Exploration and exploitation phases value chain as a framework for industrial realization of deep seabed mining

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Presentation

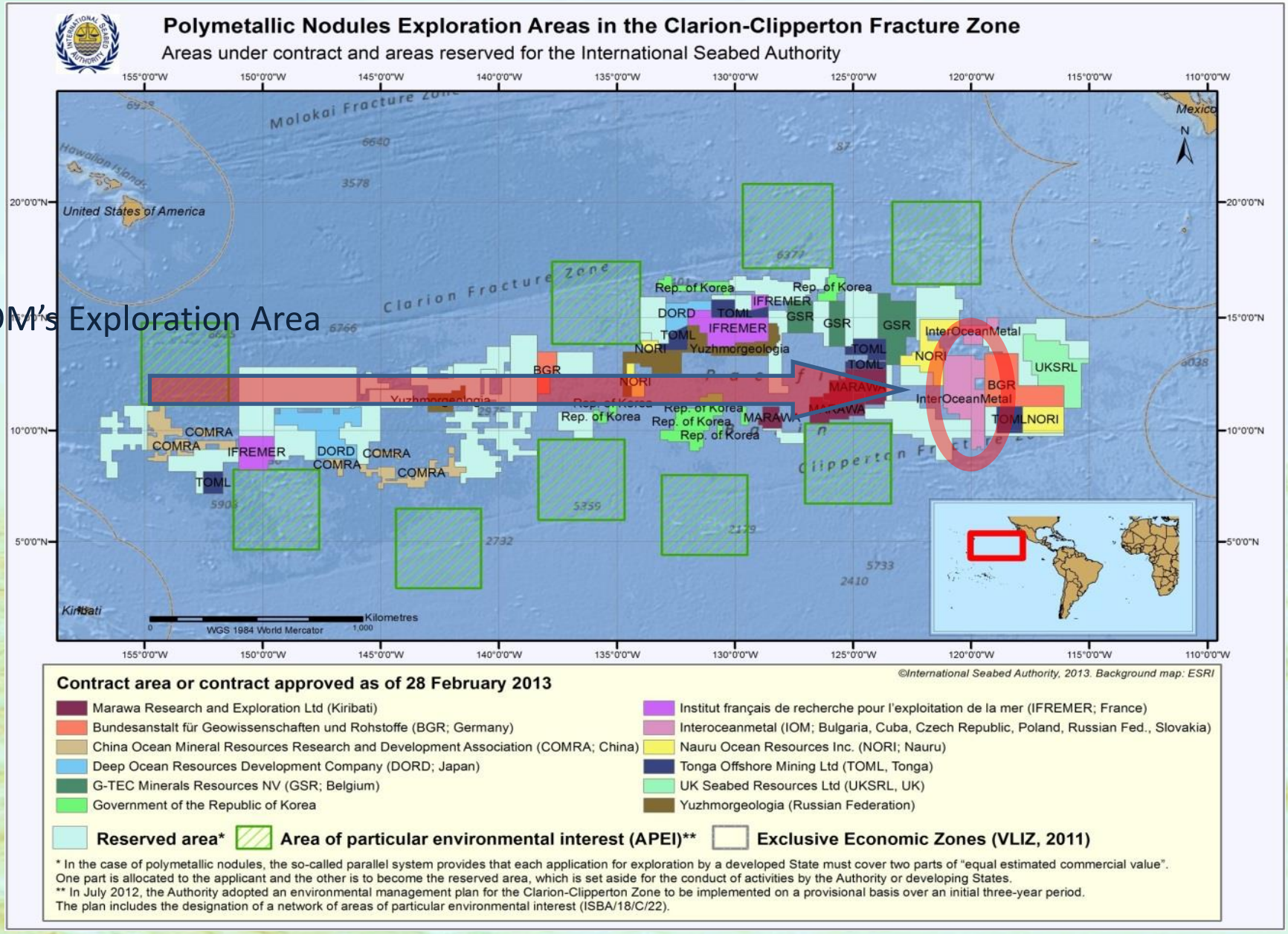
1. IOM – organization, activities
2. Classic definition: Value chain
3. Value chain stages for the deep seabed mining
4. Activities - value increases in relation to resource classification
5. Activities - value chain based on product processing
6. Exploration information flow and resources classification
7. Examples of technology for exploration
8. Valuation point in the deep seabed mining chain of technologies
9. Examples of technology for exploitation
10. Structure for business modeling
11. Influence of taxation scheme
12. Final remarks

Interoceanmetal Joint Organization (IOM) - international organization established with the objective of exploration, prospecting and production organization of polymetallic nodules in accordance with the 1982 United Nations Convention on the Law of the Sea UNCLOS.

