

The NSF CubeSat Programme

A Model for the UK?

Dr Jolyon Reburn

Spectroscopy Group Leader

Deputy Head

Earth Observation and Atmospheric Science Division

STFC RAL Space

CEOI-ST Workshop on Affordable Space



Content

- Introductions
 - People, References, Purpose
- CubeSats
- The NSF Program
 - Goals & Objectives
 - Selection
 - Examples
 - Approach
 - Philosophy
- A UK Programme?
 - Discussion



Introductions

Therese Moretto Jorgensen

Program Director, Space Weather Research
Division of Atmospheric and Geospace Sciences
National Science Foundation (NSF)

Richard Behnke

Head, Geospace Science Section
NSF

Jolyon Reburn

NSF CubeSat Review Panellist 2009, 2014
STFC RAL Space

References

Annual Report 2013

NSF Cubesat-based Science Missions for Geospace and Atmospheric Research

Nature, Volume 508, 17 April 2014

Mini satellites prove their scientific power

CubeSat Homepage

<http://www.cubesat.org/>

The aim of this talk is to outline the
NSF CubeSat Program
and so inform, suggest, encourage, and
answer the question in the title!

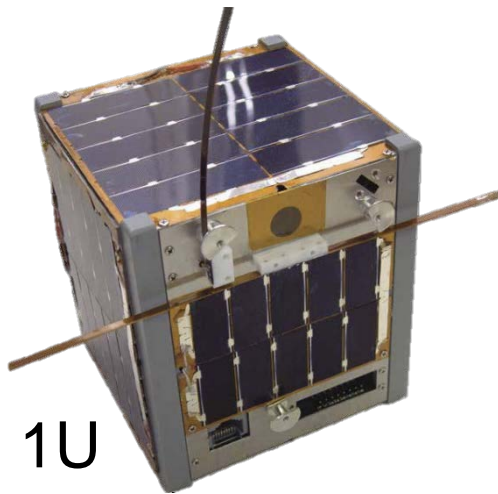
What are CubeSats ?

- A pico-satellite standard defined in 1999 by Jordi Puig-Suari, CalPoly, and Bob Twiggs, Stanford
- Small satellites with standards for build and launch
- Envisaged to be secondary payloads

Features

- Standardisation, simplicity, low risk and cost
- Size unit (1U) is a ~10cm cube with a mass of up to 1.33kg
- Typical sizes are: 1U to 6U
- Use of COTS components
- Deployed using a P-POD (Poly Picosatellite Orbital Deployer)

