



Minds for Underwater Mines

A ROYAL IHC PERSPECTIVE

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IHC Mining

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The technology innovator.

About Royal IHC– Key figures

Dredging **Mining** **Offshore**

Innovative vessels

Advanced equipment

Life-cycle support

IHC Life Cycle Support

- 1 Dredging fundamentals and new concepts
- 2 Project evaluation and equipment selection
- 3 Design, new building and construction
- 4 Training
- 5 Start-up and operations
- 6 Technical ship management and maintenance
- 7 Spare parts, logistics and component repair pool service
- 8 Dry docking and ship repair
- 9 Renovation

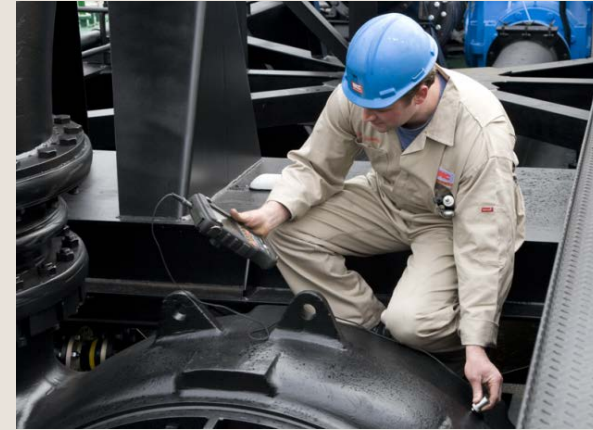
Amounts in millions of euro	2014	2013	2012	2011
Revenue	1215	985	895	1,050
Order portfolio as at 31 December	1166	1,743	964	1,179
Profit	124	56	37	103
Average number of employees	3263	3,224	3,239	3,109

Dredging





Dredging equipment



Offshore





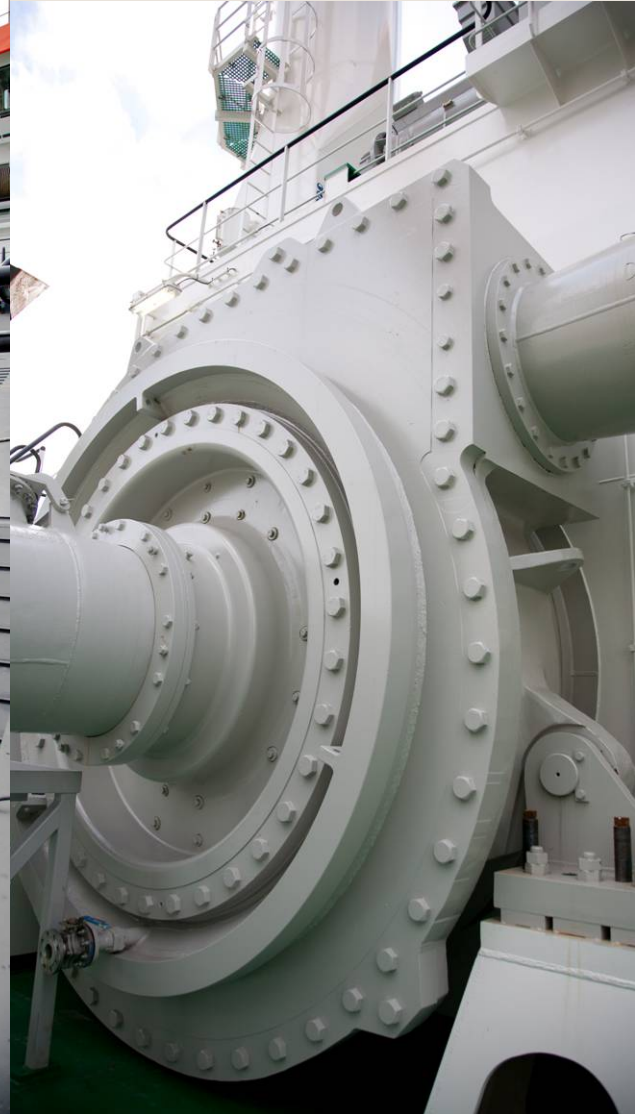
Systems, tools and components



Mining

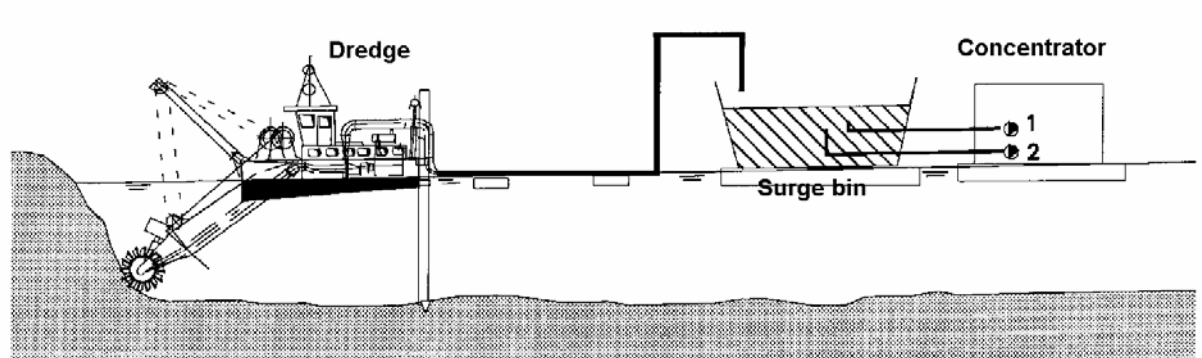
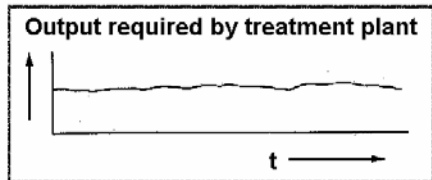
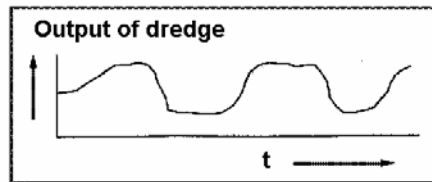


Dredging and Mining: Technology & services



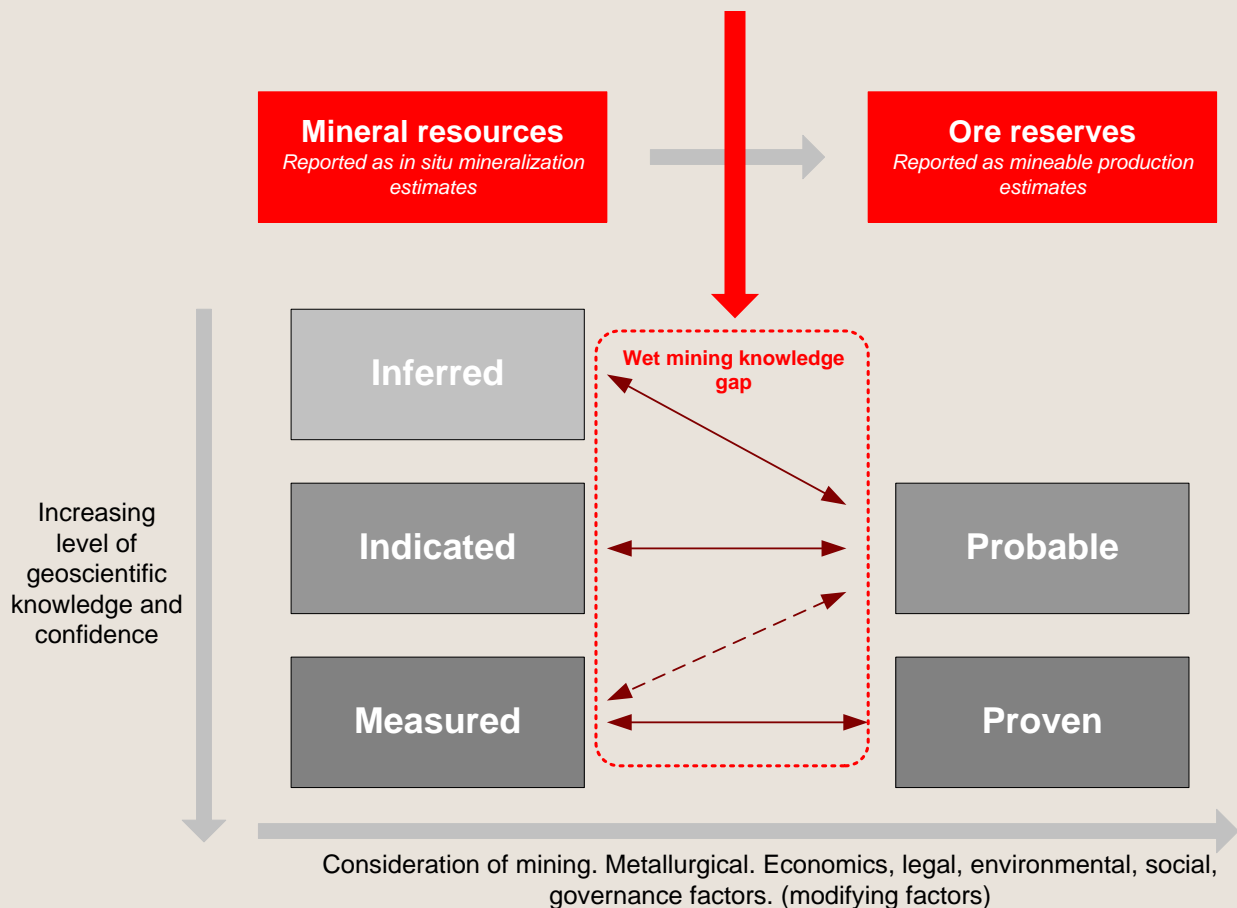
Equipment requirements for mining

- Mining for minerals
- Accuracy and selectivity
- Processing step involved
- Game of capacities
- Long term projects
- Mining life cycle





A mining project is only viable when the resource is translated into a reserve !!!

