Geoscience and some aspects of the global offshore energy sector …… and a day in the life

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www.mavenenergyservices.com

Bath Geological Society – November Presentation
Bath Royal Literary and Scientific Institution

Introduction & Agenda

Geosciences & the Offshore Energy Sector; The Inter-relationship

The role of the Geo-whatevers; who are we?

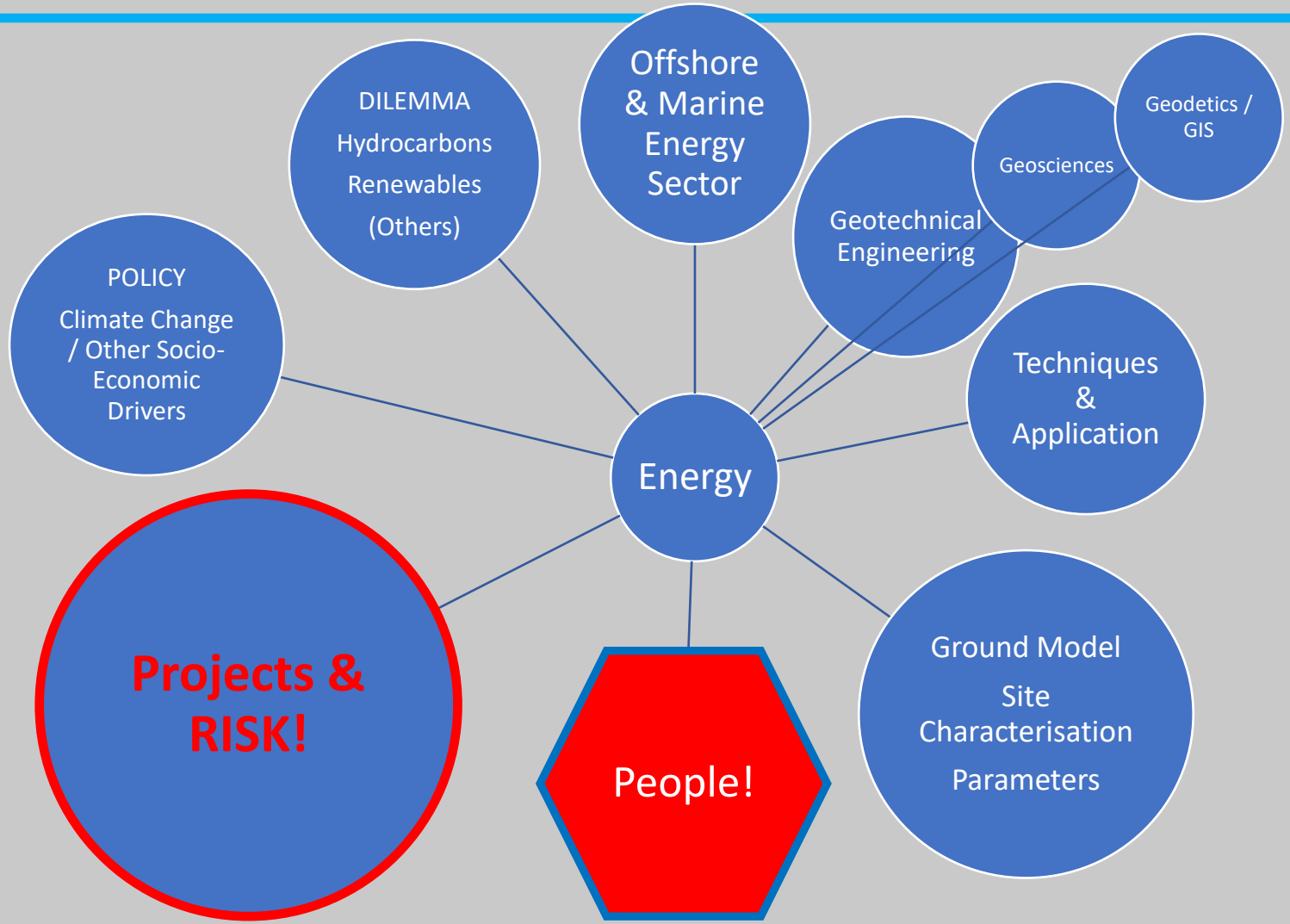
The Sectors

The Project Life Cycle & what we actually do

The role of the Geo-folk reprised – Crisis? What crisis

Some dilemmas and polemics

The Inter-relationship



I hope to demonstrate the inter-dependency and inescapable inter-relationships that exist between Society's (insatiable) quest and requirement for Energy and the Engineering, particularly;

Geotechnical Engineering and other related

Geosciences resources required to satisfy this

requirement.

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Offshore Engineering Sectors

The sectors of industry the Offshore Geoscientist commonly works in …

Meet the Geo-whatevers

- Engineering Geologists (Geotechnical Engineers*) / Geologists
- Geomorphologists
- Geophysicists
- Geomatics & Geodesy Experts
- Geospatial (GIS) Specialists

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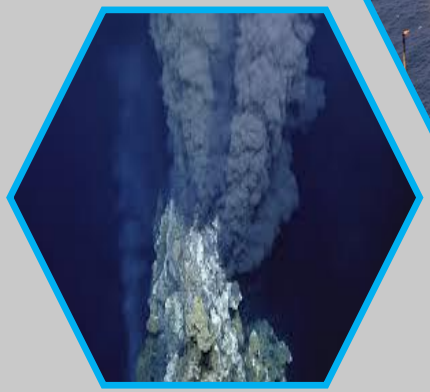
The key market sectors

- There is considerable overlap for the Geotechnical Engineer or Geoscientist
- Marine / Inshore Construction and Heavy Infrastructure Projects
- Oil & Gas
- Offshore Renewables
- Subsea Telecommunication Cables
- HVDC (Power) Cable Interconnectors and Grids
- Seabed Minerals & Mining
- Government & International Agency Mapping (e.g. UNCLOS & ISA)
- Academia



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Key market sectors | Marine / Inshore Construction and Heavy Infrastructure Projects

- Marine / Inshore Construction and Heavy Infrastructure Projects
- Often at the interface of Land / Marine Environment
- Wave / splash zone to contend with – tidal influence
- Estuarine environments and sediment transport
- Tend to be (land based) Civil Engineering contract led
- Beach / Shore Approaches for Cables & Pipelines

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Key market sectors | Offshore Oil & Gas

- Historical energy game-changer late 1800's to Present (~150+ Years)

- Essentially world wide

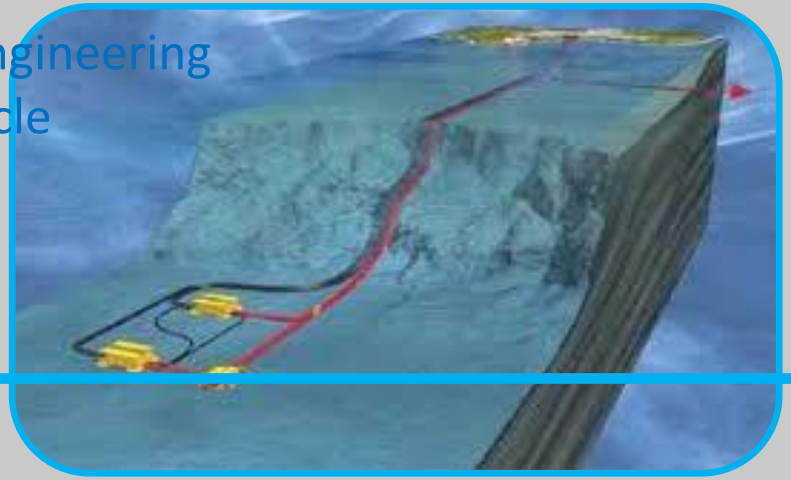
- Controversial Frontier Provinces
  - Artic
  - >3,000m WD
  - Net Zero / COP 26

- Requires considerable offshore engineering
- & Geoscience – throughout lifecycle

- CCS & Gas Storage

Colonel Drake, 1859

Colonel Drake's Drilling Rig



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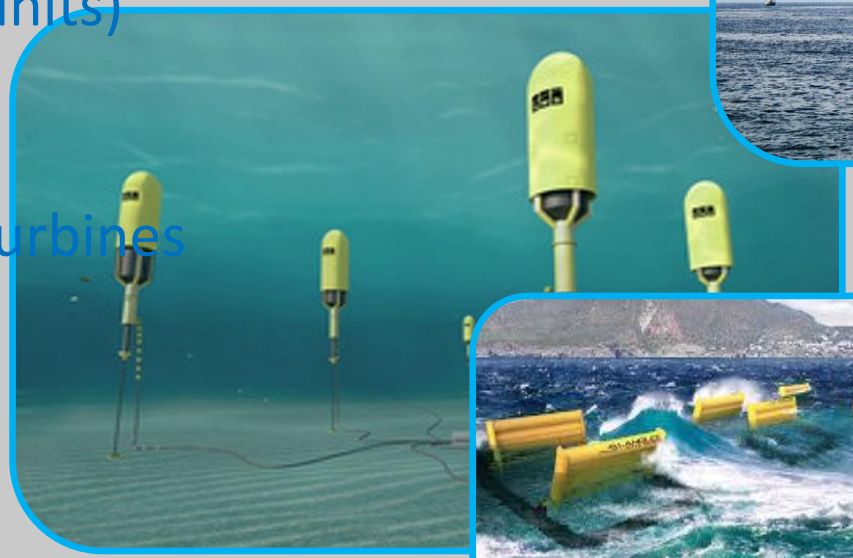
Key market sectors | Marine / Offshore Renewables

- Offshore Renewables
- Offshore Wind
  - Relatively shallow water
  - Floating (Hybrid units)
- Tidal
  - Seabed devices/turbines
  - Lagoons
  - Barrages
- Wave
- (Floating Solar Arrays)



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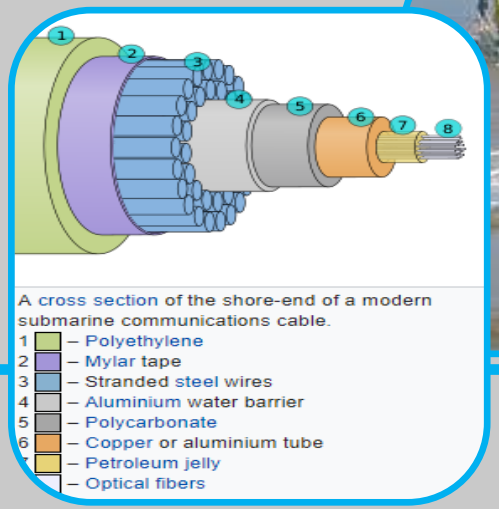
The key market sectors | Subsea Telecommunication & Power Cables

- Both share similarities and a number of differences
- Subsea Telecommunication (FoC data transfer)
- Power: HVDC or AC current transmission – thermal issues
- Shallow – Deep water regimes – Trans-Continental
- Route Design & Route Engineering
- Digital / Big Data: Google / FaceBook, Banking & Financial Markets



A cross section of the shore-end of a modern submarine communications cable.
1 – Polyethylene
2 – Mylar tape
3 – Stranded steel wires
4 – Aluminium water barrier
5 – Polycarbonate
6 – Copper or aluminium tube
– Petroleum jelly
– Optical fibers

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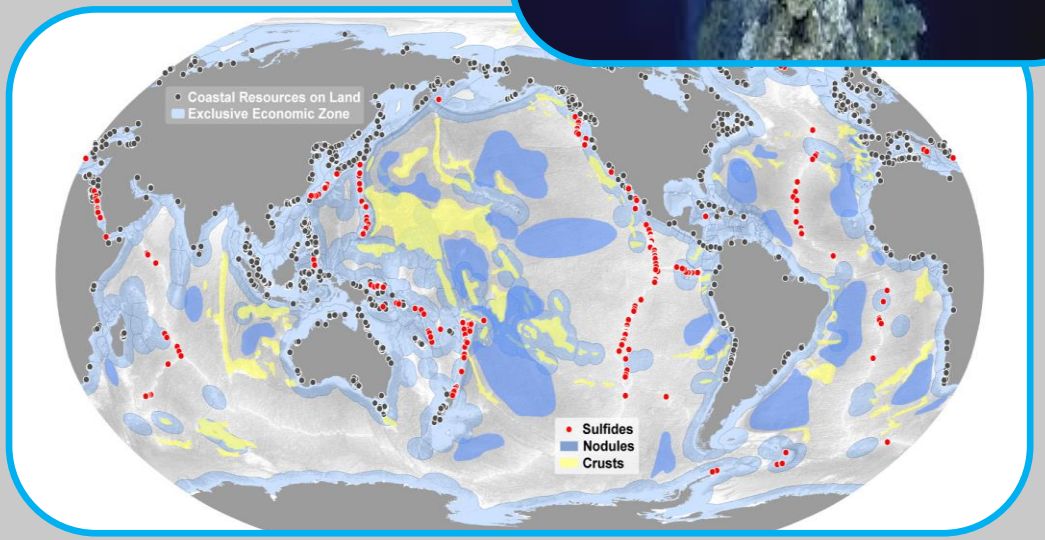
The key market sectors | Seabed Minerals & Mining

- Presents its own set of issues
- Concept has been considered since understanding Plate Tectonics and the ‘abundance’ of Seabed Polymetallic Nodules
- Jurisdiction, Legislative Framework , Consenting & Environmental Issues
- Forms part of the resource / energy dilemma – more later!!!



