

# QinetiQ Space Competencies

*Innovation for future missions*

Chris Dorn

Science on Low Cost Space Missions Workshop, Westminster

Wednesday 24th January 2007

**QinetiQ**

[www.QinetiQ.com](http://www.QinetiQ.com)

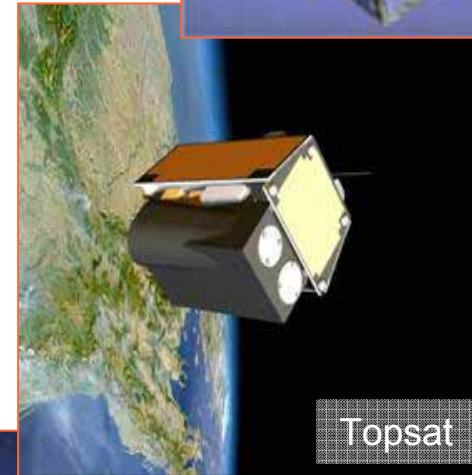
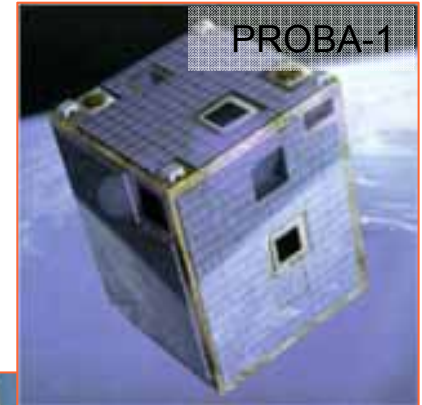
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# Overview

- Heritage missions – thinking differently
- Small satellites for Science
- Technologies to enable Small Sat Science (S<sup>3</sup>)

# Heritage Missions

- Thinking differently
  - Technology
    - New technologies, new applications of existing technologies, technology in new places
  - Teaming
    - Working with the user, focussing of their needs, building an appropriate team
  - Approach
    - Simplified approaches, “good enough”, focus on what matters
- Achieving success
  - Topsat
  - GOCE



# TopSat System

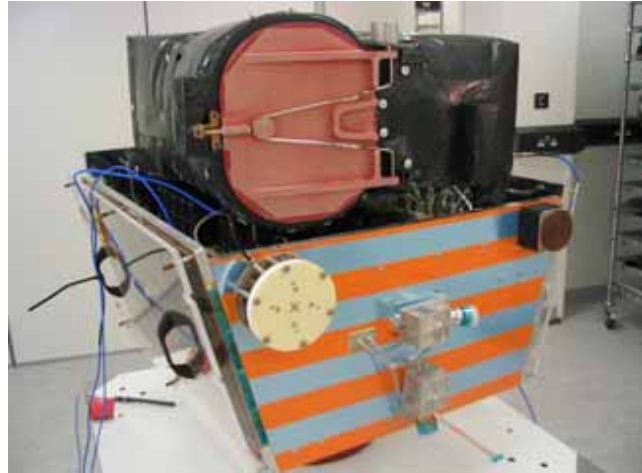
West Freugh Ground Station,  
QinetiQ



RAPIDS Mobile Ground Station,  
QinetiQ



TopSat Spacecraft  
(QinetiQ, SSTL, RAL)