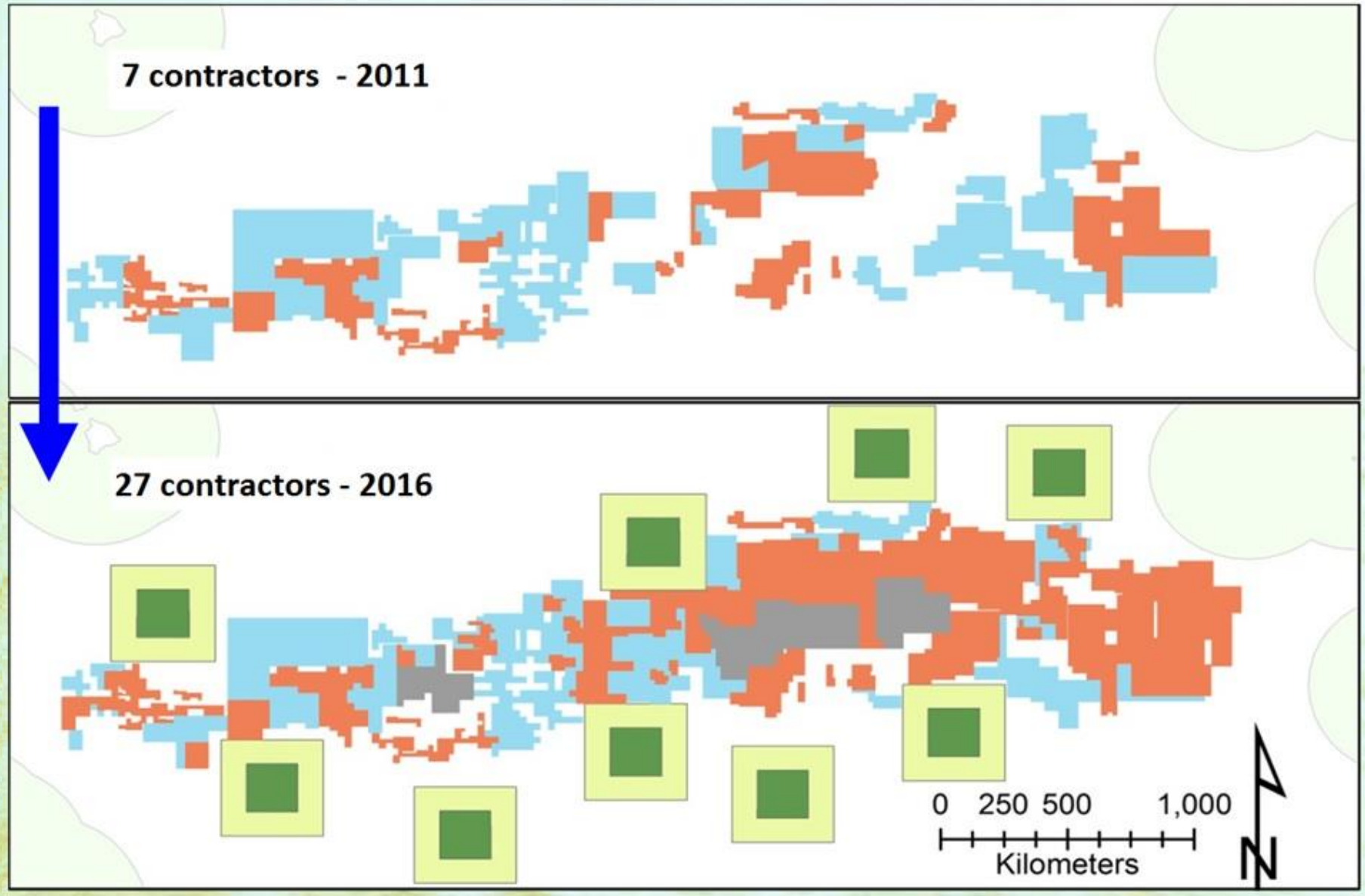
The present IOM member states are: Bulgaria, Cuba, Czech Republic, Poland, Russian Federation, and Slovakia.

In 2001 the IOM was the first international organization to be awarded exploration contract by the ISA. The organization obtained the exclusive right to explore and develop a commercial mining project in the granted area of 75,000 km^2 located in the Clarion Clipperton deep ocean deposit.