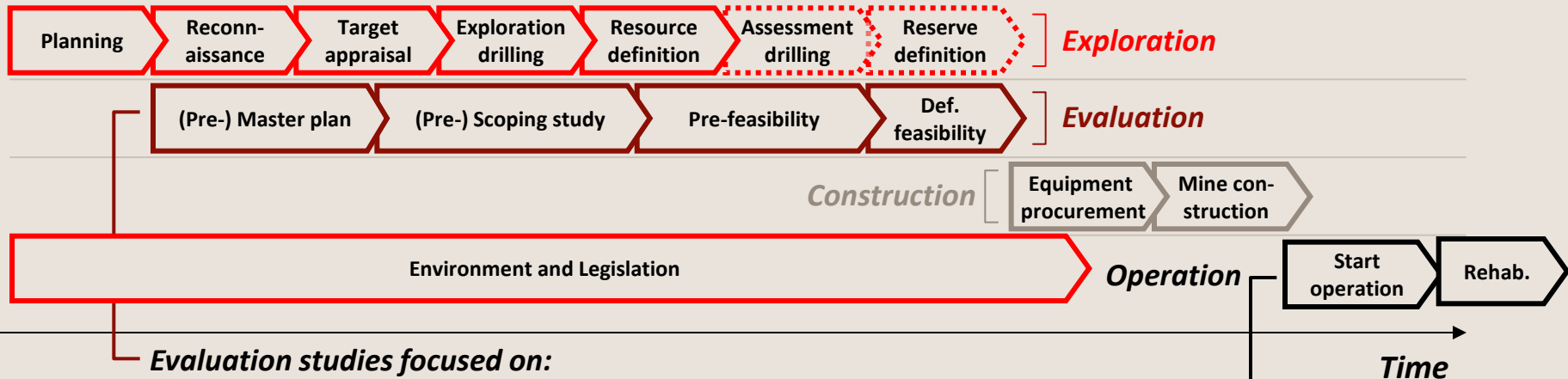




Mining Life Cycle

Exploration management focused on:

- Identification and assessment of mineral resource potential
- Coordination of site surveys, mapping and sampling programs
- Advice on regulatory and environmental reporting



Evaluation studies focused on:

- Mining
 - Mine method selection
 - Mine planning
 - Costing
 - Concept design
 - Equipment design base
- Mineral processing
 - Wet separation techniques
 - Process Flow Diagram (PFD) development
 - Mass balance calculations
 - Game of capacities
 - Design envelop
- Due diligence
 - Technical
 - Financial

Operational support

- Performance improvement
- Troubleshooting

**Integrated dredge and marine mining solutions
over total mining life cycle**



Mining reference: Rio Nova - Brasil

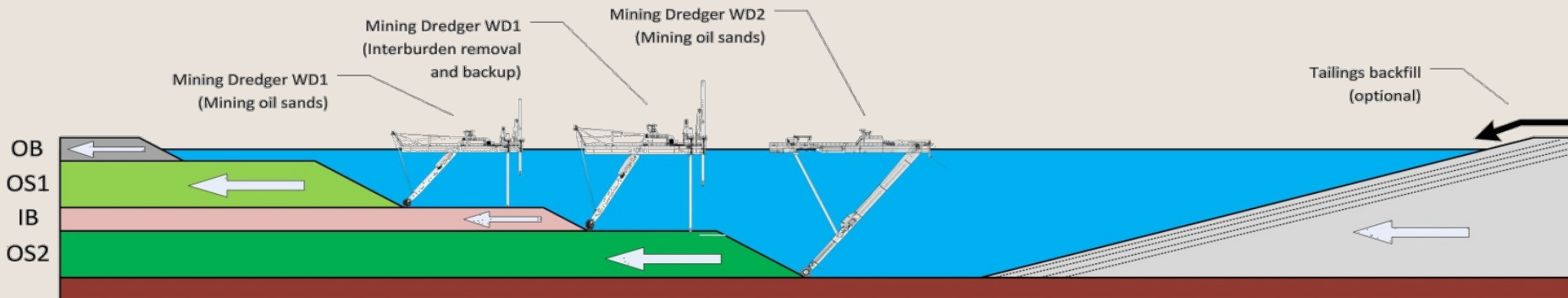


Mining reference: Vale - Brazil





Flooded mines and new opportunities



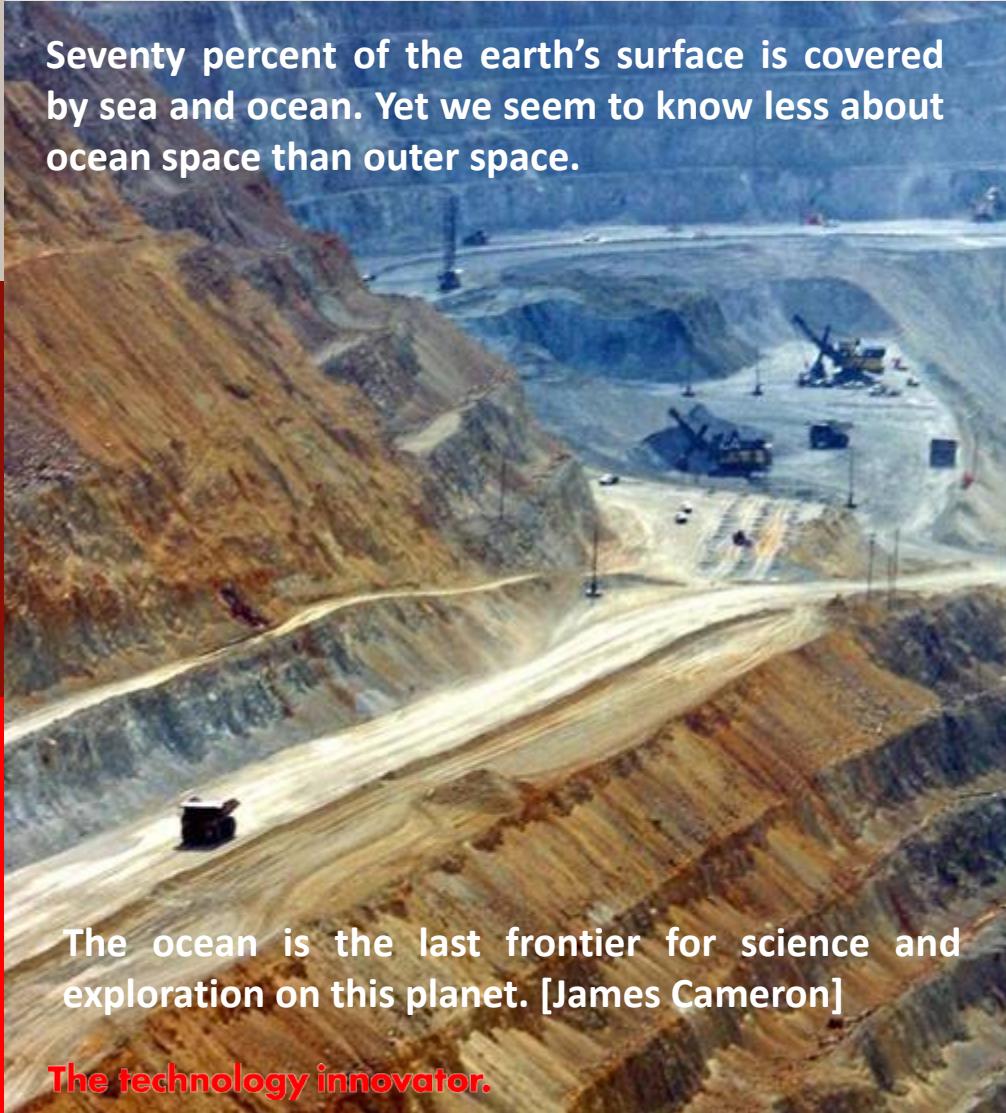
Why does the world need deep sea mining?

Why is Royal IHC involved in deep sea mining?



Why deep sea mining?

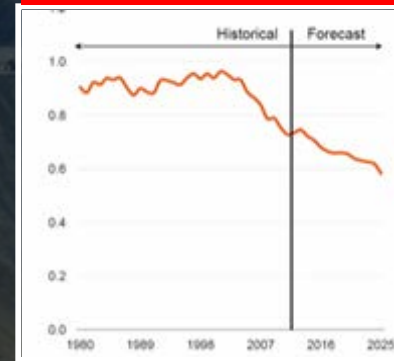
Seventy percent of the earth's surface is covered by sea and ocean. Yet we seem to know less about ocean space than outer space.



The ocean is the last frontier for science and exploration on this planet. [James Cameron]

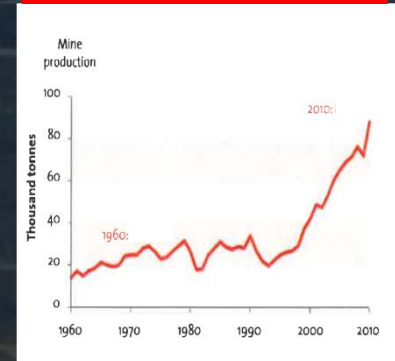
The technology innovator.

Declining grades



Source: Wood Mackenzie, BHP Billiton

Increased demand



Metal prices



Opportunity



Target minerals - types



The technology innovator.

Epipelagic Zone (0 – 200 m)

- Mineral sands (Ti-Zr)
- Gold
- Tin
- Diamonds
- Iron sands
- Tailings

Mesopelagic Zone (200 m – 1 000 m)

- Phosphates
- Cobalt rich crusts – Co, Mn & Ni

Bathypelagic Zone (1 000 m – 4 000 m)