CubeSats



1U

3U



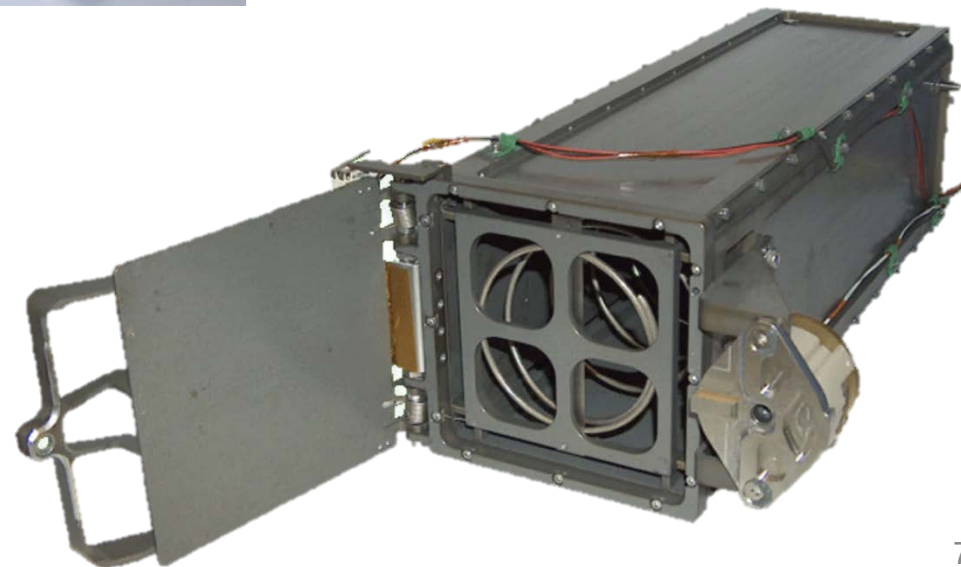
1.5U



P-POD



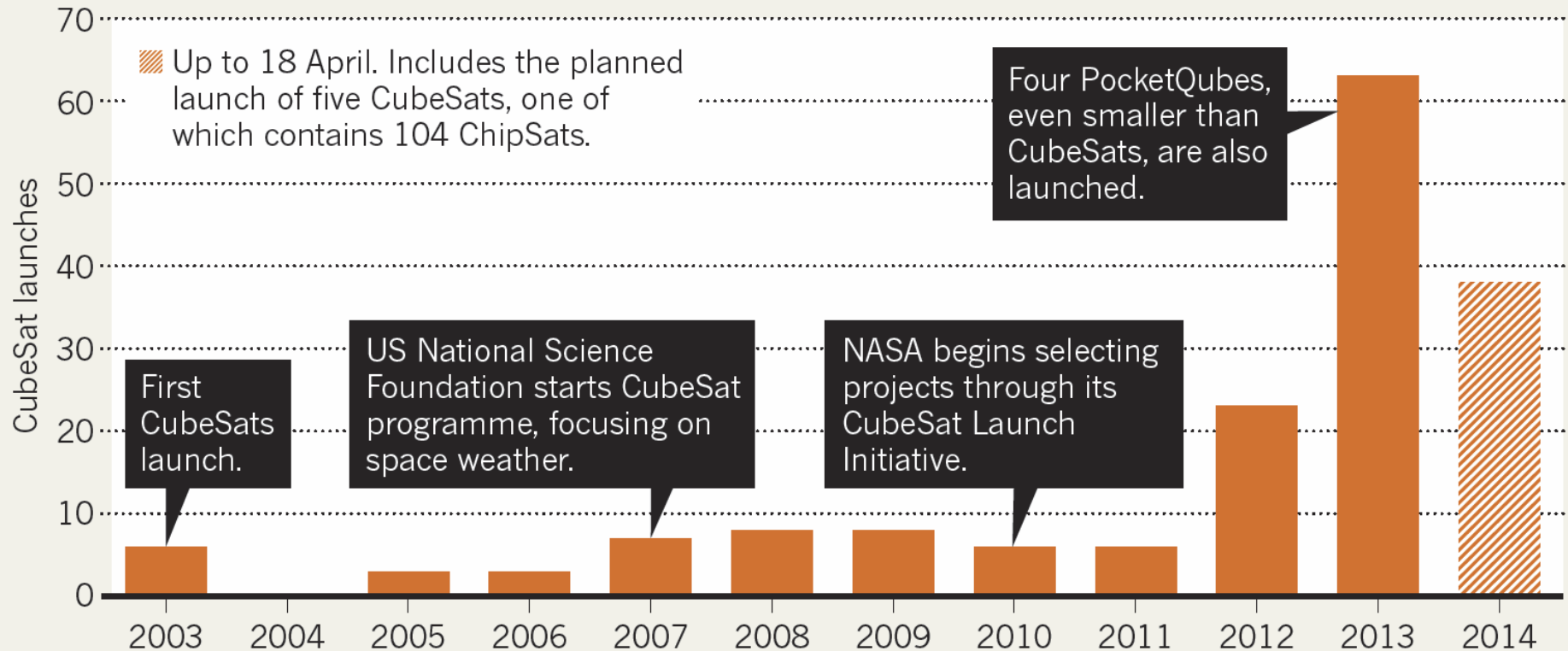
FIREBIRD- I: Flight Units 1 and 2



CubeSat Launches

GOOD THINGS IN SMALL PACKAGES

Launches of mini satellites called CubeSats reached a high last year, thanks to low-cost, standardized parts and increased deployment opportunities.