The IOM's Exploration Area



Increase of the interest in seabed mining

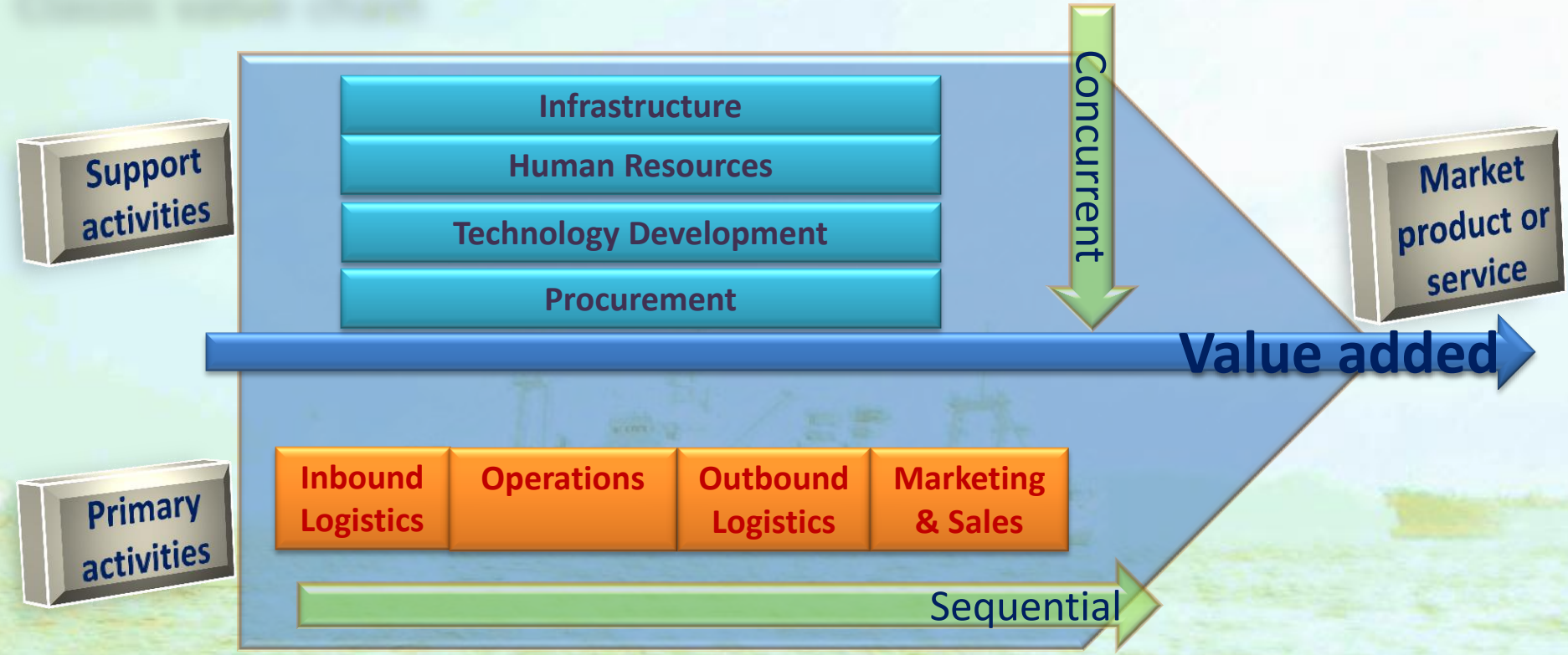


Classic definition: Value chain as a term was created by Porter (*Competitive Advantage: Creating and Sustaining Superior Performa*nce, 1985)

A value chain *disaggregates a firm into its strategically relevant activities in order to understand the behavior of costs and the existing and potential sources of differentiation*. Porter's value chain consists of a set of activities that are performed to design, produce, market, deliver and support a product or service.

The value chain is a sequence of value-enhancing activities. In its simplest form, raw materials are formed into components, which are assembled into final products, distributed, sold, and serviced. In most industries, it is rather unusual that a single company performs all value-creating activities by itself (from product design, production of components, and final assembly to delivery to the final user).

Classic value chain



Porter's value chain is characterized by classical functional separation and thinking in organizational units instead of processes, since not processes but activities are listed by organizational function. Primary activities are executed mostly sequentially whereas support activities are concurrent

Within the value chain concept of deep seabed mining (DSM), seven main stages from prospecting to sales can be identified. In principle, independent from the type of mineral to be mined, the value chain of DSM consists of the following main steps:

1. Prospecting and application
2. Exploration
3. Resource assessment, evaluation and mine planning

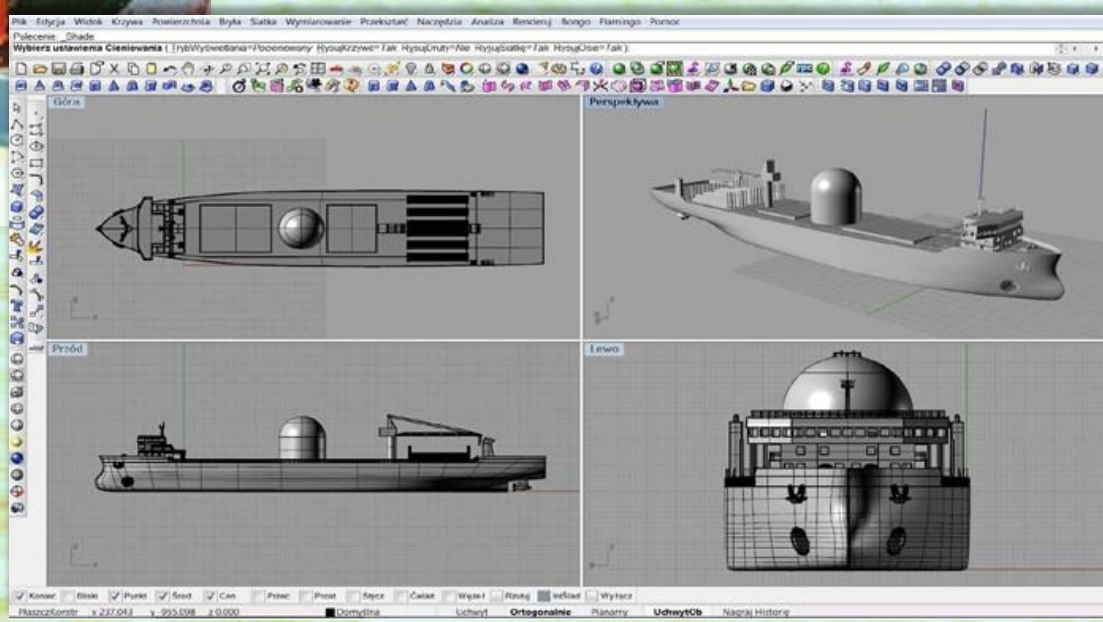
value increases in relation to resource classification

(3-4) – Pilot mining test Intermediate phase – a phase where actual value of a DSM project starts. For mature terrestrial mining value can start as early as prospecting and application

4. Extraction, lifting and surface operations
5. Offshore and onshore logistics, transport operations
6. Metallurgical processing stage
7. Distribution and sales

Value chain based on product processing

Exact components and stages can be shaped uniquely within a deep-sea mining projects of various contractors. The current focus of mining projects is aimed at exploration, evaluation and planning rather than at exploitation.



