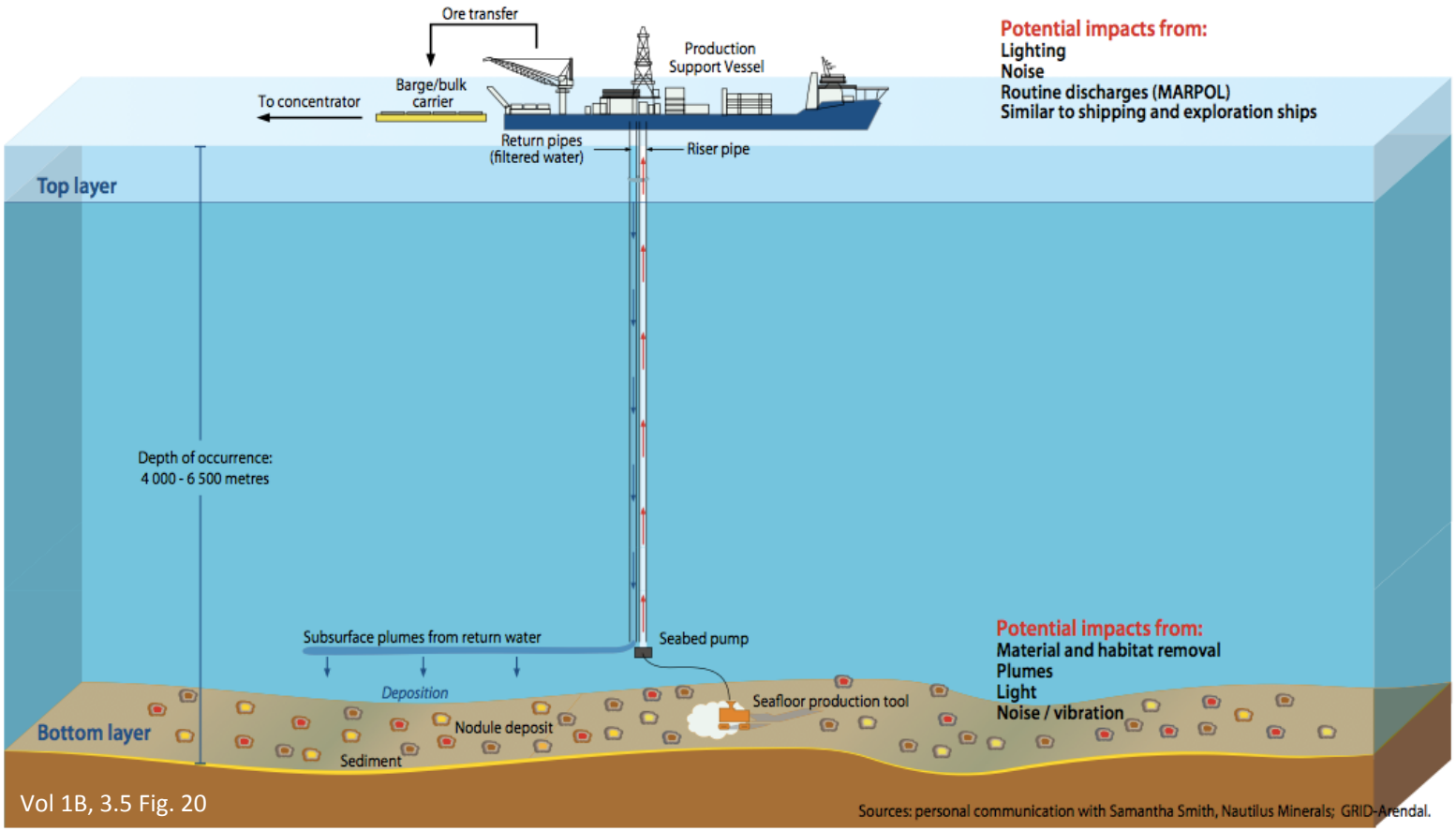
SPC-EU Pacific DSM Workshop, Rarotonga
13th May 2014

Commercial Realities in Delivering DSM Projects

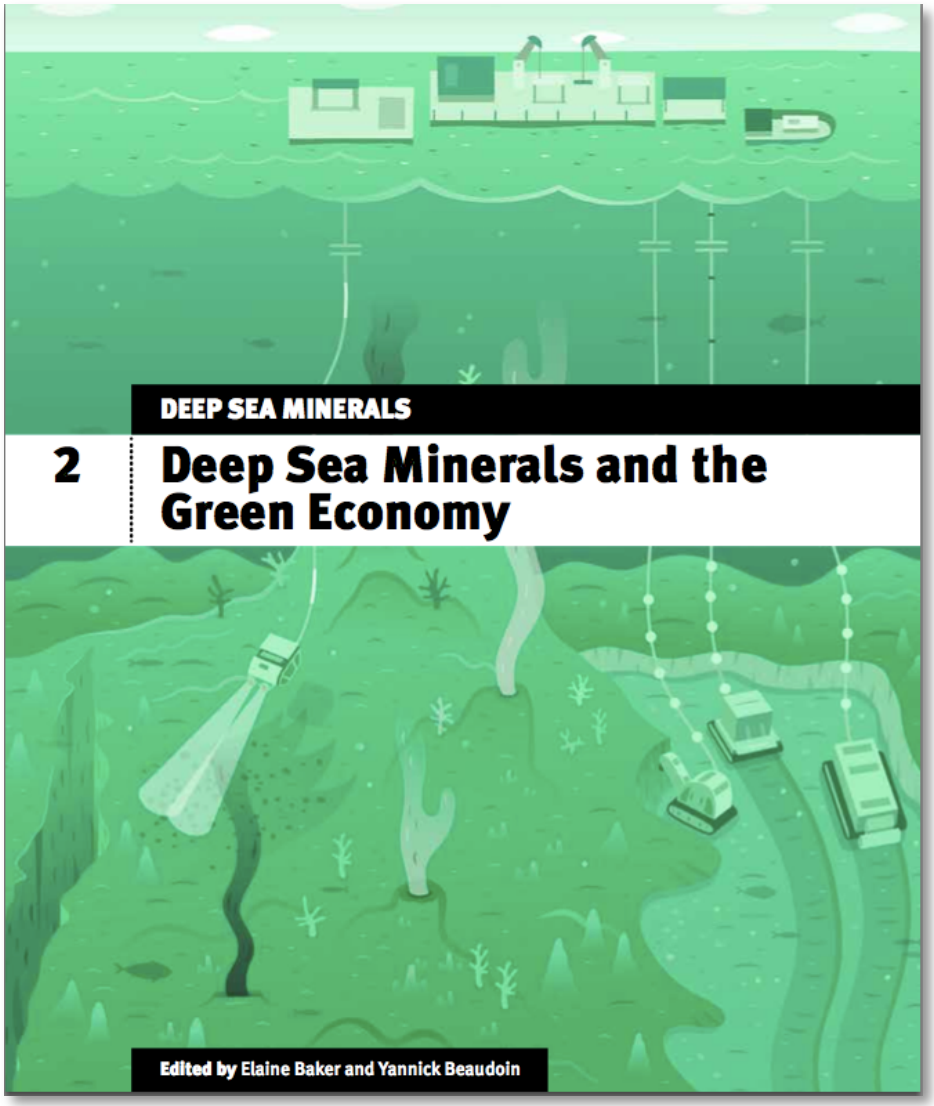


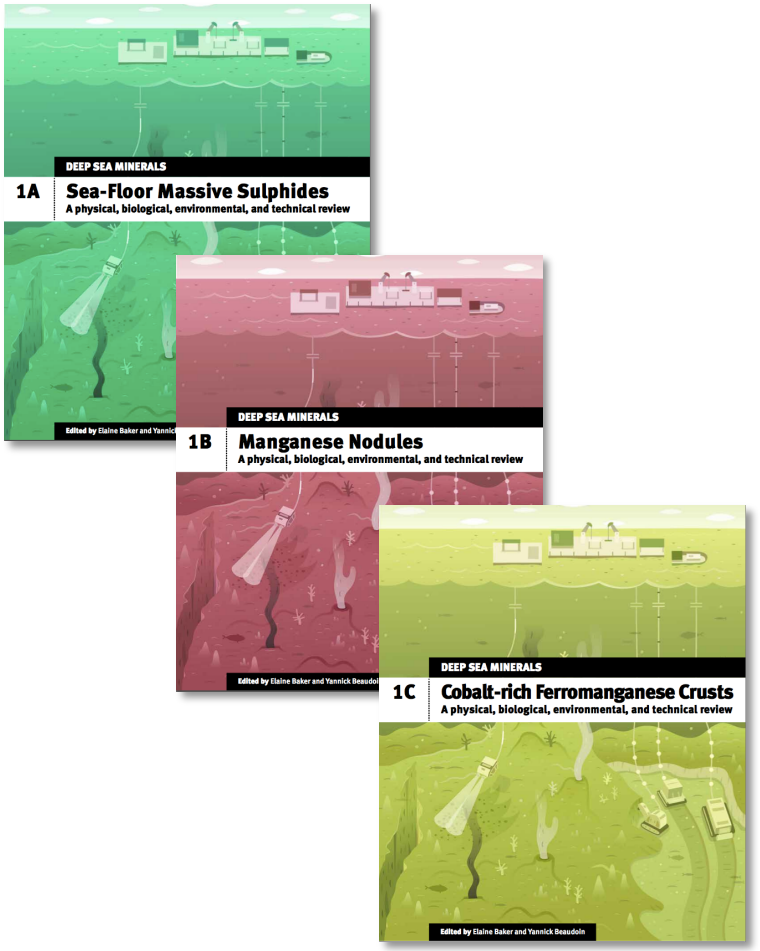
Dr. John Feenan
IHC Mining

Director Mining Advisory Services
Asia Pacific

The technology innovator.

Key DSM References





SPC-EU Deep Sea Minerals Project

Abstract

Key elements that impact the confidence of investors to finance DSM projects.

The mining lifecycle from exploration to production will be considered in the context of a potential manganese nodule development.