The NSF Program

- Program run by the NSF since 2008
 - Implements a novel approach to providing the scientific measurements in and from space that are critical for advancing discovery and understanding in many areas of science
- Based on CubeSats because:
 - they can be launched as secondary payloads
 - with virtually no risk to the launch vehicle or its primary payload
 - leading to very low cost and rapid time scales

Goals and Objectives

- The NSF CubeSat program pursues a dual goal
 - to promote original and stimulating STEM education and workforce development
 - to support frontline, interdisciplinary scientific research and technology advances by exploring untraditional, creative, and low-cost ways to provide space measurements for scientific research
- Specific objectives
 - execute small scientific satellite missions to advance space and atmospheric research
 - provide essential opportunities to train the next generation of experimental space scientists and aerospace engineers

The NSF Program

The program supports

- development & construction
- launch and operation
- the distribution and analysis of science data from the missions

The programme has funded 10+ missions at ~ US \$900,000 each

Launches are not part of the program but are provided by

- the US DOD on a collaborative or reimbursable basis and
- NASA through their Educational launch program (ELaNa)

Project Selection

Annual call, ~25 proposals scientifically and technically reviewed, 1-2 selected

Criteria

- **Compelling Science Case**

The uniqueness and importance of the observations and measurements they obtain for addressing key outstanding science questions

- **Exceptional Student Training**

The extensive and outstanding education and training opportunities they offer and the high level of student involvement in all of the various aspects of the missions

- **Technical Ingenuity and Feasibility**

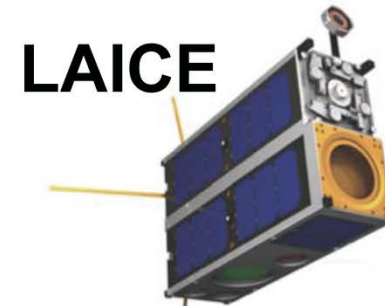
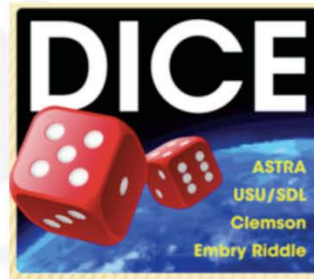
The significant degree to which they advance and make use of emerging technologies while demonstrating satisfactory technological readiness or heritage

- **Strong Team Building and Management**

The soundness of their plans for collaboration, management, scheduling, and risk reduction throughout the development, operations, and science phases of the mission, respectively

NSF CubeSats

So far, the program has carried out 4+ competitions resulting in a total of 10+ projects
Typically, the grants awarded are in the amount of \$900,000 and of 3 years duration