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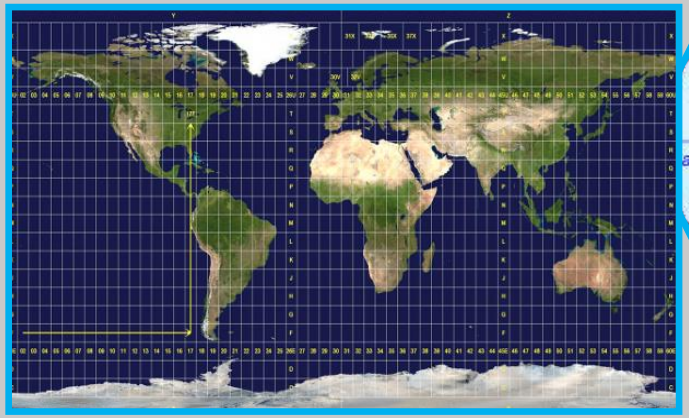
Geotechnical Engineering* & Associated Geosciences

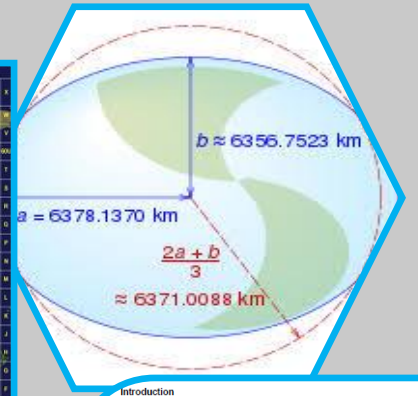
Survey & Site Investigation Methods, Tools, Techniques and Reporting

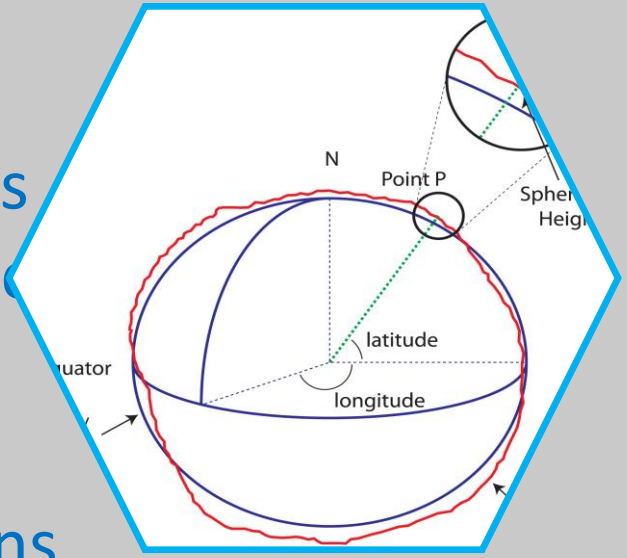
Geotechnical Engineering & The Associated Geosciences

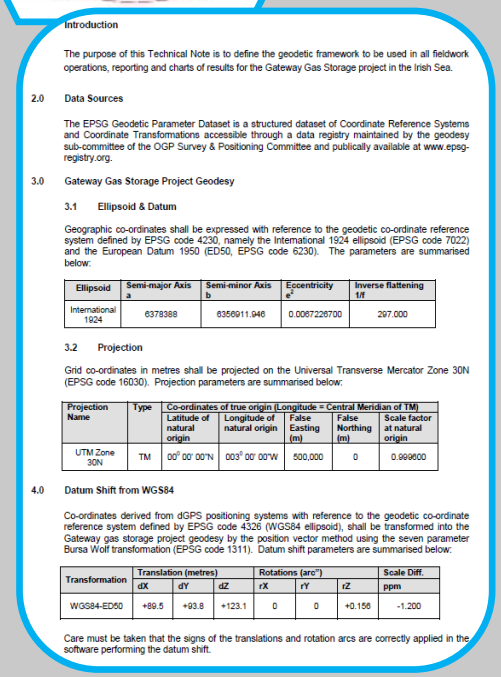
Positioning, Geodetics/Geomatics and Metocean

- Geodesy – the shape of the earth | WGS 84 Spheroid
- Map Projections – UTM Grid
- Geodetic Coordinates – different conventions
- Datums – again, different conventions – used to tie the “mathematical shape” of the earth to the Geoid
- Datum Transformations – relatively complicated mathematical conversions governed by convention.









Introduction

The purpose of this Technical Note is to define the geodetic framework to be used in all fieldwork operations, reporting and charts of results for the Gateway Gas Storage project in the Irish Sea.

2.0 Data Sources

The EPSG Geodetic Parameter Dataset is a structured dataset of Coordinate Reference Systems and Coordinate Transformations accessible through a data registry maintained by the geodesy sub-committee of the OGP Survey & Positioning Committee and publically available at www.epsg-registry.org.

3.0 Gateway Gas Storage Project Geodesy

3.1 Ellipsoid & Datum

Geographic co-ordinates shall be expressed with reference to the geodetic co-ordinate reference system defined by EPSG code 4230, namely the International 1924 ellipsoid (EPSG code 7022) and the European Datum 1950 (ED50, EPSG code 6230). The parameters are summarised below:

Ellipsoid	Semi-major Axis a	Semi-minor Axis b	Eccentricity e^2	Inverse flattening 1/f
International 1924	6378388	6356911.946	0.0067226700	297.000

3.2 Projection

Grid co-ordinates in metres shall be projected on the Universal Transverse Mercator Zone 30N (EPSG code 16030). Projection parameters are summarised below:

Projection Name	Type	Co-ordinates of true origin (Longitude = Central Meridian of TM)				
		Latitude of natural origin	Longitude of natural origin	False Easting (m)	False Northing (m)	Scale factor at natural origin
UTM Zone 30N	TM	00° 00' 00"N	003° 00' 00"W	500,000	0	0.999600

4.0 Datum Shift from WGS84

Co-ordinates derived from dGPS positioning systems with reference to the geodetic co-ordinate reference system defined by EPSG code 4326 (WGS84 ellipsoid), shall be transformed into the Gateway gas storage project geodesy by the position vector method using the seven parameter Bursa Wolf transformation (EPSG code 1311). Datum shift parameters are summarised below:

Transformation	Translation (metres)			Rotations (arc")			Scale Diff.
	dX	dY	dZ	rX	rY	rZ	ppm
WGS84-ED50	+89.5	+93.8	+123.1	0	0	+0.156	-1.200

Care must be taken that the signs of the translations and rotation arcs are correctly applied in the software performing the datum shift.

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Geotechnical Engineering & The Associated Geosciences

Positioning, Geodetics and Metocean

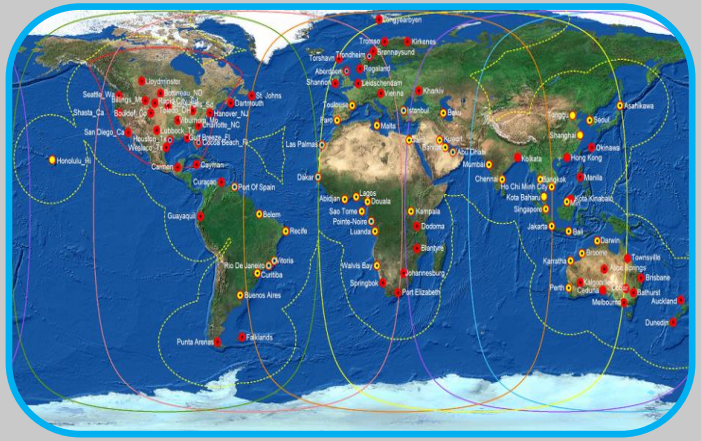
- Surface Positioning – (inc DP – Dynamic Positioning based on

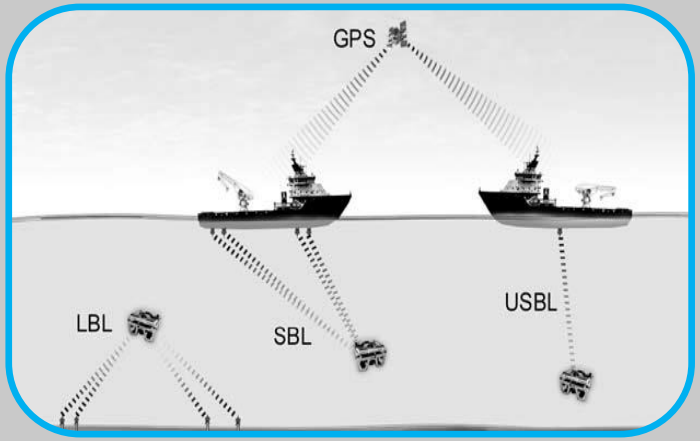
Differential GPS or DGPS with a minimum of 2 systems

- Most Offshore Projects are conducted from either a surface vessel or submerged (remote or autonomous) vehicle
- Subsurface Positioning – Tx & Rx

Acoustic Beacons to define relative positions (HiPAP)

- Subsea Vertical Accuracy is also required





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Geotechnical Engineering & The Associated Geosciences

Positioning, Geodetics and **Metocean**

- Ocean weather systems
- Ocean Systems – tides, currents, layers
- Extreme Storm conditions
- Sophisticated monitoring and modelling methods to assist the Project's understanding (and risk profile) to weather related events.

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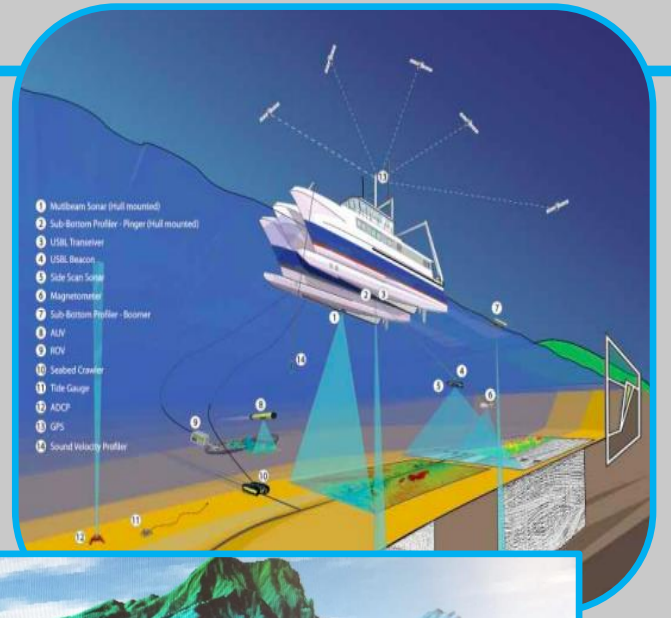
Geotechnical Engineering & The Associated Geosciences

Geophysical Survey and Methods



- (Single) Multi Beam Echo Sounder – MBES
- Side Scan Sonar – SSS
- Sub Bottom Profiler – SBP
- Hi-Res Seismic (2DHR or 3DHR)
- Magnetometer