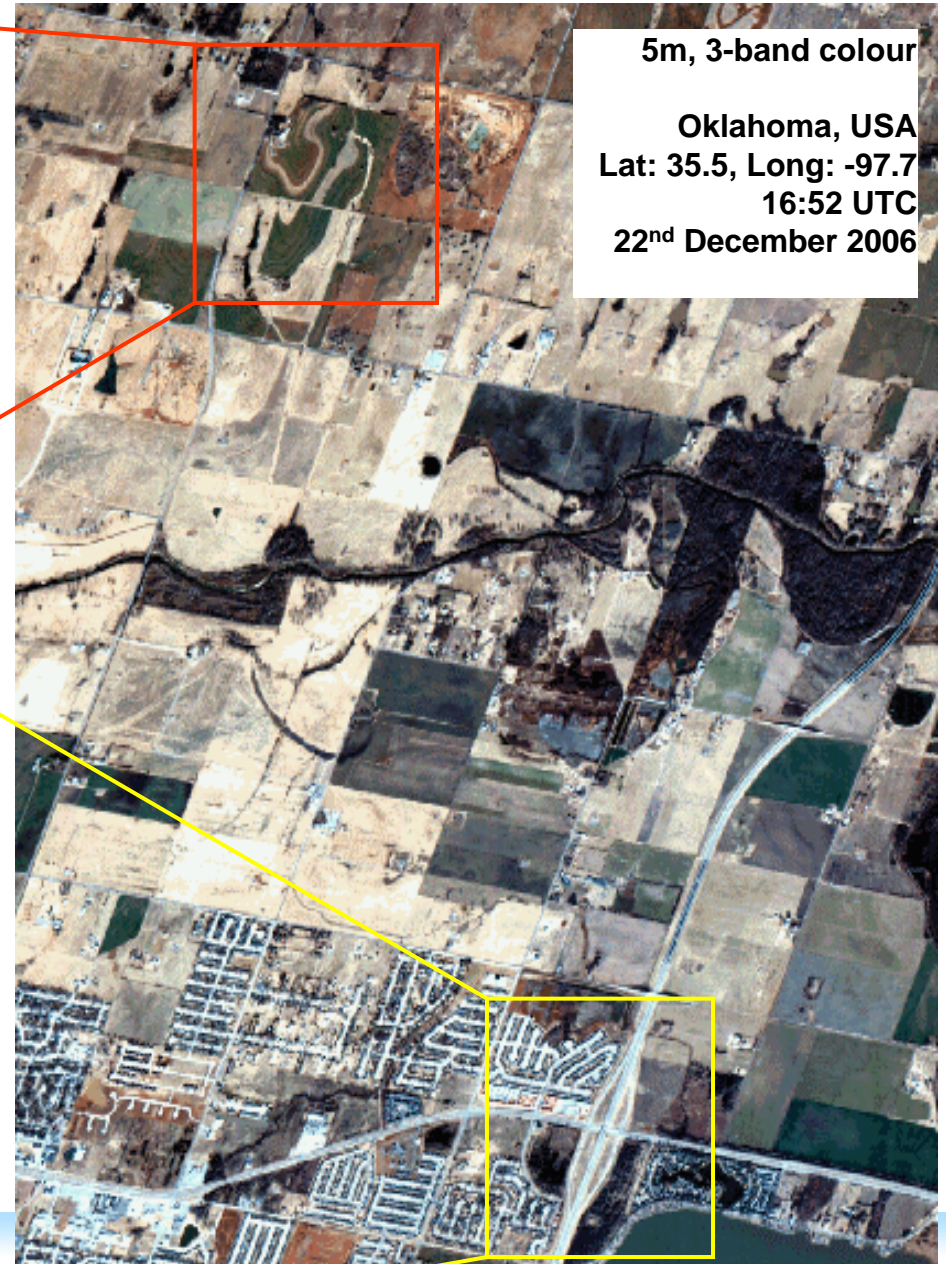
- 2.8m GSD PAN
- 5m 3-band colour
- 15km Swath
- 4 day re-visit
- ~€20M (inc launch)
- 15 months operations (and counting!)

Spacecraft TT&C  
SSTL



TopSat Payload Ops Centre,  
QinetiQ





Topsat  
Imagery

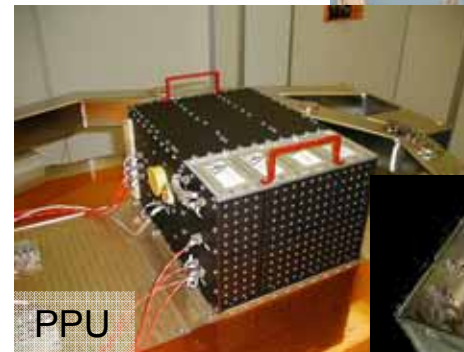
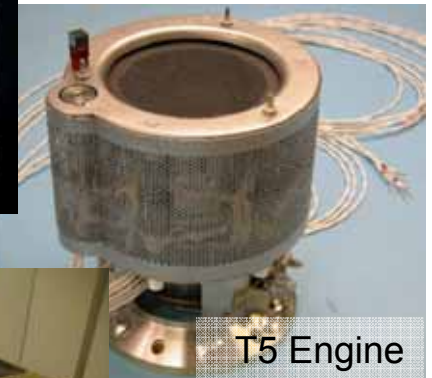