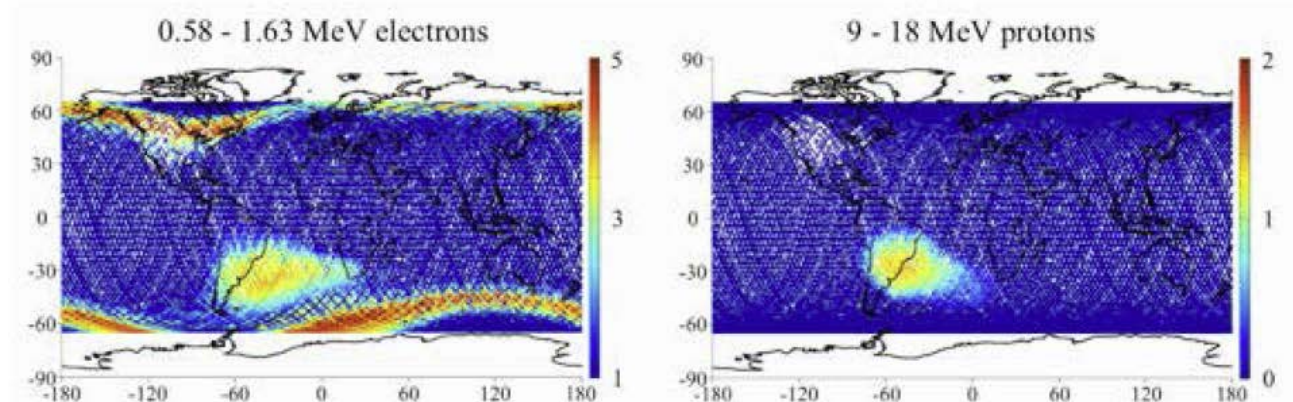
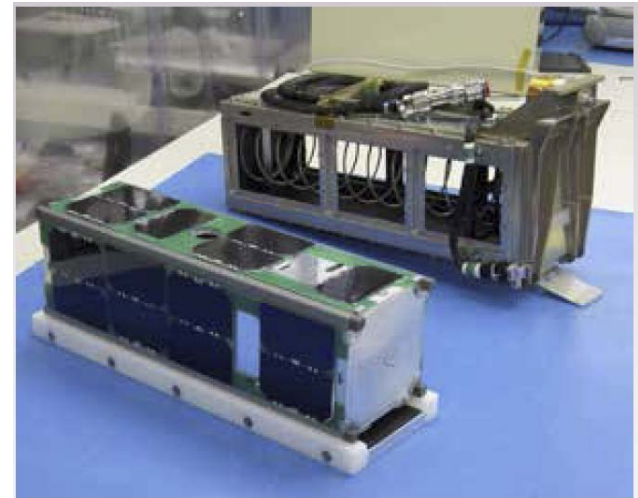


LAICE



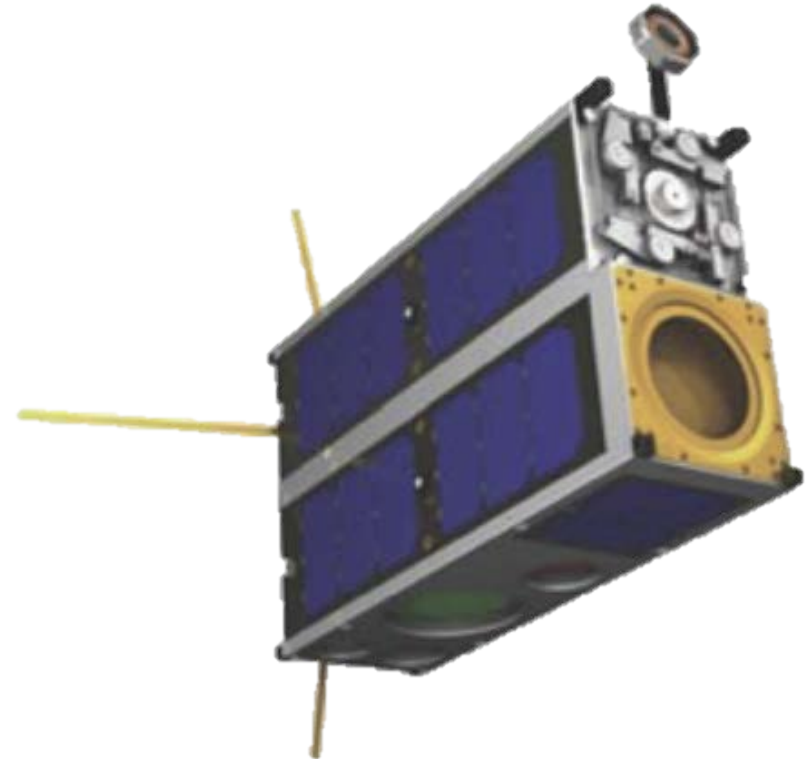
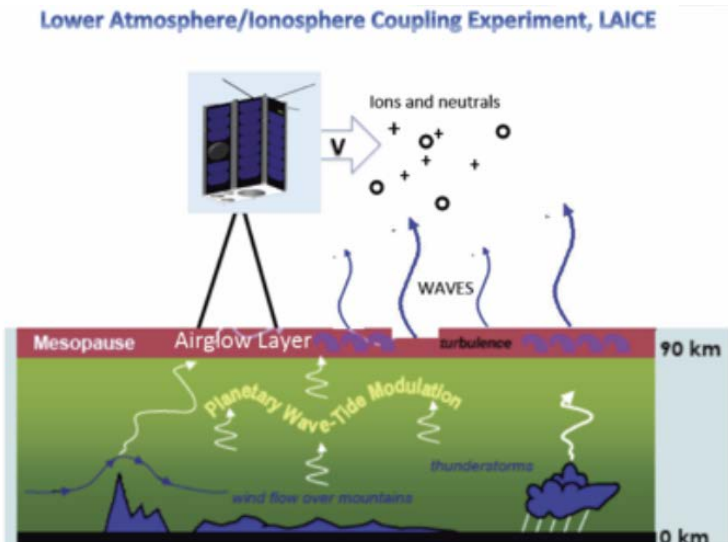
Colorado Student Space Weather Experiment