Project development value chain activities – value increases in relation to resource classification from speculative resources to economic demonstrative reserves

	Project development → Increased value				
Stage	**Prospecting**	**Exploration**	**Pre-industrial operations**	**Pilot mining test**	**Full production scale**
Operations	Identification of potential area of resources - expeditions at sea	Deposit identification, dense grid sampling, high coverage sonar images, environmental baseline studies	Detailed bathymetry, benthic impact experiments, metallurgy experiments, collector testing	Actual mining at 1/10 – 1/5 assumed full production scale	Deep sea mining, transportation, processing, logistics and commerce
Technical Instruments	Research ship, sampling devices, side scan sonar, ROV, AUV, multibeam echosounder	Research ship, sampling devices, side scan sonar, ROV, AUV, multibeam echosounder	Benthic disturbing devices, AUVs, laboratories for deposit processing	Technical support ships, transportation systems, vertical riser, collector	Mining ships, transportation and PSV vessels , mining equipment, environmental monitoring instrumentation
Legal actions	Application for prospecting or information to the administering body	Contract for exploration, reports on activities	Stakeholder survey, building social positive awareness	Contract for exploitation	Contract for involved parties
Deliverables	Application for exploration license	Report on indicated sub-economic resources in accordance with reporting standards on resources	Environmental impact assessment, Scaling-up analysis, processing and mining at TRL 4-6	Commercial (bankable) feasibility study, Application for exploitation	Economic report on production and interests

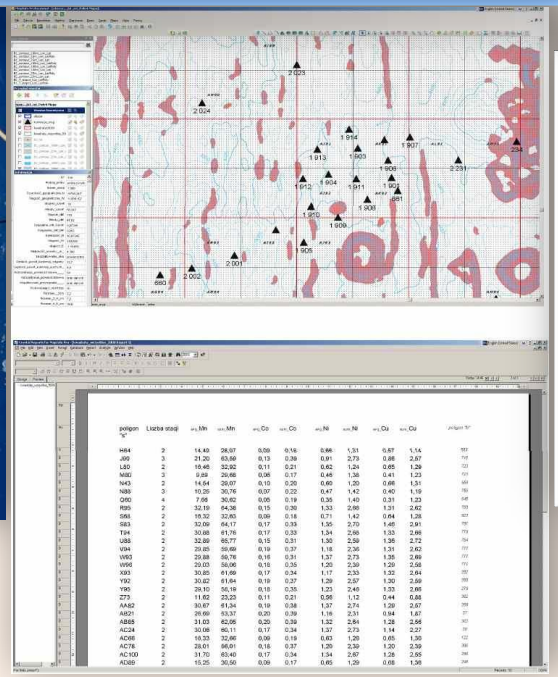
Exploration information flow - link between exploration and economic feasibility. Value is added to intangible assets