Issues to be addressed include:

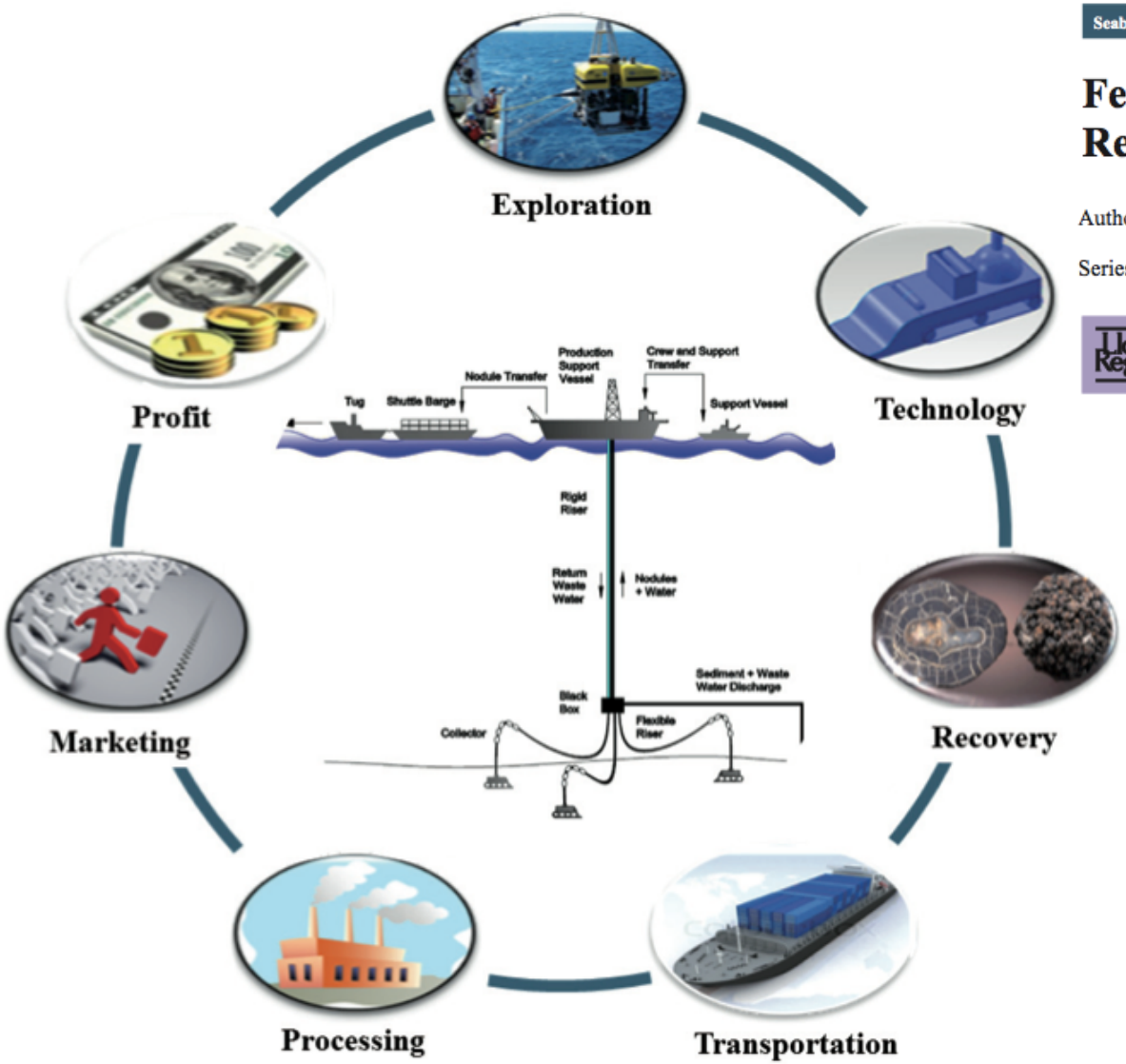
- Mineral resource reporting and licencing
- Mining technology maturity
- Costs of development
- Sources of finance and the appetite of investor risk
- Potential implications for Pacific Island DSM legislation.

Bridging the gap between what is known from the onshore mining industry…

…to what is yet to be known about the DSM industry…

...is perhaps one of the most important factors to strengthen the confidence to invest at this early stage in DSM projects.

Case Study – Manganese Nodules



Seabed Exploitation — The LRET Collegium 2012 Series, Volume 2

Feasibility Study on Manganese Nodules Recovery in the Clarion-Clipperton Zone

Authors: B Agarwal, P Hu, M Placidi, H Santo, J J Zhou

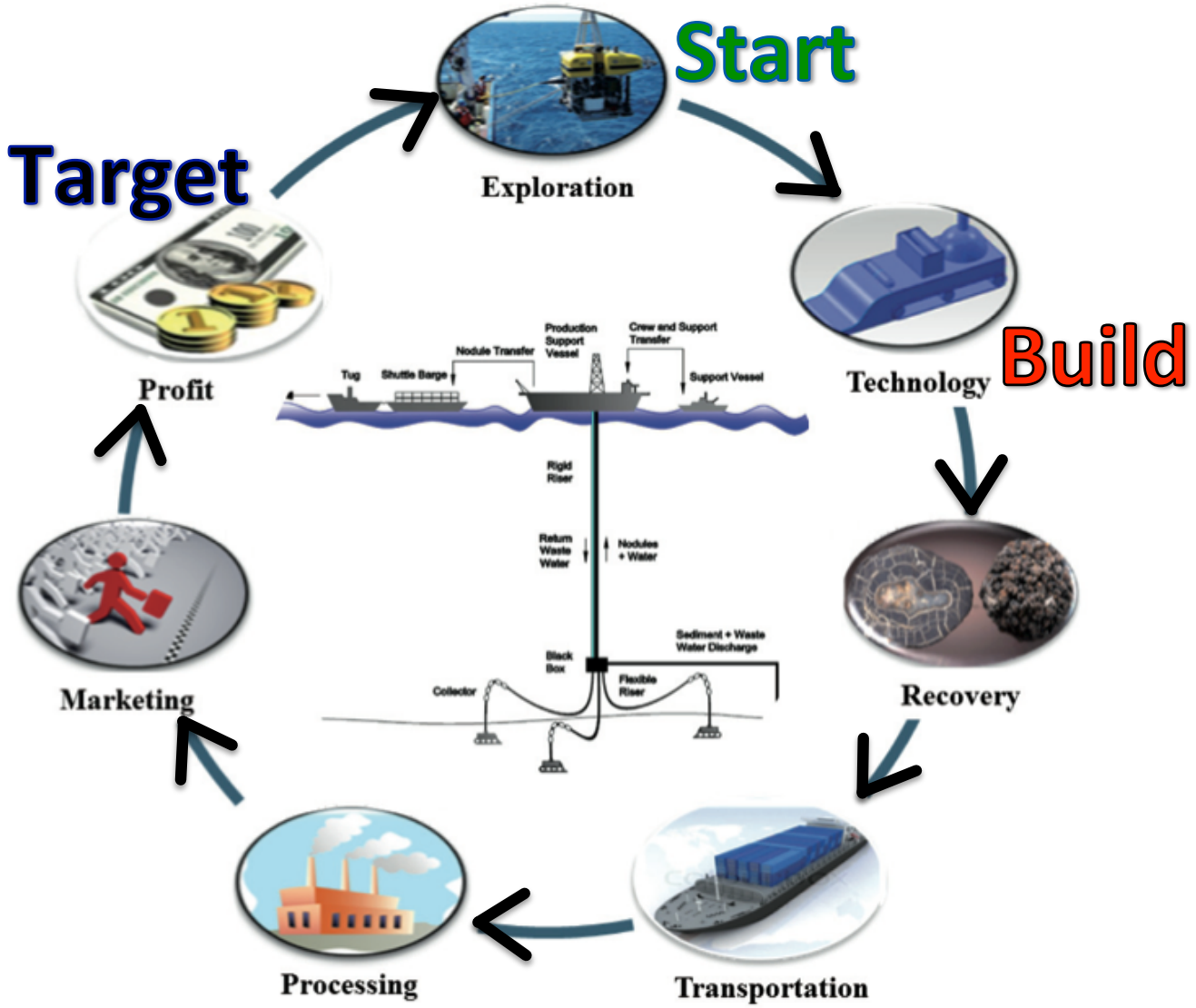
Series Editors: R A Shenoi, P A Wilson, S S Bennett

Lloyd's Register Educational Trust

University of Southampton

The technology innovator.

A Virtuous Mining Life Cycle



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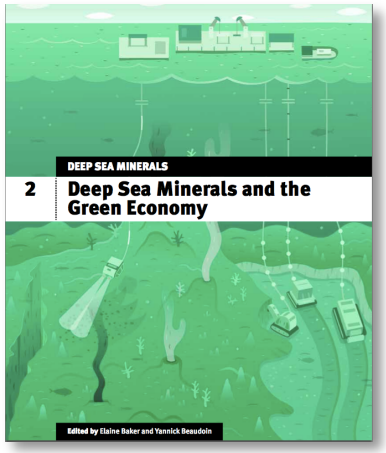
Where does the new, confident $ come from to Start

…then to Build

Context - Drivers & Restricting Forces of DSM



Sec. 3.0 "Drivers for the Development of Deep Sea Minerals in the Pacific"

Table 1

Drivers and restricting forces of deep sea mining

	Global	Industry	Pacific Island countries
CONFIDENCE	Global economic growth: supply and demand, population and consumption, increased industrialization and urbanization	Innovative, frontier field in an industry used to high-risk investment	Alternate development option: alleviate poverty, meet rising aspirations, lack of comparative advantage in other areas
	State actors: securing access to essential resources, capable of vertical integration of resource extraction and processing with product manufacture	Increasing difficulty and complexity of terrestrial mining: increasing costs, decreasing grade, slowing discovery, environmental issues, social and cultural issues	Marine minerals are a new natural resource capable of commercial exploitation in a region with few economic industries/choices
	Growing societal aspirations for environmental and social sustainability	Technological improvements and scalable applicability	National independence and autonomy
	New uses/markets, the green economy		
RISK	Price volatility	Availability of finance, financial uncertainty	Increasing community concerns about governance of, impact and returns from extractive industries
	Concerns over threats to marine environment, lack of marine science to inform conservation planning	Regulatory uncertanty in EEZ and the Area Significant obligations to share knowledge proceeds	Lack of governance, capacity, and regulation