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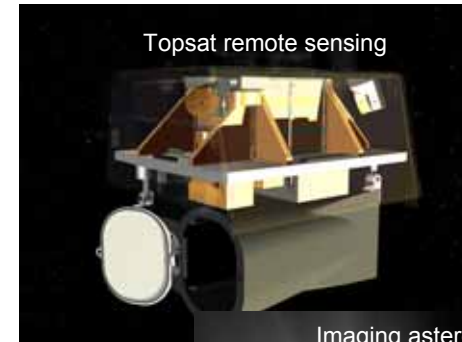
# GOCE *(Gravity Field and Steady-State Ocean Circulation Explorer)*

- Twin T5 thrusters
- Fast throttling required over a wide thrust range
  - 1-20mN Range, with control to  $\pm 12\mu\text{N}$
  - Rapid thrust response rate ( $> 2.5 \text{ mN/s}$ )
  - Simply not possible with chemical systems
- Cycle life  $> 5500$  On/Off cycles
- Mission only possible with the mass efficiency of ion engines
- 240km operational altitude  $V = 10\text{km/s}$
- 40kg of propellant for a 22 month mission
- Specialised test facility (designed with NPL) to measure thrusts down to:
  - $43\mu\text{N}$  @  $1\text{mN}$  and  $140\mu\text{N}$  @  $20\text{mN}$
- Testing completed Dec 06
- Launch due 2007 for 2 year mission



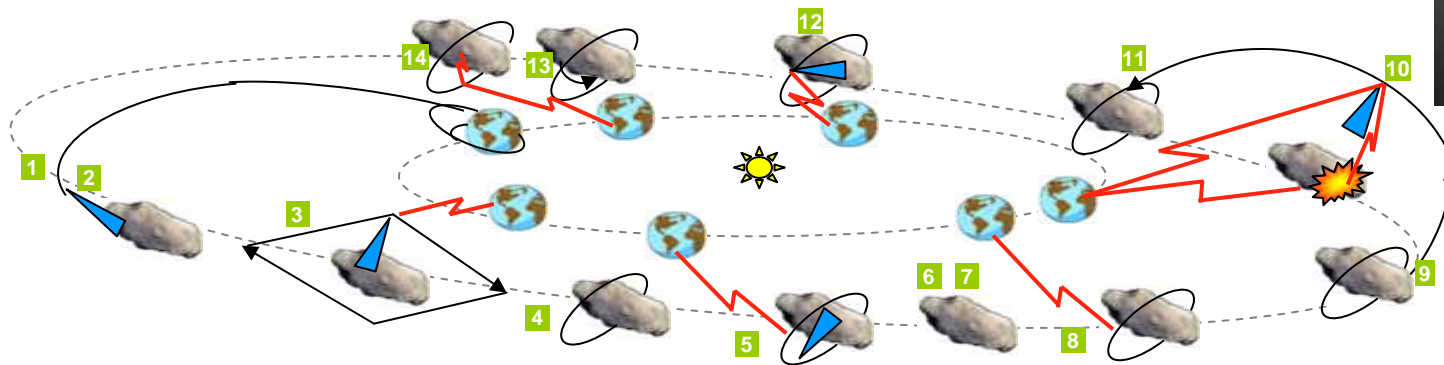
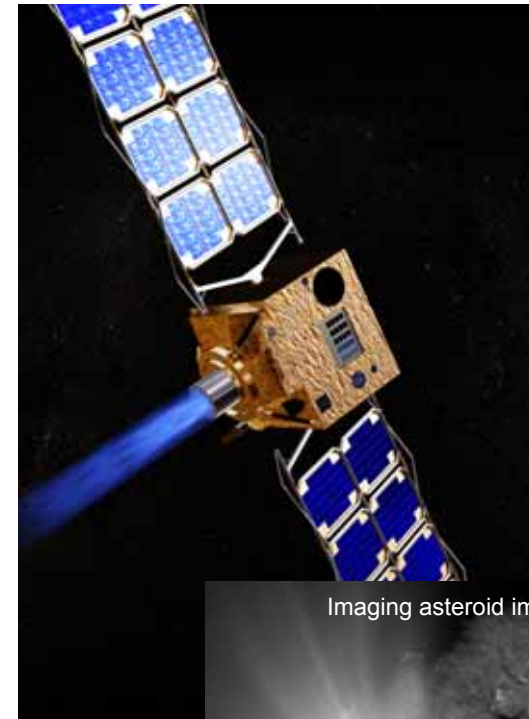
# Small Satellites for Science