Experiment at sea

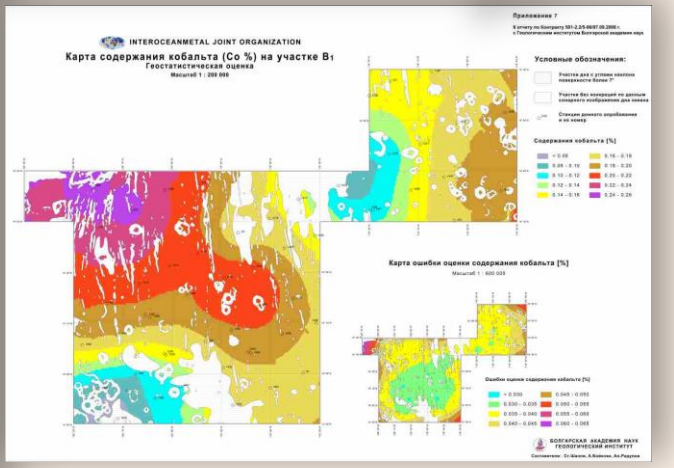
Results processing

Documentation

Sample taken at sea
Nodule abundance
Chemical analysis for metal content



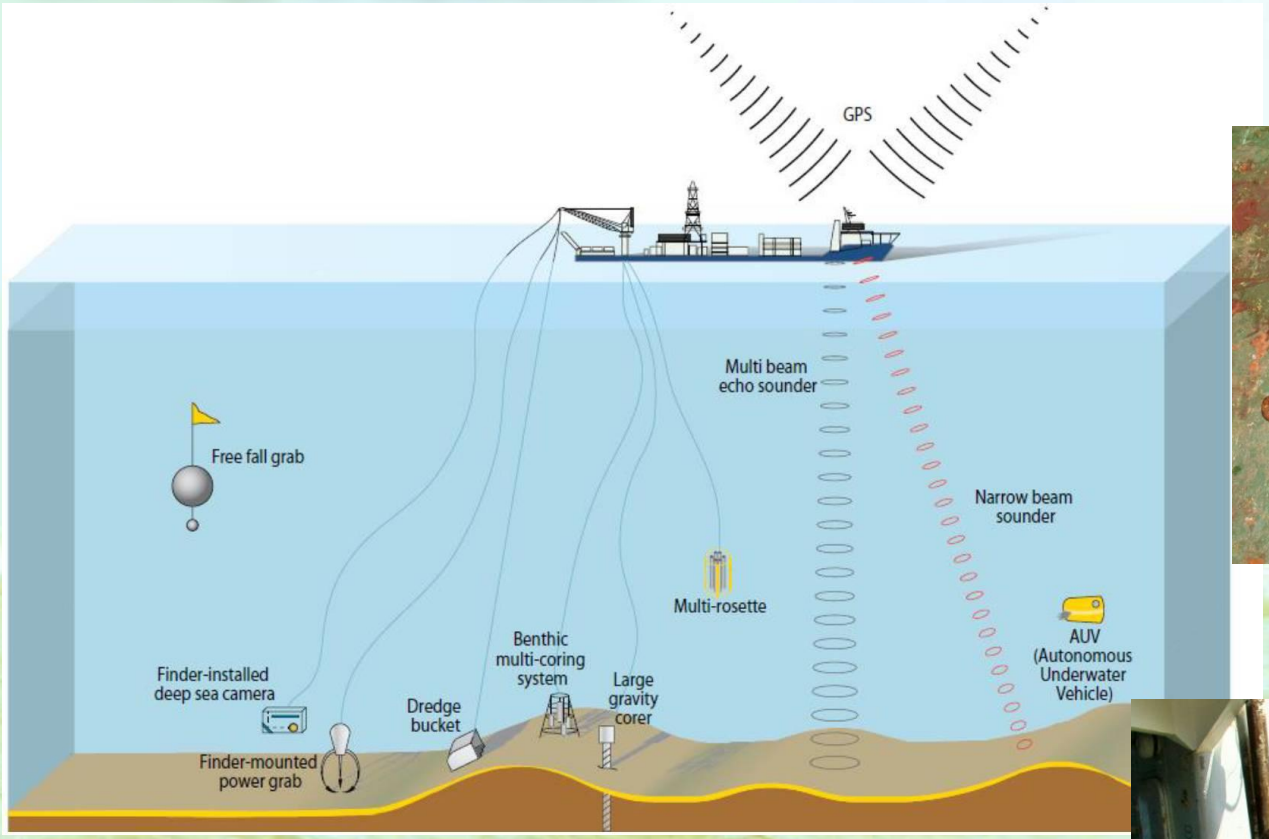
Data processing
GIS database

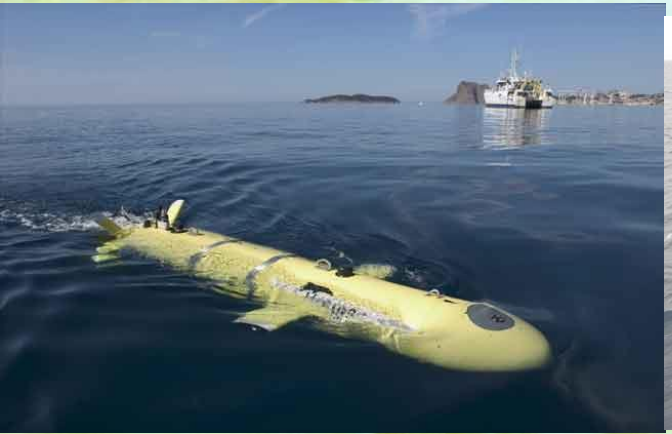


Estimation of nodule resources and metal distribution