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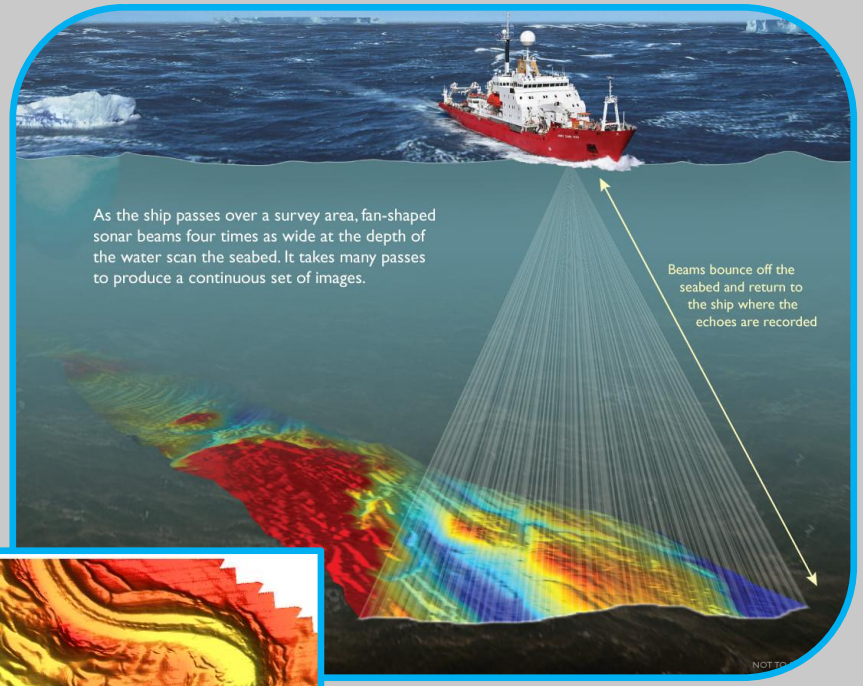
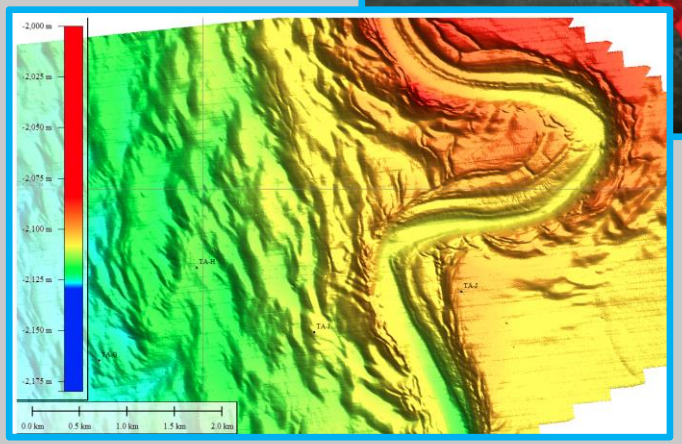
Geotechnical Engineering & The Associated Geosciences

Geophysical Survey and Methods

- **(Single) Multi Beam Echo Sounder – MBES**
- “Multi Beam” or MBES / A Seabed Map
- Calibration & Verification
- Real time acquisition monitoring
- Processing, Gridding – DTM (Scale)
- LiDAR





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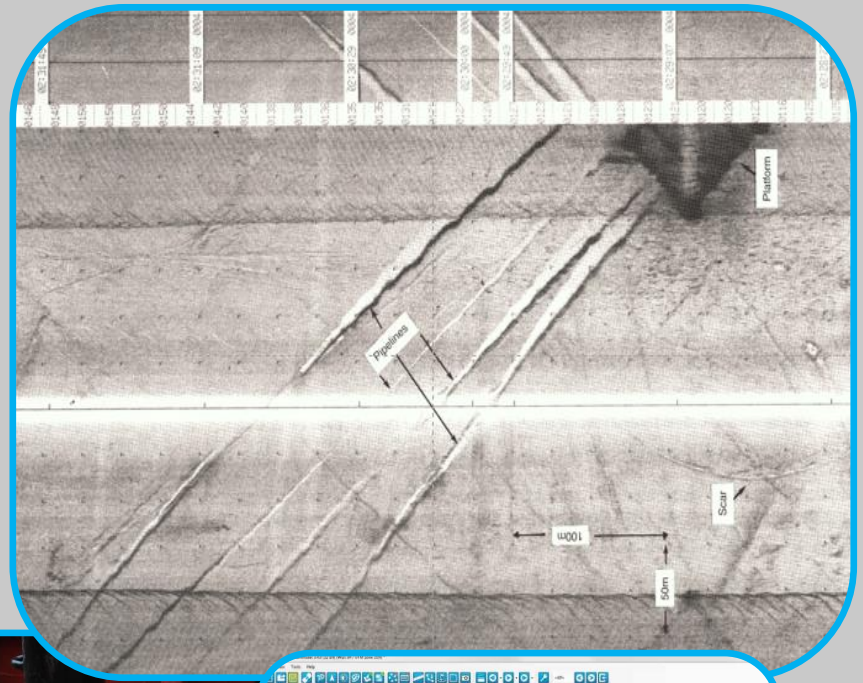
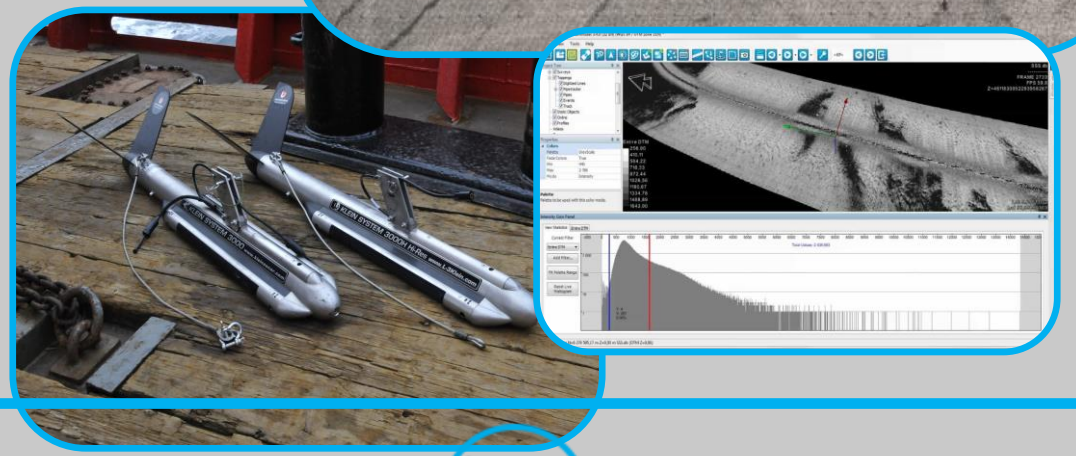
Geophysical Survey and Methods

- **Side Scan Sonar**
- To define seabed features (& obstructions)
- Platform: Tow Fish, ROV/ … increasingly AUV
- Provides potentially good, reliable imagery of the seabed via Georeferenced Mosaics (see image)

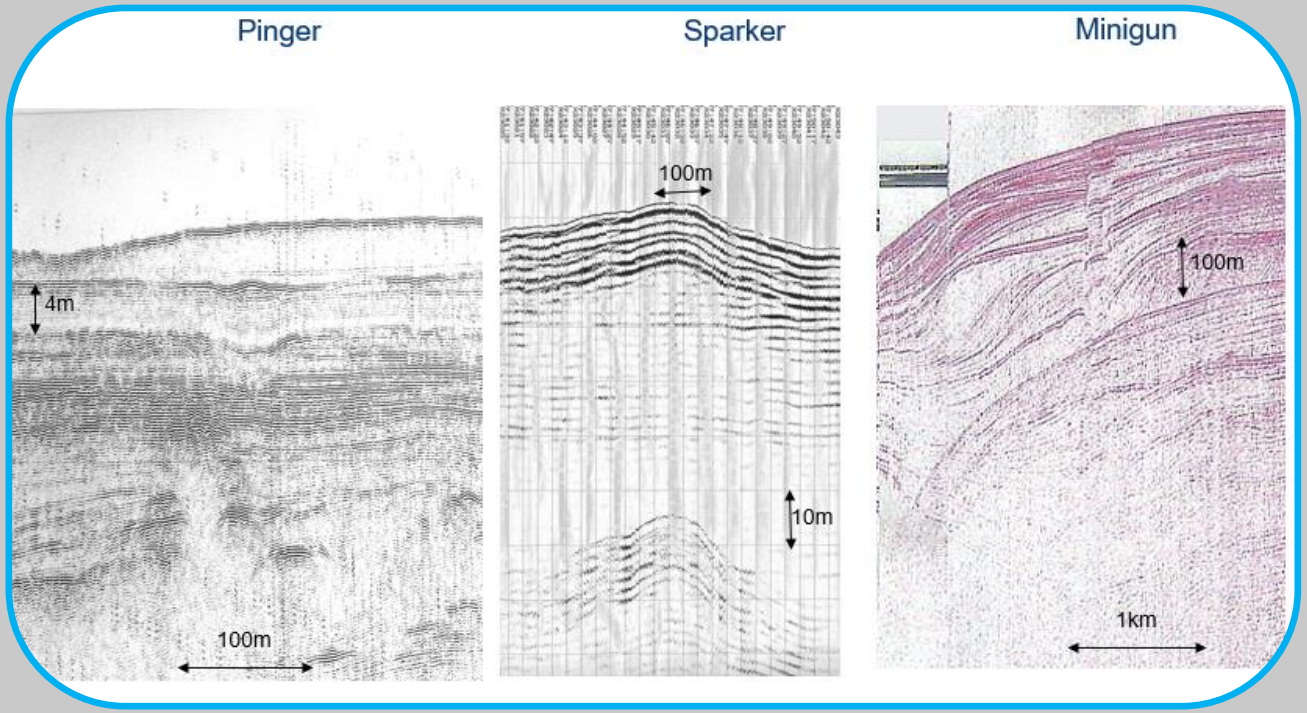


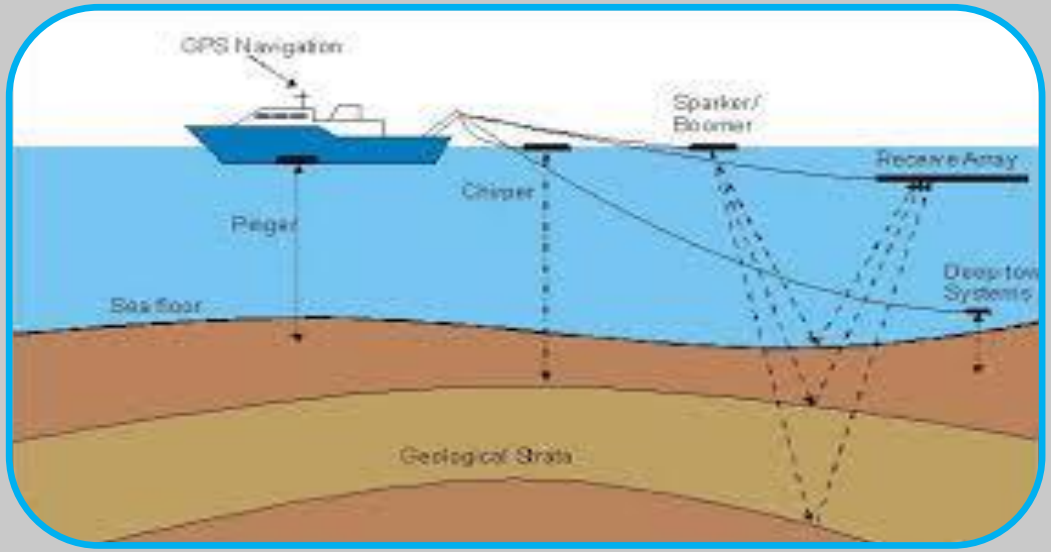


Geophysical Survey and Methods

- **Sub Bottom Profiler – SBP**

Sub-bottom Profiler	No. of channels	Approximate frequency range (Hz)	Expected sub-bottom penetration (metres below seabed)
Pinger	Single	2,000-7,000	Up to 50 in soft soils, typically 5-10
Chirp	Single	2,000-8,000	Up to 50 in soft soils, typically 5-15
Sparker	Single/Multi	50-4,000	Up to 100, typically 50, multichannel up to 300m
Boomer	Single/Multi	300-3,000	Up to 60, typically 30
Single 10 cu.in. airgun	Multi	20-500	Up to 500 in soils and soft rocks, dependent on water depth





