the reach of hundreds of Universities worldwide (viz. 250 missions so far) and small companies, *including those not traditionally* associated with the space sector
- The lead has been taken by the US, Japan and Europe the UK, a pioneer of educational satellites, should not be left behind!
- Today, COTS technologies, including advanced, highly integrated processors, micro-sized imaging sensors and MEMS, give us new opportunities to develop advanced "Cubesat" missions

Key Messages

 A CubeSat platform is an ideal solution to the risks involved in developing space technologies, making it easier to climb the technology readiness ladder quickly with in-orbit demonstrations

 Can also bring new players into the market, broadening the UK's capabilities and highlighting our expertise

• With UKube-1, we are showing how academic research and commercial industry can work together to exchange knowledge and develop innovative systems and applications – *putting innovation into practice*

• CubeSats can play a wider role in education, supporting the broader Science Technology Engineering & Maths agenda

 Having a national cubesat programme will be an essential element of the UK Space Agency strategy for growth

 Today's students will become the flag-bearers for "doing space differently" – fostering a new spirit of innovation and entrepreneurship in space!