Source: Charles Roche

Measure of The Confidence to Invest in DSM

A Measure of DSM Investor Confidence

=

RISK Acceptance

=

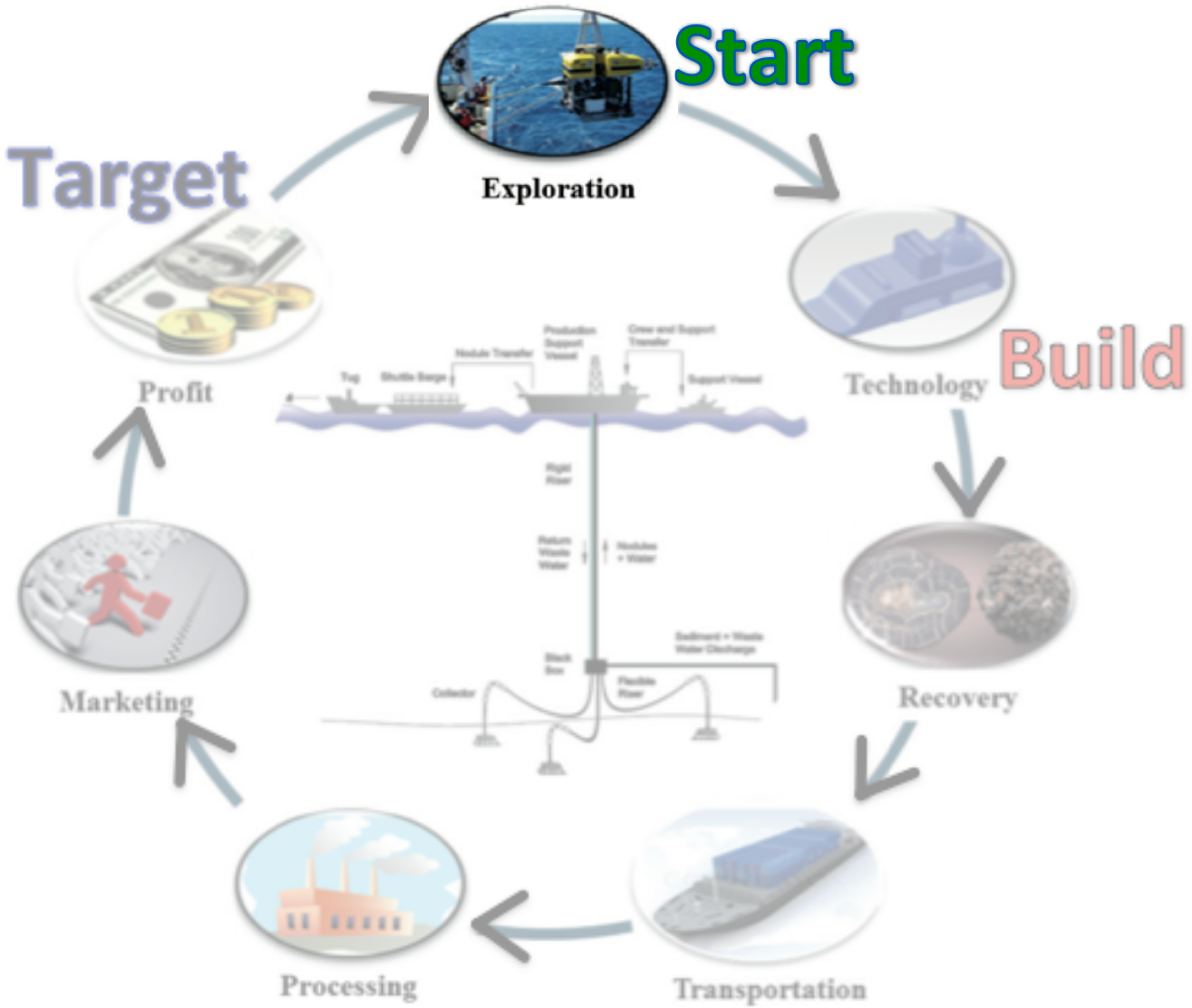
Availability of Finance

Drivers and restricting forces of deep sea mining

	Global	Industry	Pacific Island countries
Primary drivers	Global economic growth: supply and demand, population and consumption, increased industrialization and urbanization	Innovative, frontier field in an industry used to high-risk investment	Alternate development option: alleviate poverty, meet rising aspirations, lack of comparative advantage in other areas
	State actors: securing access to essential resources, capable of vertical integration of resource extraction and processing with product manufacture	Increasing difficulty and complexity of terrestrial mining: increasing costs, decreasing grade, slowing discovery, environmental issues, social and cultural issues	Marine minerals are a new natural resource capable of commercial exploitation in a region with few economic industries/choices
Secondary drivers	Growing societal aspirations for environmental and social sustainability	Technological improvements and scalable applicability	National independence and autonomy
	New uses/markets, the green economy		
Restricting forces	Price volatility	Availability of finance, financial uncertainty	Increasing community concerns governance of, impact and returns from extractive industries
	Concerns over threats to marine environment, lack of marine science to inform conservation planning	Regulatory uncertainty in EEZ and the Area Significant obligations to share knowledge proceeds	Lack of governance, capacity, and regulation

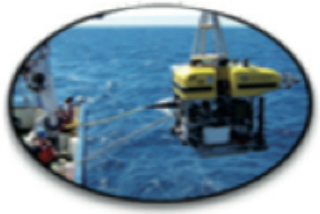
Source: Charles Roche

The Foundation of any DSM Project



The quality of the mineral resource.

Most Exploration Projects Do Not Reach Mining*



Exploration

No. potential mining projects

Project Attrition (over 5 – 15+ years)

Exit

Exit

* Based on onshore experience

Operating mining projects

~ 10%

Prospecting

Exploration

Feasibility

Construct & Operate

DSM is the Exception for Mining

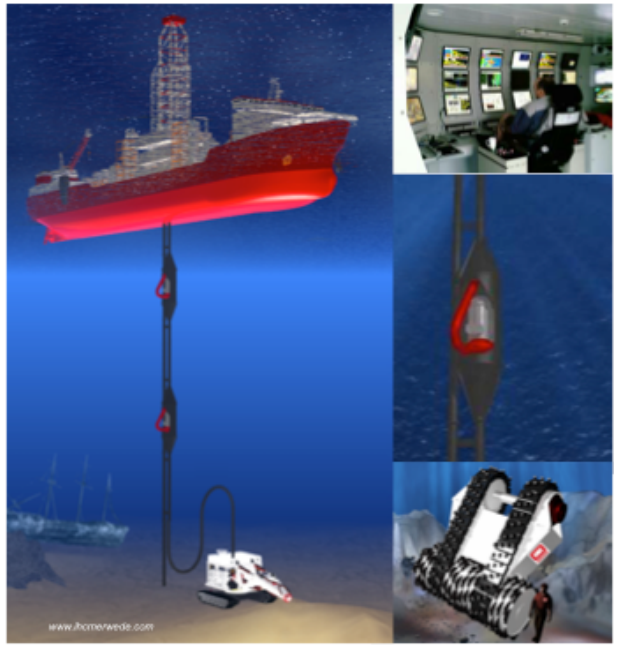
99% of mining in dry onshore deposits*:

- Fixed infrastructure, for a
- Limited mineral deposit, &
- Technology, risk & value that is well understood.

≠

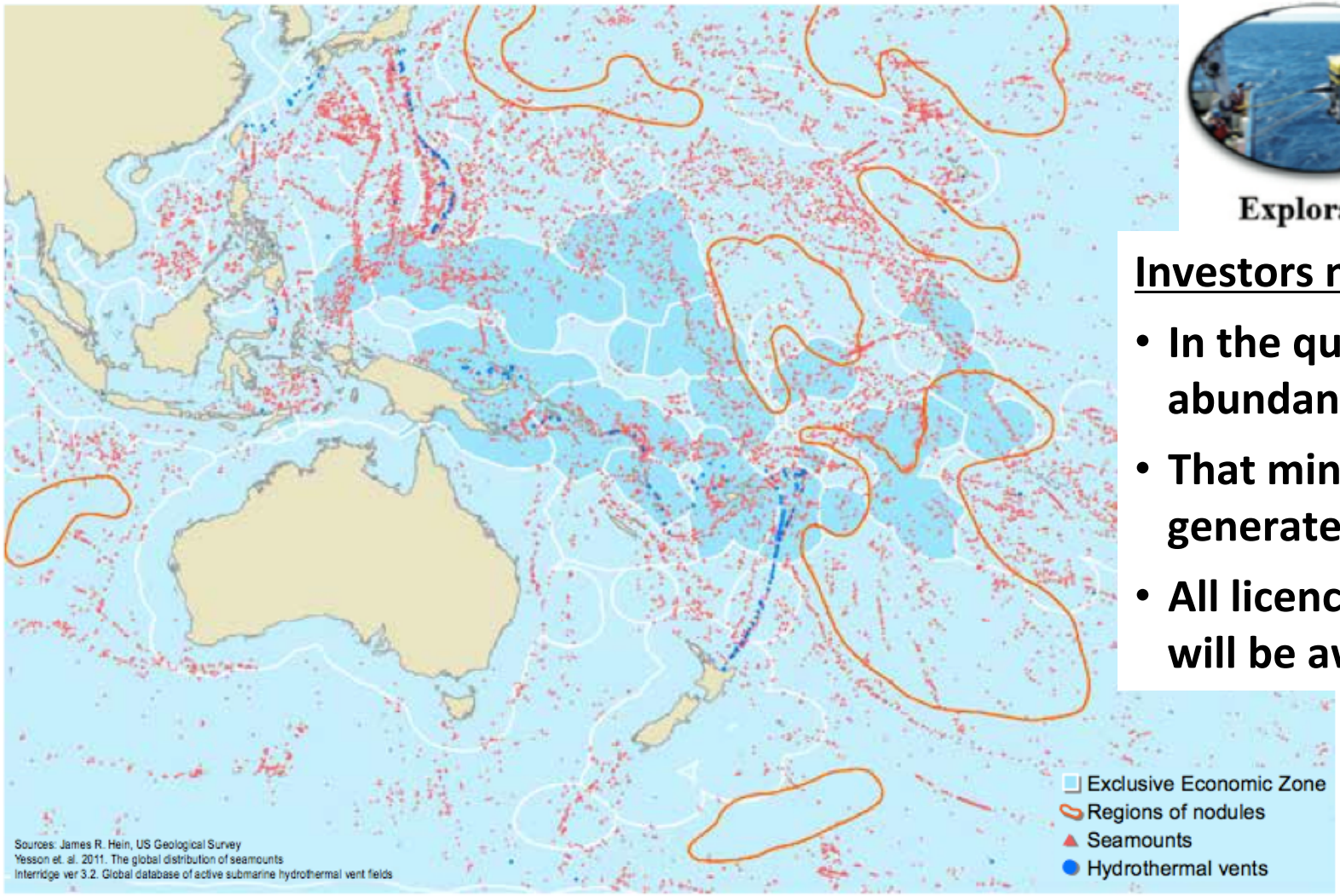
Deep sea mining has not started:

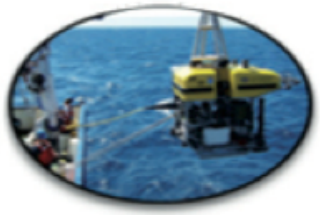
- Mobile infrastructure, for
- Widespread mineral deposits, &
- Technology, risk & value is not as well known or understood.



** Ref. Bain & Co. 2012*

DSM Mineral Potential





Exploration

Start

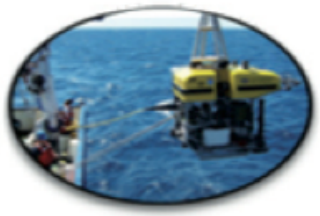
<u>Investors need confidence</u>:

- **In the quality & abundance of minerals;**
- **That mining is likely to generate profits; &**
- **All licences and permits will be awarded.**

Supporting Investor Confidence

Mineral resource reporting against known standards (e.g.):