- U. Colorado, Boulder
- Solar proton events & radiation belt dynamics
 - 3U CubeSat
 - Energetic electrons (0.5-3MeV) and protons (10-40MeV)
- Launched Sep 2012
 - Complete mission success
 - More than 2 years operation



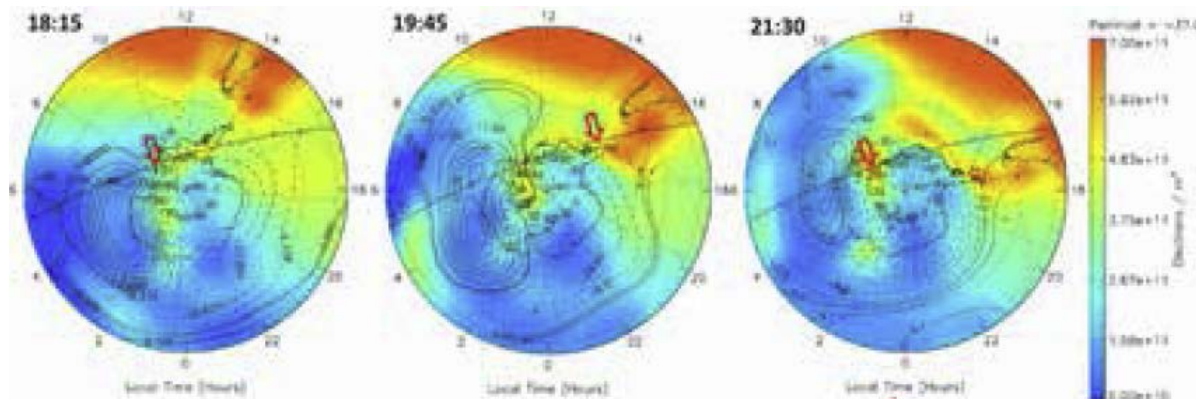
Lower Atmosphere/Ionosphere Coupling Experiment

- Virginia Tech; U. Illinois; Aerospace Corp. & NWRA, Inc.
- Atmospheric gravity waves
 - 6U CubeSat
 - In-situ and remote sensing; plasma and neutral temperature and density; airglow ~90km
- Project Started May 2013
 - Expected launch early 2016



CubeSat Contributions

- Fill in gaps in coverage
 - Geographic, local time, sky-view, long-time monitoring
- Small-scale structure
 - Multi-point measurements to avoid space-time aliasing
- Interferometry & Tomography
 - Satellite constellations
- New measurements
 - Technology experiments



DICE plasma density observation compared with model

The NSF Program

The program employs a management approach that is unusual for satellite programs:

- Minimal directives and oversight obligations are imposed on the management of the projects during their implementation, with the only strict requirements being the ones that are dictated by launch acceptance.
- This implies that the Principal Investigators of the projects are fully responsible for conducting the missions, including scheduling, reviews, testing, documentation, and risk management, and for meeting the requirements for any of this set by the launch provider.