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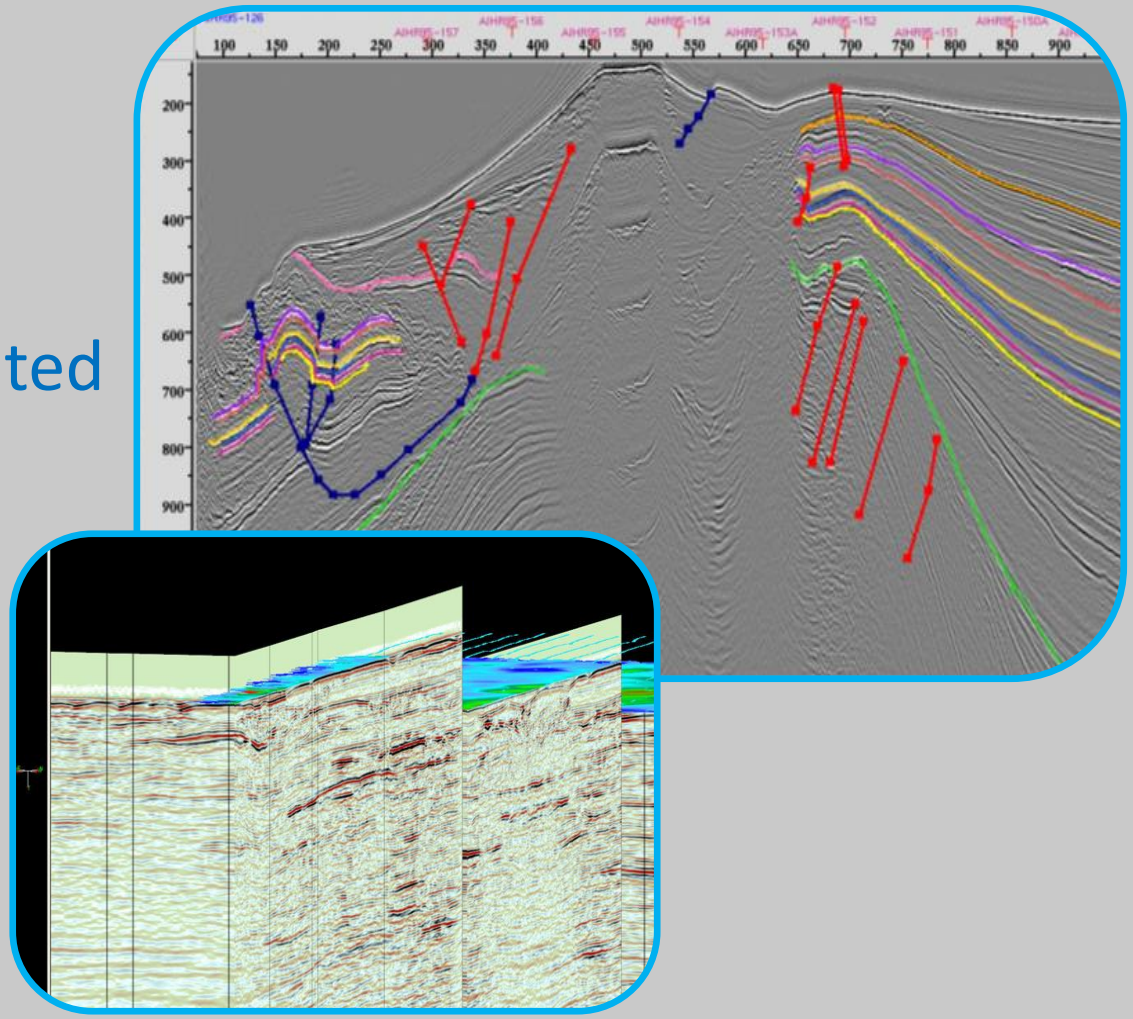
Geotechnical Engineering & The Associated Geosciences

Geophysical Survey and Methods

- **HR & UHR Multi Channel Seismic**
- Use of Offset (3D-Exploration) & Dedicated Survey Data
- Geohazard Assessment – Shallow Gas!
- Acquisition Parameters
- (Re-) Processing, Resolution



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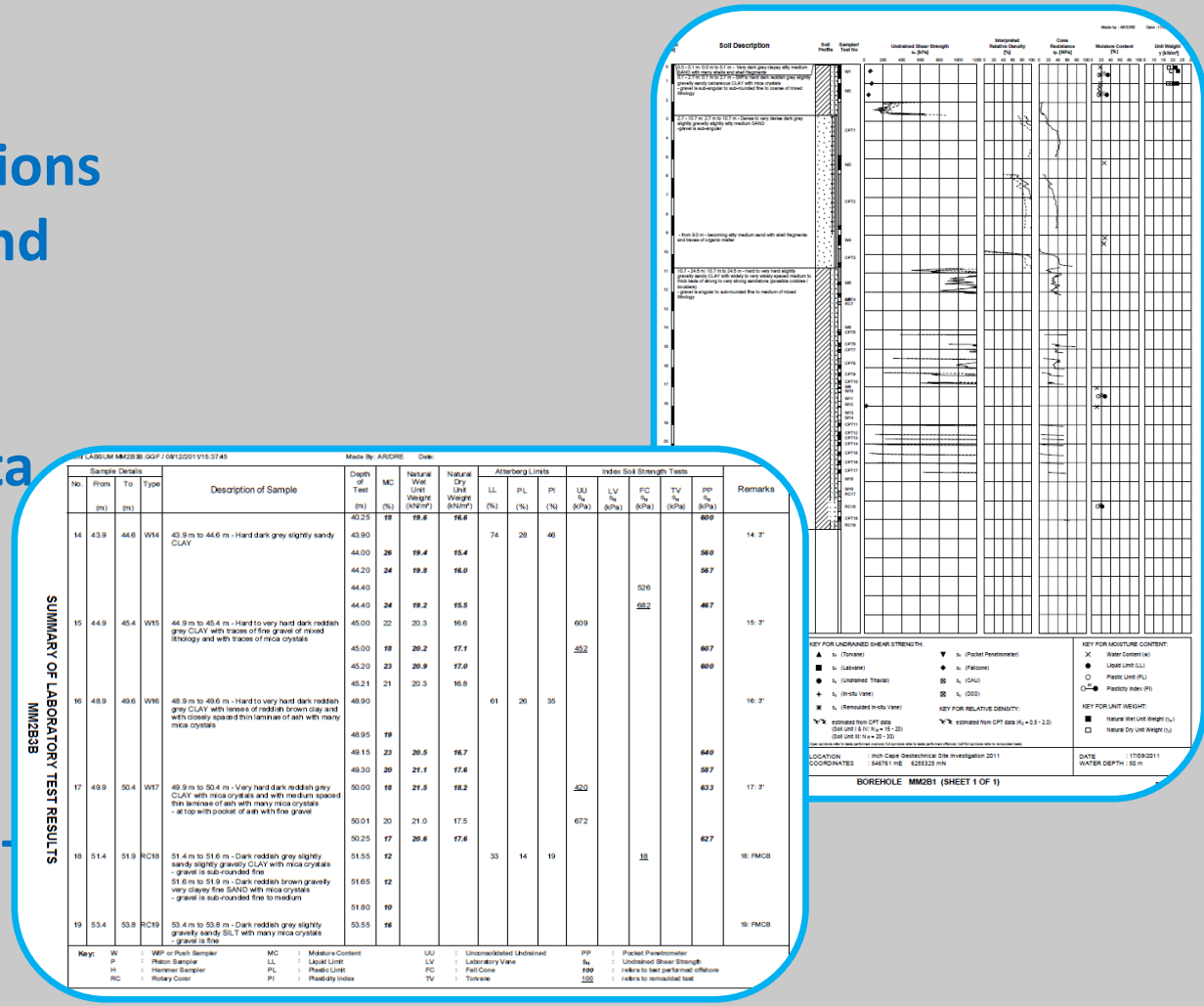
Geophysical Survey and Methods

- **Magnetometer / Gradiometer Survey**
- Metallic Debris with a magnetic signature
- Geohazard Assessment – UXO!
- UXO poses a huge issue to project developments

Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- The relationship between structures/foundations or other ‘appurtenances’ e.g. cables, pipes, and the geological materials and seabed
- Site Investigation – this is how we acquire data samples
- What do we do with this data
- Understanding / Characterising the materials - Parameters
- Design & Installation



SUMMARY OF LABORATORY TEST RESULTS
MM2B3B

No.	From (m)	To (m)	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	LL (%)	PL (%)	PI (%)	UU S_u (kPa)	LV S_u (kPa)	FC S_u (kPa)	TV S_u (kPa)	PP S_u (kPa)	Remarks
					40.25	18	19.6	16.6								600	
14	43.9	44.6	W14	43.9 m to 44.6 m - Hard dark grey slightly sandy CLAY	43.90				74	28	46						14: 3"
					44.00	26	19.4	15.4								560	
					44.20	24	19.8	16.0								567	
					44.40									526			
					44.40	24	19.2	15.5						682		467	
15	44.9	45.4	W15	44.9 m to 45.4 m - Hard to very hard dark reddish grey CLAY with traces of fine gravel of mixed lithology and with traces of mica crystals	45.00	22	20.3	16.6				609					15: 3"
					45.00	18	20.2	17.1				452				607	
					45.20	23	20.9	17.0								600	
					45.21	21	20.3	16.8									
16	48.9	49.6	W16	48.9 m to 49.6 m - Hard to very hard dark reddish grey CLAY with lenses of reddish brown clay and with closely spaced thin laminae of ash with many mica crystals	48.90				61	26	35						16: 3"
					48.95	19											
					49.15	23	20.5	16.7								640	
					49.30	20	21.1	17.6								587	
17	49.9	50.4	W17	49.9 m to 50.4 m - Very hard dark reddish grey CLAY with mica crystals and with medium spaced thin laminae of ash with many mica crystals - at top with pocket of ash with fine gravel	50.00	18	21.5	18.2				420				633	17: 3"
					50.01	20	21.0	17.5				672					
					50.25	17	20.6	17.6								627	
18	51.4	51.9	RC18	51.4 m to 51.6 m - Dark reddish grey slightly sandy slightly gravelly CLAY with mica crystals - gravel is sub-rounded fine 51.6 m to 51.9 m - Dark reddish brown gravelly very clayey fine SAND with mica crystals - gravel is sub-rounded fine to medium	51.55	12			33	14	19			18			18: PMCB
					51.65	12											
					51.80	10											
19	53.4	53.8	RC19	53.4 m to 53.8 m - Dark reddish grey slightly gravelly sandy SILT with many mica crystals - gravel is fine	53.55	16											19: PMCB

Key: W : WIP or Push Sampler; P : Piston Sampler; H : Hammer Sampler; RC : Rotary Corer; MC : Moisture Content; LL : Liquid Limit; PL : Plastic Limit; PI : Plasticity Index; UU : Unconsolidated Undrained; LV : Laboratory Vane; FC : Fall Cone; TV : Torvane; PP : Pocket Penetrometer; S_u : Undrained Shear Strength; 100 : refers to test performed offshore; 100 : refers to remoulded test

BOREHOLE MM2B1 (SHEET 1 OF 1)

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Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Geotechnical Site Investigation Methods
  - **Shallow Samplers & Corers** & In-situ Testing
    - **Grab Sampler (Van Veen)**
    - **Vibro corer (3-6m)**
    - **Gravity Sampler**
    - **Piston Sampler**
    - **Box Sampler**





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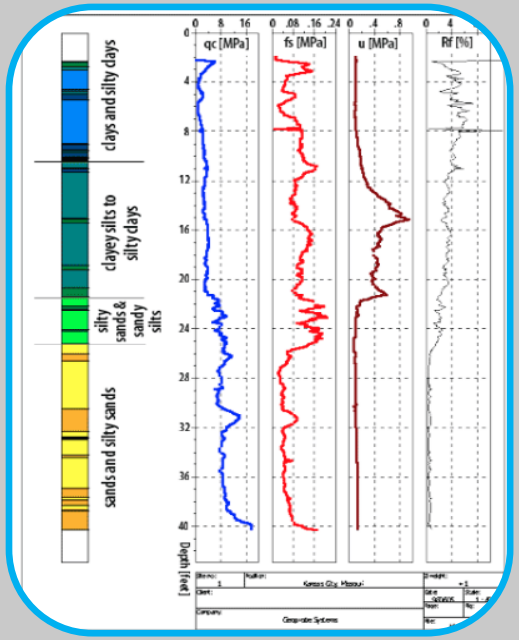
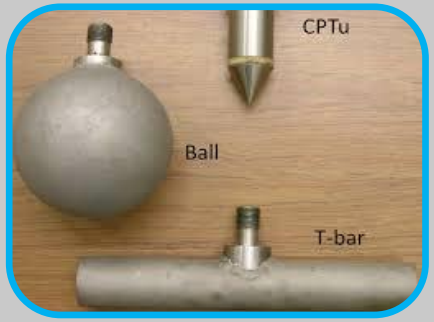
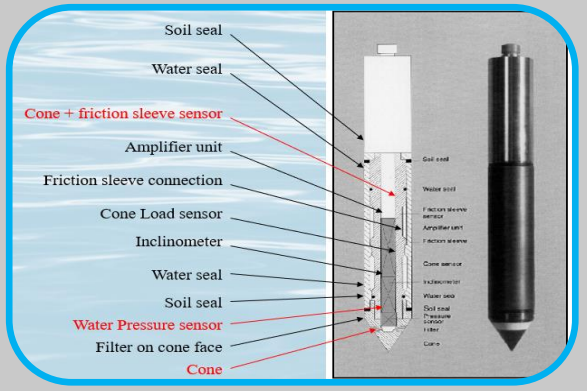
Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Geotechnical Site Investigation Methods
  - Shallow Samplers & Corers & **In-situ Testing**
    - **The Cone Penetrometer Test - (CPT)**
    - **In situ Vane Test**
    - **Bespoke Scale Model Units**
      e.g. *SmartPipe*







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Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Geotechnical Site Investigation Methods
  - Borehole Drilling (& Sampling)

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Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Typical Soil / (Rock) Parameters
- Foundation Concepts
- Soil Parameters Geotechnical (Foundation) Design
- Design Considerations
- Analysis Tools & Methods