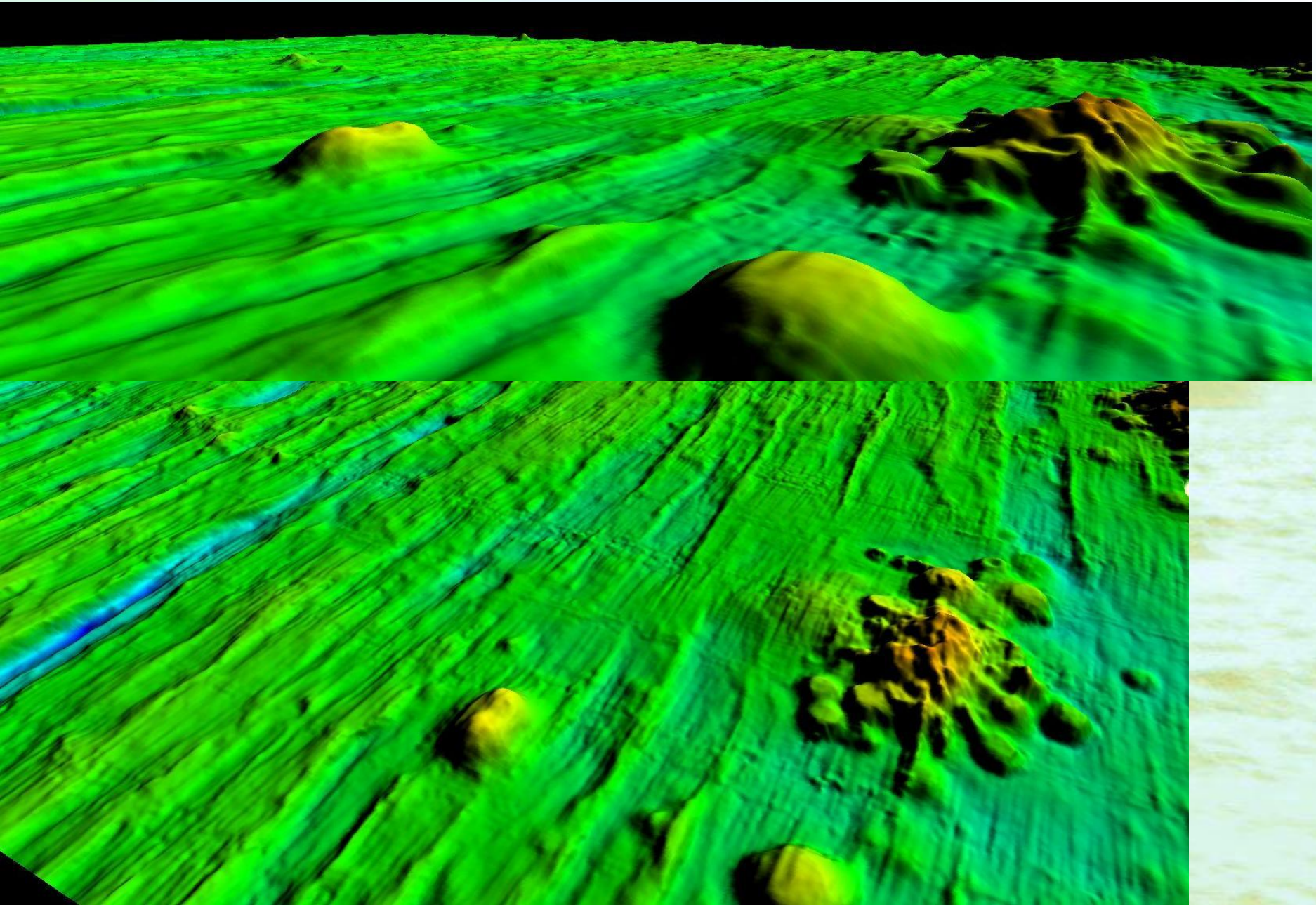
Deliverable: Mineral resource classification

Technology for exploration

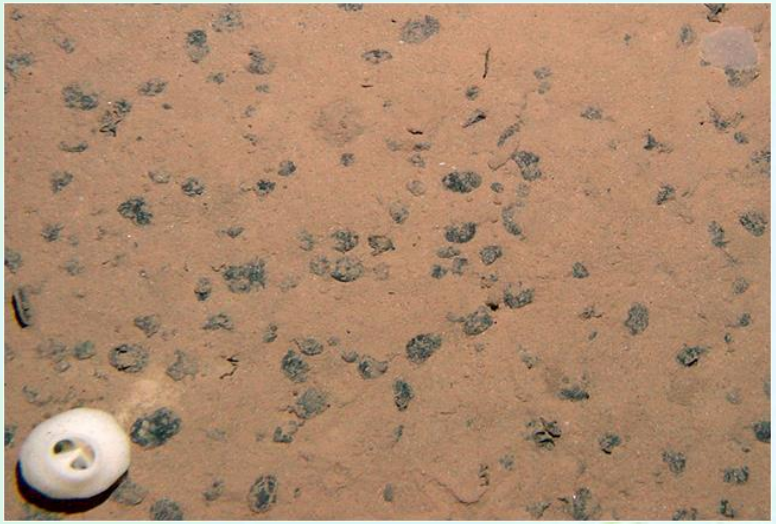


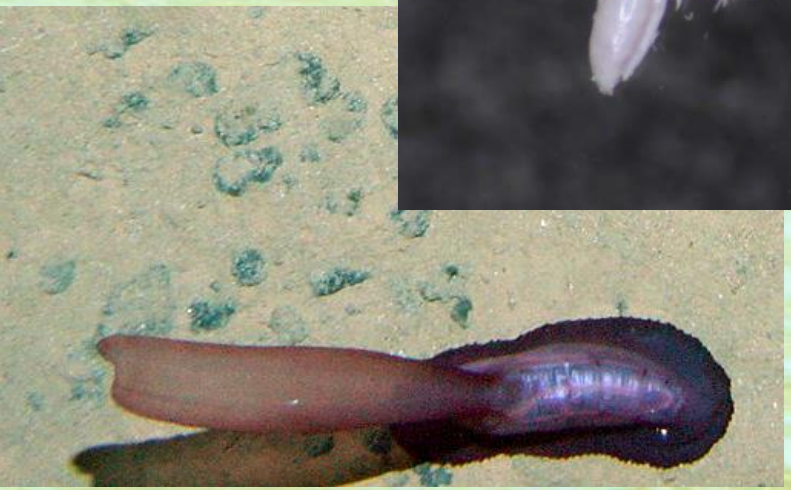


Bathymetry processing – multibeam sonar data analysis



Environmental baseline studies - examples of organisms revealed and classified during exploration