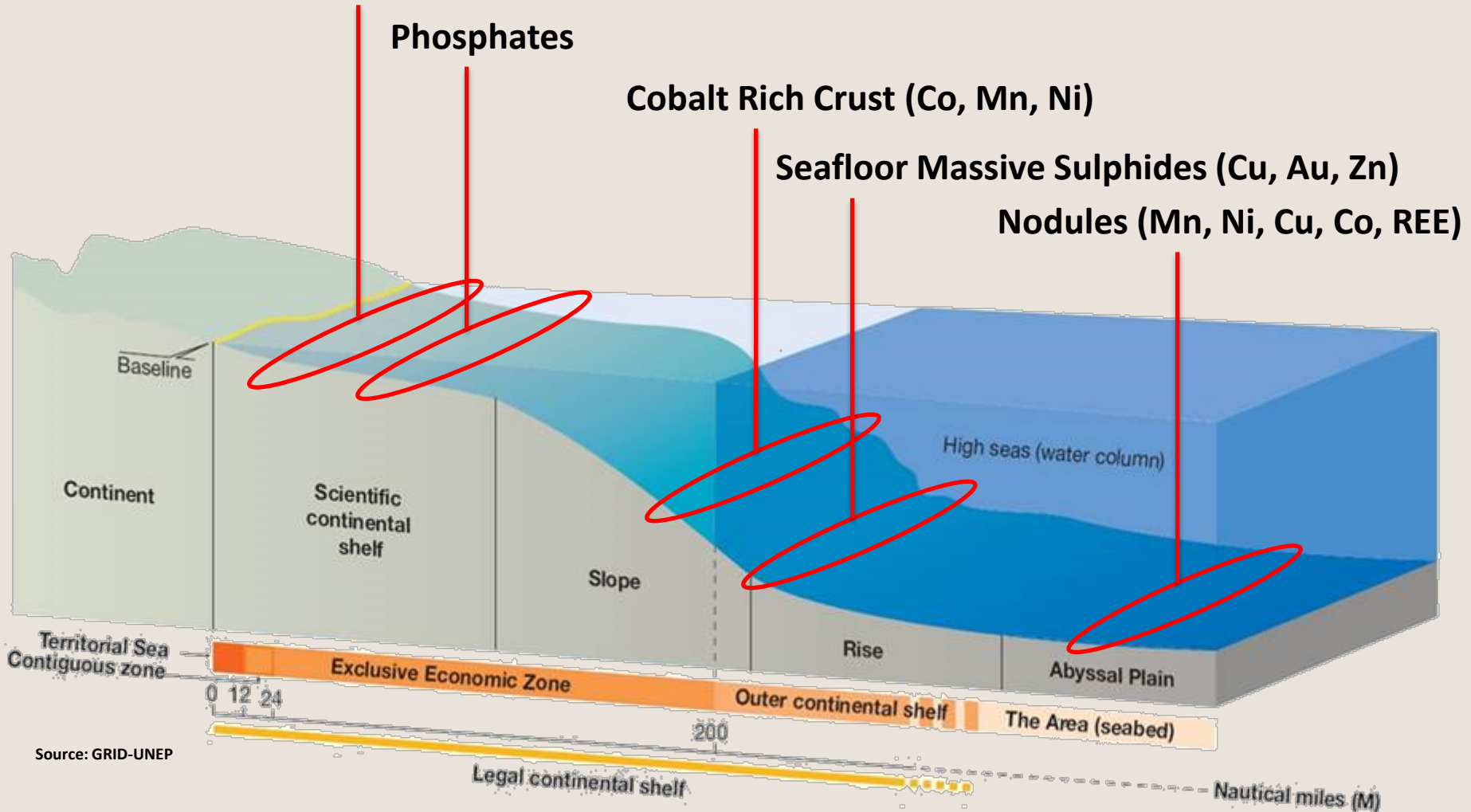
- Polymetallic massive sulphides (SMS deposits) – Cu, Au & Zn
- Cobalt rich crusts – Co, Mn & Ni

Abyssopelagic Zone (4 000 m – 6 000 m)

- Polymetallic manganese nodules - Mn, Ni, Cu & Co (REE)

Target minerals – location on the sea floor

Offshore placers: Diamonds, gold, tin, heavy minerals (Ti-Zr)



Source: GRID-UNEP

History of sea floor mining

Diamond mining - 1960s



Manganese nodule mining - 1974



Discovery of Manganese Nodules – 1868





Mining reference: PT Timah - Indonesia

Location

- Indonesia (Bangka and Karimun area)

Tin mining

- Wheel dredger
- Rebuild bucket ladder dredger
- Cassiterite

Operation

- Start 2012
- Dredging depth 60-70 m
- Production 1500 – 2500 m³/hr

Equipment

- 1 IHC rebuild Wheel Suction Dredger



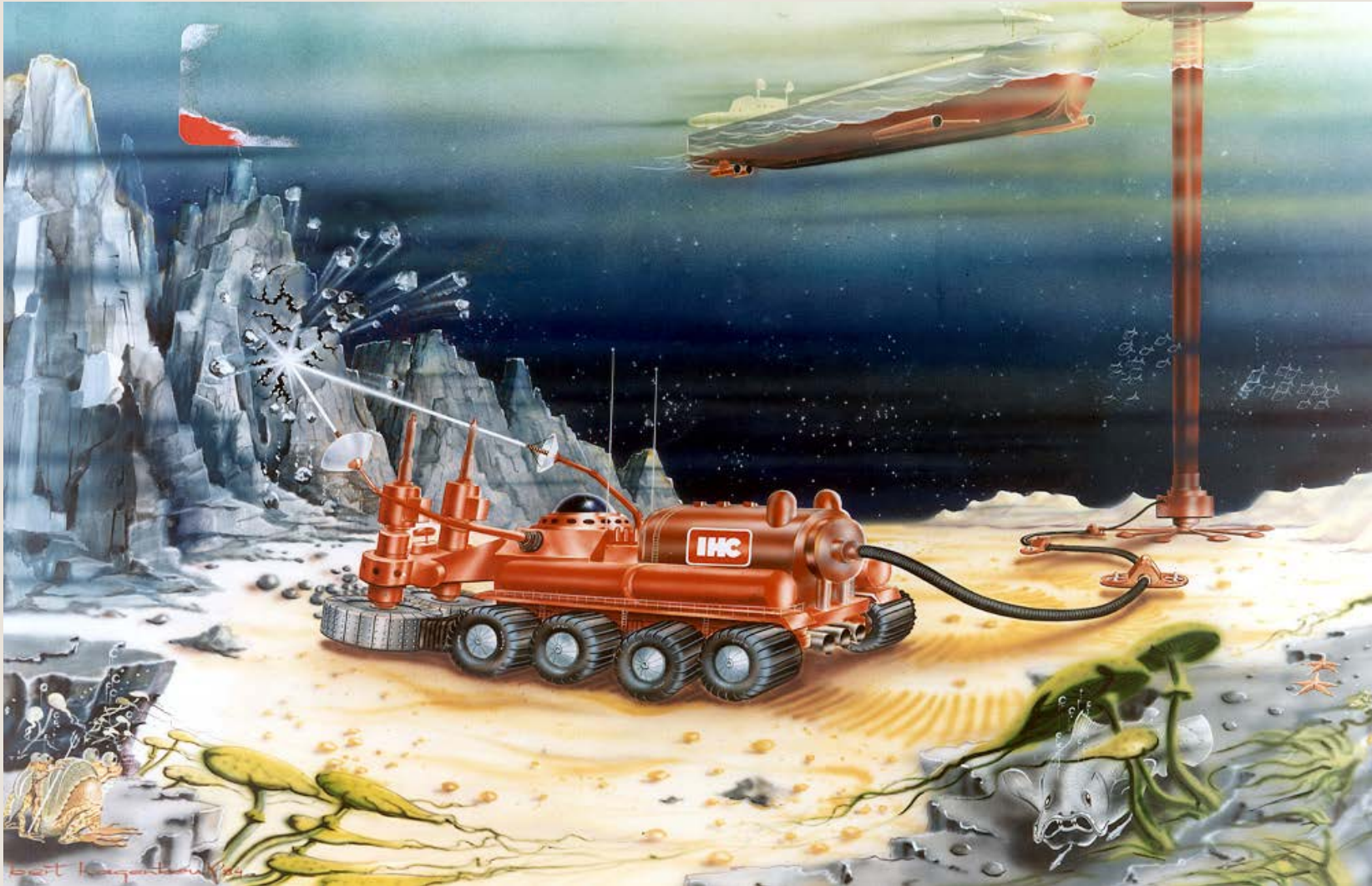


Aggregate mining





Already in 1982 FUTURE GROWTH: DEEPSEA MINING



Red Sea Mud

156 Hydrothermal mineral deposits

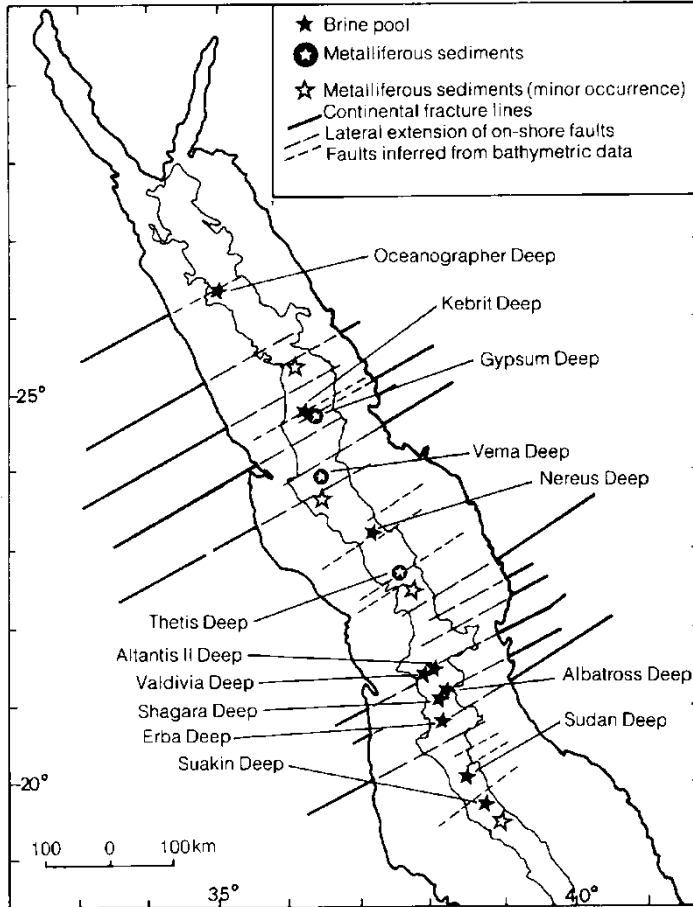


Fig. 8.9 Locations of major hydrothermal occurrences in the Red Sea and their relationship to faulting (from Bignell, 1975).