- Advantages
  - More measurements = better science
  - Lower cost = affordable where previously assumed not
  - Single primary instrument = optimised missions
  - Smaller consortia = less compromise (on mission issues)
  - Shorter build times = faster response
  - Lower cost and faster response = more missions
- QinetiQ Involvement
  - Concept Development (technical and consortia)
  - System prime
  - Technology insertion (into science group designed instruments)
  - Technology adoption at bus level (for greater payload capacity)
  - Technology delivery (key subsystems with flight heritage)
  - Mission Management and operations



# Mission Example - Don Quijote

- Dual small sat mission to study and modify the orbit of an Near Earth Object.
  - 500kg Orbiter, solar electric propulsion for efficiency and versatility
  - 360kg Impactor, bi-propellant for maximum impact velocity and optimised mass.
- Optimised launch dates and options

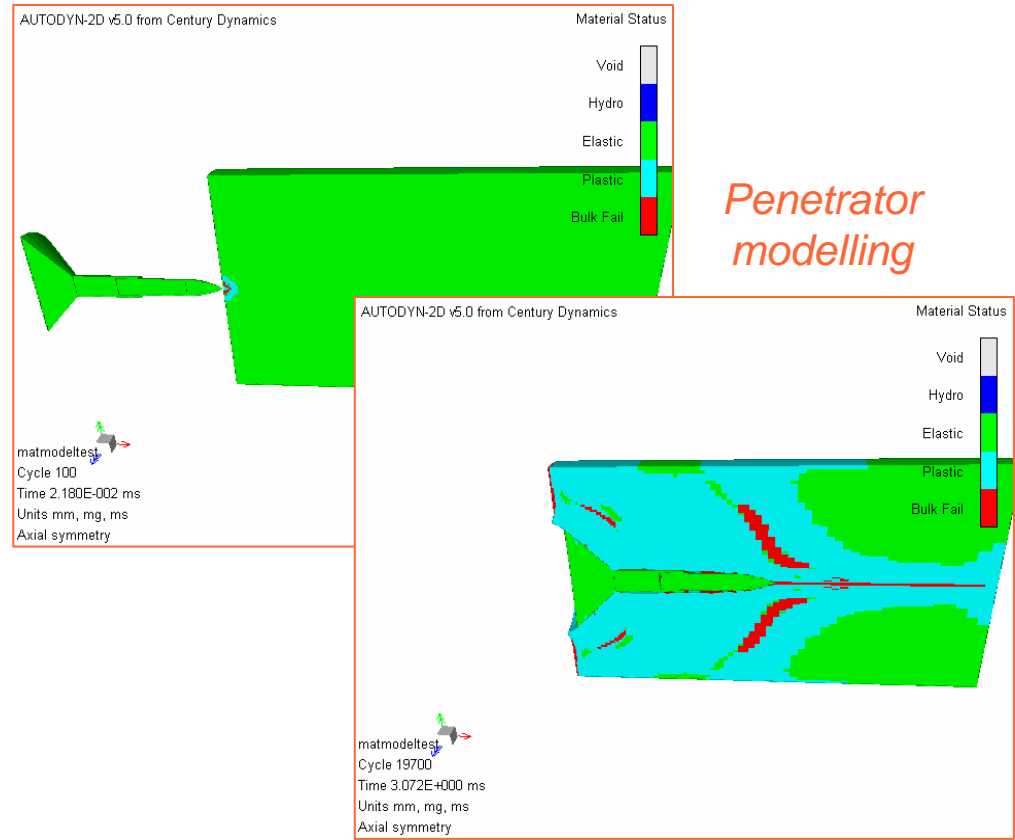


# Technologies to enable Small Sat Science (S<sup>3</sup>)

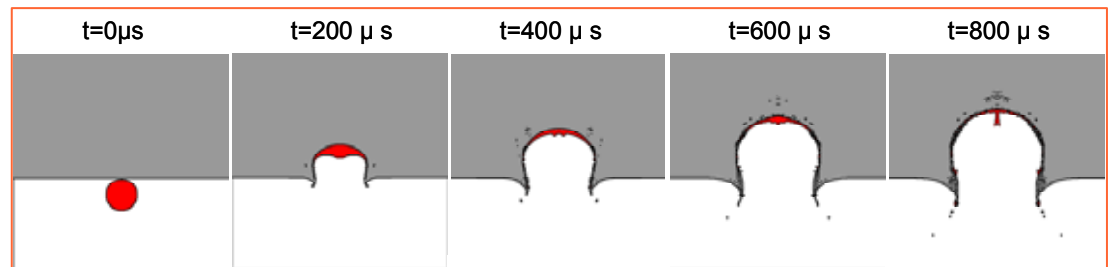
- QinetiQ has many unique technologies that have potential applications in space missions:-
  - Bus
  - Instrument
  - Operations
- The challenge is developing the technology from the laboratory to the spacecraft.
- The following are highlighted:-
  - Penetrometers for in-situ surface science
  - Hollow Wave Guides for low mass, high performance optical systems
  - Gallium Nitride for low mass, high performance microwave systems
- Many others exist – please talk to us about your specific area of interest

# Impactors and Penetrators

- Instrumented (“Smart”) shell and shaped penetrator technologies for planetary exploration
- Low cost access to surface
  - Simplified entry and decent
  - No atmosphere – no problem
  - Designed for rough landings
  - Access sub-surface features
  - Wide spacing of sensors on low cost mission
- Ejecta, impact and penetration modelling validated by gas gun experiments