Value chain based on product processing – full scale production for the case of polymetallic nodules

Support activities, logistics, subcontracting, legal actions, human resources, distribution

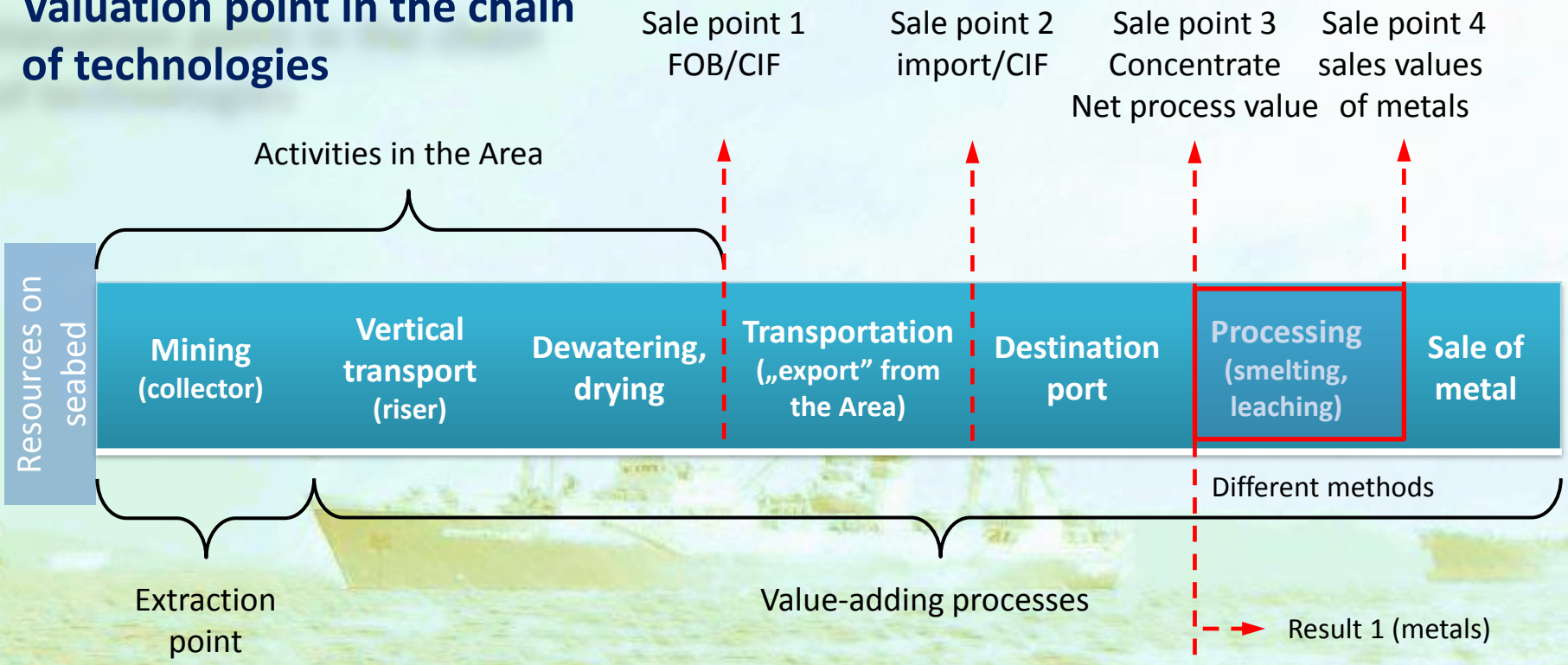
Feedback from market and environmental monitoring for the design assumptions of mining system

Equipment or device	Robotic mining collector(s)	Hydraulic lifting system, pumps, riser	Mining ship	Purpose adapted bulker	Metallurgy plants or plant for pre-processing upstream activities, processing, metal extraction
Operation	Mining on seabed	Vertical transport	Storing, dewatering, drying	Ocean transport, drying	Pyro- hydro – metallurgy, HPAL processing, etc.
Parameter	130 - 400 t/h	4500 - 5500m	Ships deadweight 50 kT - 150 kT	Up to 5000 nautical miles in one outbound and return cycle	Productivity depending upon technology, market demand and storage capabilities

Monitoring and environmental impact reducing

Devices and operations: CTD probe for depth profile, Remotely operated vehicles (ROVs for plume intensity, land-based environmental practises for metallurgy processing, decommissioning and re-cultivation programme.

