UK Cold Atom Sensors: a Fast Track Demonstrator

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Outline

1. Quantum Technologies & the UK National Programme
2. Teledyne e2v & Cold Atom Sensors
3. RAL Space & Quantum Technologies
4. Cold Atom Space Payload (‘CASPA’)
5. Conclusion (AV)
What is Quantum Technology?

- Utilising the properties and subtle effects of single or small groups of atoms or photons
Initial UK £270M investment over 5 years in 2013; grown now to £385m; phase 2 for a further 5 years being planned at similar scale: £80m hub renewal already announced 9/2018 by Chancellor
Initial UK £270M investment over 5 years in 2013; grown now to £405m; phase 2 for a further 5 years at similar scale: announced 11/2018 by Chancellor
This is Teledyne e2v
Teledyne e2v - part of Teledyne Imaging

Part of the $3bn p.a. Teledyne group

A remarkable portfolio of specialist components & systems in sensing, signal generation and processing

Machine Vision
DALSA | e2v | TS&I | ICM
Image sensors, cameras, processing hardware and software
Infrared, Visible, UV, X-Ray

Medical and Life Sciences
DALSA | e2v
Radiography detectors, Radiotherapy generators

Aerospace & Defense
e2v | TS&I | DALSA
Sensors and systems for astronomy, earth science, and defense
High reliability chipsets & subsystems

Geospatial
Optech | CARIS
Lidar & Sonar 3D Surveying, Geographic Information Systems Software

Semiconductors
DALSA | e2v
MEMS foundry
CCD foundries
Packaging services
Quantum Technology at Teledyne e2v

Gravity
Using gravity to detect objects beneath the ground for the construction sector and defence.

Space
Gravity sensing from space for future science missions. Timing from space for navigation and synchronisation.

Timing
Synchronisation of large networks in telecoms, navigation and synthetic aperture radar for defence.
**Projects**

A growing portfolio...

- FREEZERAY (Cold atom preparation)
- Gravity Imager [Dstl]
- REVEAL (commercial gravity sensor)
- Gravity Platform (ruggedization)
- MinAC (miniature atomic clock)
- CASPA (cold atom space payload)
- NSTP-2 (atomic clock for space)
- Sub-Orbital (space payload study)
- SYNCHRONICITY (atomic clocks)
- QUANTIFY (Earth observation)
- GRAM (Gravity new applications)
- Ixon Science camera (with Andor)
- KAIROS (Pioneer)
- Gravity Applications (Pioneer)
- QKD via satellite (ARQIT - Pioneer)

(*) CR&D partners in Innovate UK projects

**Partners**

- UNIVERSITY OF BIRMINGHAM
- NPL | QMI
- RSK
- XCAM
- Fraunhofer
- optocap
- ANDOR
- CATAPULT
- Fraunhofer
- UNIKLASERS
- AIRBUS Defence & Space
- Geomatix
- RAL Space
- EPSRC
- ATKINS

**Team**

- Full time equivalent staff at Te2v

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RAL Space and Quantum
The Fast Track Demonstrator

Cold Atom Space Payload (CASPA)
CASPA: Cold Atom Space PAyload
Project Lead: Teledyne e2v

**Mission**
Build a 6U CubeSat capable of autonomously producing a cold atom cloud in the space environment.

Image courtesy of Clyde Space

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Why CASPA?

• Strategic technology for ESA and NASA with additional commercial applications
• Hindered by high complexity and low TRL
• CASPA first step to address complexity, increase robustness, build TRL, develop supply chain
• UK capability and supply chain for future cold atom space instruments (building on e2v heritage in vacuum and space instrumentation)
• CubeSat constraints provide useful focus for setting clear but challenging engineering challenge
CASPA Spacecraft

- 6U CubeSat
- 4U payload
- 40W peak power
- Payload mass < 4kg
Breadboard Integration
The University of Birmingham

Physics package – Vacuum Assembly and Telescope
High Voltage Power Supply
Integrated laser system
Engineering Model Integrated

$10^7$ atoms at microkelvin temperatures
Next Phase

- CASPA project has developed much of necessary hardware / capability

- In parallel, RAL Space has developed complimentary electronics capability and other UK organisations have developed leading technology in this area

- The UK now has the capability to lead in this area

- Now is the time for the UK community to pool resources and take a leadership position by rapidly moving to an in-orbit demonstration.
Options for scale up

Time and cost to launch

Low sensitivity sensor (tech demo)
e.g. 6U CASPA CubeSat

Mid sensitivity sensor (science / commercial applications)
e.g. SSTL 42 platform

Cold atoms (tech demo)
e.g. 12U+ CubeSat

High sensitivity sensor (science mission)
e.g. GOCE

Functionality/Sensitivity

9.8

\[ g = 9.8072467 \ldots \text{m/s}^2 \]

The constituents of ‘g’

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Benefits

• Leveraging the significant investments in the current and future UK National Quantum Technology programme

• Combines best offerings from UK Quantum Sensors for Space community (industry, SME’s, academia, RTO)
  • Develops UK capability in a strategic future sensor technology
  • Lots of non-Space spin off applications
  • Big supply chain opportunities

• Builds on UK strength in cost effective, small satellite technology

• Potential to use the planned UK’s Scottish small sat launch facility

• Potential to use the National Space Test Facility at Harwell
Conclusions
Where to next

Develop the mission specifications;
• Systems, Gradiometer hardware : Teledyne E2V
• Electronics, optics : RAL Space

Accelerate developments in key areas;
• Lasers and laser control systems
• System level control, data handling

Build support and a business case
• Users (hydro, civil-eng, minerals)
• Science community

Makes the UK the World leader across science and commercial QT applications
Conclusion

- With thanks to the CASPA team:
  - TELEDYNE E2V
  - UNIVERSITY OF BIRMINGHAM
  - XCAM
  - CLYDE SPACE
  - G&H
  - covesion
  - UNIVERSITY OF SOUTHAMPTON

- With thanks to RAL Space and STFC
  - RAL Space
  - Science & Technology Facilities Council

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Thank you