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Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Typical Soil / (Rock) Parameters
  - Soil classification
  - Soil Density
  - Soil Strength
    - In situ, remoulded*, time gained*
  - Soil sensitivity*
  - Soil consolidation characteristics and permeability

Soil Parameters	*In Situ* Testing: Type of Tests	Applicability: SAND	CLAY	C&C (D)	WEAK ROCK	Laboratory Testing on Samples: Type of Tests	Applicability: SAND	CLAY	C&C (D)	WEAK ROCK
Geological description	Geological logging	N/A	N/A	N/A	N/A		3	4	4	4
Soil classification	CPT	5	5	3	2	Grain size (sieve)	5	3	4	1
						Water content	1	5	5	1
						Atterberg limits	N/A	5	5	1
Soil density	CPT	3 to 4	2	3	2	Unit weight and water content measurement	1 to 2	5	5	5
Soil strength (undrained shear strength)	CPT	N/A	3 to 4 (a)	3	2	Unconsolidated undrained (UU) triaxial compression	N/A	5	5	3
	In situ vane	N/A	4 to 5	2	1	Consolidated triaxial compression	N/A	5	4	1
	T bar	N/A	5	3	1	Small T bar	N/A	5	3	1
						Fallcone, pocket penetrometer, Torvane, lab vane, direct simple shear	N/A	2	2	2
						Unconfined or uniaxial (UCS) testing	N/A	1	3	5
						Point load testing (PLT)	N/A	1	3	4
Friction angle (drained shear strength)	CPT	3 to 4	2	3	2	Consolidated triaxial compression,	5 (b)	5	2	2
						direct shear (shear box), direct simple shear	4 (b)	1	2	2
Sensitivity	CPT	N/A	2	2	2	Fall cone, lab vane, triaxial	N/A	5	3	1
	In situ vane	N/A	3							
Consolidation characteristics permeability	CPT (piezocone)	1	3 (c)	3	2	Oedometer	2 (b)	5	4	2

Image courtesy of SUT-OSIG

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Geotechnical Site Investigation and Engineering

- Typical Soil / (Rock) Parameters
  - Soil stiffness
  - Soil deformation
  - Interface friction (soil/steel, soil/pipe)
  - Cyclic behaviour
  - Permeability
  - Thermal conductivity
  - Electrical resistivity
  - Gas content

Soil Parameters	*In Situ* Testing Type of Tests	Applicability SAND	CLAY	C&C (D)	WEAK ROCK	Laboratory Testing on Sample Type of Tests	Applicability SAND	CLAY	C&C (D)	WEAK ROCK
Interpolation of soil layering in between borings/CPTs	Instrumented plough	2	2	2	2	N/A				
Soil density and stiffness	Electrical resistivity probe	2 to 3	1	1	1	Small strain effective stress testing	3 to 4 (e)	2	3 to 4	4
	Nuclear density probe	1 to 2	2 to 3	2 to 3	1					
	Pressuremeter / high pressure dilatometer	4	4	4	4					
	P-S logging	4	3	3	3					
	Seismic cone	3 to 4	3 to 4	2	2					
Soil strength and deformation	Pipe model test / Plate load test	3 to 4	3 to 4	3 to 4	3 to 4	Direct simple shear	4 (b)	4	3	1
Interface friction	N/A					Ring shear	3 to 4	5	3 to 4	N/A
Cyclic behaviour	Seismic cone	3 to 4	3 to 4	4	4	Resonant column (small shear strain modulus)	4	4	4	1
						Direct simple shear - static/ cyclic	4 (a)	4	3	1
						Cyclic Consolidated triaxial	5 (b)	5	4	3
Permeability	CPT (piezocone) - dissipation tests, BAT probe	2	4	4	1	Special permeability tests	5 (b)	4	2	2
	Piezoprobe	2	4	4	1					
Thermal conductivity	Heat flow probe	4	4 to 5	2	1	Transient method / Steady state method	5 (b)	5	2	1
Corrosion or chemical effect potential	Electrical resistivity cone	4	4	3	3	Mineralogy and porosity	4	4	4	4
						Electrical resistivity	4 (b)	4	4	3
						Sulphate				
						Carbonate				
						Chloride testing				
						pH				
Gas content	BAT/DGP (deep gas probe)	4	4	4	1	Geochemical	5	5	2	

Image courtesy of SUT-OSIG

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Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Foundation Concepts
  - Foundations should be
    - economic,
    - Acceptable reliability over lifetime
    - Installable and removable
- Deep (eg Piles)
- Shallow (including Gravity Base Structures [GBS])
- Suction caissons (buckets/cans)
- Anchors & Tension Leg (taut wire / catenary)





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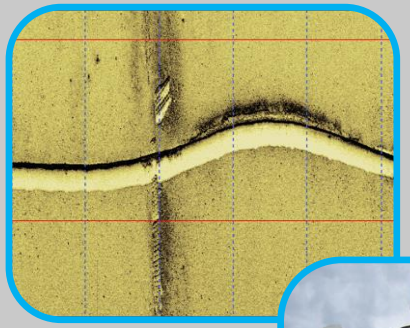
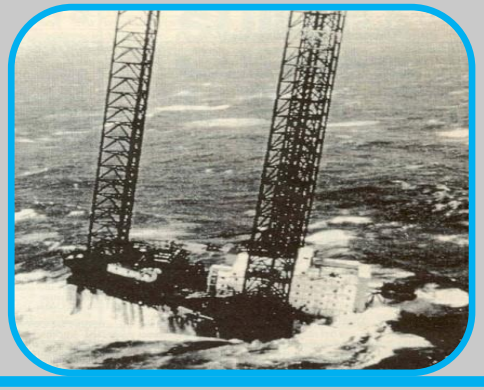
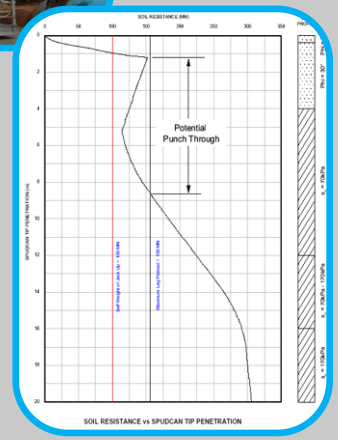
Geotechnical Engineering & The Associated Geoscienc

Geotechnical Site Investigation and Engineering

- Other Foundation (or Mooring) Concepts and Applications include
  - Pipelines*
  - Jack-up Rigs* (SI, Drilling, Construction, Decomm)
  - Rock berms
  - (O&G) Well Conductor casings
  - Anchors - (Holding capacity – penetration and drag resistance)
  - Temporary works and Port & Harbour Construction (Sheet piles / Blocks, Wave protection measures)







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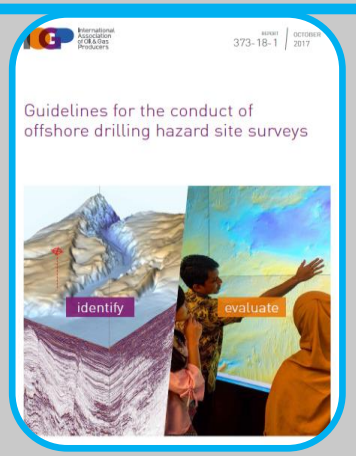
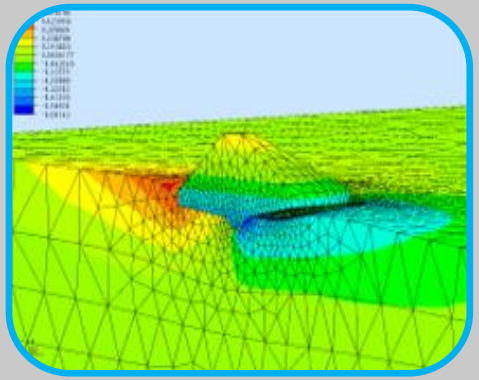
Geotechnical Engineering & The Associated Geosciences

Geotechnical Site Investigation and Engineering

- Geotechnical Analysis Tools & Methods
  - Design Codes & Published Methods
  - Geotechnical Established Principles
  - Limit equilibrium methods / models
  - Numerical Modelling
  - Physical Modelling
  - Back-Analysis
  - Scale & Centrifuge modelling





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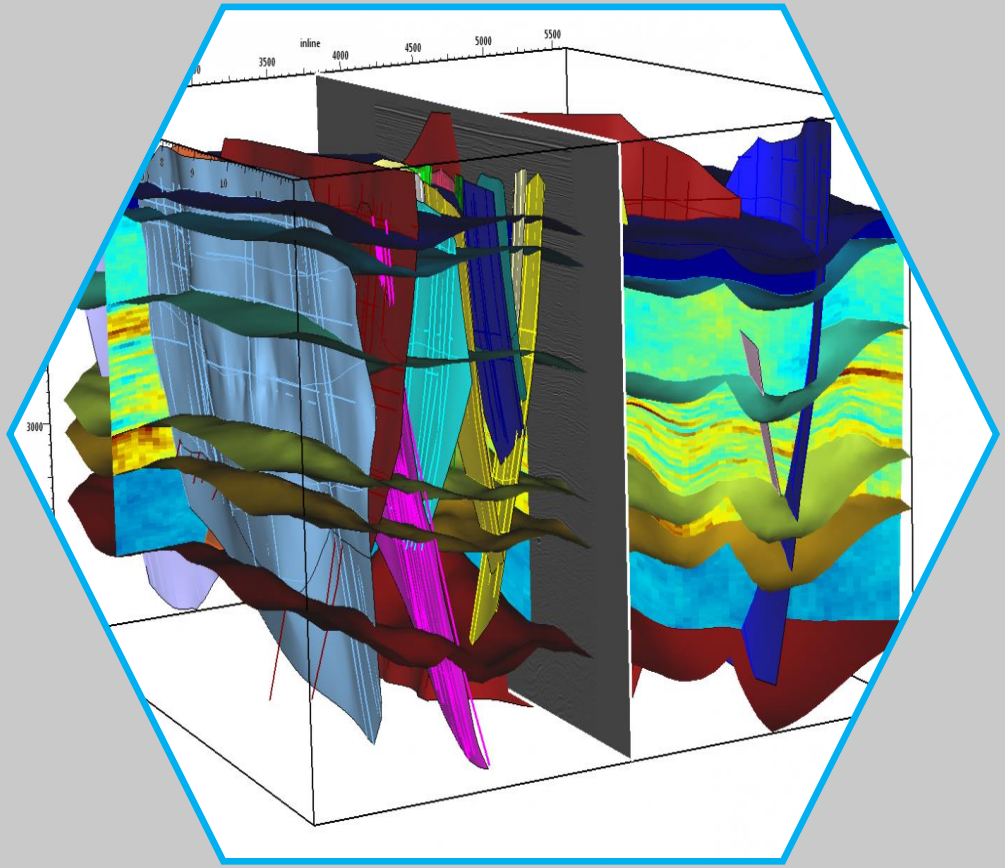
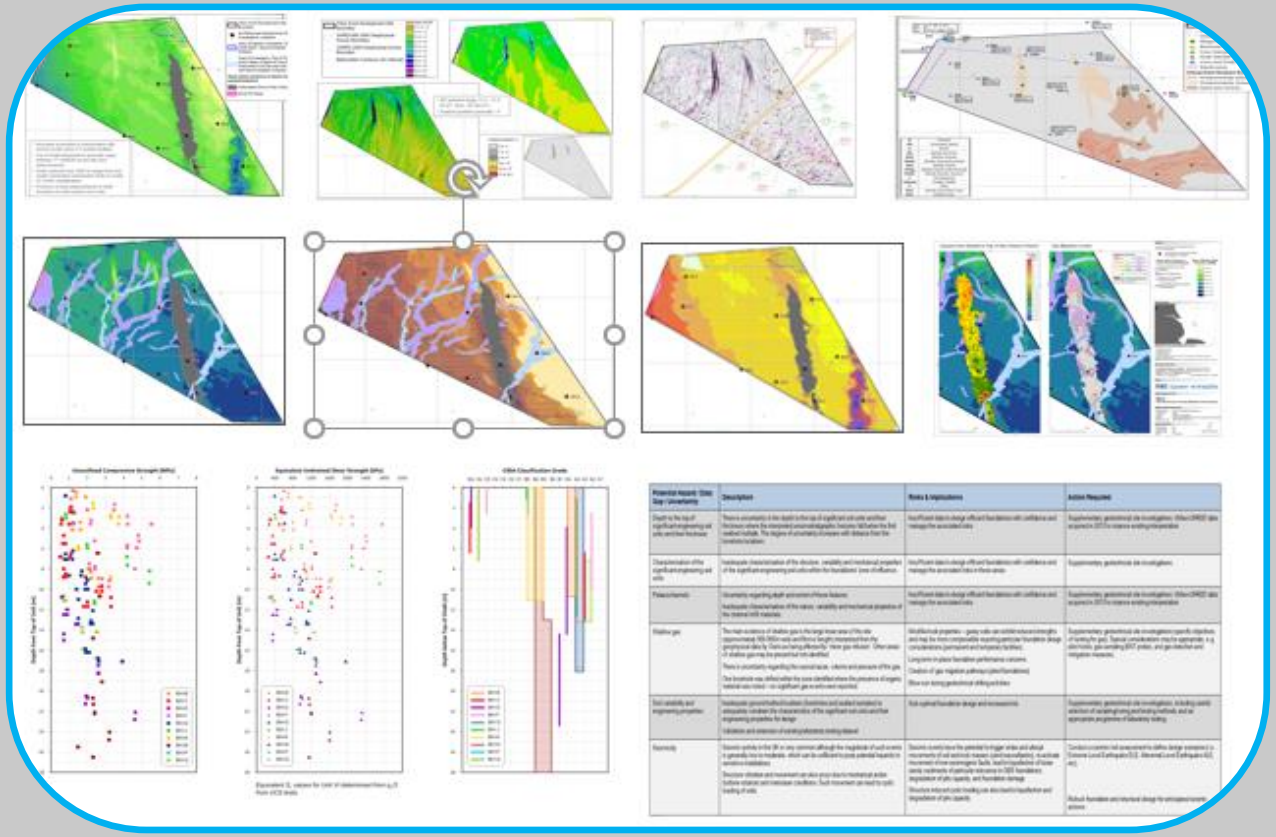
Data Integration, the Ground Model, GIS & Visualisation

