



University
of Glasgow



British
Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Mars Sample Return to Subglacial Bedrock Sampling

Ryan Timoney

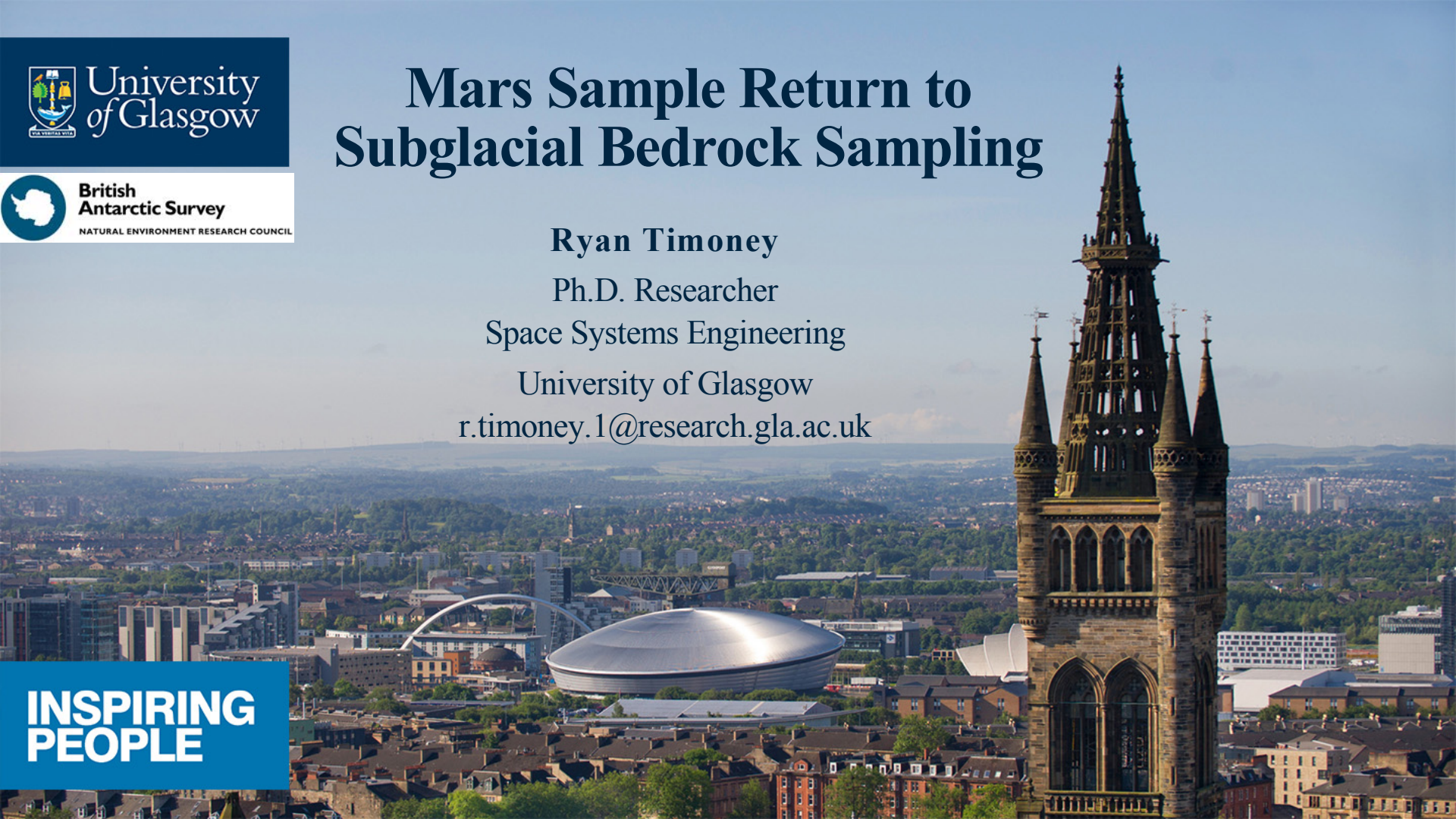
Ph.D. Researcher

Space Systems Engineering

University of Glasgow

r.timoney.1@research.gla.ac.uk

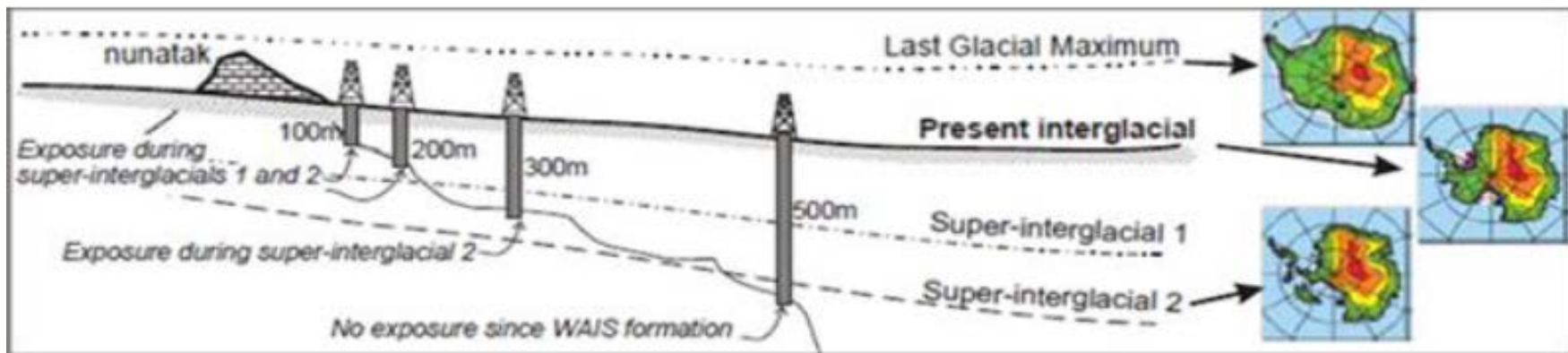
INSPIRING
PEOPLE



The Need for Subglacial Bedrock Sampling



- Knowledge of subglacial environment is poor.
- **Reliant on airborne geosurvey** to map Antarctic subsurface.
- Little knowledge of **geological composition and age of terrain**.
- **Isotopic analysis** of bedrock provides history of exposure, hence **allows us to map glacial front over time**.

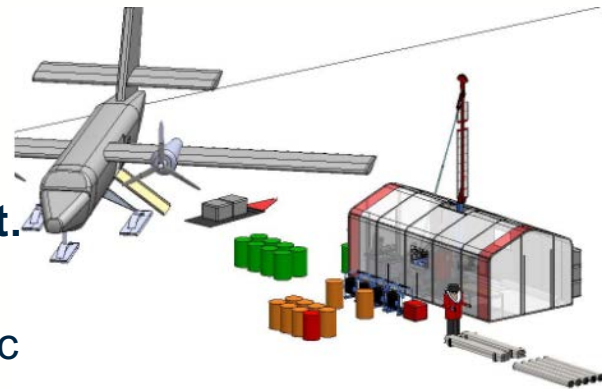


Subglacial Drilling on Continental Antarctica

- Bedrock sampling rigs do exist!
- “Agile Sub-Ice Geological (ASIG) Drill” operated by USA.
- Rock core samples from **700 m** depths.
- **Complex, utilising large quantities of drilling fluid and heavy machinery.**
- **Complexity comes at a logistical cost.**
- Best explained using the Antarctic metric of logistical complexity, the **Twin Otter flight**.



ASIG Rig



ASIG Rig
Schematic

Twin Otter Logistics

- De Havilland Canada Twin Otter are an Antarctic workhorse, used for ferrying people (~ 4) and ~ 1 tonne of cargo up to 800 km from base.
- **BAS operate six Twin Otters from Rothera station.**
- Twin Otter availability is **major** limitation on fieldwork ambitions.



BAS 'RAID' Twin Otter Demand



US 'ASIG Drill' Twin Otter Demand



How!?