- **JORC** Australasian Code
- **NI-43-101** Canadian Code
- Others…



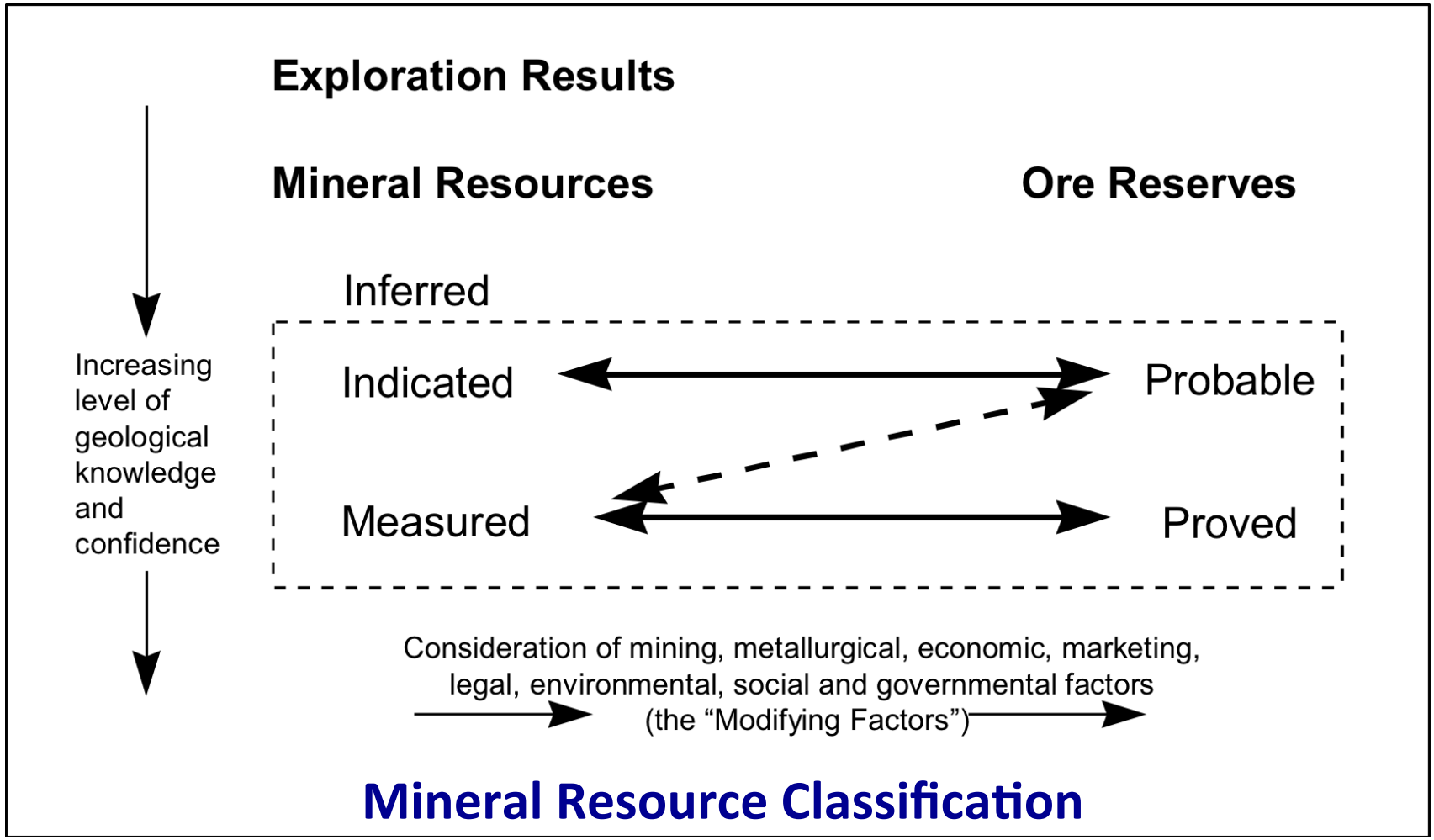
Exploration

DSM Challenge!

JORC et al **were not developed with DSM in mind!**

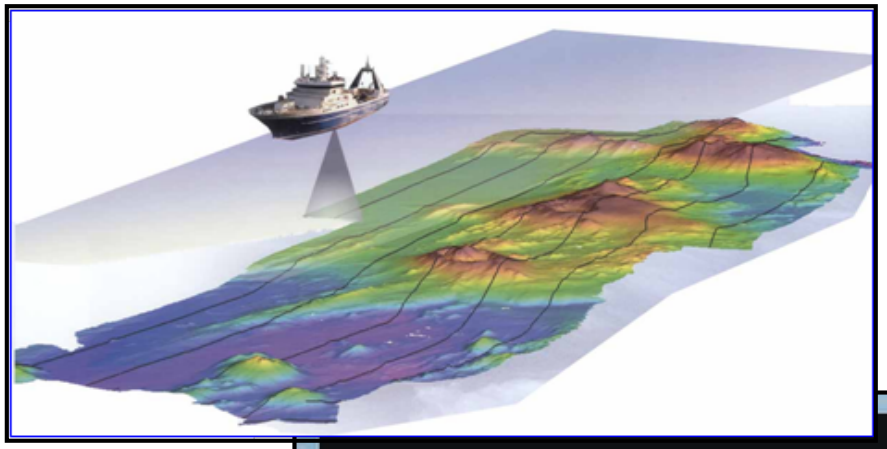
The *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves* (the 'JORC Code' or 'the Code') sets out minimum standards, recommendations and guidelines for Public Reporting in Australasia of Exploration Results, Mineral Resources and Ore Reserves. The Joint Ore Reserves Committee ('JORC') was established in 1971 and published several reports containing recommendations on the classification and Public Reporting of Ore Reserves prior to the release of the first edition of the JORC Code in 1989.

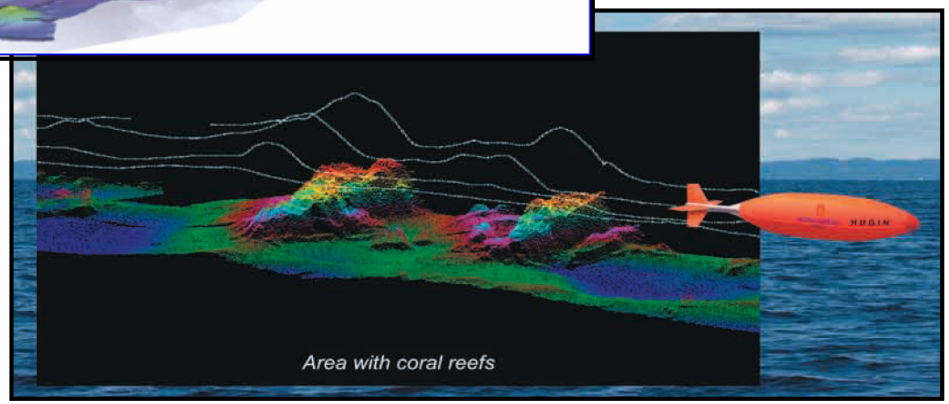
JORC – An Investor Reference



‘Exploration Results’

Exploration Results include data and information generated by exploration programs that may be of use to investors. The Exploration Results may or may not be part of a formal declaration of Mineral Resources or Ore Reserves.





‘Mineral Resources’ & ‘Ore Reserves’

Mineral Resource: A concentration of minerals of intrinsic economic interest

Order of increasing geological confidence in tonnage & grade:

	Inferred →	**Indicated** →	**Measured**
Confidence:	*(low)*	*(reasonable)*	*(high)*

Ore Reserve: The economically mineable part of indicated/measured resource

Order of increasing confidence in economic mineral extraction:

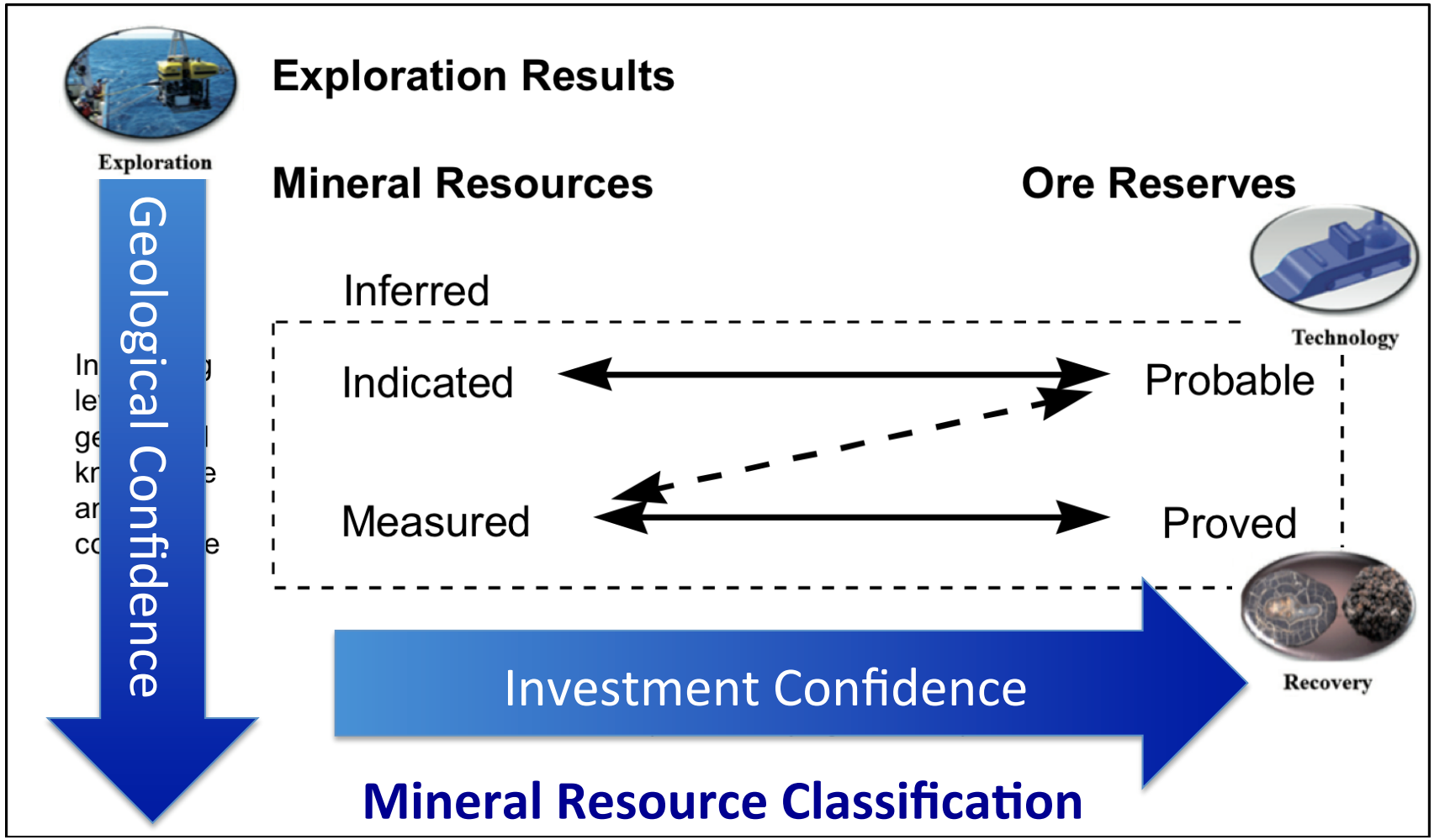
	Probable →	**Proved**
Confidence:	*(reasonable)*	*(high)*