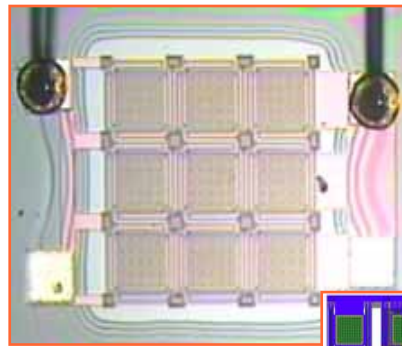


*Penetrator modelling*

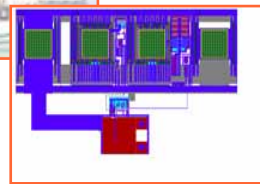


*Ejecta modelling*

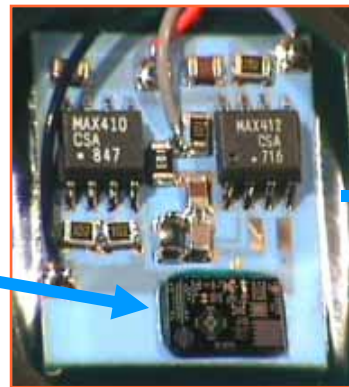
# Microsystems for High-g Environments



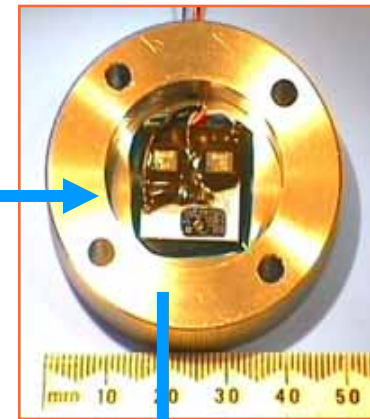
Micromachined accelerometer



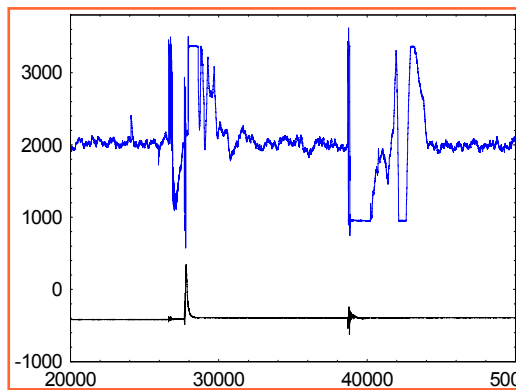
Instrumentation



Hybrid system



High g packaging



Results



Concrete target



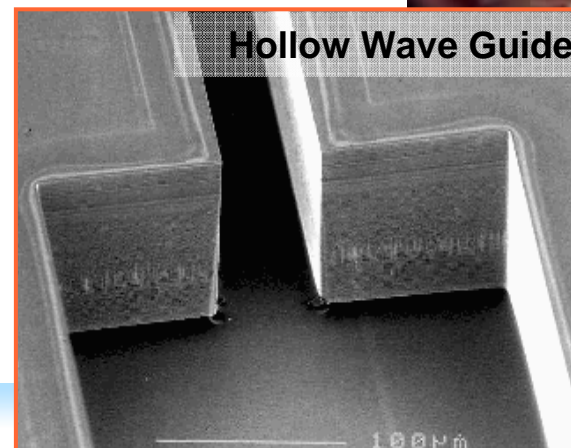
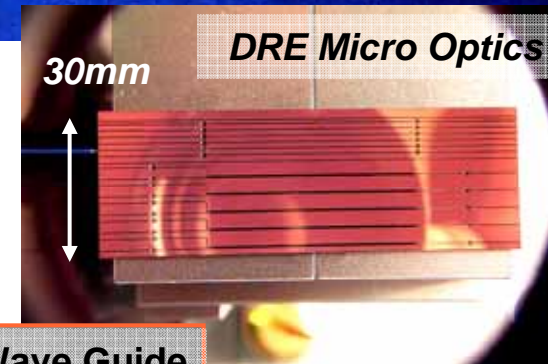
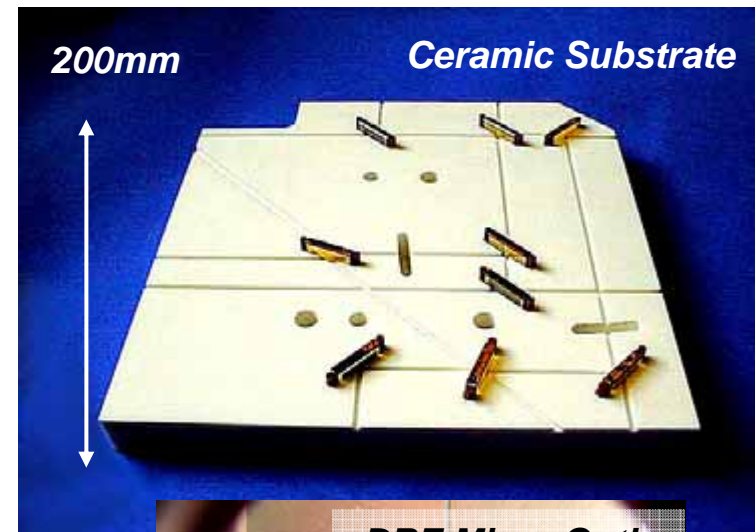
Steel penetrator

# Hollow Waveguide Technology

## Hollow Wave Guides (HWG)

- Compact optical bench
- Rugged design
- Excellent optical performance
- Inexpensive
- Suitable for a variety of future missions
- Simplified assembly and component changes
- Reduced contamination