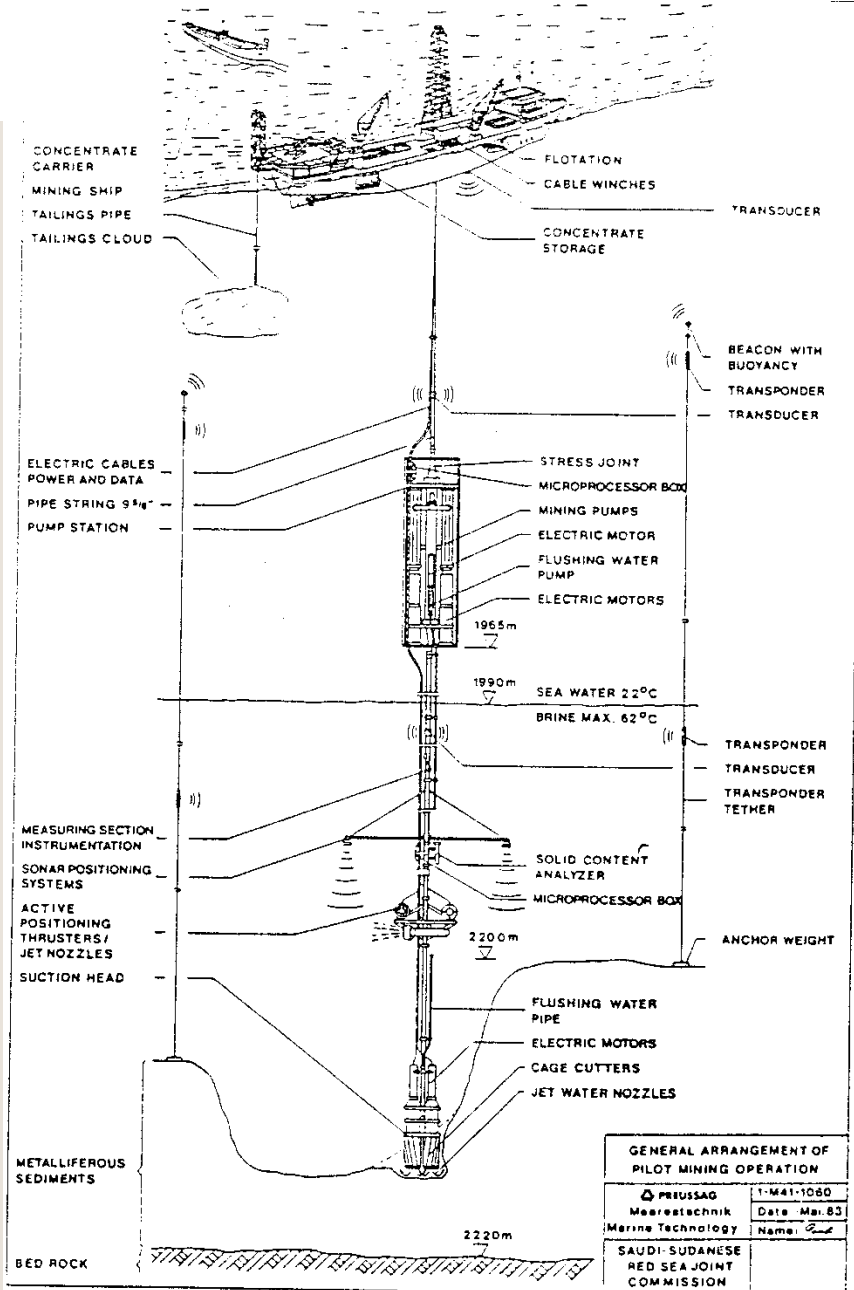
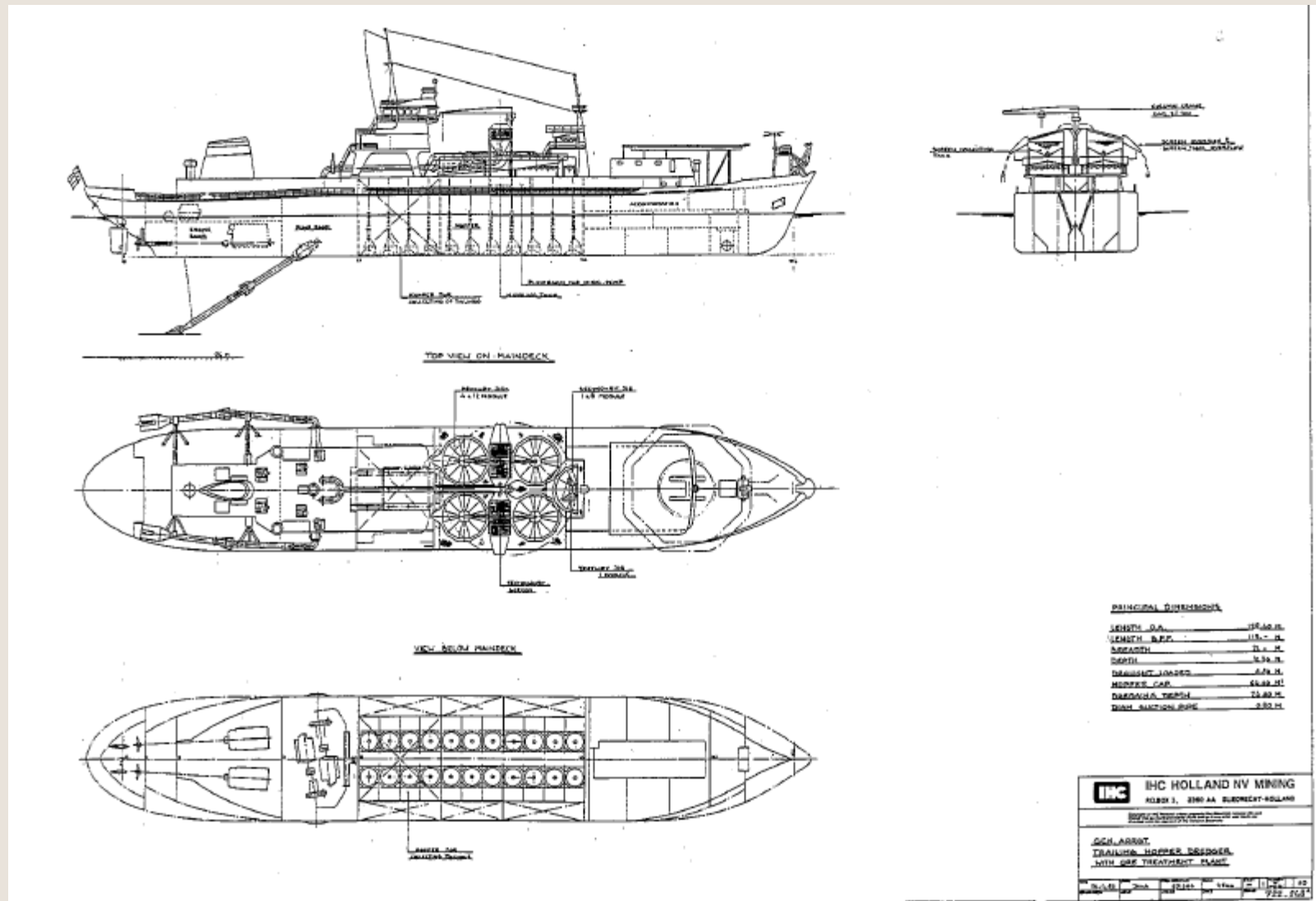
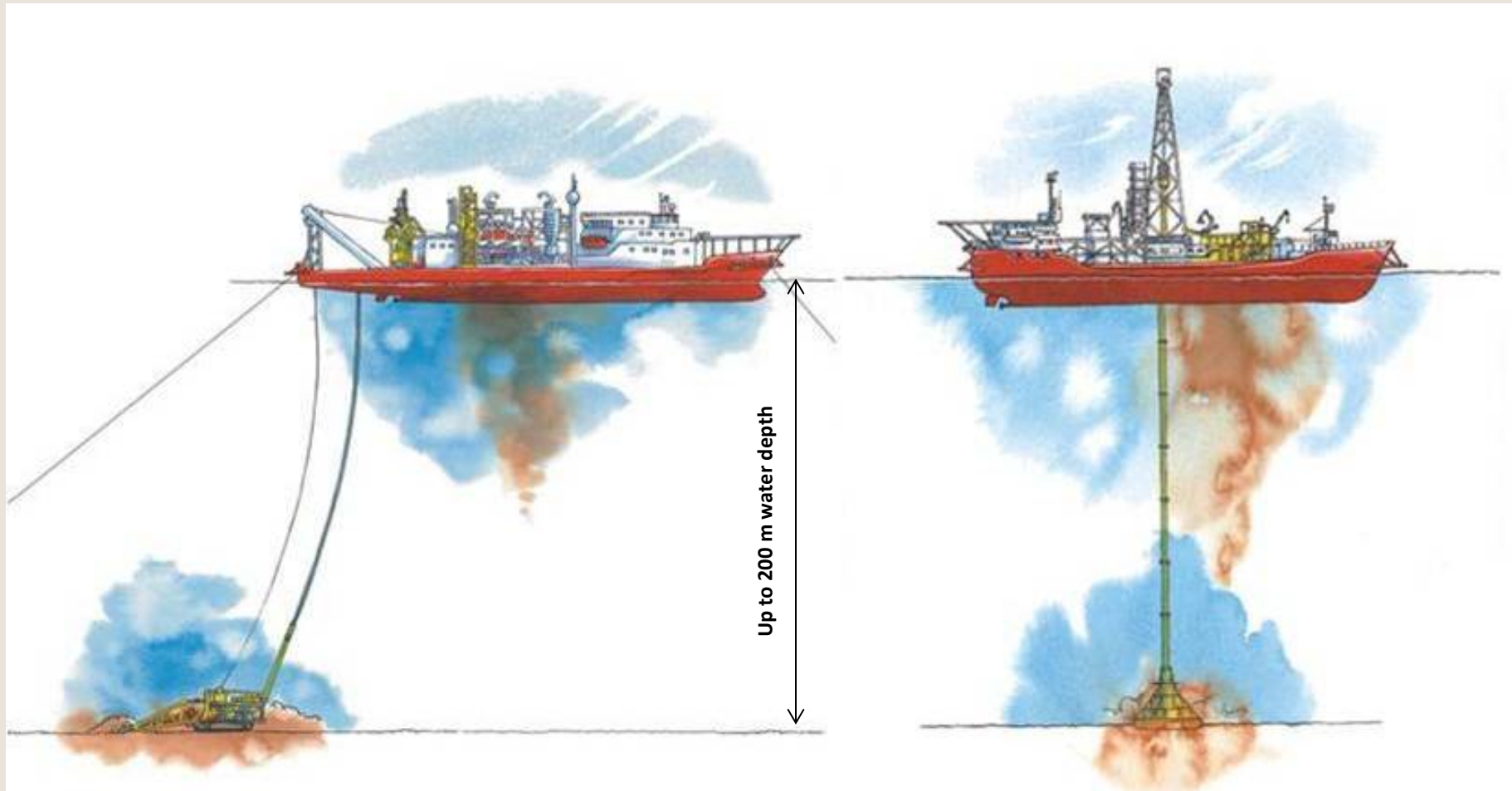


Fig. 3 Mining of metalliferous sediments in the Red Sea

Hopper for gold mining



Offshore diamond mining - technology development 1980's



Subsea Crawler

Vertical Drill System

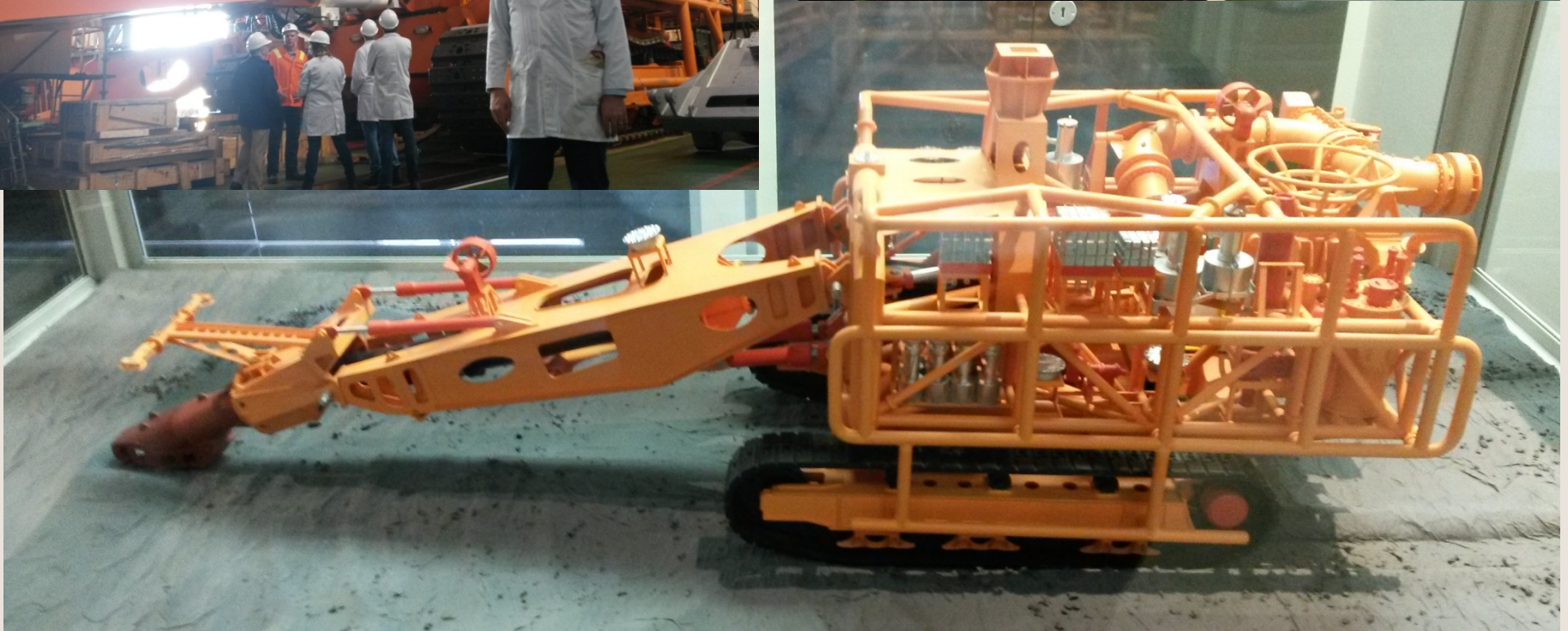


Offshore diamond mining – vertical drill system

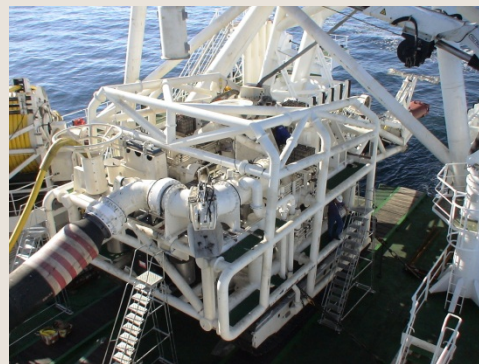




De Beers Marine Namibia - Crawler



Offshore diamond mining – subsea crawler system





IHC Marine Mining

Result of many years experience at IHC Merwede

Offshore

Dredging

Maritime Industry

(Offshore) Mining

Deep Sea Dredging and Mining

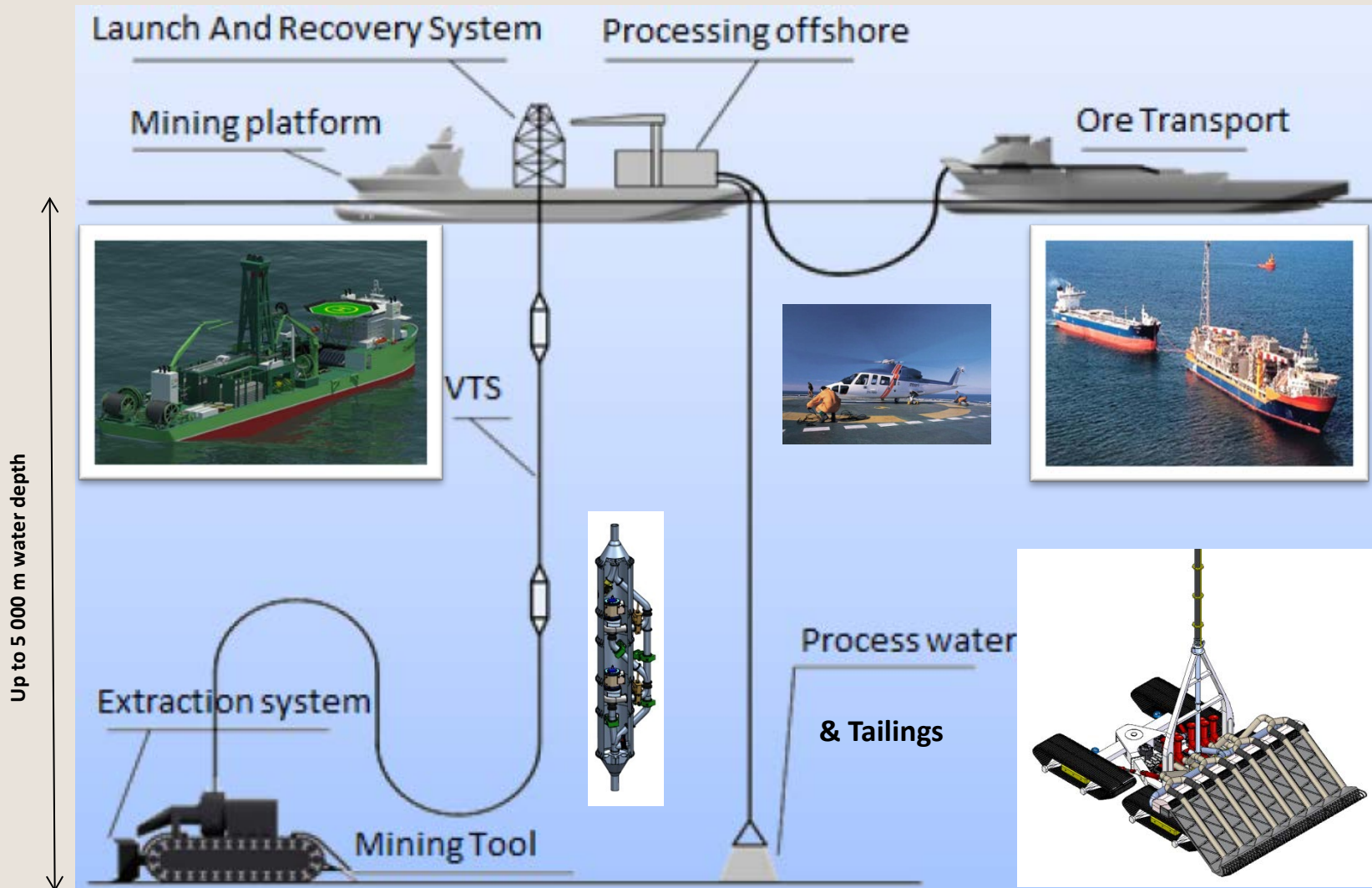
IHC EB Trencher and Handling System

Trailing Suction Hopper Dredger – Queen of Penta Ocean

Rigid Reeled Pipe Lay Vessel - Seven Oceans

Mining wheel suction dredger – Queen Thoma

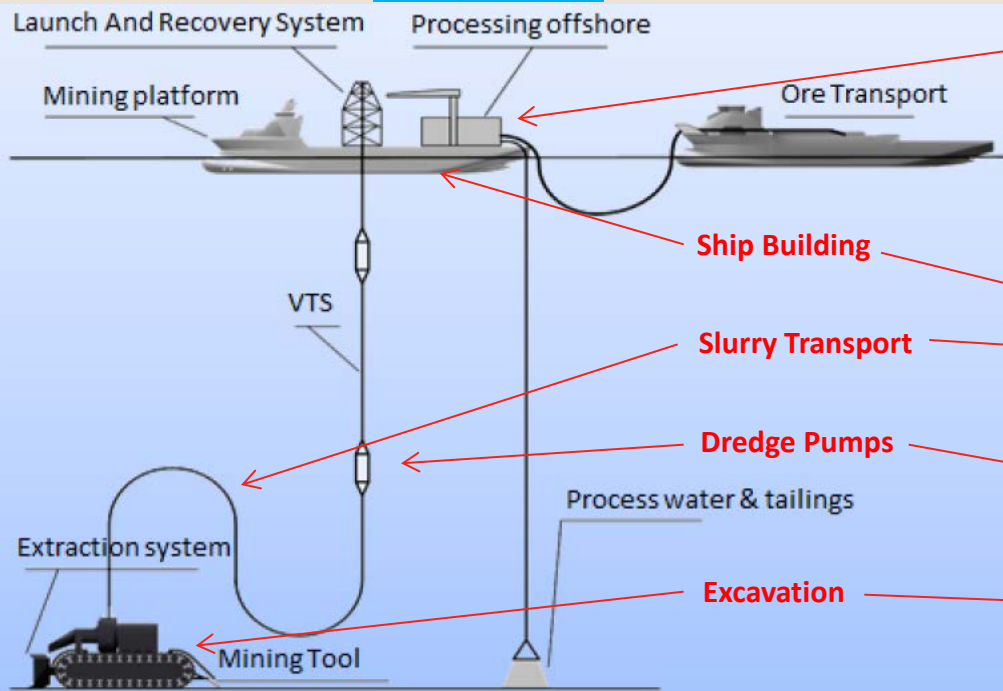
Deep sea mining – technology development



Deep sea mining - synergy with dredge mining

Deep Sea Mining

Dredge Mining



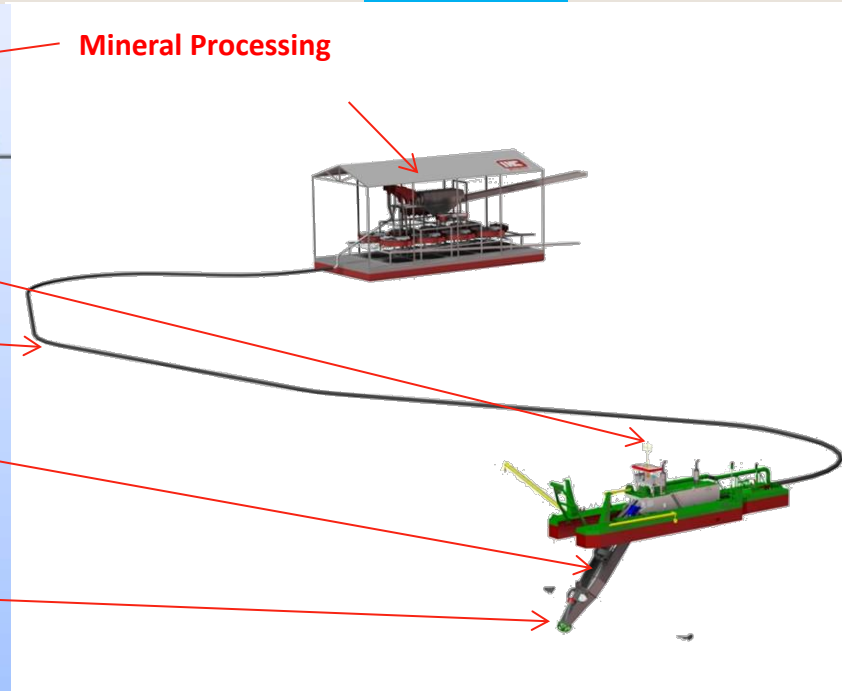
Mineral Processing

Ship Building

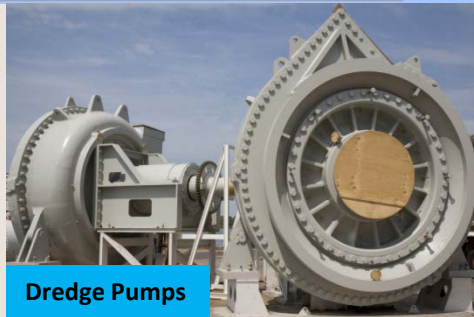
Slurry Transport

Dredge Pumps

Excavation



Excavation



Dredge Pumps



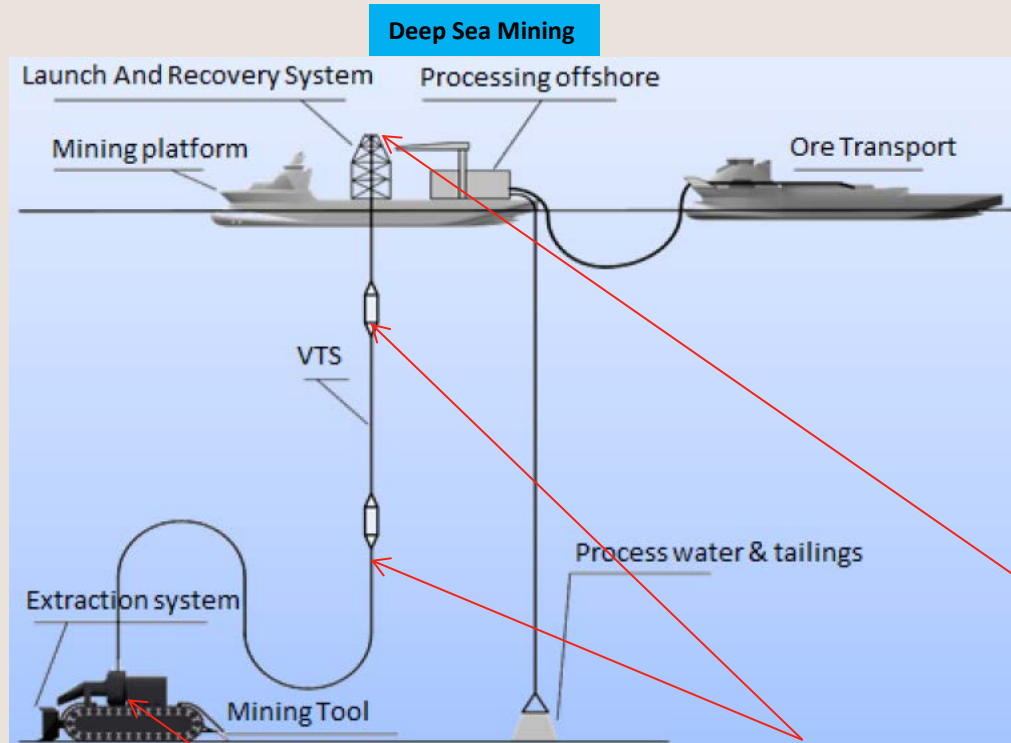
Ship Building



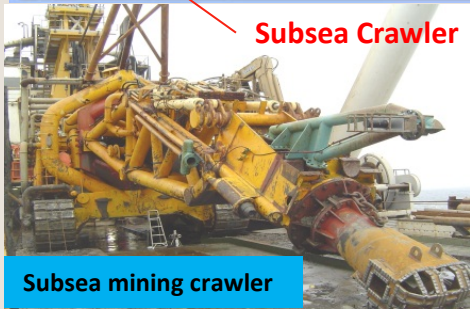
Dredge Mining

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Deep sea mining - synergy with offshore diamond mining



Diamond Mining



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IHC Mining – new constraints require new developments

New machines



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Royal IHC Track Record



Diamond mining, 2010, working depth to 200 m.

Backfill & Pipeline (1 550 mm dia.) plough, 2009, working depth to 1 000 m.

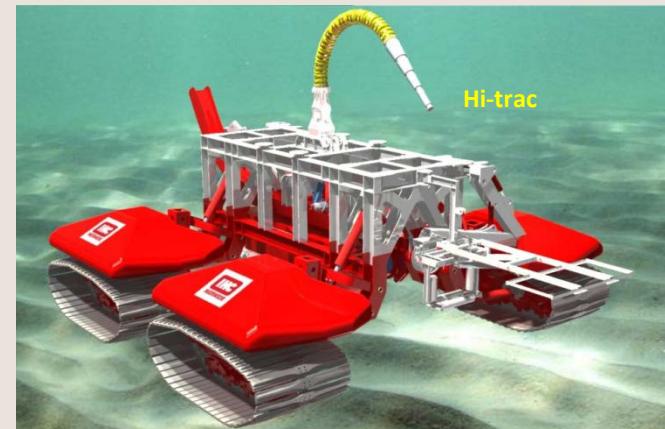


Cable trenching, 2008, working depth to 1 500 m.

Diamond mining, 2000, working depth to 200m.

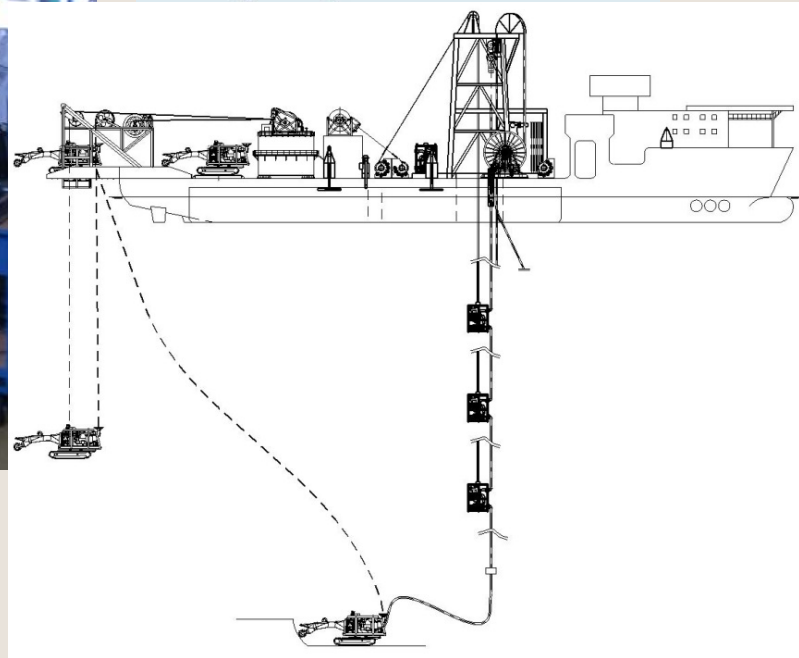
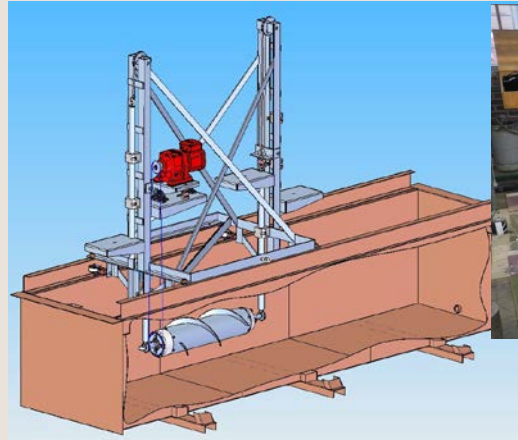
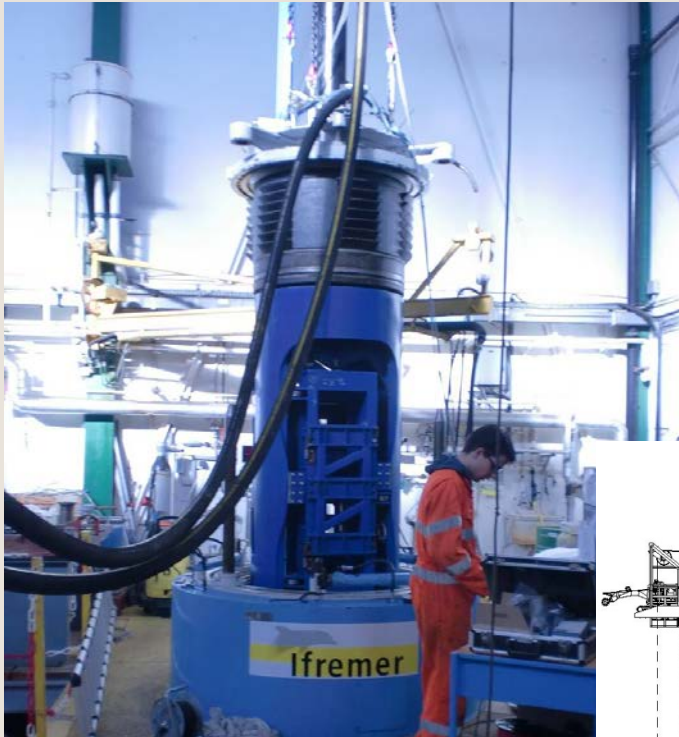
The technology innovator.

Other sea bottom track records



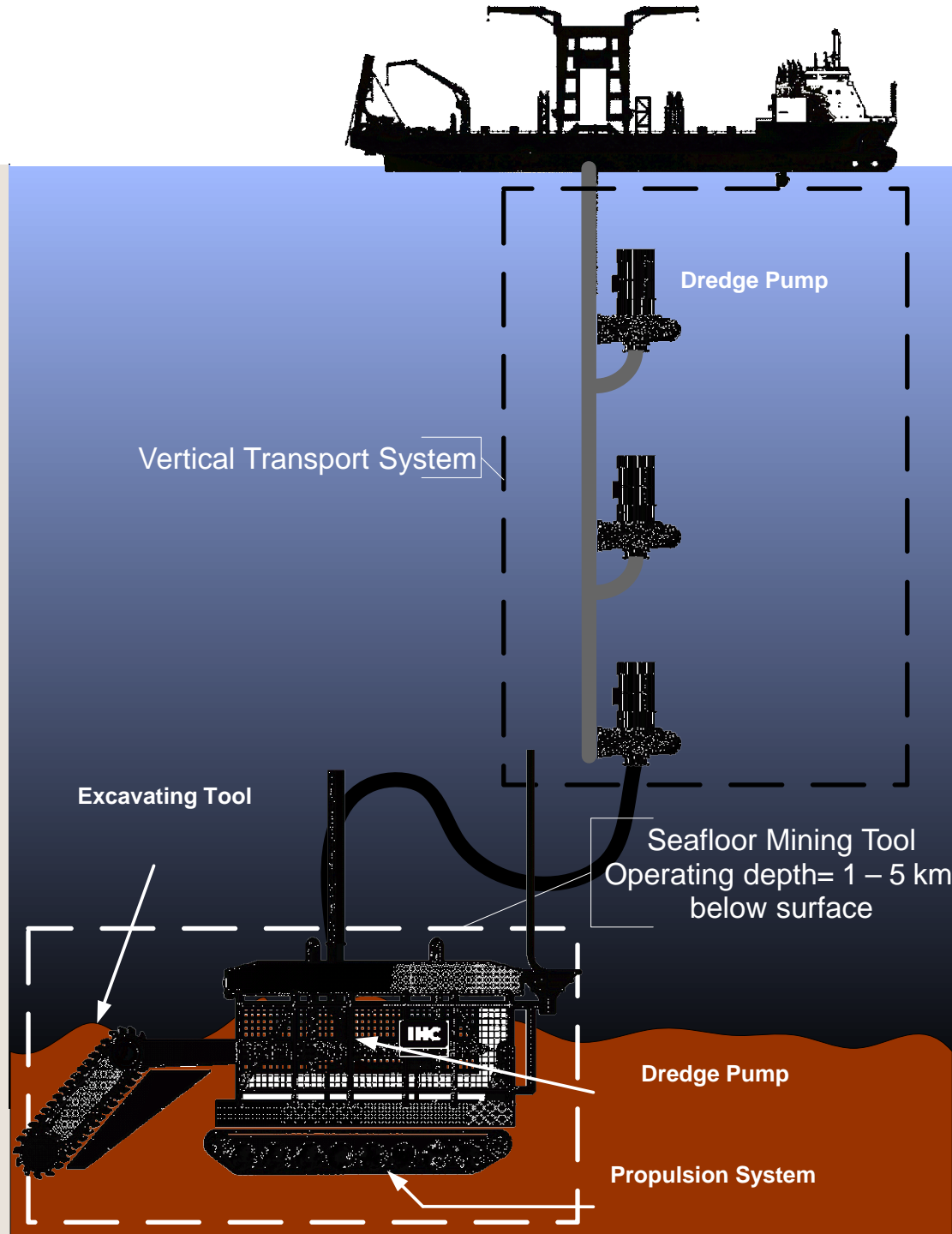
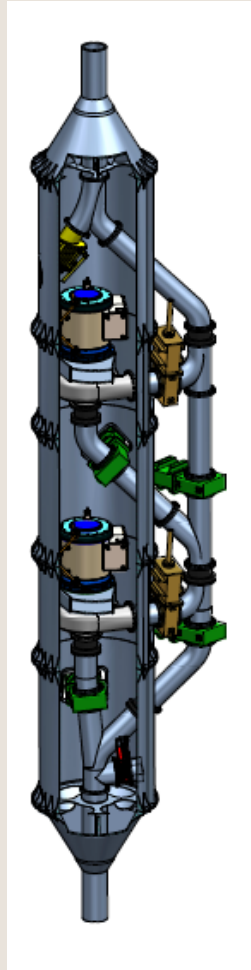
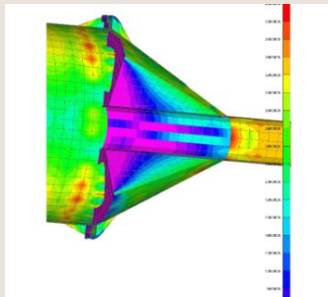
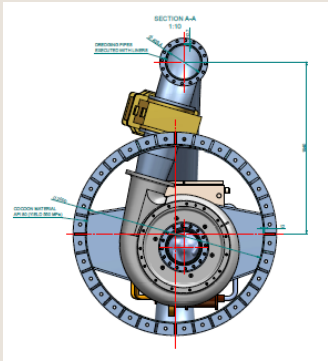


Deep sea mining technology developments





Technology – VTS



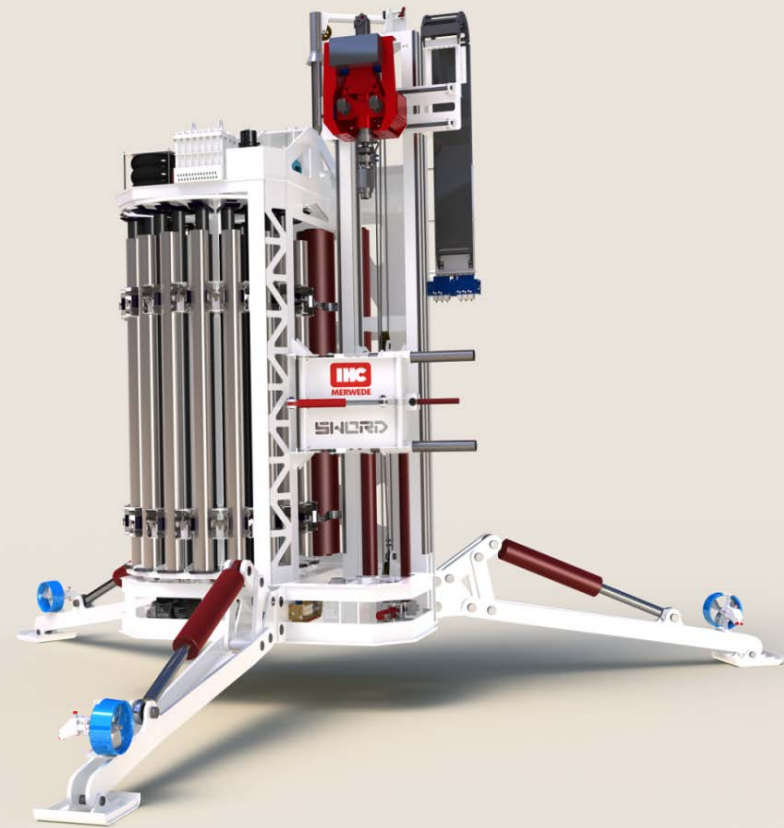
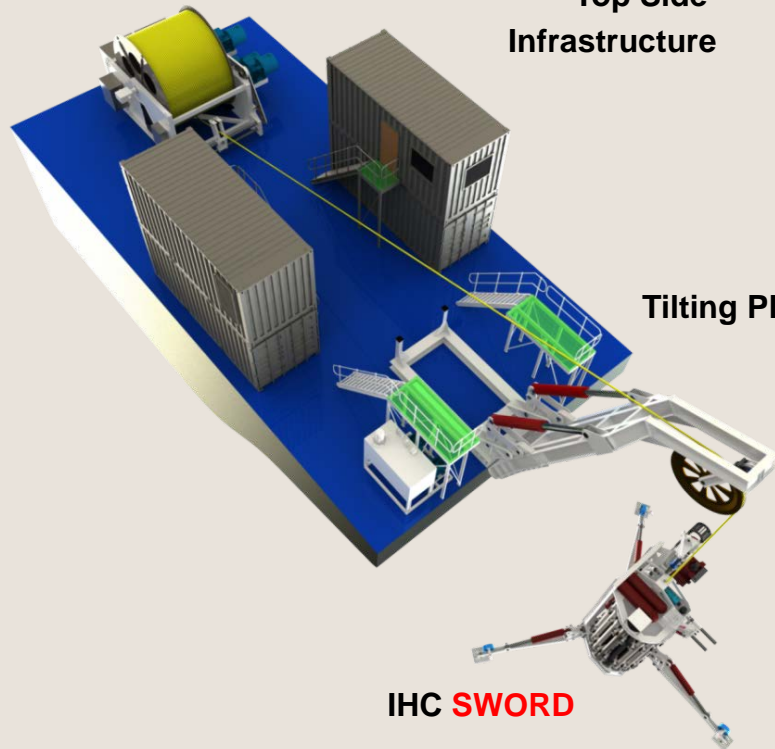
Product Development – IHC SWORD: TI Geo