Source of Confidence via Competent Person

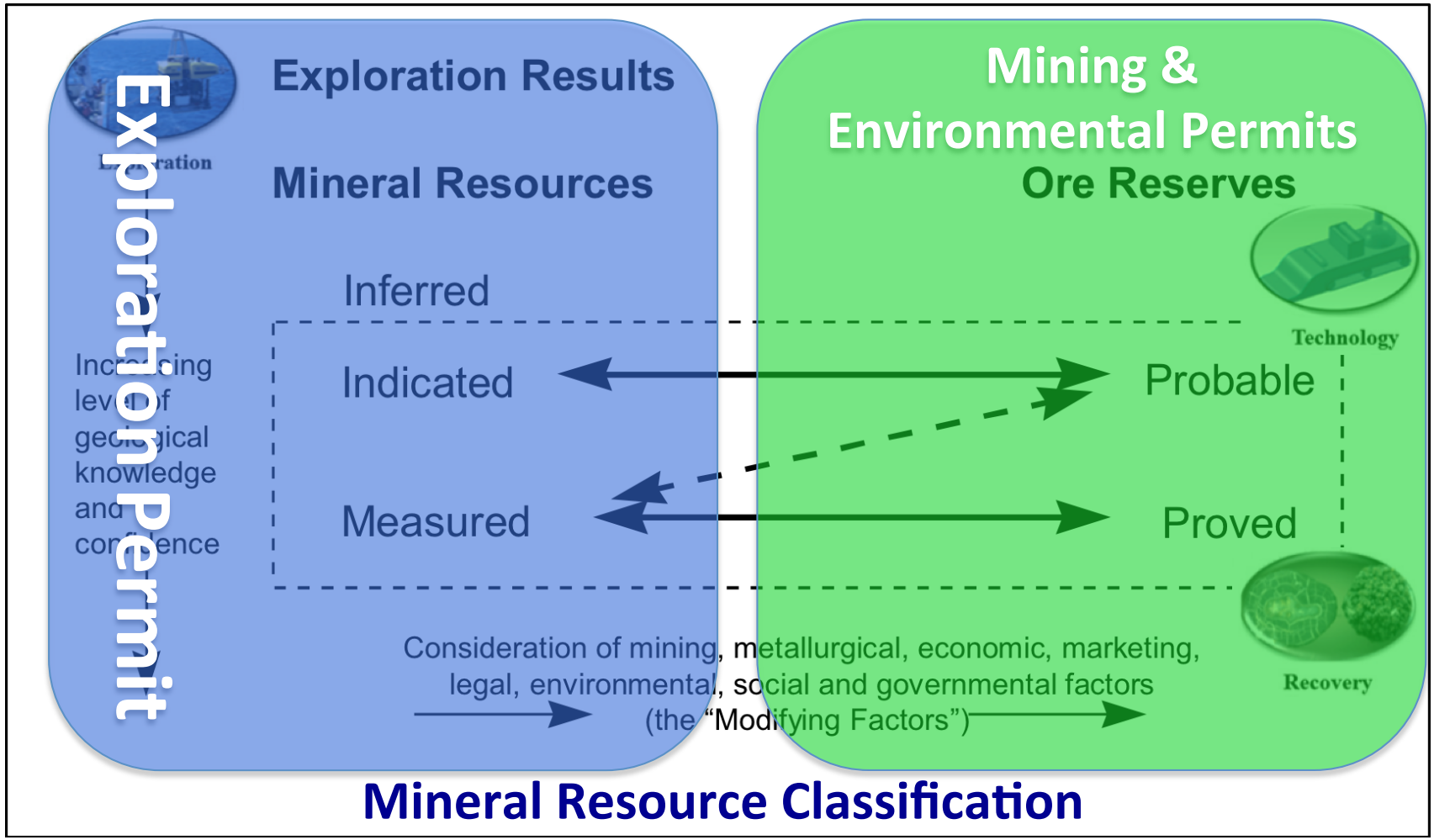
- **JORC classification provides a measure of mineral resource confidence.**
- **Requires a qualified expert, a Competent Person, to sign off.**

The JORC Code requires the **Competent Person**(s), on whose work the Public Report of Exploration Results, Mineral Resources or Ore Reserves is based, to be named in the report.