Project Support

- Technical and management support
 - through the collaboration with NASA Wallops Flight Facility (WFF)
 - includes access to test and ground-station facilities
 - contributes essential engineering and mission management expertise and capabilities that are critical for ensuring that all of the missions are successfully qualified for launch and completed
 - limited in scope but a crucial element of the program
- Open inter-team discussions
 - to promote transfer of knowledge
 - develop and implement best practices
 - provide continuity between the individual projects



The NSF Approach

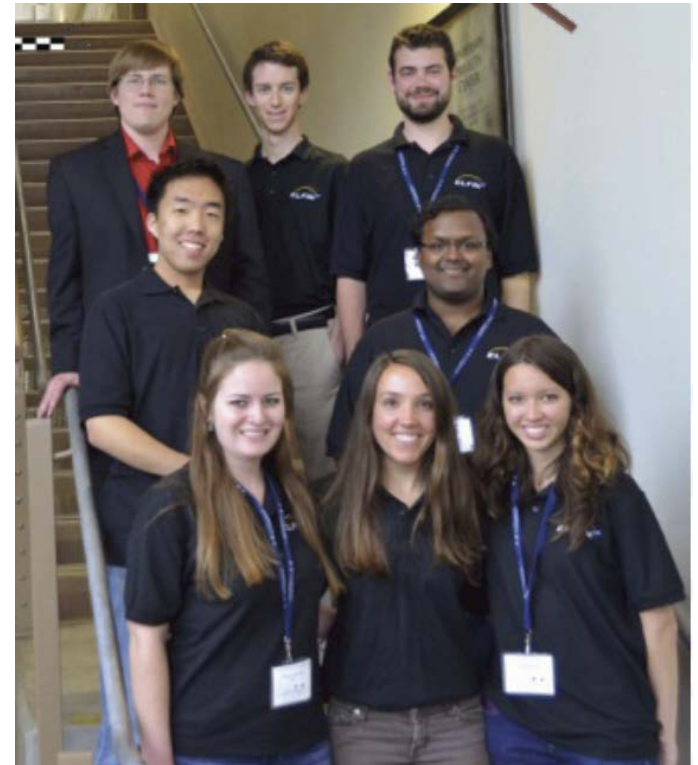
The Program

- makes space measurements achievable within the scope of the traditional NSF grants programs (~3 years)
- greatly enhances the participation of the larger university community in space activities
- spurs science innovation and creativity and also motivates and inspires engineering inventions and advances

The NSF Approach

The Projects

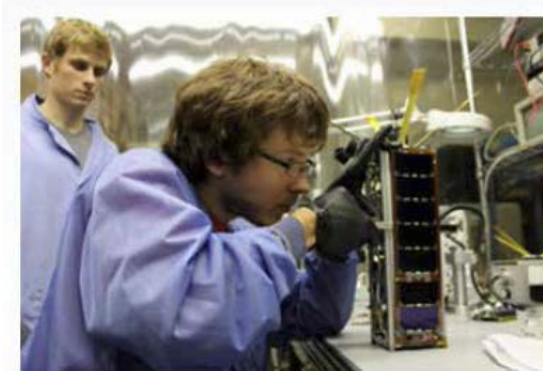
- offer extraordinary educational benefits, allowing students, through hands-on work on real, exciting, end-to-end projects, to develop the necessary skills and experience needed to succeed in STEM careers
- are also an effective tool to broaden the participation amongst underrepresented groups in STEM research and education
- stimulate widespread excitement and involve a uniquely diverse set of skills and interests and so appeal to a broader range of participants than more traditional science and engineering projects



A UK Programme?

- **Benefits**

- Training
- Low cost and risk
- Wide interest
 - Academia
 - Institutes
 - Industry
- Sustainability
- Showcase
- Speed and impact



Some of the RAX team members in the Michigan Exploration Laboratory (MXL) of Professor James Cutler.

A UK Programme?

- Would this work in the UK?
- What can we do?
 - Advertise, support and lobby
 - Spread the word and the philosophy
 - Develop the concept
 - ...

CubeSat ISS Launch



NASA

Two 30-centimetre CubeSats released from the ISS in February 2014