Umbilical / Lift
Winch

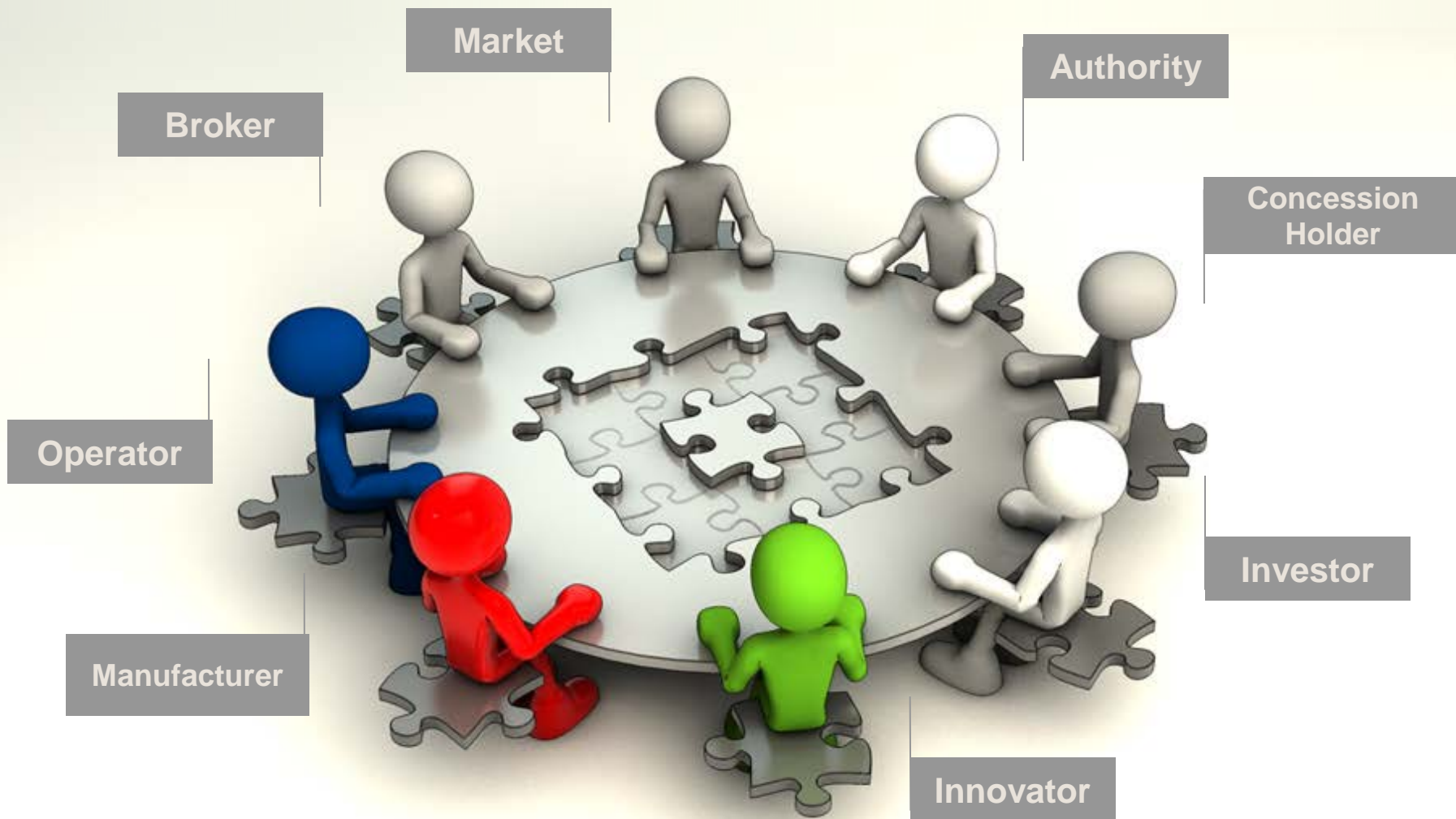
Top Side
Infrastructure

Tilting Platform

IHC SWORD



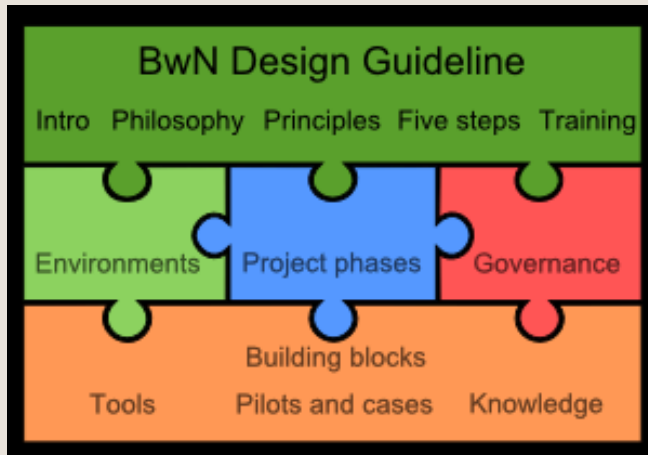
Develop the marine mining playing field





Partnering and Financing Developments

- (A) Internal IHC Merwede R&D Funding (since 2009), Partnering & Clients.
- (B) Member of EU Funded Environmental Project – Midas (2013 to 2016).
- (C) Leading role in EU Funded Project - Blue Mining (2014 to 2017)



Dutch initiative; relation with larger European network

The technology innovator.

Industry



Research Institutes



Service Supplier



Responsibilities in sphere of influence

Assess to prevent

- Prediction tools
- Risk assessments

Engineer to mitigate

- Safety
- Reduce environmental impact

Monitor to optimize

- Optimize equipment performance
- Environment

Collaborate to complete

- Community

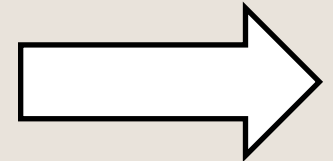
Sustainable development



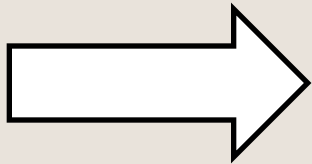
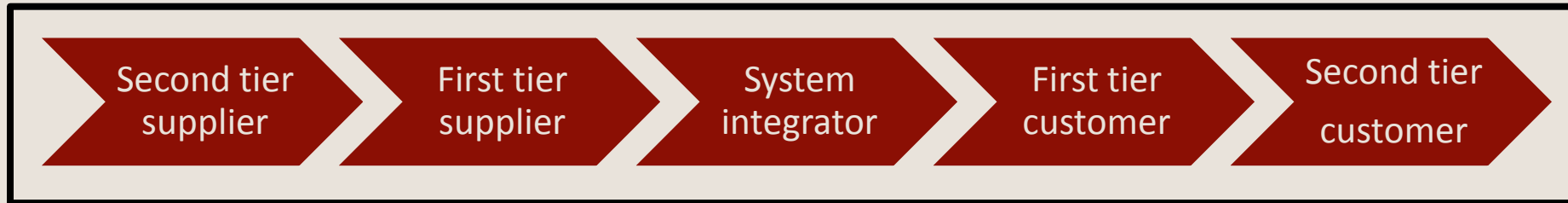


Encouraging external influences

United Nation (and ISA)
European Union
Government
Knowledge institutes
Media



Revenues



Resources



Restrictive external influences

Competitors
Non-governmental organizations
Interest groups / communities / councils

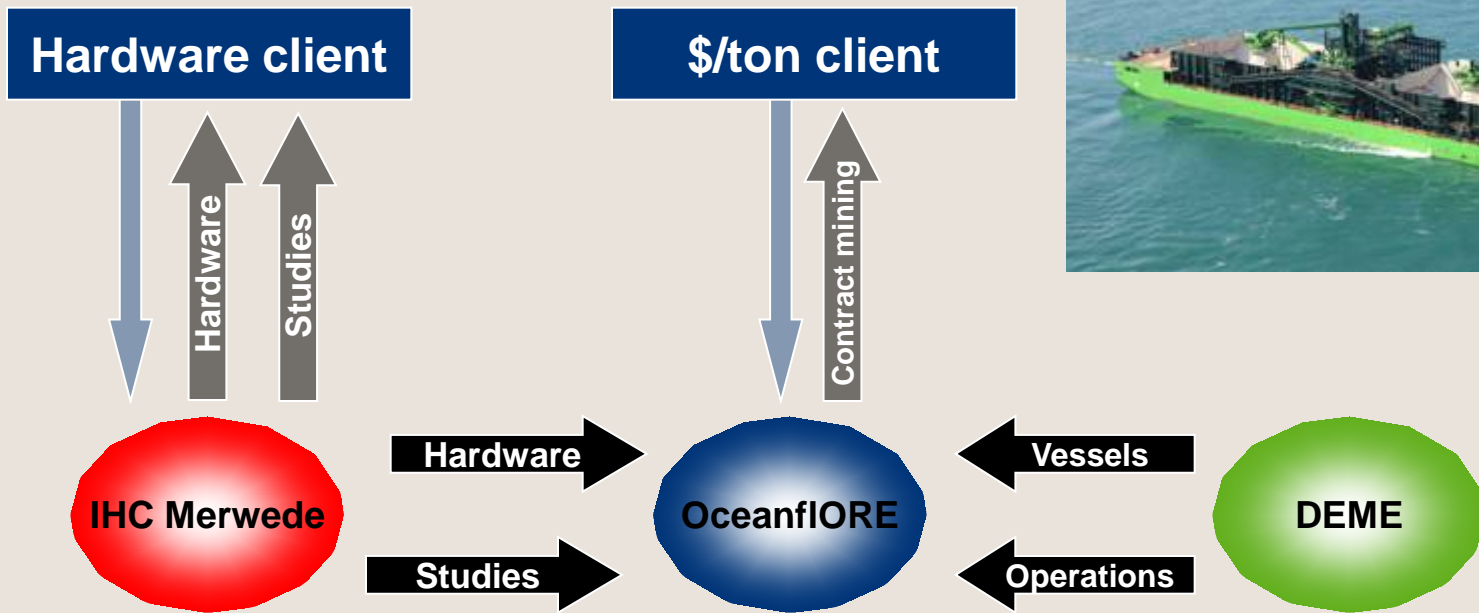
- public
- social
- political
- environmental



Market Development

OceanfLORE makes offshore mining possible, profitable and sustainable

IHC Market Development



OceanfLORE: A vehicle to develop the deep sea mining market

Conclusions

- Approach the mining market with the right mind set
- Dredge mining : near to mid term
- Marine mining: mid term – long term
- Resource scarcity
- Development of the mining playing field is necessary
- Dutch cluster can benefit
 - offshore based knowledge
 - knowledge is available
 - Dutch government has to play a role and develop legislation to become sponsor state
 - Geo-policy of other countries



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