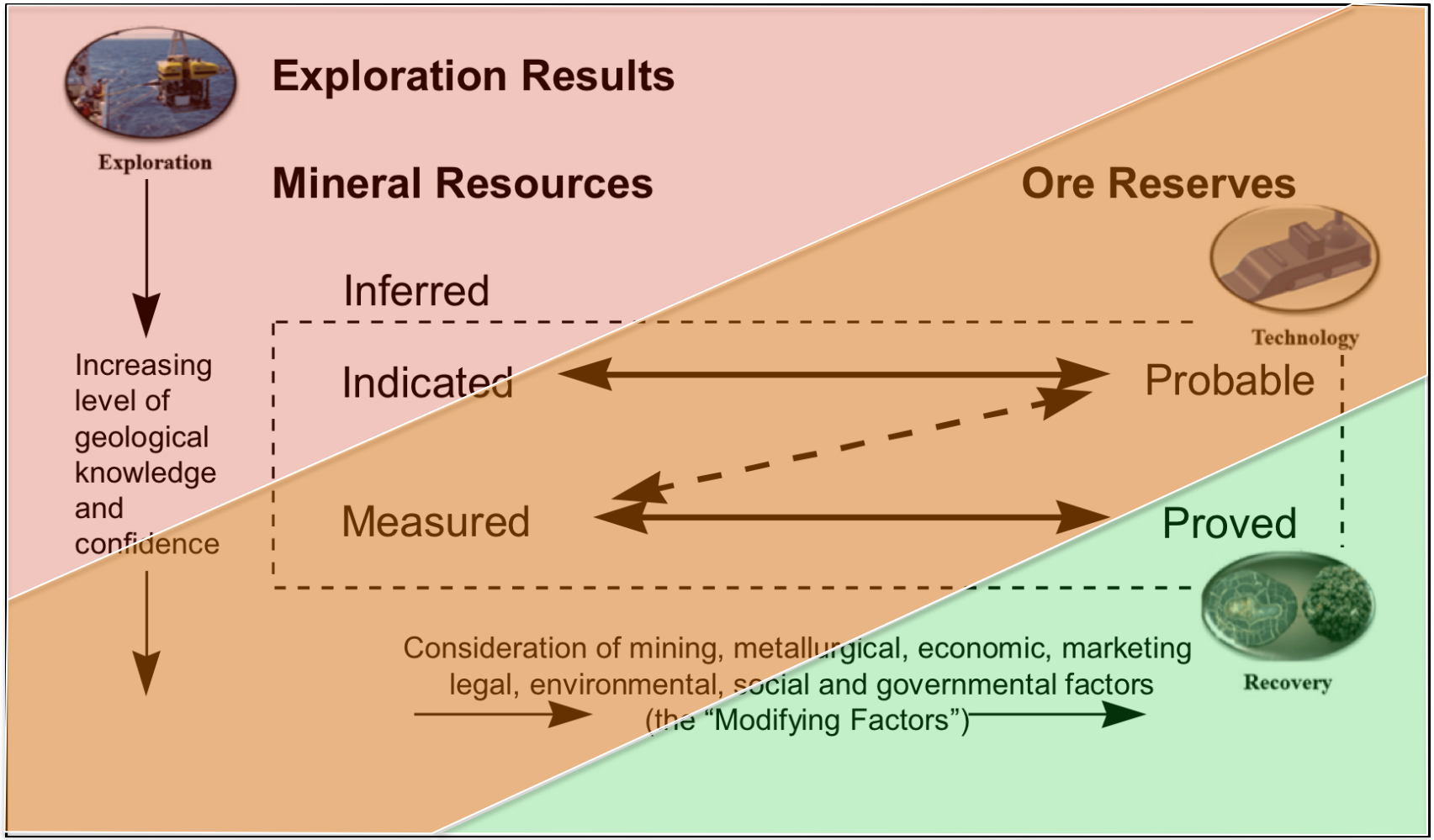
JORC – An Investor Reference



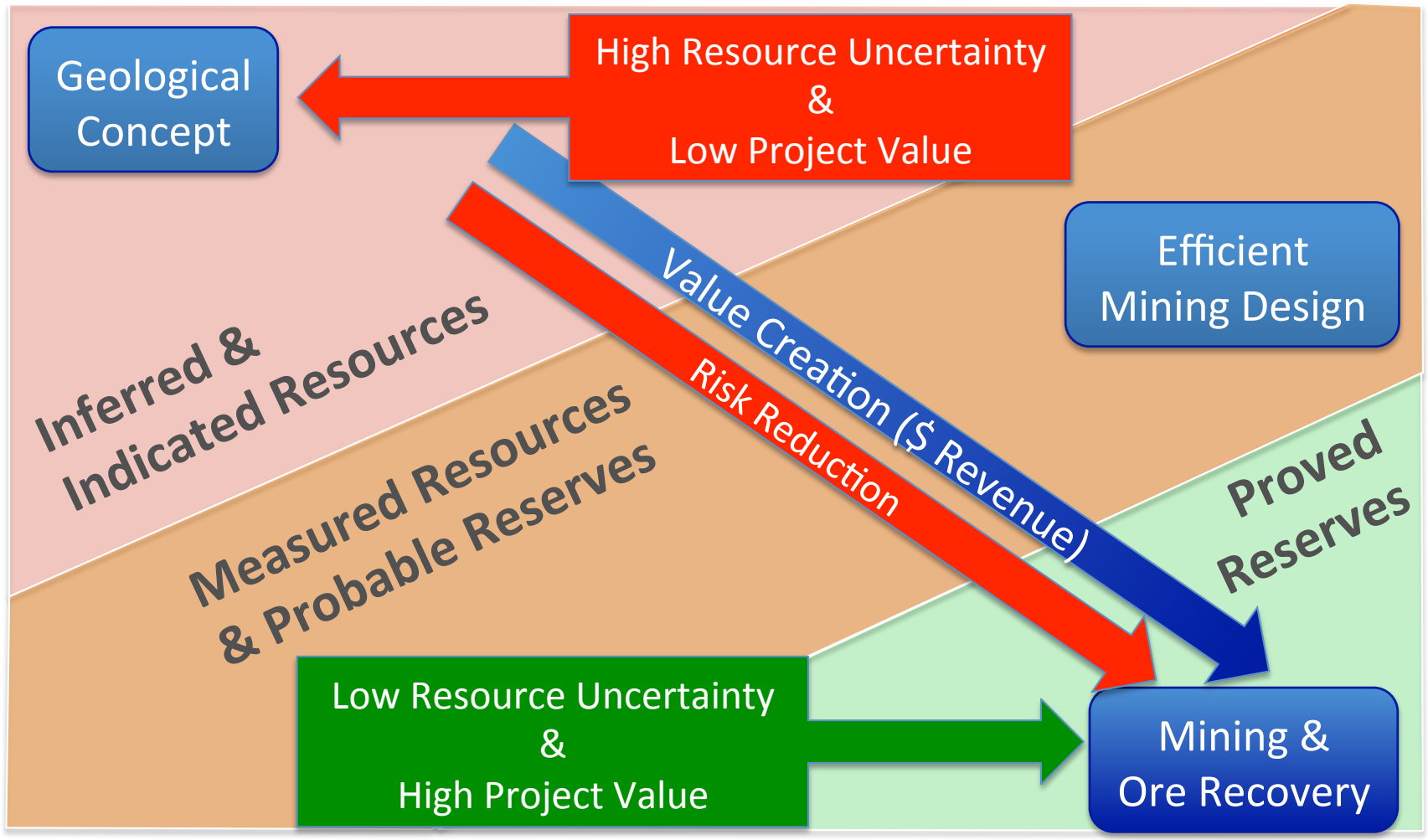
Licence & Permit Expectations



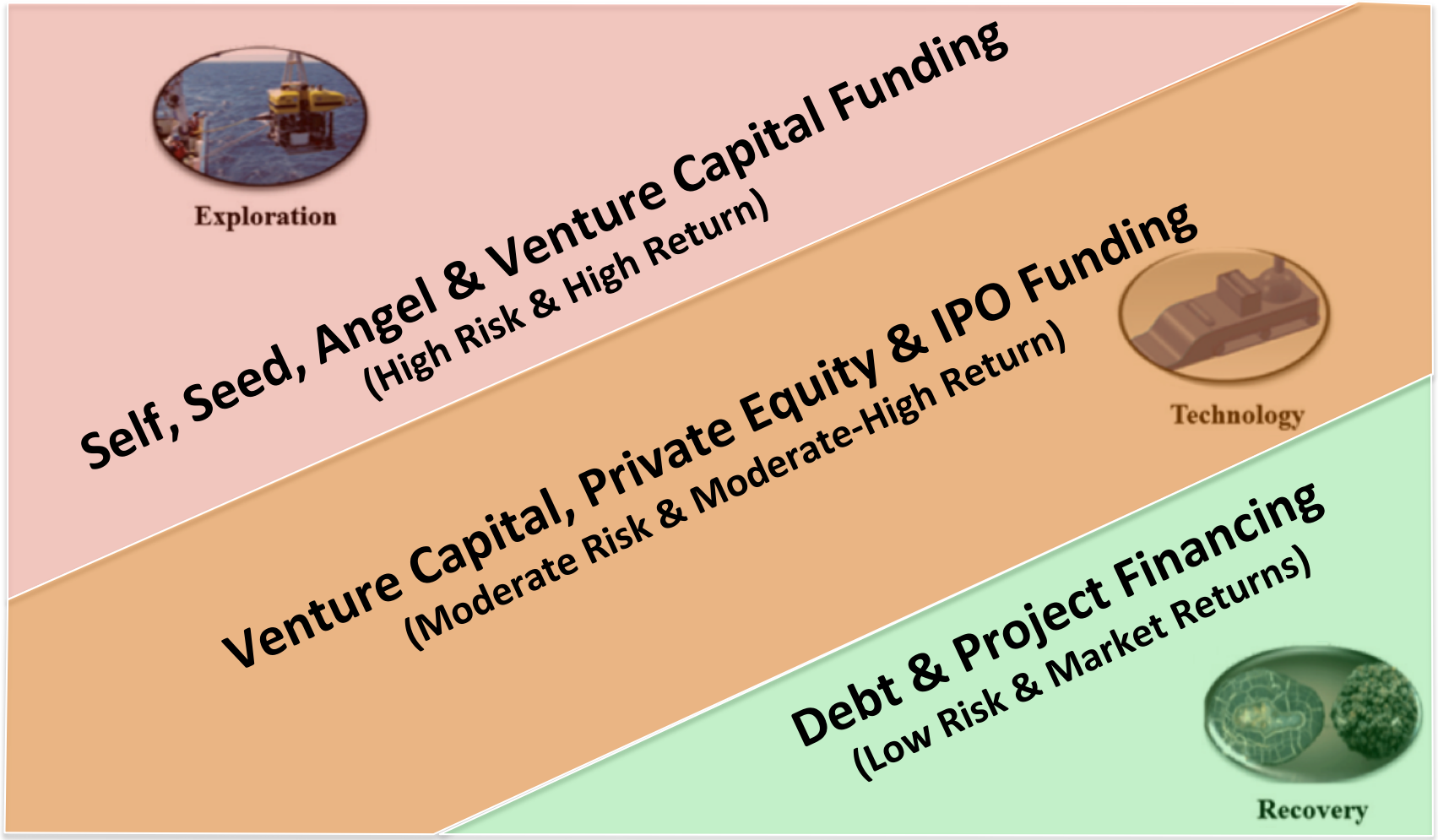
Availability of Finance Perspective



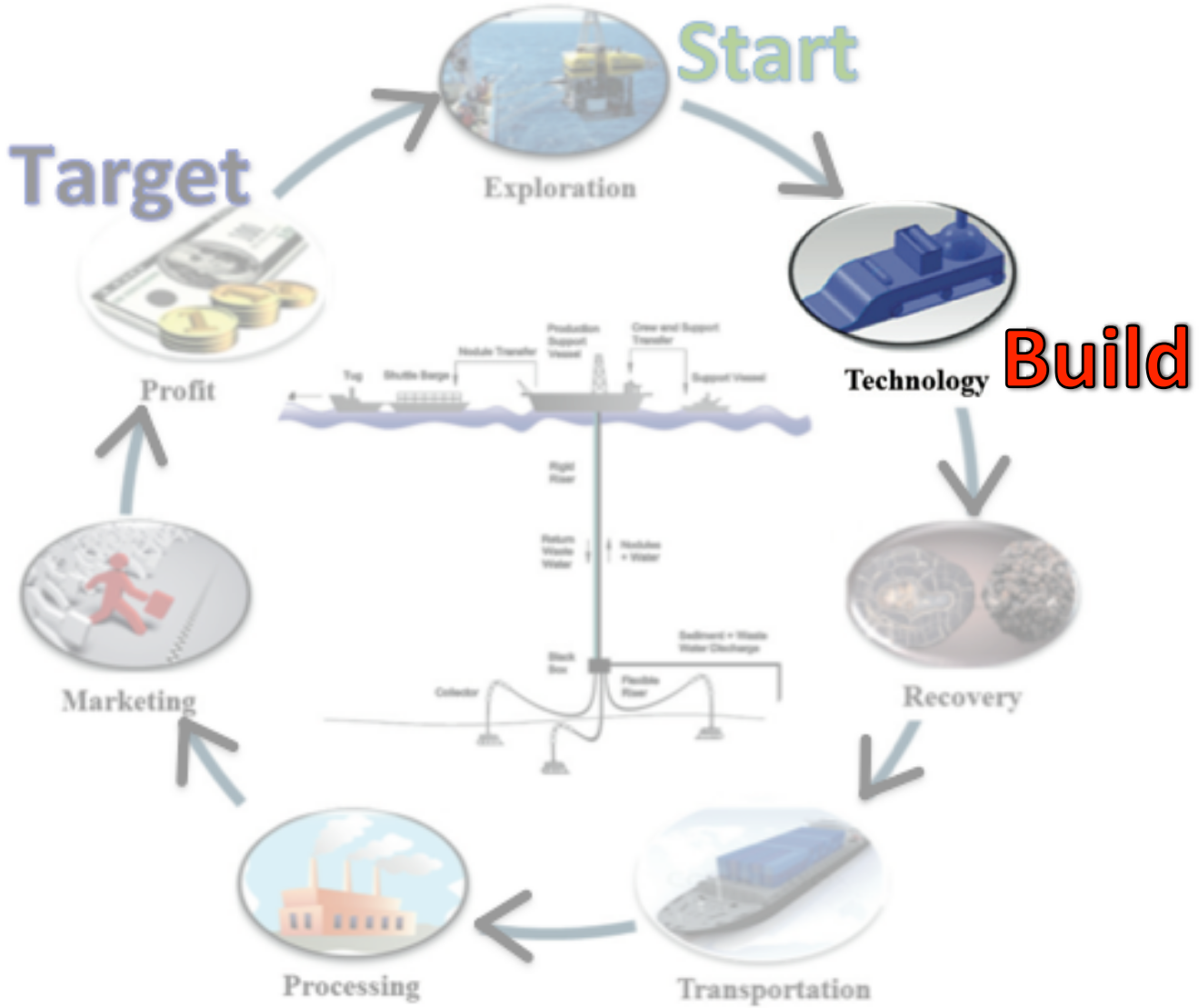
Stages of De-Risking a Project



Sources of Investor Funding

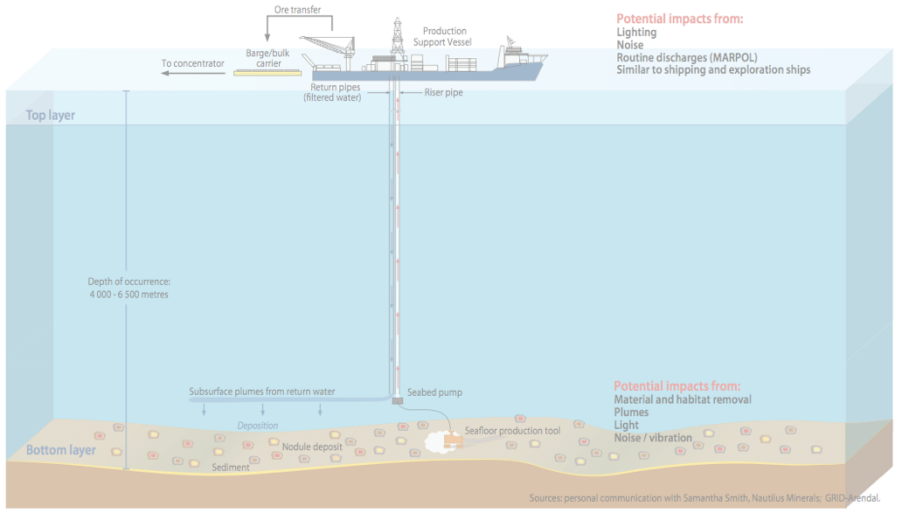


Measure of The Confidence to Invest in DSM



The maturity of the technology.

De Beers Offshore Diamonds Story

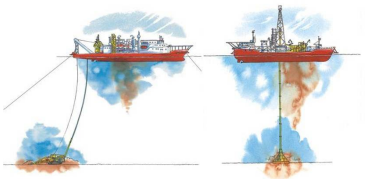


DeBeers Marine – *Peace in Africa*

DeBeers Marine – *Debmar Atlantic*

De Beers – Technology Evolution vs Water Depth

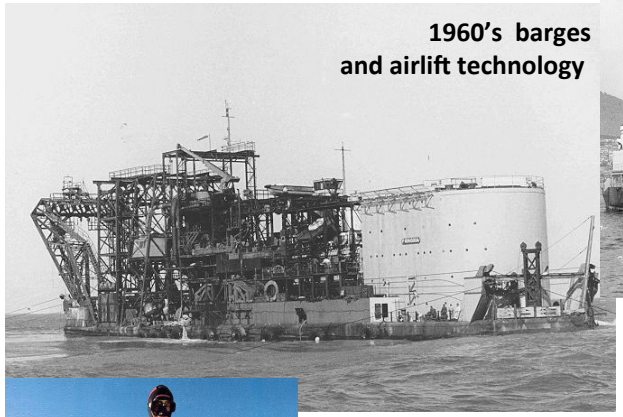
1961 – 1965	1965 – 1971	1971 – 1984	1984 – 1993	1993 – Present
Mining WD < 30 m	Mining WD < 30 m	Sampling WD 30 – 200 m	Technology Development WD 90 – 200 m	Production WD 90 – 200 m
• Sammy Collins a Texas oil millionaire recovers the first diamonds from the sea on 15 Nov 1961 • Sammy Collins Establishes Marine Diamond Corporation • Financial woes plague MDC due to lack of resource definition	• De Beers exercise their option and take a majority shareholding in MDC • Due to exhaustion of reserves De Beers ceases operations in March 1971	• Sampling operations move to deeper waters • Team remaining given the brief to prove the absence of a potential economic reserve • In 1983 a deposit of world-class proportions identified, although total caratage unknown • In 1984, De Beers Marine is formed to develop the technology for mining in deep waters (90 – 200 m)	• By 1986 two approaches, remote control crawler and vertical drill technology identified • In 1989 the first crawler pilot mining vessel commissioned (mv Louis G Murray) • In 1991 first pilot mining vertical drill technology vessel commissioned (mv Coral Sea)	• 1993 – mv Grand Banks (vertical drill mining vessel) commissioned • 1994 – mv Debmar Atlantic (vertical drill mining vessel) commissioned • 1997 – mv Debmar Pacific (vertical drill mining vessel) commissioned • 2001 – mv Coral Sea becomes part sampling / part mining vessel • 2003 – mv Gariep (vertical drill mining vessel) • 2007 – mv Peace In Africa (crawler mining vessel) • In 2006 production reaches 1 million carats