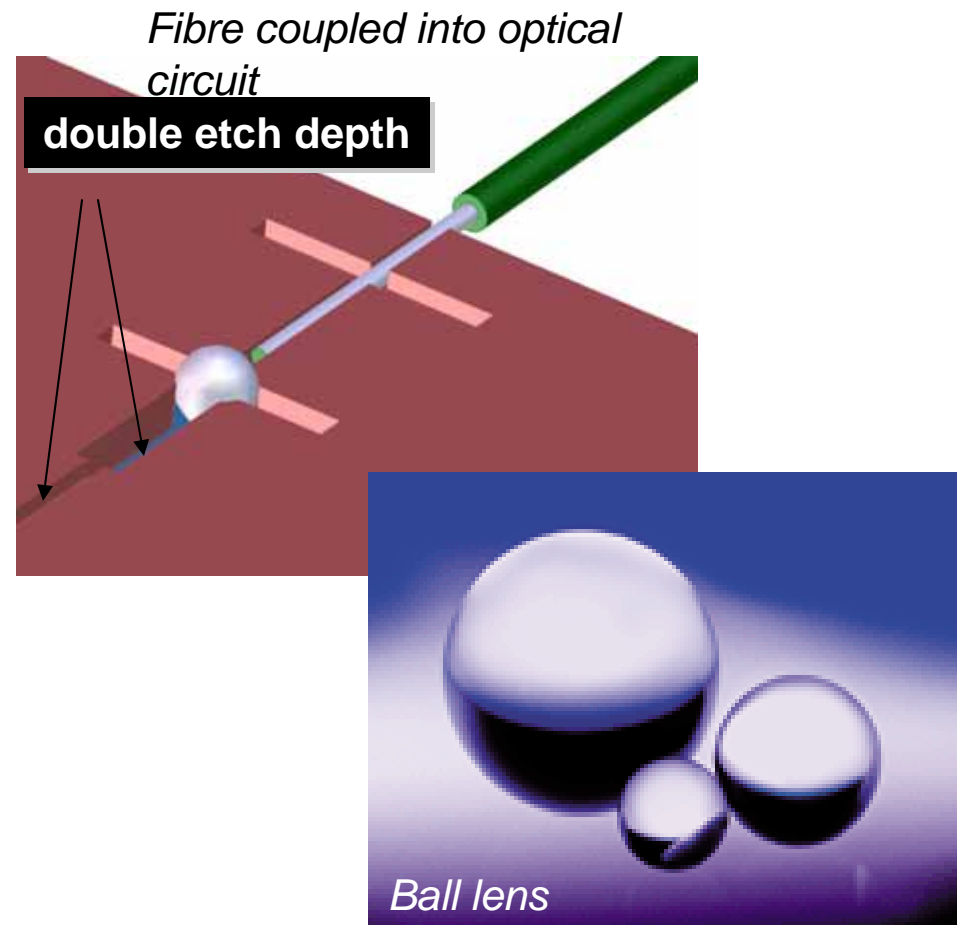
Demonstration LIDAR built



# Hybrid Integration of Discreet Components

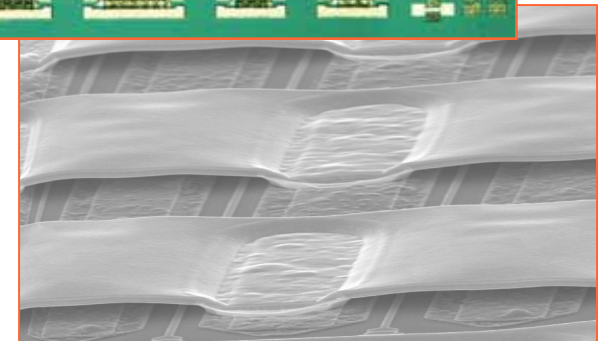
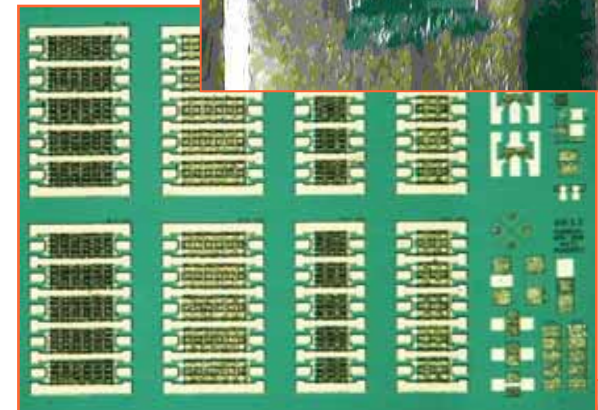
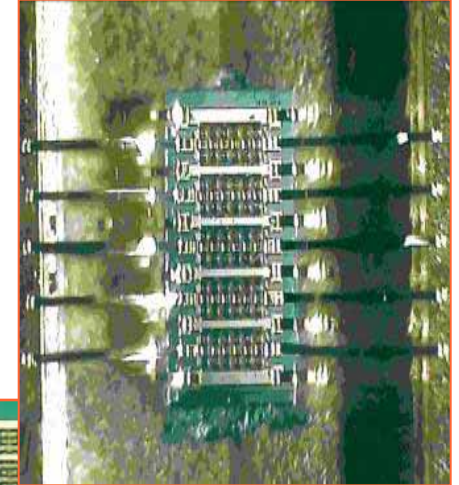
## Micro Optics

- Passive
  - Fibres
  - Lenses - ball/GRIN
  - Mirrors
  - Beam Splitters
  - Gratings
  - Optical isolators
  - TFF & AWG (PLC)
- Active
  - Lasers
  - Modulators (PLC)
  - Detectors

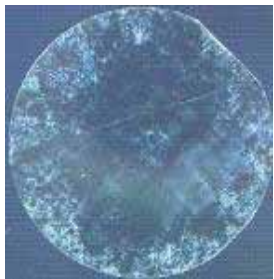


# Gallium Nitride (GaN) for Microwave Devices

- Material advantages
  - High bandgap :- High Temperature (>300°C c.f. 150°C for GaAs)
  - High breakdown field :- High Voltage (> 200V c.f. < 20 for GaAs )
  - High thermal conductivity :- High Power
  - High saturated velocity:- High Speed
- Deployment / Life costs
  - Reduce size (1/4 size of GaAs systems
  - Reduced mass and volume
  - Increased efficiency - Reduced cooling
- Increased range
  - Power and packing density
- Robustness
  - Higher temp limits
  - Higher Breakdown voltage
  - Linearity