- Data Integration – *Cálice Sagrado!*



Data Integration, the Ground Model, GIS & Visualisation

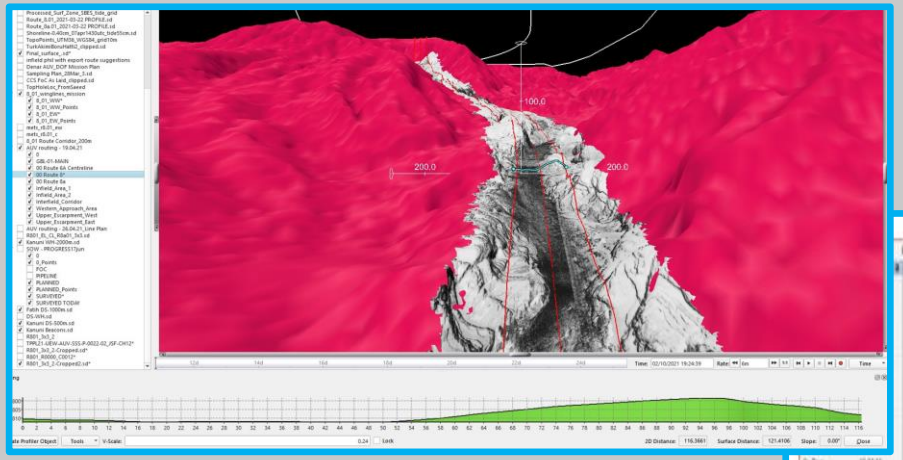
- Ground Model Development
  (a joia da coroa?)
  - Collation of all available project (and related) data – REGISTER OF DATA SETS
  - Facilitates SITE CHARACTERISATION
  - Collates and identifies GEOHAZARDS (graphically and as a register)

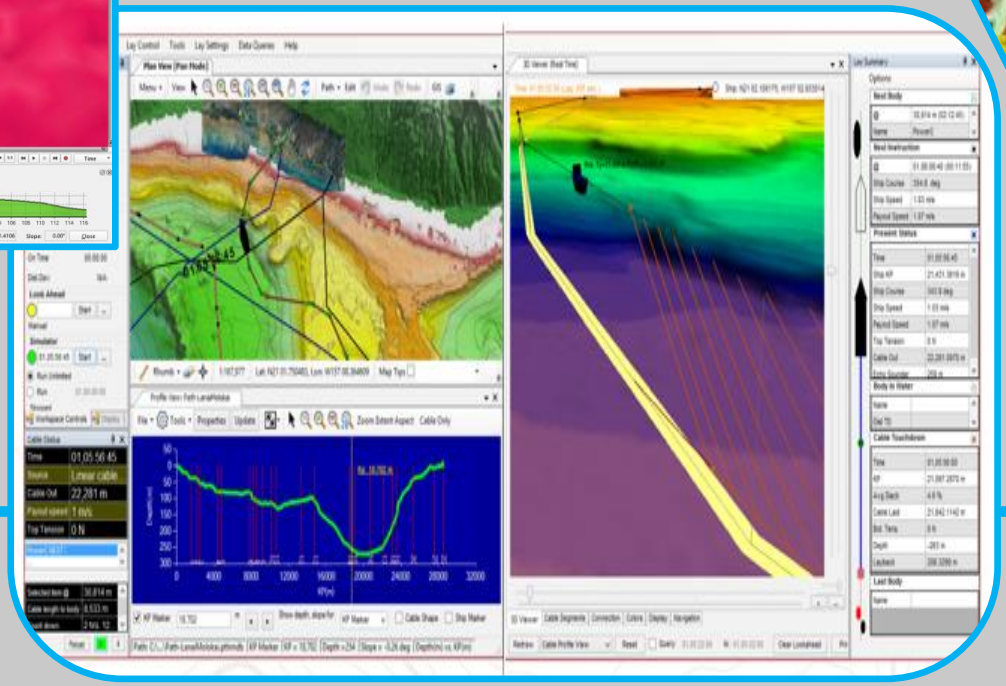


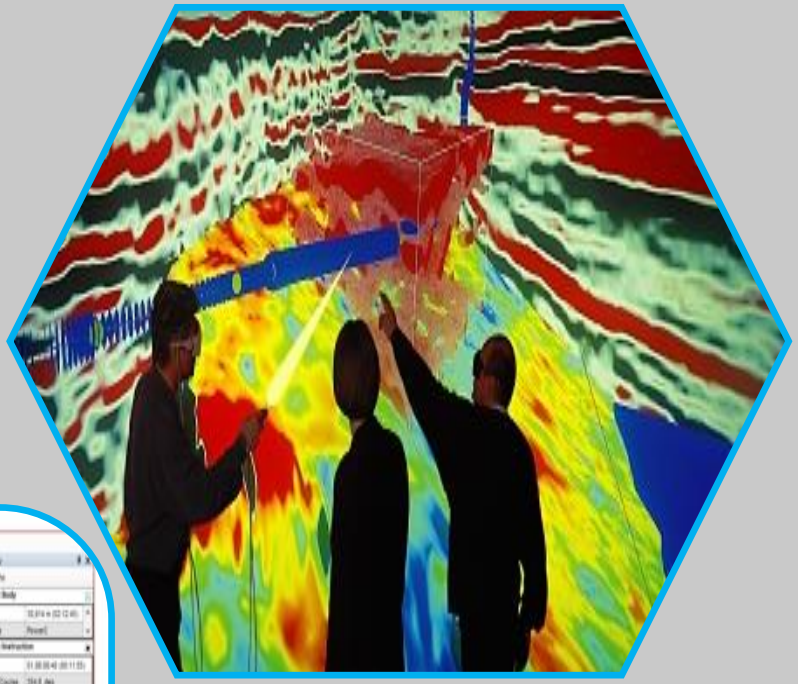
Geotechnical Engineering & The Associated Geosciences

Data Integration, the Ground Model, GIS & Visualisation

- GIS & Data Visualisation







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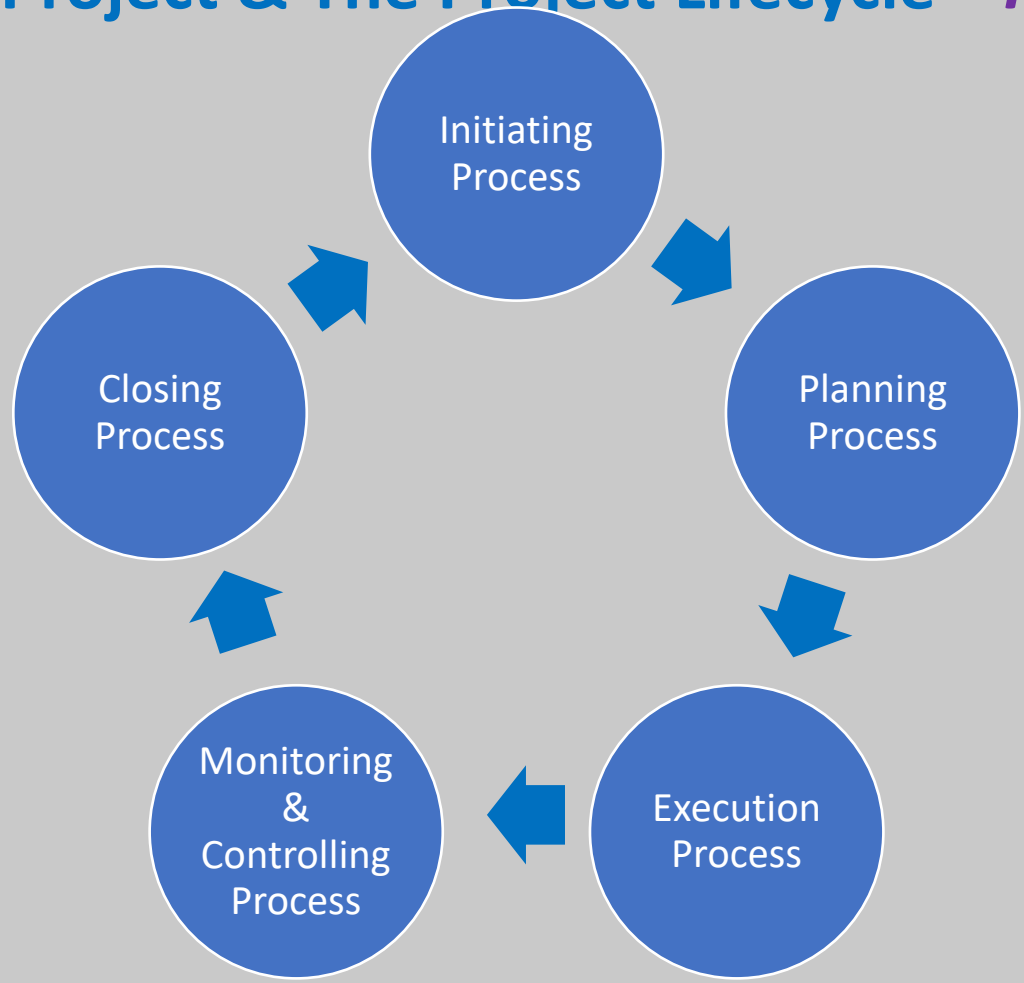
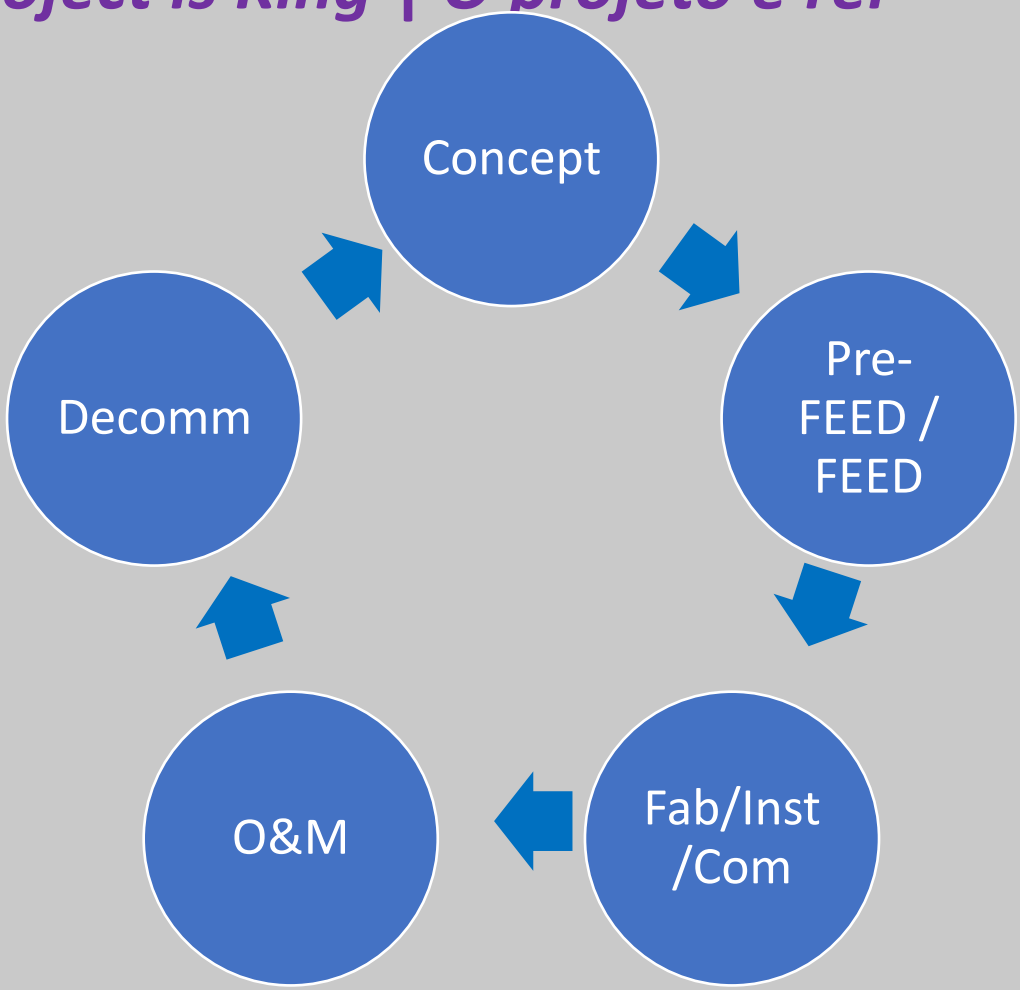
The Project Lifecycle
&
Project Risk