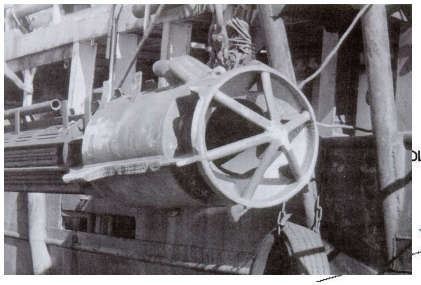


Ref. all photos from De Beers Mining

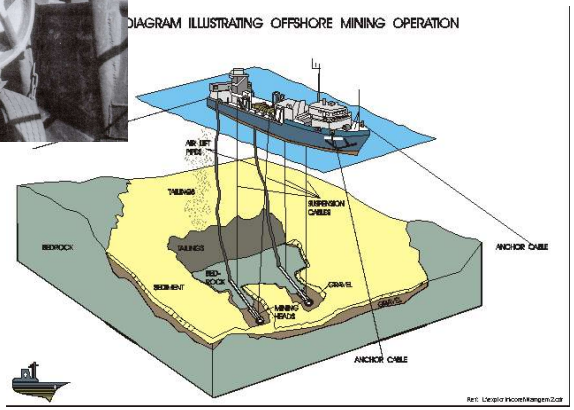
De Beers Marine Operating Systems

1960's barges and airlift technology

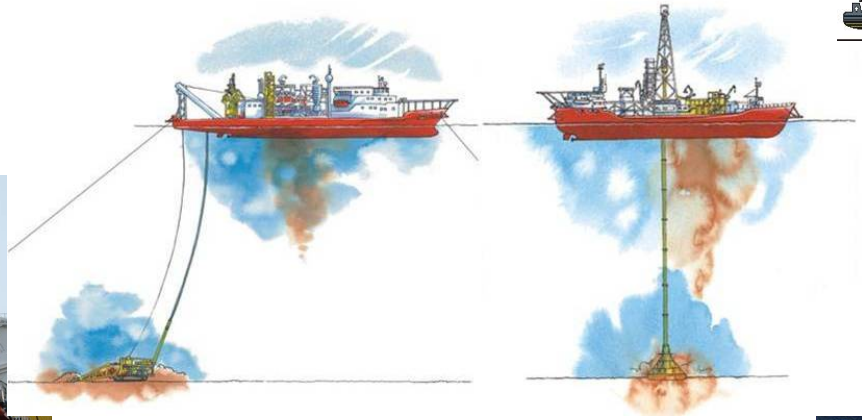




1980's and 1990's airlift technology



Diver operations



Mid 1990's – mid 2000's
Crawler & pump technology

1990's Large diameter drill technology

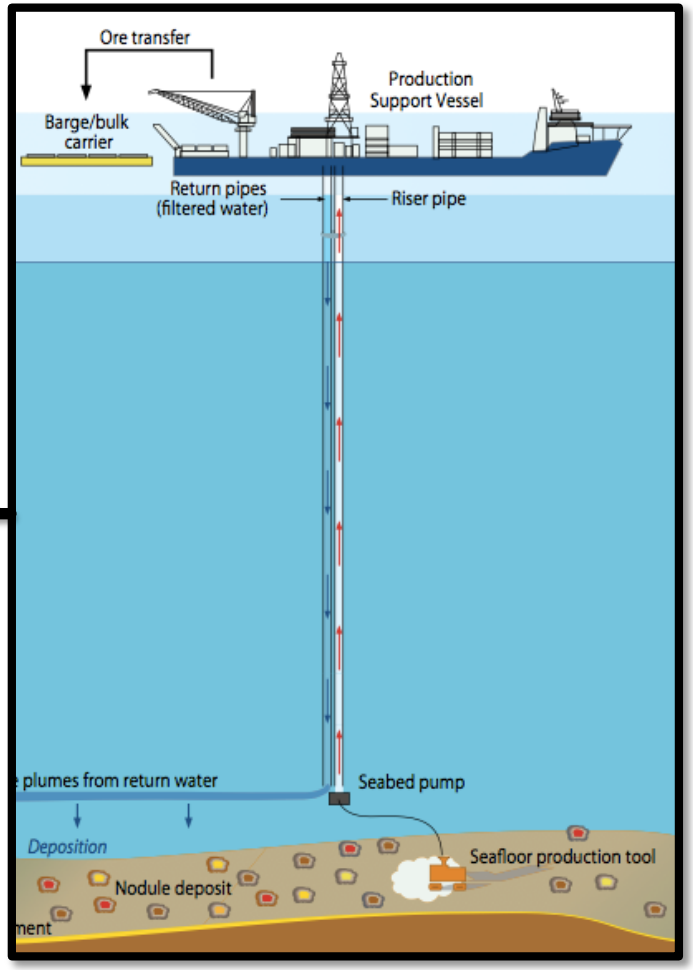
Ref. all photos from De Beers Mining

The technology innovator.

Technology Readiness Level Classification

- TRL 9 Actual system proven in operational environment
- TRL 8 System complete and qualified in operational environment
- TRL 7 System prototype demonstration in operational environment
- TRL 6 Technology demonstrated in relevant environment
- TRL 5 Technology validated in relevant environment
- TRL 4 Technology validated in lab
- TRL 3 Experimental proof-of-concept
- TRL 2 Technology concept formulated
- TRL 1 Basic principles observed

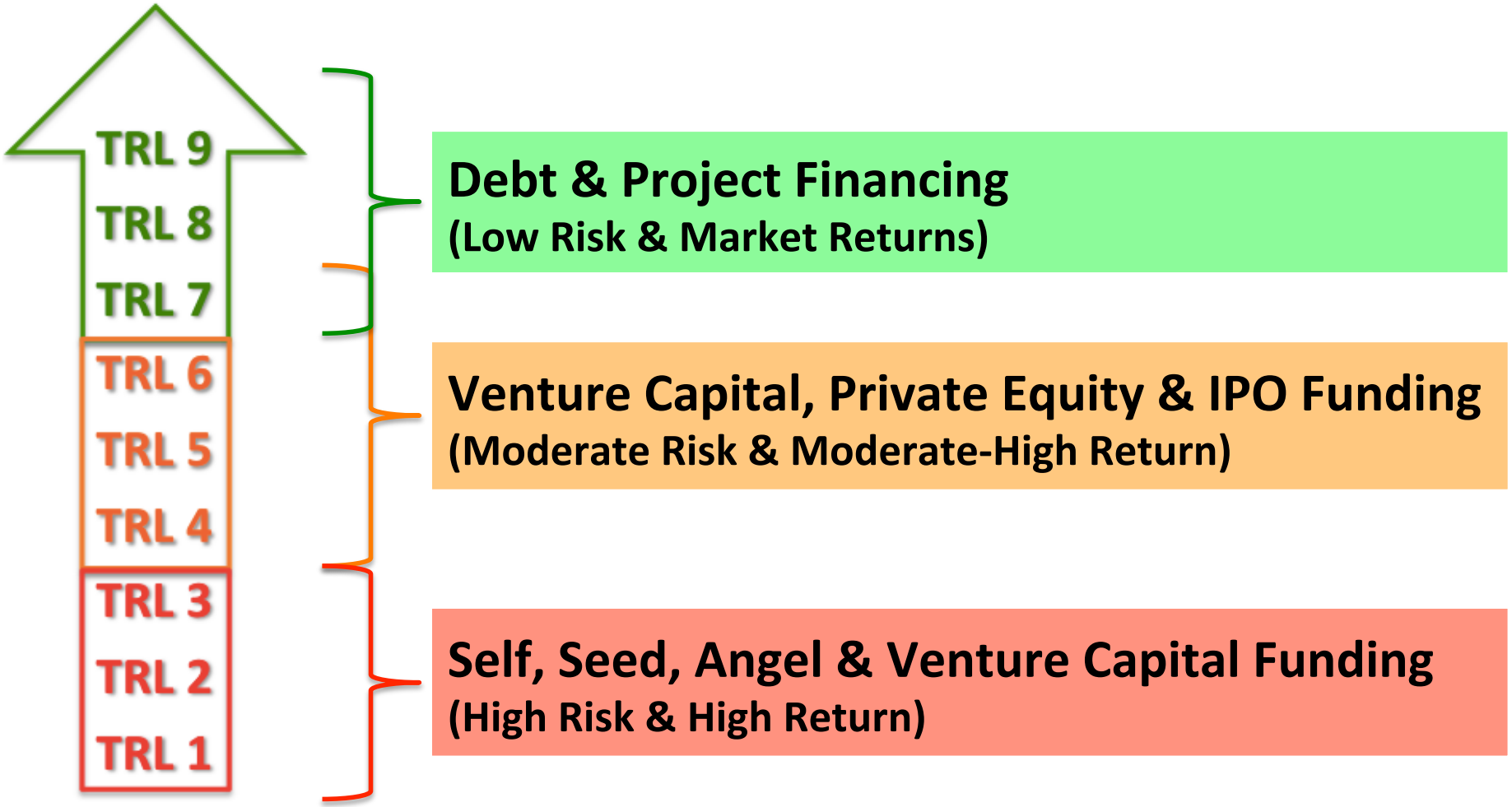
How Mature is DSM Technology Today?



Manganese Nodules

Mining System	TRL 3 - 7:
Ore Processing	TRL 3 - 4
Ore Transfer	TRL 3 - 4
Vessel	TRL 6 - 7
Vertical Tr'sport	TRL 3 - 4
Mine Vehicle	TRL 3 - 5