The Planetary Drilling Approach



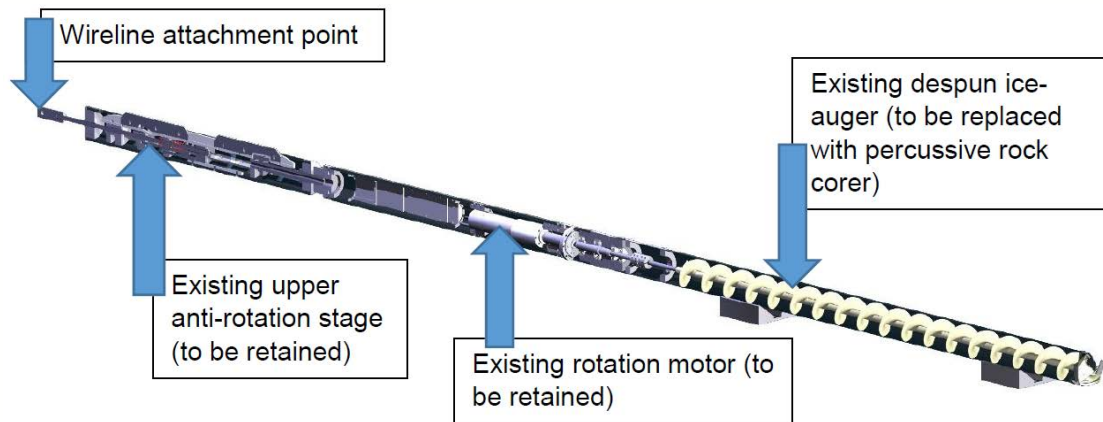
- The UoG Space Systems team have **experience developing planetary drilling systems**.
- Approach requires **different mindset** to industrial-scale drilling.
- Planetary systems are typically designed to operate with **low power, mass, volume, weight-on-bit and torque**.
- Remoteness of target sites requires **high degree of reliability, autonomy and dry drilling** (no drilling fluid) in a cold, harsh environment not dissimilar to Mars.
- **UoG undertake collaboration with British Antarctic Survey (BAS)** to develop a “**Subglacial Bedrock Sampler**”.



- Building upon heritage of **Rapid Access Isotope Drill (RAID)**, designed to sample ice cuttings from depths up to 1 km.
- **Lightweight wireline system** provides solid baseline for new development.
- Proven, robust system breaking records in dry drilling.
- **Incapable of sampling bedrock.**



RAID Retrofit



- Proposed retrofit of RAID ice-drill.
- Existing ice-auger replaced with self contained percussive drilling system. **Drill within a drill.**
- Existing design significantly constrains maximum diameter system diameter (80 mm), torque (< 10 Nm) and power (< 1 kW) of proposed Subglacial Bedrock Sampler.

Subglacial Bedrock Sampler Overview



Bellows Coupling and
Percussive Splined Shaft

Maxon EC60
Percussive Drive Motor

SKF Deep Groove
Ball Bearings

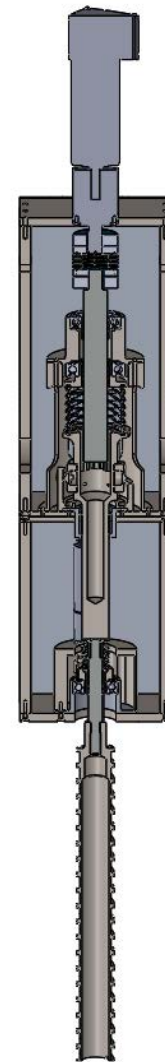
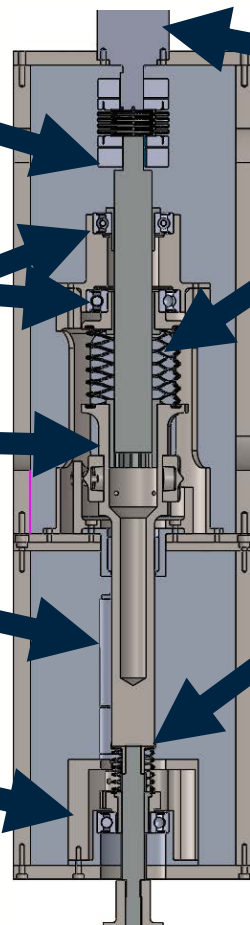
Compression Wave Spring

Hammer Assembly

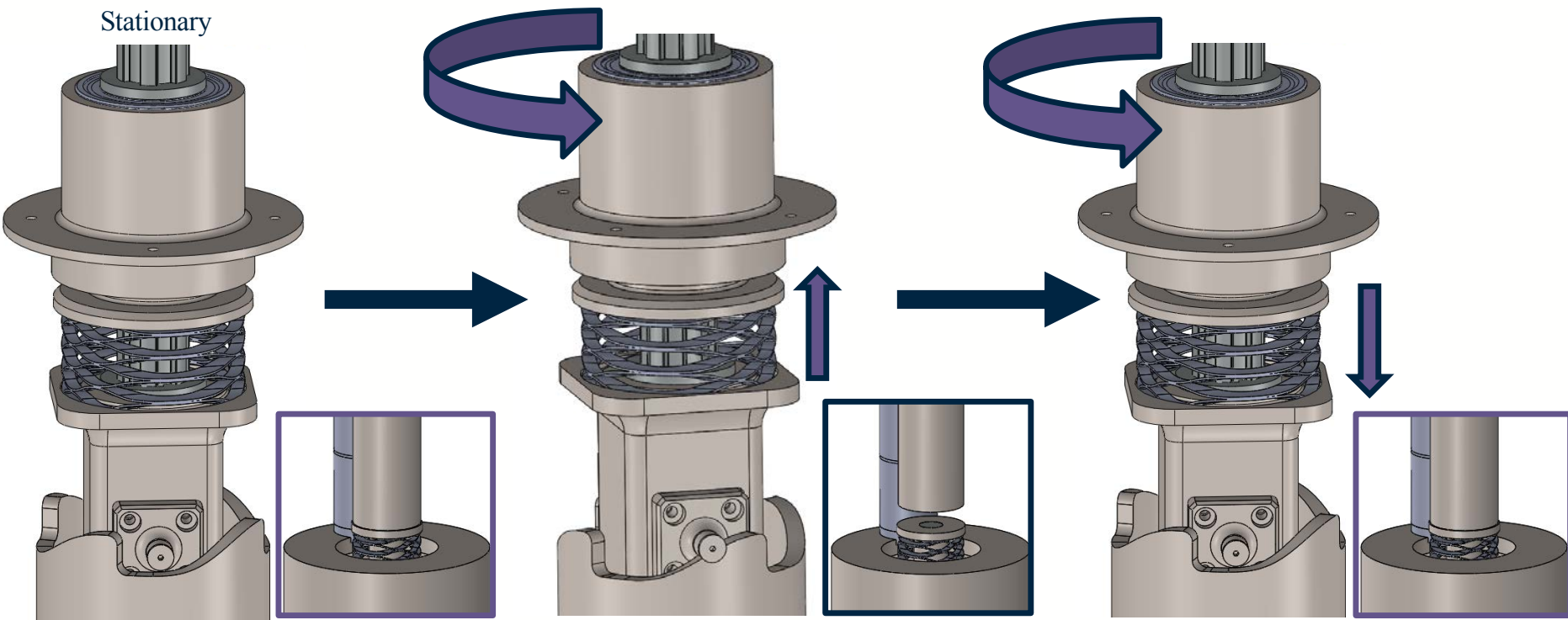
Maxon EC 4-pole 22
Drill Bit Rotation Motor

Percussive Anvil

Rotary Gear Box



Cam Hammer Principle





University
of Glasgow



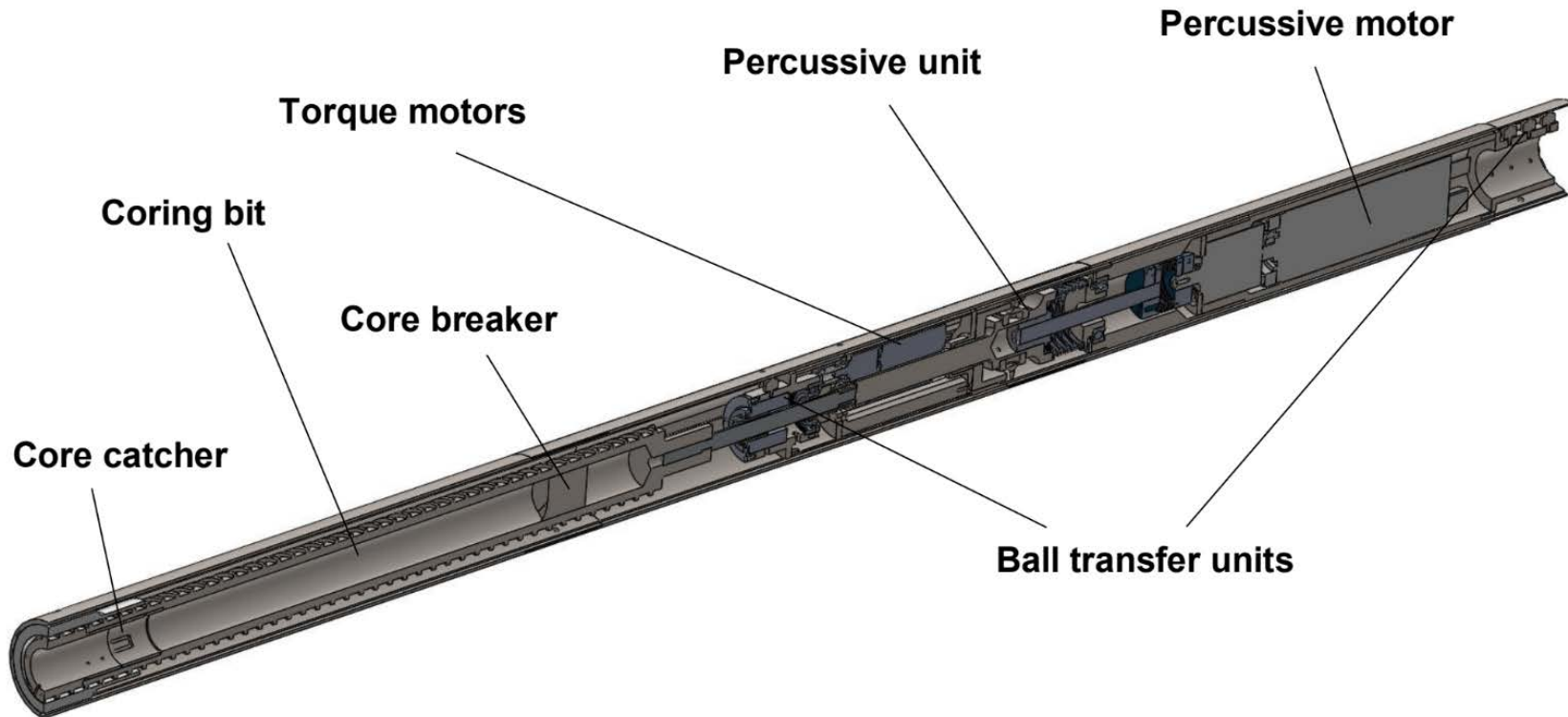
**British
Antarctic Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

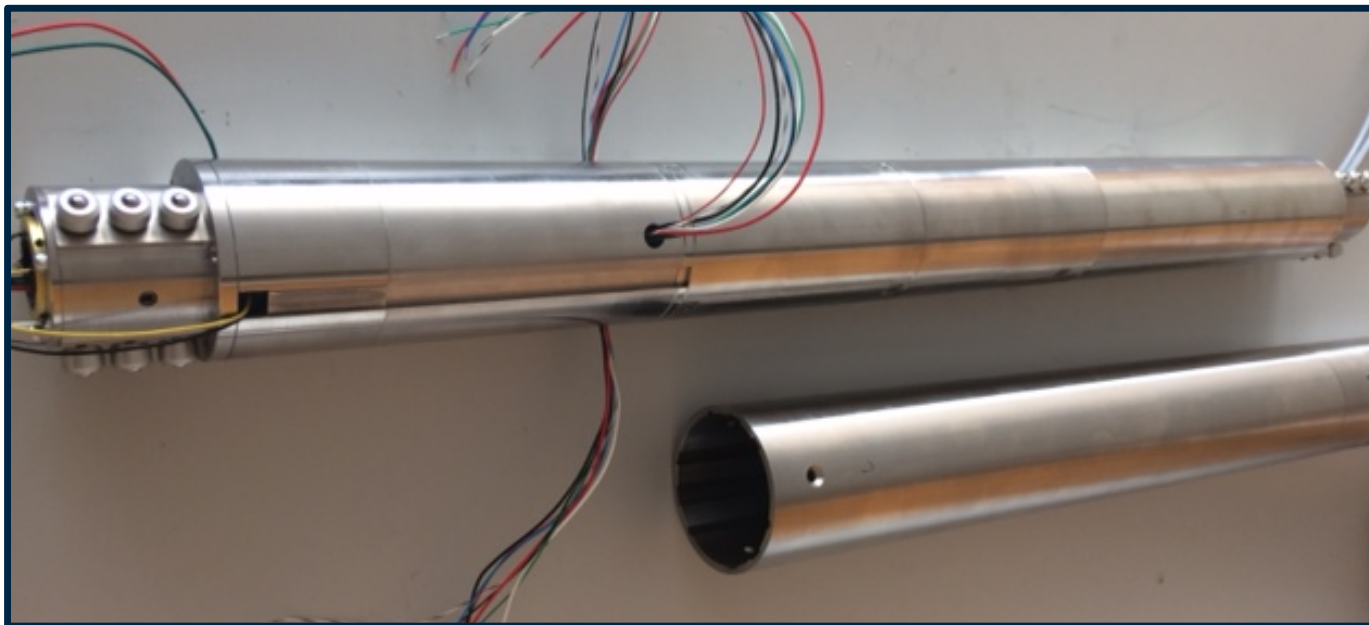




P-RAID - Industrialised



P-RAID - Industrialised



Summer Campaign 2018 – Skytrain Ice Rise



Summer Campaign 2019 – Sherman Island



British
Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL





Questions?

r.timoney.1@research.gla.ac.uk