- Radiation hard



# QinetiQ - Vertically Integrated Capability



SUBSTRATES (bought in)  
• SiC 2" to 3", Si, Sapphire



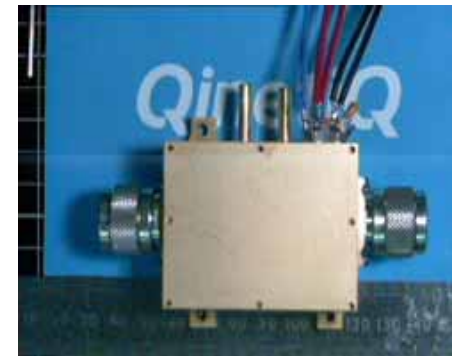
EPITAXY



DEVICE PROCESSING



PACKAGED DIE



DEMONSTRATORS

**S-band Amplifier Module**  
Demonstrated peak power  
= 57.5W

$V_{ds} = 30V$   
(2.4W/mm)  
10% duty 1ms/9ms  
32% PAE  
50 x 50 x 15mm

**Design Guide available  
for QinetiQ processes**

# Conclusions

- QinetiQ is leading new approaches to missions
  - Introducing new mission types
  - Pulling new technologies into space
- Small satellites have delivered mission successes
- Many studies now baseline small satellites for dedicated science missions
  - We need to think differently about what we do and how we do it
- Small Sat Science (S<sup>3</sup>) will be enabled by key QinetiQ technologies
  - Solar Electric Propulsion
  - Penetrometers
  - Hollow Wave Guides
  - Gallium Nitride

QinetiQ looks forward to working with both industry and academia to deliver the next generation of low cost missions