Sources of Investor Funding



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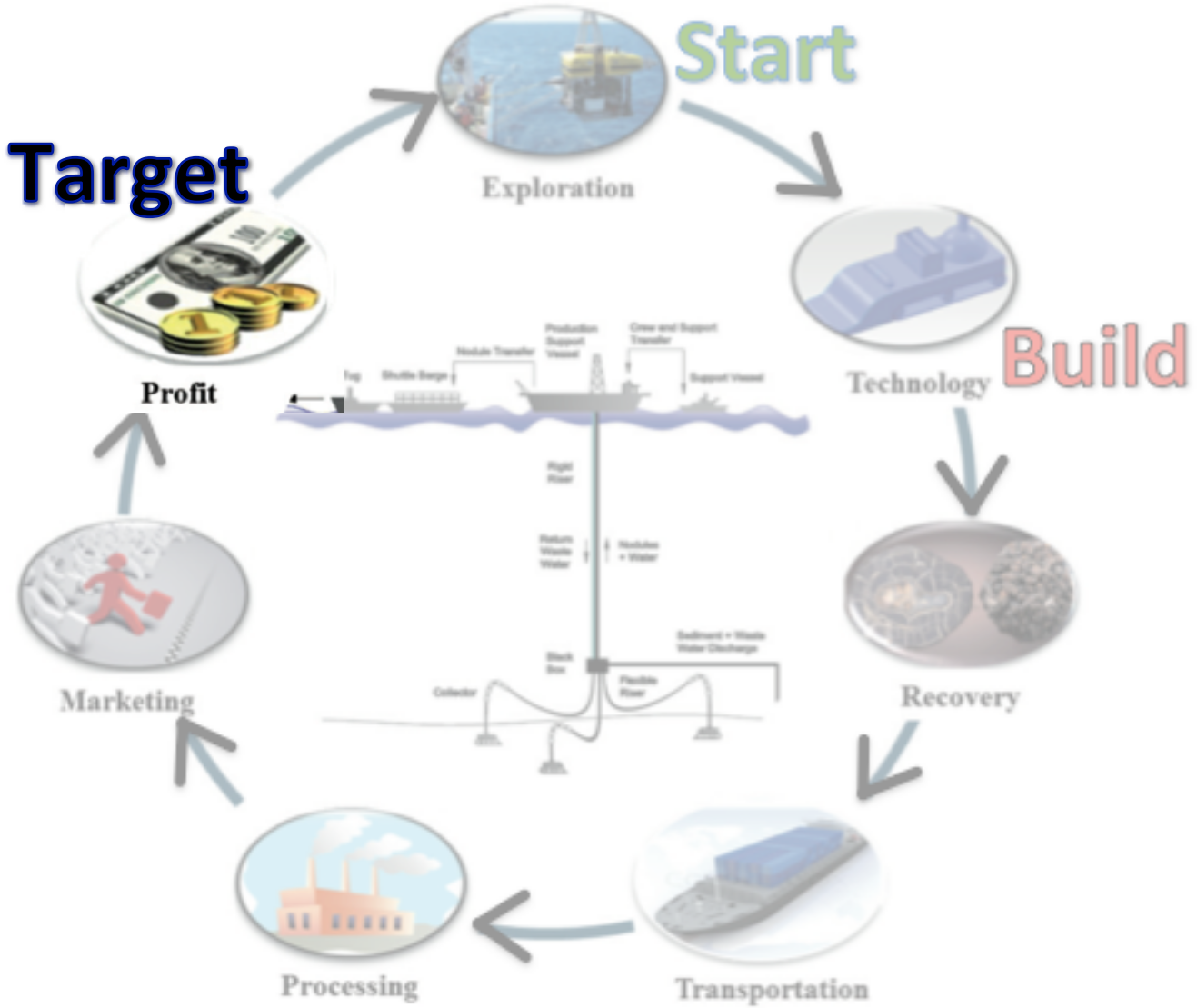
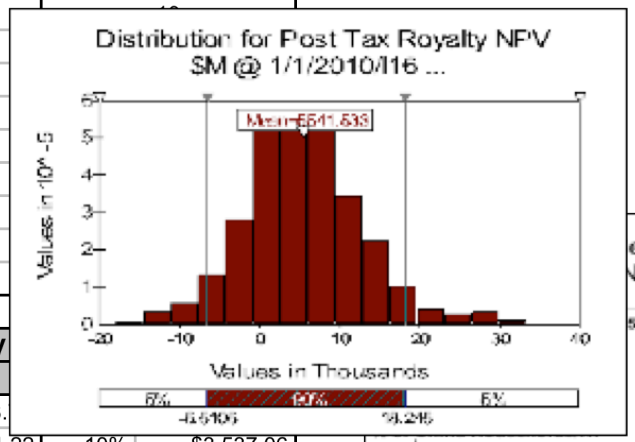


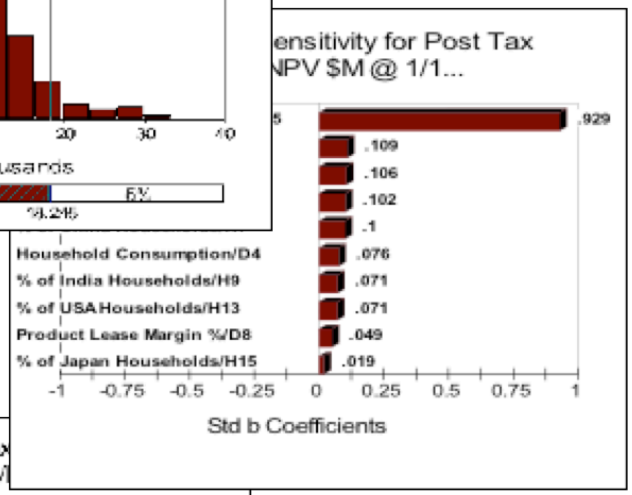
The strength of the business case.

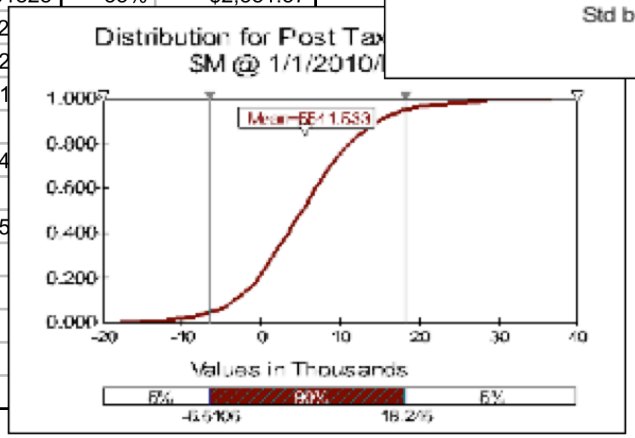
Models of a DSM Investment Business Case

Summary Information	
Workbook Name	0 yr Royalty NPV @Risk
Number of Simulations	
Number of Iterations	
Number of Inputs	
Number of Outputs	
Sampling Type	
Simulation Start Time	
Simulation Stop Time	
Simulation Duration	
Random Seed	

Summary			
Statistic	Value		
Minimum	-$17,838.		
Maximum	$36,811.22	10%	-$3,537.06
Mean	$5,541.53	15%	-$1,632.55
Std Dev	$7,609.13	20%	-$426.59
Variance	57898784.67	25%	$590.79
Skewness	0.425691442	30%	$1,550.52
Kurtosis	3.948861828	35%	$2,381.57
Median	$5,22		
Mode	$13,12		
Left X	-$6,51		
Left P			
Right X	$18,24		
Right P			
Diff X	$24,75		
Diff P			
#Errors			
Filter Min			
Filter Max			
#Filtered			







Include:

- Mine lifecycle forecasts
- Ranges of assumptions
- Multiple uncertainties
- Risk discounts
- Cost-benefit analyses
- Investor demands
- Government take
- Market prices
- More assumptions…
- More uncertainties…

Example - Project Input Assumptions

Input (Mining & Processing)	CCZ (LRET, 2012)	Cook Is. (Imperial, 2010)
Production Rate	**0.5 Million tpa**	**1.3 Million tpa**
Total Tonnes (Project Life)	**10 Million t.** (20 years)	**26 Million t.** (20 years)
Lifetime Capital Cost (US$)	**$66/t ($660M)**	**$46/t ($1,196M)**
Operating Cost (US$/tpa)	**$290/tpa**	**$117/tpa**
Revenue (US$/tpa)*	**$550/tpa***	**$548/tpa****

(grade) & % Revenue

* **Nickel (1.4%)** 69%; **Cobalt (0.2%)** 16%; **Copper (1.1%)** 15%

** **Nickel (0.7%)** 14%; **Cobalt (0.5%)** 18%; **Copper (0.2%)** 2%; **Mn (20%)** 66%

** Manganese dropped from sales revenue due to smaller market size.*

Example - Project Economic Results

Output Results	CCZ (LRET, 2012)	Cook Is. (Imperial, 2010)
NPV	**US$ 361 M** (@ 8%)	**US$ 293 M** (@10%)
IRR	**14.8%**	**13.9%**
Payback Period	**10 years**	**8.6 years**
Co. Annual Taxable Income	**US$ 130 Million**	**US$ 361 Million**
Co. Annual Profit After Tax	**US$ 104 Million**	**US$ 201 Million**
Govt. Annual Take (% of Rev.)	**US$ 26 M** (9.5%)*	**US$ 150 M** (27%)**

* No estimate of royalties; 20% Govt. corporate tax

** 10% mineral tax & 25% Cook Isl. corporate tax

Rare Earth Elements (Hidden Value?)

Table 3: Values of rare earth element content/tonne of manganese nodules, beneficiated manganese … byproduct (after Ni, Cu, Co and Mn have been extracted), Kutessay II ore and Mountain Pass ore. The manganese nodule … material is a very competitive source of heavy rare earths.

Element	Symbol	REE $/kg 12/16/2011*	CCZ Nodule Value/tonne	CCZ Nodule Byproduct** Value/tonne	Kutes… Va…	
Light REE						
Lanthanum	La	$80.0	$7.74	$25.14		
Cerium	Ce	$100.00	$31.60	$102.70		
Praeseodymium	Pr	$270.00	$8.40	$27.29	$22…	
Neodymium	Nd	$270.00	$35.37	$114.95	$49.13	$2,200.85
Samarium	Sm	$170.00	$5.80	$18.84	$15.52	$62.99
Europium	Eu	$5,300.00	$41.87	$136.08	$26.69	$392.74
Total Light REE			**$130.77**	**$425.00**	**$187.31**	**$9,177.61**
Heavy REE						
Gadolinium	Gd		$6.02	$19.56	$16.14	$29.94
Terbium			$20.00	$65.00	$138.39	
Dysprosium			13.36	$238.42	$382.59	
Holmium						
Erbium			$3.37	$10.94	$19.00	$200**** (estimated)
Thulium	Tm					
Ytterbium	Yb	$90.00	$1.14	$3.71	$6.58	
Lutetium	Lu	***				
Yttrium	Y	$170.00	$12.92	$41.99	$101.14	
Total Heavy REE			**$1…**	**$…**	**$663.85**	**$229.94**
Total REE			**$247.58**	**$804.63**	**$851.16**	**$9,407.55**

*Prices from "metal-pages.com"

**Byproduct beneficiation is due to the removal of the sum of 9.6% adsorbed water, 8.0% structural water, 48% MnO2, 3.7% NiO+CuO+CoO = 69.3%

*** These elements are very rare and the applications very few. They are very thinly traded, buts individual lots can sell for $10k/kg or more. They are not included here due to their extreme price volatility.

**** Estimated based on combined 0.2% relative content of Table 1.

Not yet included in Mn nodules economic models

Attractive for investment!

Some of the Challenges to Achieving Success…

3.4 Discussion

The factors drivin
ic are complicate
factors may be g
may leave small
ments outside th

On one hand, a
tion or substituti
modity – such as
which produced
(Romboy 2013)
adoption of deep sea mining. On the other hand, rising demand could shift from one commodity to another within the typical mine developme
it difficult to justi

While the develo
province of small
A fast-tracked de
from the increas
prises or the ent
Lockheed Martin
pany would be e
indication that l
and mining activ

Without these ac
of finance, togeth
cerns, may combi
investment in the
ic. Whatever the cause, ongoing delays in projects or unsuccessful project implementation could continue to erode confidence and further set back commercialization by many years.

Some commentators have suggested that deep sea mineral exploration is inevitable (Yeats 2012). Others are far less certain

remains to be tested in practice. However, the global focus on sustainability is unlikely to change. If the deep sea mining in-

contribution it could make to Pacific development. There are some factors that these countries can control and that will help the industry progress. They include continued knowledge sharing and the development of capacity and governance structures (including regional mechanisms) to ensure a stable and transparent environment that encourages industry participation.

"…deep sea mining… will continue to be dominated by strong external influences over the key drivers…. this means Pacific Island states have little direct influence over many of the drivers of deep sea mining."

"…some factors that these countries can control and that will help industry progress…include":

- continued knowledge sharing, and
- development of capacity and governance structures

…"to ensure a stable and transparent environment that encourages industry participation."

Three Take-Away Points

Bridging the DSM investor confidence gap:

1. **Look thru the eyes of an onshore mining investor**
2. **Build solid & credible knowledge foundations**
3. **Stable, transparent & globally competitive fiscal terms**

SPC-EU Pacific DSM Workshop, Rarotonga
13th May 2014

Commercial Realities in Delivering DSM Projects

www.ihcmerwede.com/mining/

Thank You!

The technology innovator.