Goals and Projects

1. Increase the sensitivity and duty cycle of GW detectors across the entire frequency band by improving the low frequency stability
2. Measure low frequency seismic noise to estimate Newtonian noise
3. To directly measure Newtonian noise

Tilt meter—ALFRA
TorPedDo Sensor
Euler-LaCoste ULF pre-isolator
CDS: LIGO type digital control

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John Winterflood
Perry Forsyth
Joshua McCann
Nathan Holland
David McManus
+ Master & intern students.....
**Advanced Low Frequency Rotation Accelerometer (ALFRA)**

- Sensing the ground tilt and feedback to the isolation stage to reduce horizontal to tilt coupling
- Could be mounted in any orientation
  - Modelling complete
  - Bar in manufacturing stage
  - Flexure design complete
  - Vacuum chamber designed and under construction
  - Optical readout experimentally tested
Walk-off sensor (WOS)

Optical readout system for ALFRA
- Readout system tested
- Paper ready for P&P
- Integrated design complete

- Readout Sensitivity on table top (in air):
  - Seveal nrad/rt(Hz) > 1mHz
  - 0.4nrad/rt(Hz) >100mHz
- Needs to go into vacuum

See Joshua McCann’s poster
TorPeDo Seismic Chain Design

Torsion Pendulum Dual Oscillator (TorPeDO) -- low frequency gravitational force sensor

**Inverted Pendulum**
- MultiSAS base
- Uses 3 Trilliuns to isolate linear motion
- Soft platform for actuation
- Contains GAS filter for vertical isolation.

**Intermediate Mass**
- 140kg 6-way cross / hollow sphere hybrid
- Large inertia combined with single wire suspension provides high passive isolation.
- Spherical structure raises the frequency of internal modes.
- 6-way cross allows for fine tuning of CoM and moment of inertia.

**Penultimate Mass**
- 40kg 6-way cross.
- Acts as suspension point for TorPeDO system.
- High moment of inertia per mass provides additional isolation for rotation.

**TorPeDO System**
- Two dual wire torsion pendulums.
- Operation between 30mHz to 10Hz.
- Optical differential yaw readout.

Torpedo Sensor is operating with its initial control prototype running on a continues basis.
Optical levers have been implemented on the TorPeDO for sensing:

- Pitch, Roll and Vertical modes.
- We now have control of all six degrees of freedom of each bar.

*See poster by Nathan A. Holland, et al.*
Sensor response and Detection

Earthquake Source Data

TorPeDo Response (modelled)

Range / Warning Time

See David McManus’ poster
Euler-LaCoste ULF pre-isolation stage

- Replacing the coil spring in LaCoste stage with maraging steel Euler springs
  - Reducing the creep of the coil spring
  - Higher internal frequency of the spring elements
Improved Euler Spring design

• New Euler blade shape designed and tested
• Euler-LaCost designed
• Frame under construction

• Special shape with uniform stress and minimum blade mass
• Monolithic double blade for symmetry and minimum clamping loss.

See Joris van Heijningen’s poster
Control and Data acquisition System (CDS) @ ANU and UWA

- LIGO type digital control system CDS are operational in both groups
  - Extensive discussions between the groups
  - With the help from Keith Thorne (LLO), problems are being discussed and solved
Exchange and Collaboration

- Weekly **low frequency** program zoom meeting
- Sharing ideas, experiences, tips and tricks
- UWA PhD Joshua McCann visited ANU for 2 weeks in June

Next....
- Instruments running
- More mutual visits