Valuation point in the chain of technologies

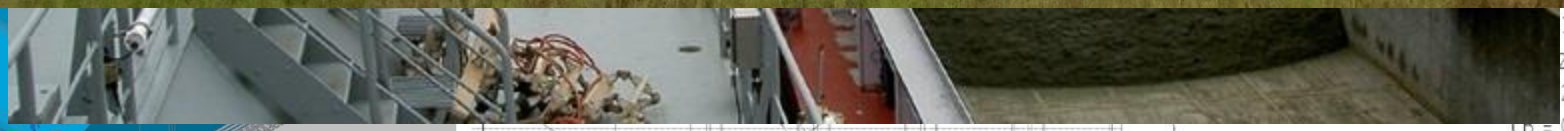


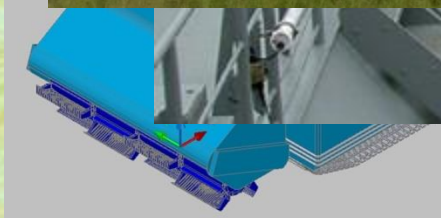
This is a fundamental point and requires an explicit definition in the nodules exploitation regulations. It is the point at which a value needs to be determined for e.g. royalty calculation purposes.

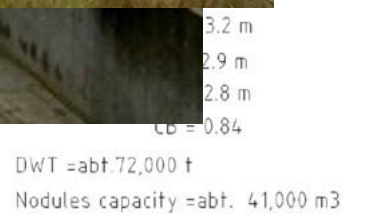
It is sometimes acknowledged that the valuation point needs to be at, or as close to, the extraction point of a resource. This point in land-based mining is referred to as the "ex-mine" or "mine head" value. It is the point at which compensation is due to be paid to the owner of the non-renewable resource. A standard valuation point provides consistency across all mining projects and may have impact on mechanical designing of machinery*

*Working Paper for consideration by the Members of the Legal and Technical Commission, International Seabed Authority

Technology for production phase of deep seabed mining







Structure for business modeling

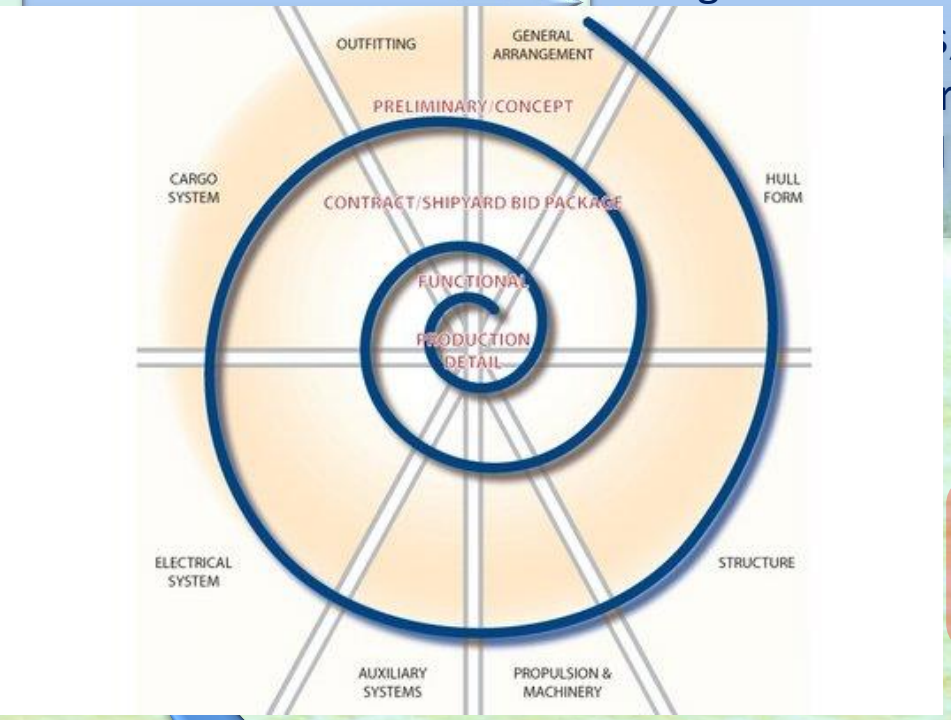
Key assumptions:
- Production rate
- Operations time

Composition of mining and processing systems:
e.g. number and
rs,

- Development cost
- CapEx
- OpEx
- Indicators

for each component of mining and processing system

EBIT



Cash flow calculations

Taxation scheme

Key financial indicators: NPV, IRR, payback period, revenue

Feedback for adjusting assumptions

Final remarks - models and policy should also consider:

1. Value of the final product of metallurgical processing (high-selective processes like HPAL can extract more effectively but require higher CapEx)
2. Influence of metals production from marine minerals on global metal market
3. Ad valorem case - what does it mean „production value" and how the value of nodules before processing can be estimated?
4. Structure of CapEx/OpEx/Revenues ratio. The metal prices presently are at the bottom of the cycle but in DSM operations energy is created almost exclusively from oil with bottom prices as well. Thus the project is smaller in terms of absolute value but IRR or NPV may still be plausible.
5. Risk and sensitivity analysis vs. expected income.
6. CapEx intensive models should be compared against CapEx light where initial expenditures are transferred from CapEx to OpEx e.g. chartering of ships instead of new built ships.
7. Technical feasibility of introducing the taxation schemes under consideration should be carefully checked, e.g. royalty unit based scheme may require actual weighting of nodules which is hardly achievable with sufficient accuracy at sea

Thank you very much for your attention

This is going to become reality soon: