Penetrators for Europa

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on behalf of UK
Penetrator Consortium

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Birkbeck College London
Imperial College London
Open University
Leicester University
Cambridge University
SSC Surrey University

QinetiQ
Astrium
SSTL
Magna Parva

+ international support

Contents

- Introduction...
- Science
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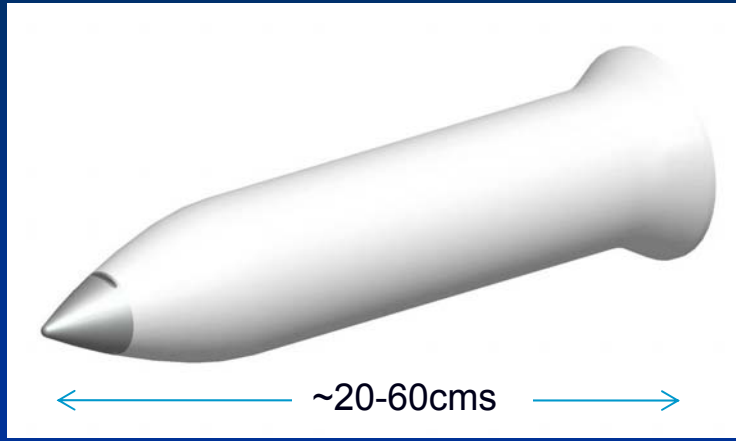
Micropenetrator & Instruments

- Low mass [~5-15Kg]
- Very tough
  [~100-500m/s, impact ~10-50kgee]
- Perform science from below surface
  [~0.5-few m]



Example Payload (~2kg)	Science Capability
Micro seismometers	sub-surface ocean, inner body structure tectonics, cryovulcanism
Chemistry package (mass spect.)	organics and inorganics
Soil/environment package (accel, magnetometer,therm,...)	soil mechanical properties, thermal & electrical properties
Sample imager/astrobiology camera	Mineralogy, UV DNA flouresence
Descent camera	impact site context & PR

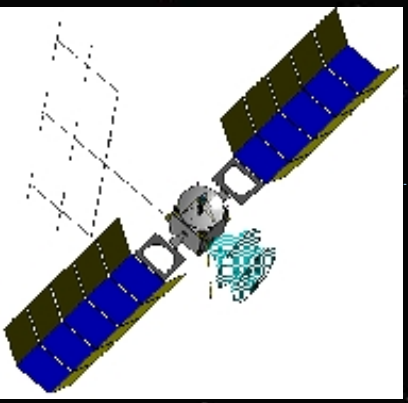
Technology

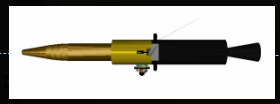
..more than just a penetrator

- Spacecraft support
  - Attach/eject, power, comms
- Descent module
  - De-orbit motor
  - Attitude control
- Penetrator
  - Platform (shell,power,thermal, comms,data proc)
  - Science instruments

Courtesy SSTL

Penetrator delivery





Release from Orbiter

Spin-up & Decelerate

Spin-Down

Reorient

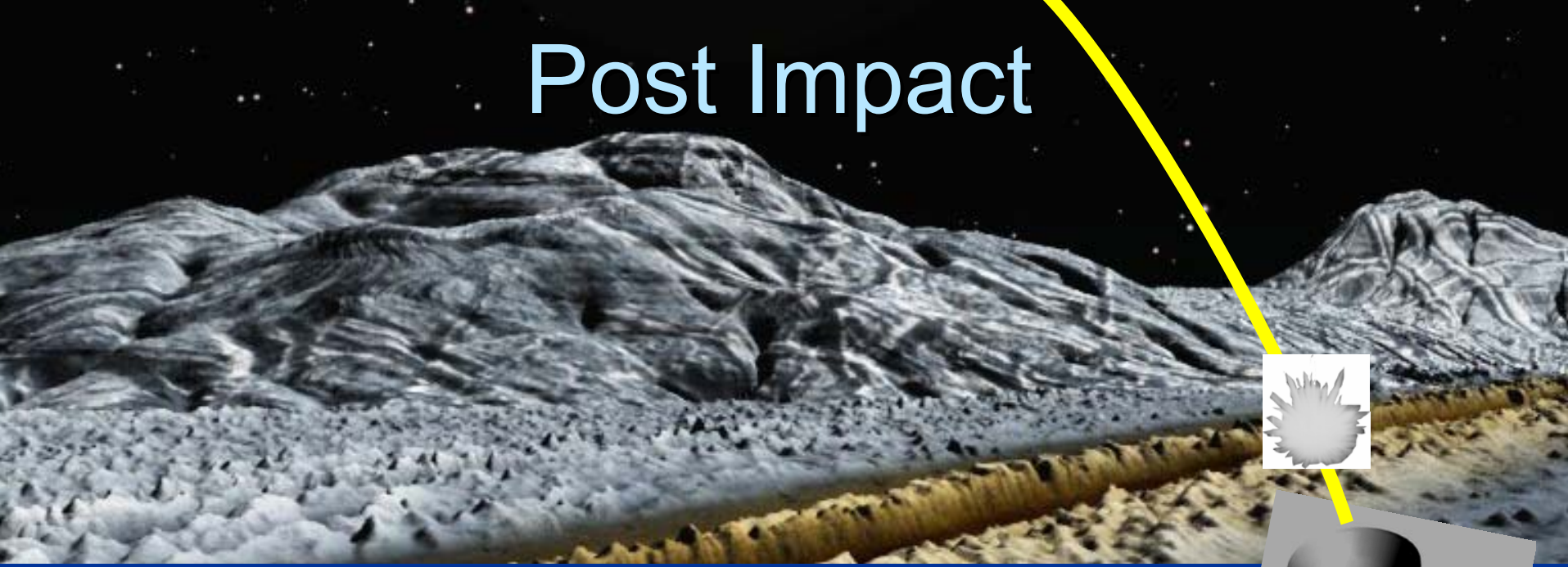
Penetrator Separation

Penetrator & SDS surface Impact

Delivery sequence courtesy SSTL

Operate from below surface

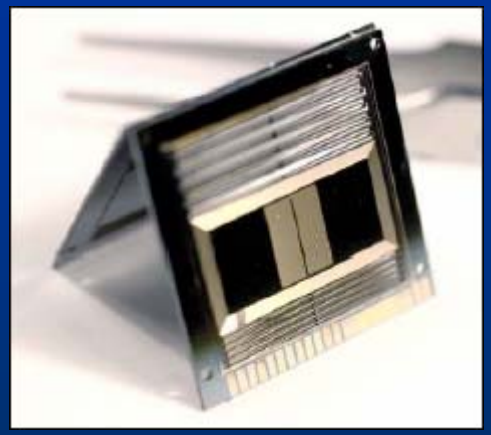
Post Impact



- Target area of upwelled material (astrobiology)
- ~0.5 to few metres below surface (reduced radiation)
- 2 in-situ elements de-risk/improve performance
- Ground truth/complementary to surface landers/orbiter
- Lifetime: few hours (geochemistry/astrobiology, soil properties) to few orbits (seismic measurements) (rhu)

TRL

- Previous Mars96, DS2, Lunar-A developments
- UK currently developing technology for lunar mission
- Most instruments have existing space heritage.
- + successful full scale impact trial in UK.



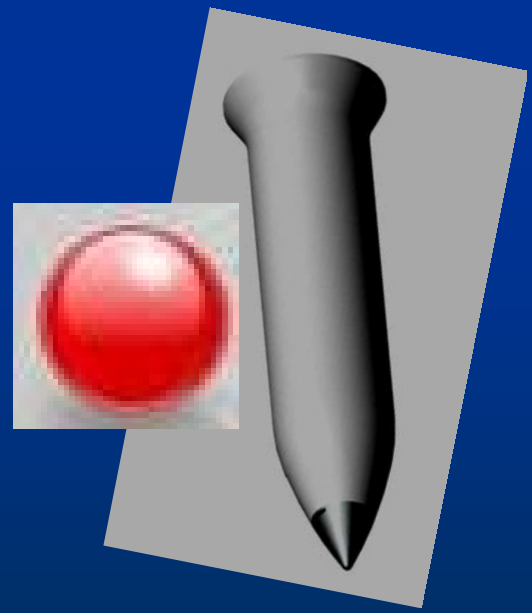
Micro-seismometer
Imperial College
(ExoMars)

Prototype,
ruggedized ion trap
mass-spectrometer
Open University
(Rosetta)

Δ developments required for Europa… (beyond MoonLITE)

- Impact (hard,rough)
- Targetting
- Radiation
- Planetary protection
- Transmission
- Long cruise phase
- Telemetry

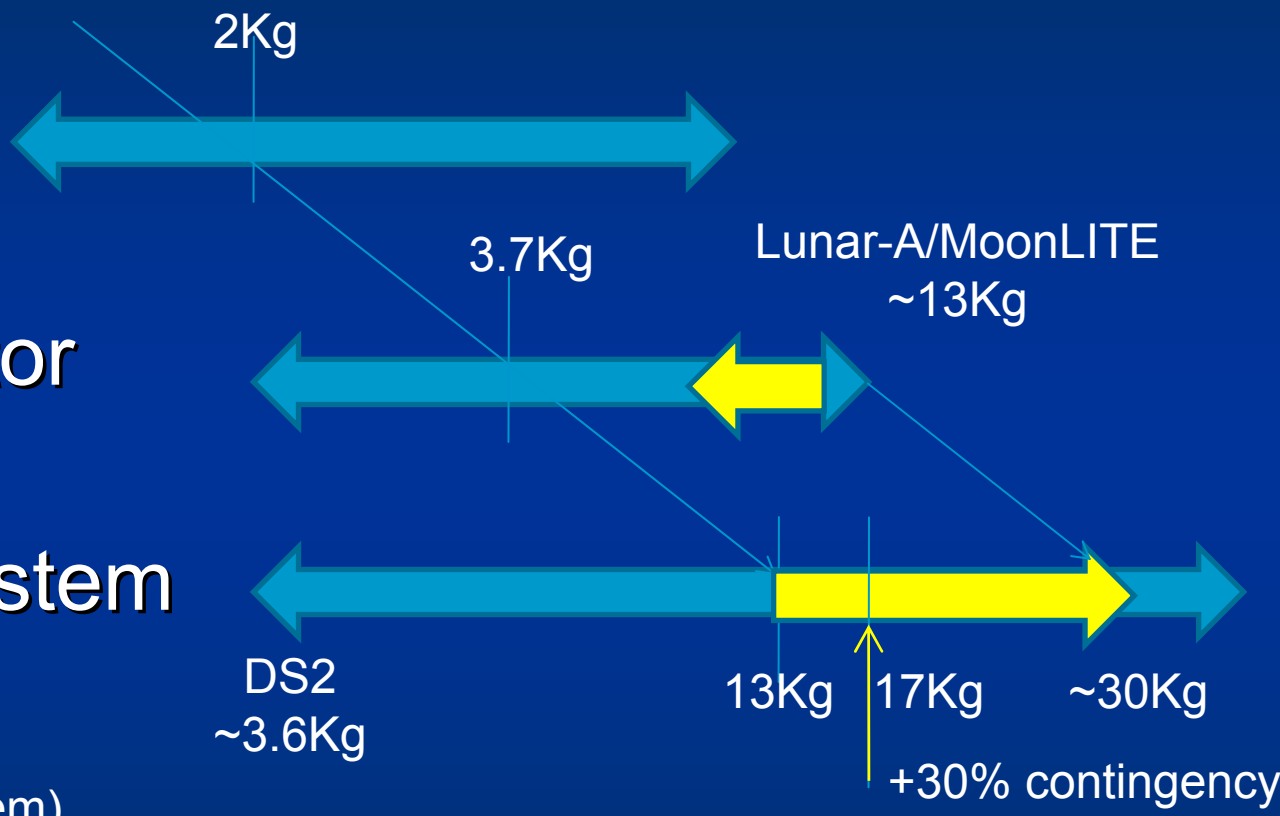
Key requirements:
1.'Unbreakable'
2.Can do the science



Mass

- Payload
- Penetrator
- Total System

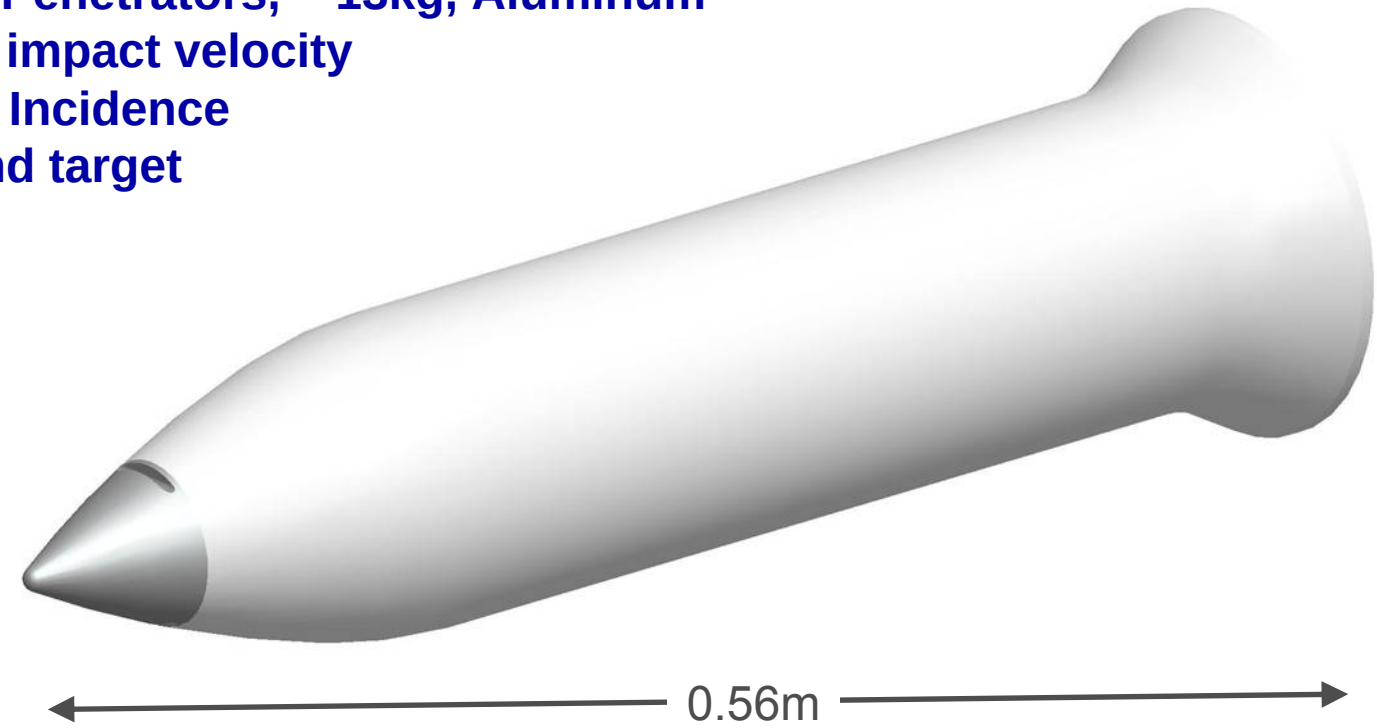
(payload
+penetrator
+delivery system)



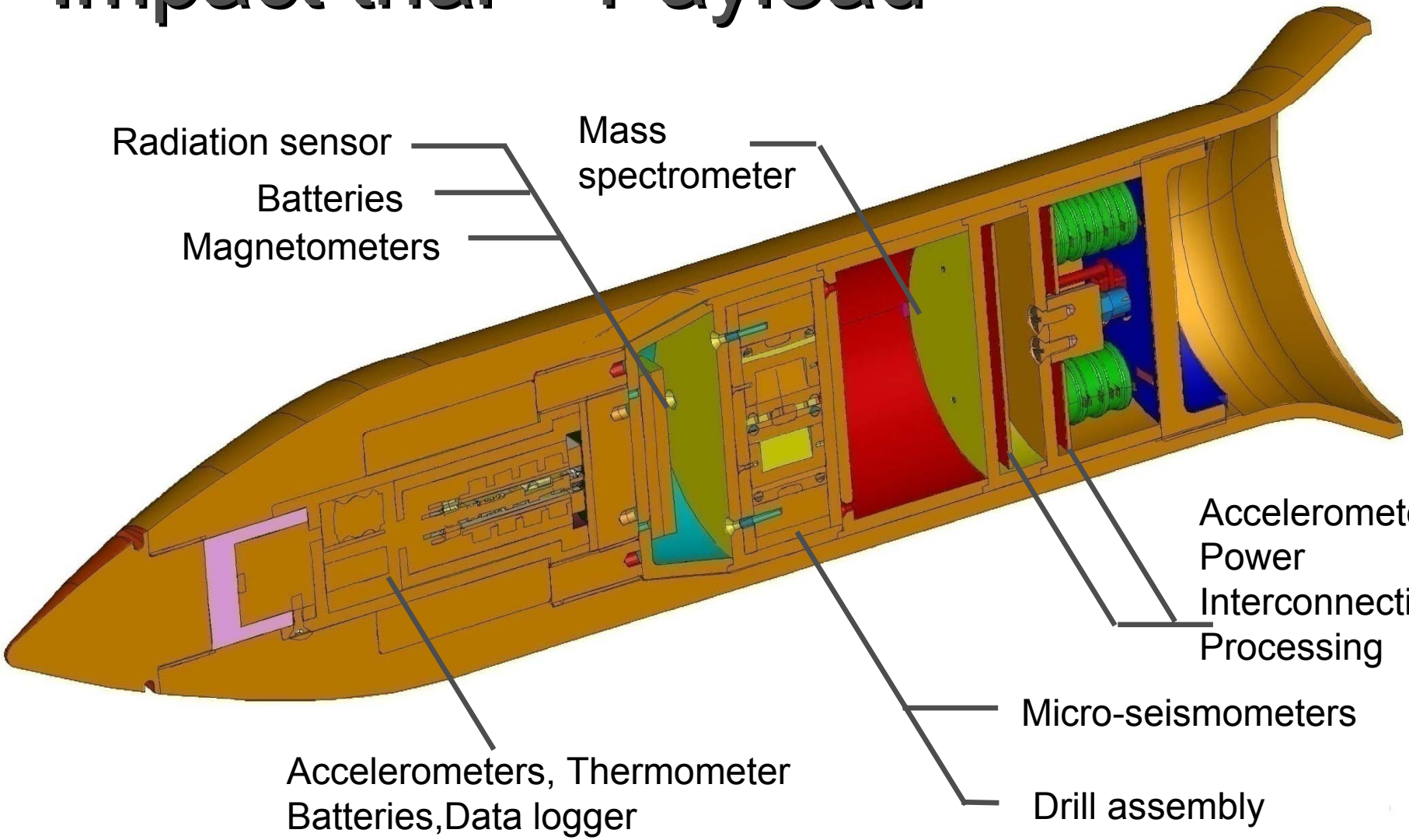
Status

Performed Full-Scale Impact Trial 19-21 May 2008

- **Fired 3 Penetrators, ~13kg, Aluminum**
- **300m/s impact velocity**
- **Normal Incidence**
- **Dry sand target**



Impact trial – Payload

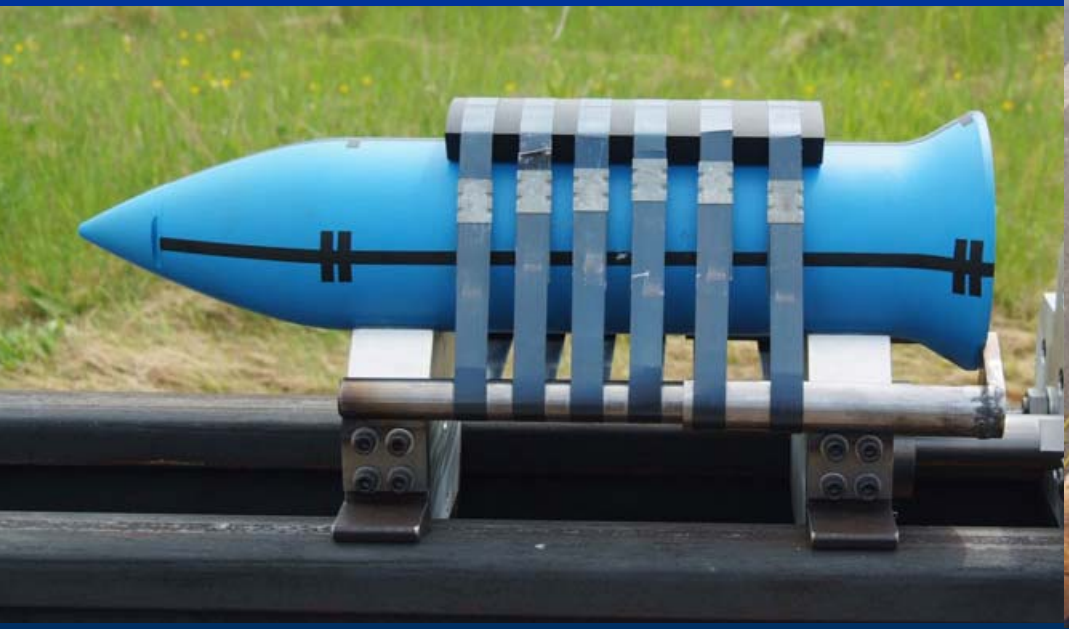


Trial Hardware

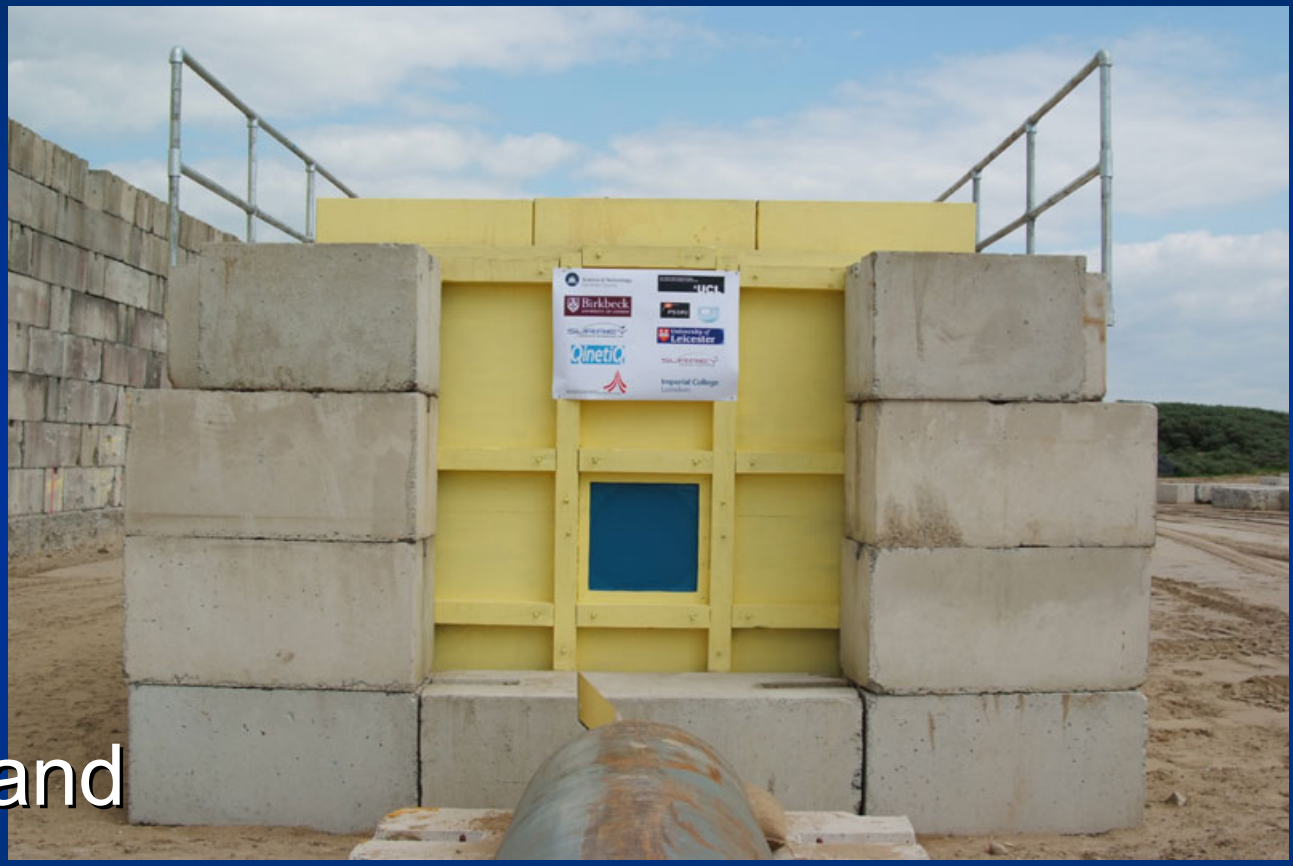
Inners Stack

Impact Trial - Configuration

- Rocket sled
- Penetrator



Target

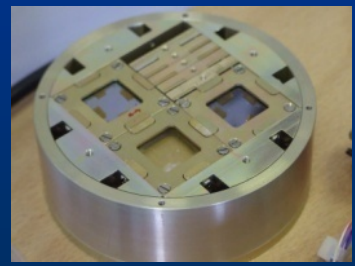


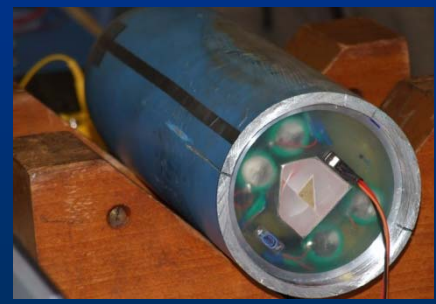
- Dry sand
- 2m x2m x6m
- Small front entrance aperture (polythene)

Real-Time Impact Video

Pendine Trials

- All 3 impacts ~310m/s (nearly supersonic), ~10° nose up (worst case)
- Penetration depth ~3.9m significant ablation to nose and underside, but no distortion to inner payload bays
- Gee forces: ~5kgee along axis, to ~16kgee spikes
- All 3 penetrators survived and still operational ✓
- No critical failures.





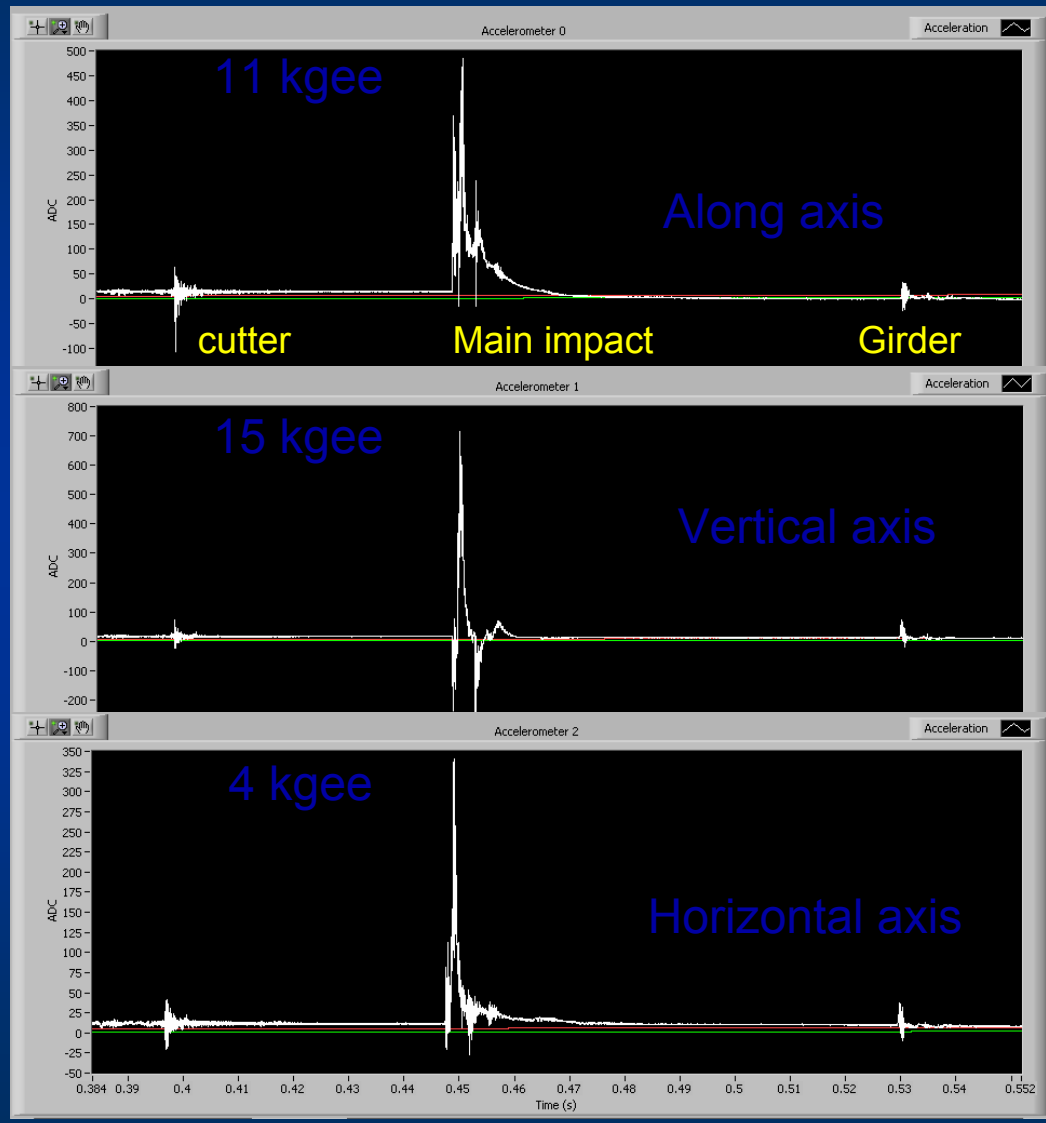
1’st Firing – MSSL accelerometer data

Peak gee forces in rear of penetrator

Firing	Along axis	Vertical	Horizontal
1’st	10 kgee	15kgee	4kgee
3’rd	11kgee	17kgee	7kgee

Along axis:

- Cutter: 3kgee
- Main: 10kgee
- Girder: 1kgee



Survival Table

Item	Firing 1	Firing 2	Firing 3
Penetrator	✓	✓	✓
Q-accel sys	✓	✓	✓
Rad sensor	✓	n/a	n/a
Batteries	✓	n/a	n/a
Drill components	✓	n/a	n/a
Magnetometer	✓	n/a	n/a
Micro seismometers components (protected)	n/a	✓	✓
Mass spectrometer	n/a	Minor damage	Minor damage
MSSL accel system including data logging and internal harnessing	✓	✓	✓

No critical failures

Development Plan

Apr 2009 - MoonLITE -> phase-A start

May 2009 - MoonLITE TRL5 18 month development start

2009 - delta developments for Europa ?

Jan 2010 - full scale trial #2

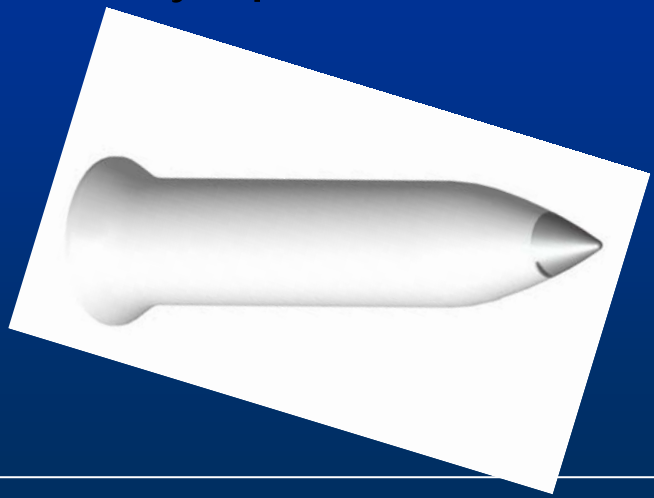
Mar 2011 - full scale trial #3

Apr 2011 - lunar (MoonLITE) -> Phase-B

2014 - MoonLITE launch

Conclusions

- Penetrators offer a credible approach and have the potential to deliver excellent science.
- Penetrators can provide ground truth and complement orbital and other surface elements.
- We are open to international collaboration.
- We need to start penetrator ‘outer planets’ science/technology studies
- We need a delivery spacecraft !



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