The Project Lifecycle & Project Risk

The Project & The Project Lifecycle - *The Project is King | O projeto é rei*





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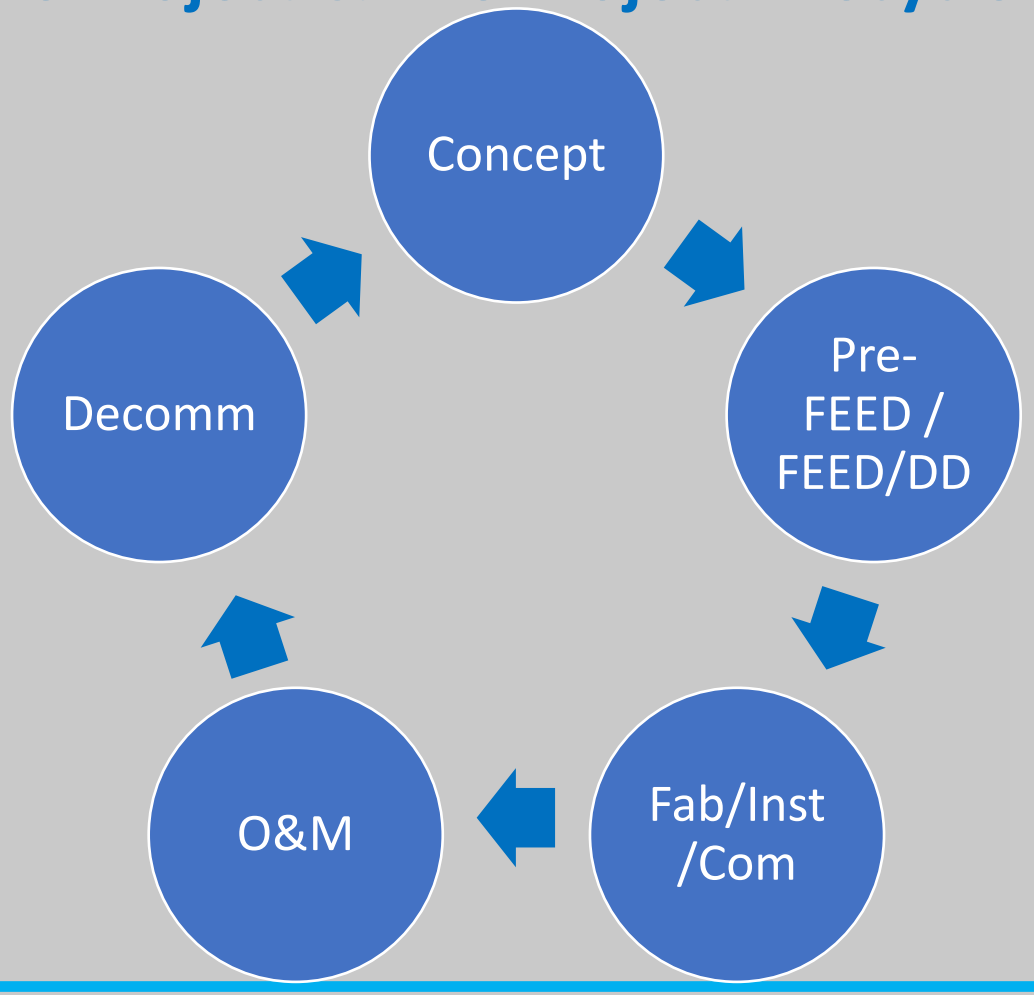
The Project Lifecycle & Project Risk

The Project & The Project Lifecycle - The Project is King | *O projeto é rei*



Geo-input?
Concept | Desk Study, Literature Search

Pre-FEED&FEED | Limited data acquisition leading to max data acquisition for Detailed Design

Fabrication & Installation | May require further data input

O&M | Generally period of lowest input and activity though if instrumentation & monitoring forms part of the project this may result in additional input

Decommissioning | Is becoming a major part of project engineering and input esp. O&G.

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The Project Lifecycle & Project Risk

Risk - Project Risk

"No construction project is risk free. Risk [including Geotechnical] can be managed, minimised, shared, transferred or accepted……..

It cannot be ignored"

Managing Geotechnical Risk – Improving Productivity in UK Building & Construction
Clayton, C.R.I., DETR & ICE, 2001

Oft quoted maxim:
"You pay for a site investigation whether you do it or not"
Prof. Stuart Littlejohn (1990's)

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The Project Lifecycle & Project Risk

Risk - Project Risk

What is Risk? -

An occurrence exposing a person(s), structures, equipment and the environment to danger, harm or loss

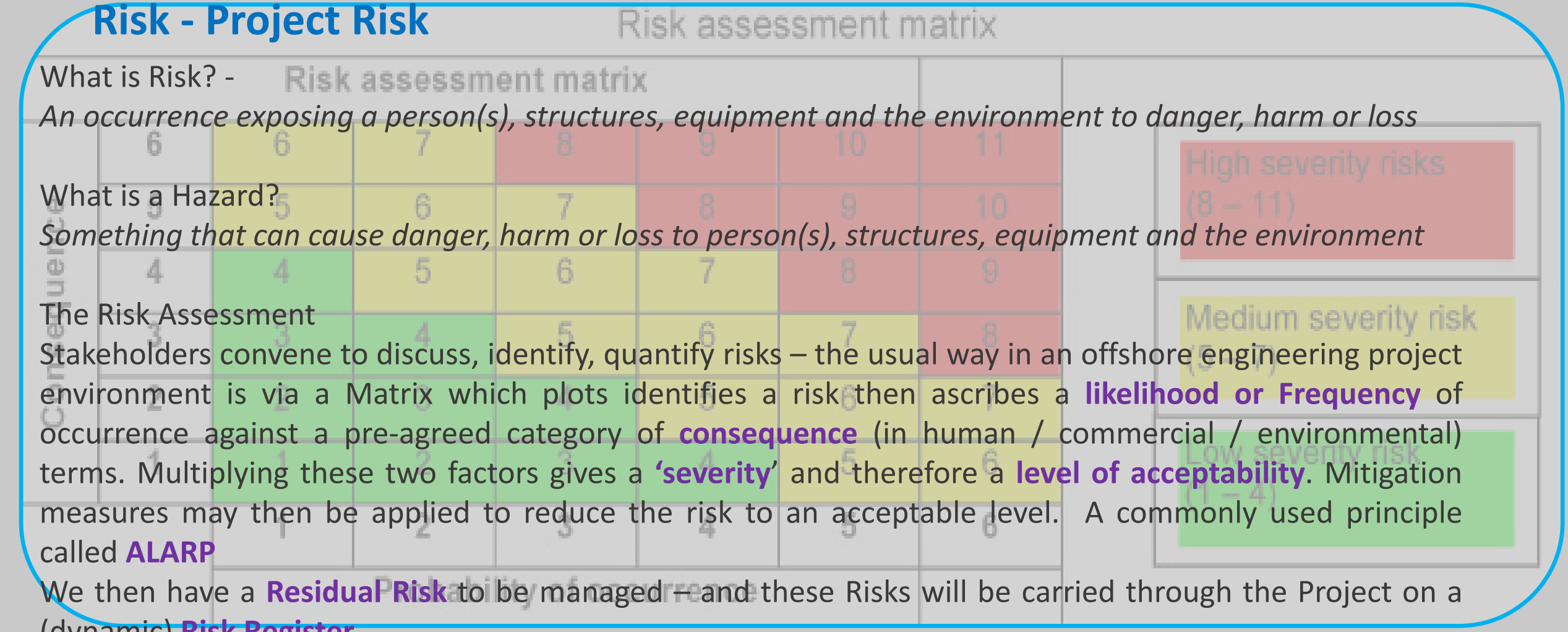
What is a Hazard?

Something that can cause danger, harm or loss to person(s), structures, equipment and the environment

The Risk Assessment

Stakeholders convene to discuss, identify, quantify risks – the usual way in an offshore engineering project environment is via a Matrix which plots identifies a risk then ascribes a **likelihood or Frequency** of occurrence against a pre-agreed category of **consequence** (in human / commercial / environmental) terms. Multiplying these two factors gives a **'severity'** and therefore a **level of acceptability**. Mitigation measures may then be applied to reduce the risk to an acceptable level. A commonly used principle called **ALARP**

We then have a **Residual Risk** to be managed – and these Risks will be carried through the Project on a (dynamic) **Risk Register.**



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The Project Lifecycle & Project Risk

Project Risk – Geohazards / Geohazard assessment

Man-made features	Natural Seabed features	Subsurface geological features
Pipelines: on or buried below the seabed	Seabed topography and relief	Sedimentary sequences
Communications cables	Seabed sediments	Stratigraphy
Wrecks, including ships aircraft & Submarines	Sand: banks, waves, and mega-ripples	Buried infilled channels
Wellheads and abandoned well locations	Glacial features including iceberg plough marks	Hard grounds / cemented sands or buried land surfaces
Unexploded ordnance (UXO)	Rock outcrops, pinnacles and boulders	Gravel beds
Navigation or metocean buoys	Seabed channels and scours	Boulder beds
Archaeological remains	Gravel beds	Rock head or igneous intrusion near seabed
Miscellaneous debris	Hard grounds / cemented sands	Peat
Power and umbilical lines & cables	Submerged forest or terrestrial palaeo-landscape	Erosion and truncation surfaces
Waste, chemical or other dumping grounds	Unstable or steep slopes	Shallow water flow zones / loose sands
Jack-up rig footprints	Gas vents and pockmarks	Relict glacial features
Rock dumps	Collapse features	Faults - tectonic or glacigenic
Scour protection material	Fluid expulsion features	Shallow gas charged intervals
Gravel extraction areas	Fault escarpments	Gas chimneys
Export and intra-array cables	Reefs	Salt or mud diapirs and diatremes
Wind turbines, wave, tidal arrays	Mud: flows, gullies, volcanoes,	Buried slumps and mass transport complexes
Manifolds and templates	Slumps	complexes
Platforms: active, abandoned, or toppled	Diapiric structures	Gas hydrate zones and hydrated soils
Anchorage	Gas hydrate mounds	

The Energy Question?
&
The Energy/Resource Dilemma – a few polemics – perhaps?

"F:\Madiera_Uni_Presentation\BathGS_20211\bp-stats-review-2021-full-report.pdf"

https://www.instituteforgovernment.org.uk/explainers/net-zero-target

The Energy/Resource Dilemma

Insatiable Energy Demand | Energy Policy | Energy Security

- In an Offshore Energy Context we generally derive Energy from Hydrocarbons (Oil & Gas) or Offshore Renewables, predominantly Offshore wind and increasingly Wave & Tidal.

- Balance of opinion recognises global warming (with a significant anthropogenic input) and the need for the human race to do something about it …….. So, simple – no? We need to stop putting petrol in cars (and ships and aeroplanes) allowing us to drastically reduce the amount of Hydrocarbons we produce – using them to better ends – pharmaceuticals and specialised materials.

- Electric cars? More wind turbines? Better still tidal and wave devices?

- What about consumer electronics from iPhones to TVs to sophisticated electronics and components – where do these resources come from?

The Energy/Resource Dilemma

Insatiable Energy Demand | Energy Policy | Energy Security

Decarbonization of energy supply relies on new technologies that require exotic metals, minerals and REE/REY - the obtaining of which is raw material intensive – to sustain this growth, a significant increase in production is required to sustain this growth – but from where??

The transition from a global hydrocarbon economy to a green economy and a rapidly growing middle class in developing countries are driving the needs for considerable new sources of critical materials ……and deep ocean minerals can help to fulfil that need

(I would contend unless human nature and socio-economic drivers change radically – unlikely!)

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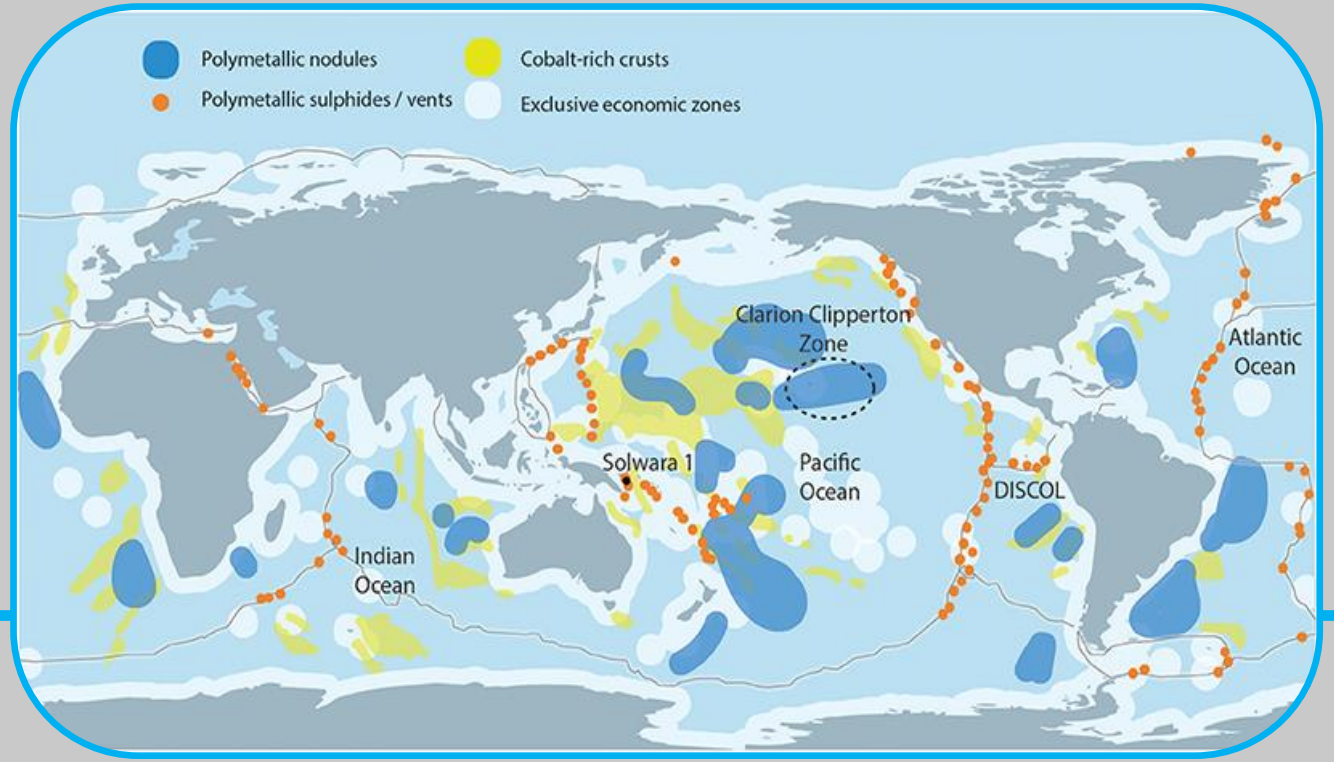
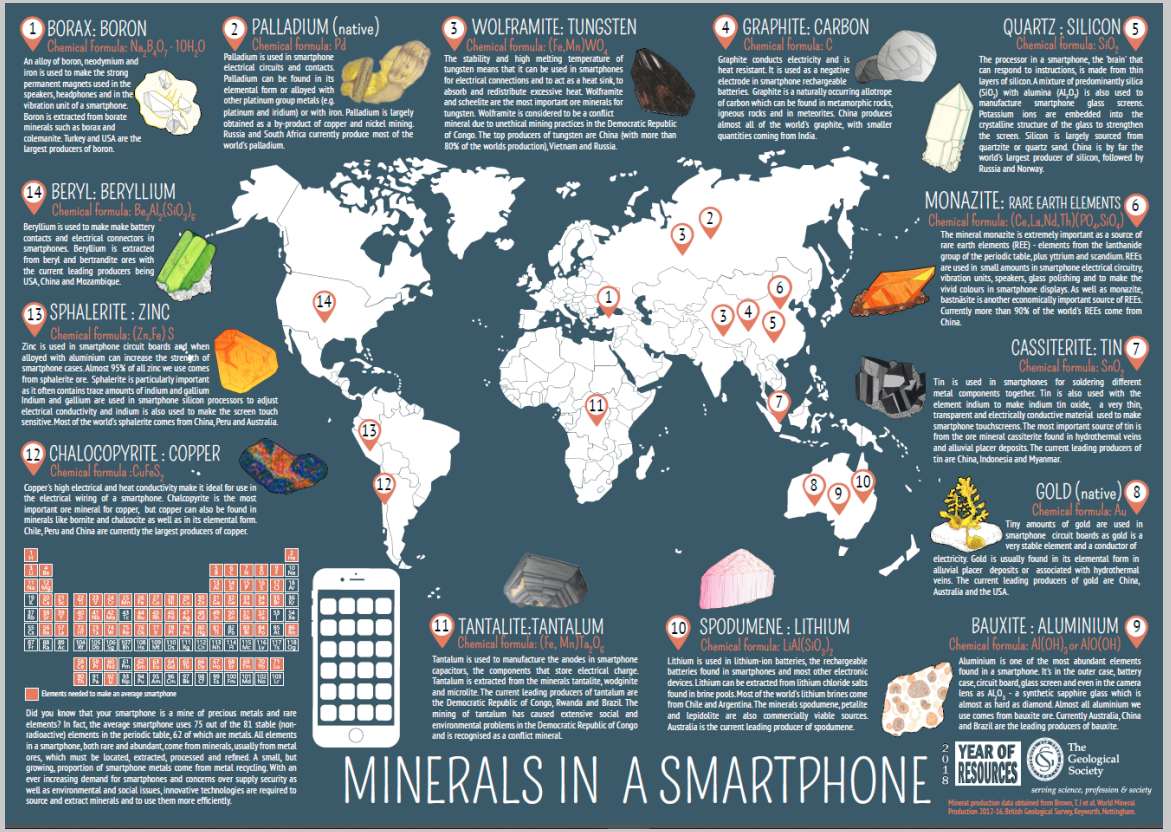
The Energy/Resource Dilemma

Insatiable Energy Demand | Energy Policy | Energy Security

Infographic of the minerals required to make a Smartphone (or electronic engine or wind turbine) and where they currently come from





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The Geosciences are in crisis ……

Agenda

Geosciences & the Offshore Energy Sector; The Inter-relationship

The role of the Geo-whatevers; who are we?

The Sectors

The Project Life Cycle & what we actually do

Some dilemmas and polemics

The role of the Geo-folk reprised – Crisis? What crisis

Opportunities & Employment

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Geoscience crisis

- More STEM!!
- The numbers of school / college leavers going into the Geosciences are falling significantly.
- Consequently, University and Tertiary College Earth Science courses are closing.
- I would contend Geo-scientists / Geo-engineers are best placed to aid policy makers and society in general to best manage resources and drive reduced and/or carbon free solutions.
- The Geo-subjects are now largely regarded as ‘uncool’ and tainted with the association of mining and O&G.
- There are a number of initiatives to try and reverse this trend - we desperately need Geoscientists

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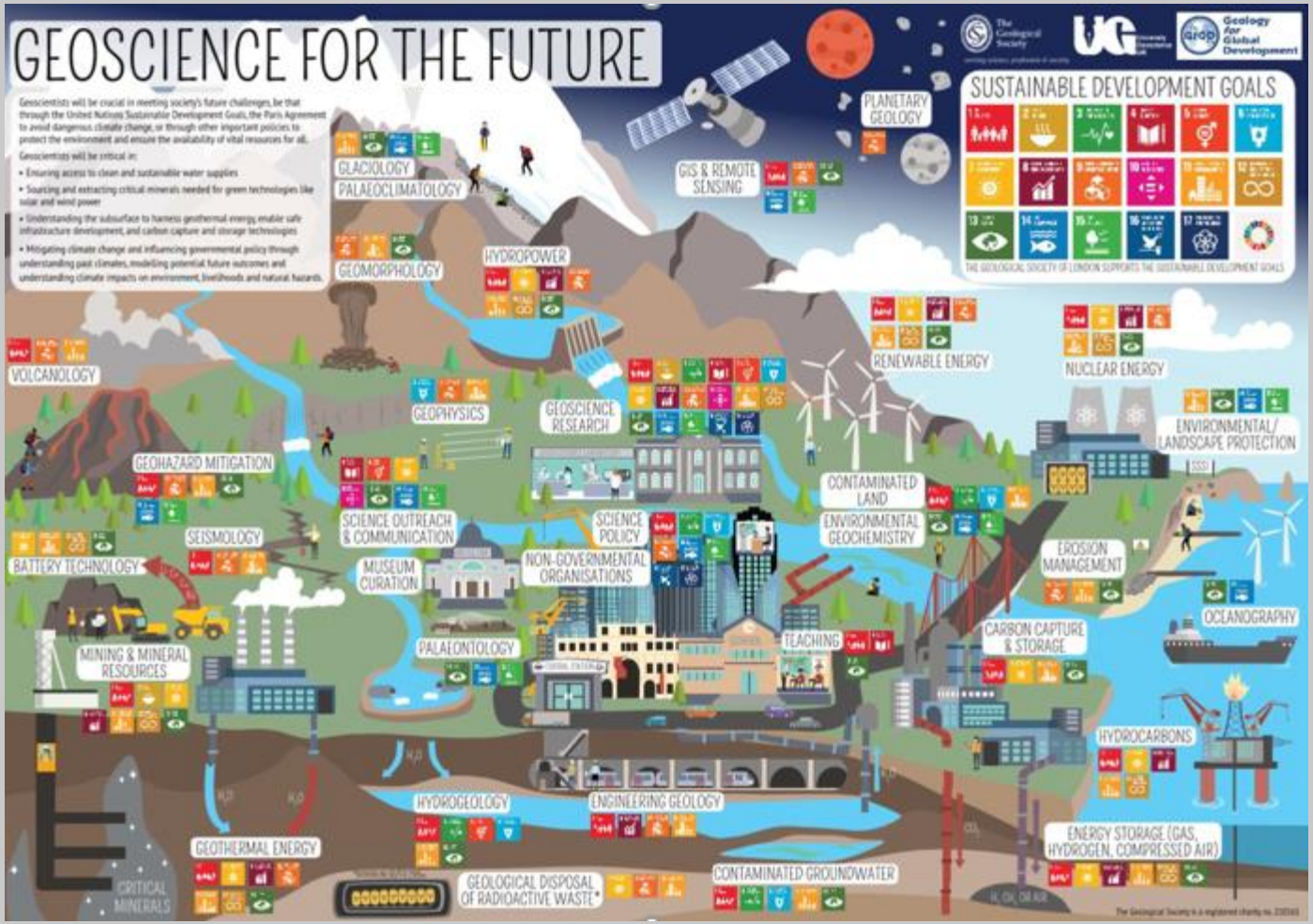
Geoscience crisis

To end – here this info-graphic poster from the GSL, Uni. Geoscience-UK & Geology for Global Development nicely sums up the future roles and opportunities for the Geo …. Whatever we're going to call them



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Thank you for your time and attention
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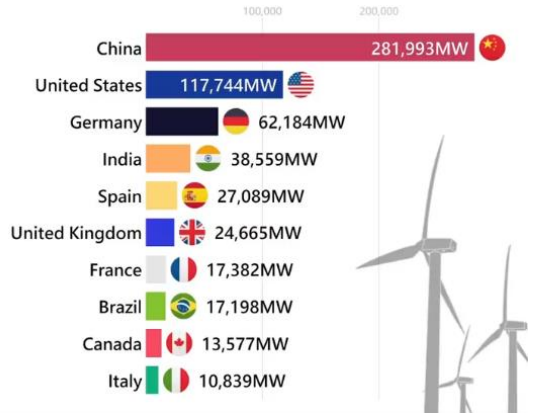
[O&G Animation]

[OW Animation]

[First Jacket]

I thoroughly recommend this guy – if you're not already aware:

https://www.linkedin.com/in/felipe-ochoa-cornejo/



Unattributed source from a iPS Baltics LinkedIn posting