



NAURU OCEAN RESOURCES INC.

# **PROCESSING TECHNOLOGIES, METAL RECOVERIES & ECONOMIC FEASIBILITY OF DEEP SEA MINING**

Warsaw, Poland

September 4, 2018

## ONSHORE PROCESSING PLANT



- Cost Estimation
- Technical Complexities
- Ramp-up Profile
- Ore Characteristics
- Metal Production

# CAPEX OVERRUNS

Project	Owner	First budget announced	Initial budget (USD billion)	Year concluded	Final budget (USD billion)	Capacity (000 tpy)	CapEx overrun (%)
Ambatovy	Sherritt	2007	3.4	Ramping up	5.5	60	62
Koniambo	Xstrata	2007	3.8	2013	5.0	60	32
Goro	Vale	2007	3.2	Ramping up	4.3	60	34
Onça Puma	Vale	2005	1.4	2010	2.3	52	64
Long Harbour	Vale	2009	2.8	2013	3.6	50	29
Barro Alto	A. American	2006	1.2	2011	1.9	36	58
Ramu	CNMC	2008	1.2	2013	1.5	31	25
Taganito	Sumitomo	2008	1.1	2013	1.3	30	18
Fenix	Solway	2008	1.0	2014	1.1	24	10
Kevista	First Quantum	2009	0.35	2012	0.4	10	14

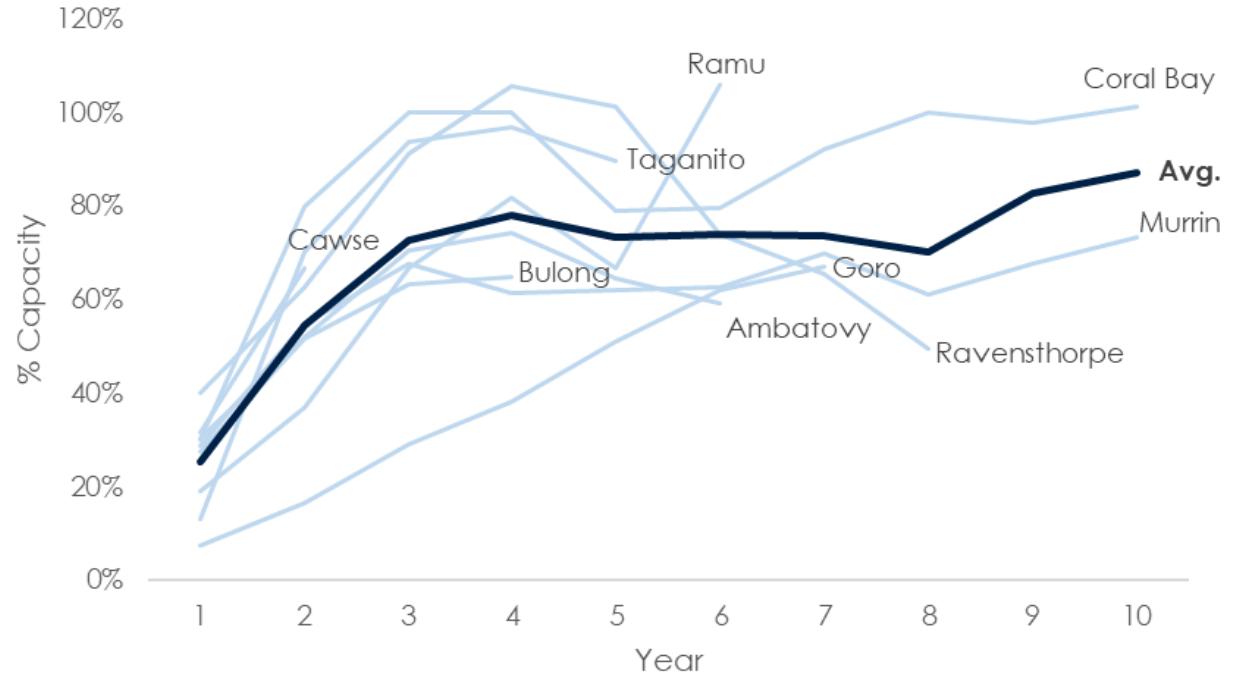
Avg<sup>1</sup>=38%

<sup>1</sup>Weighted average of CapEx overruns in selected projects

Source: Companies' websites and reports; press clippings; L.E.K. analysis

## RAMP-UP RISKS

- Can take a long time to reach nameplate capacity
- Failures – Bulong, Goro, Murrin Murrin and Ravensthorpe

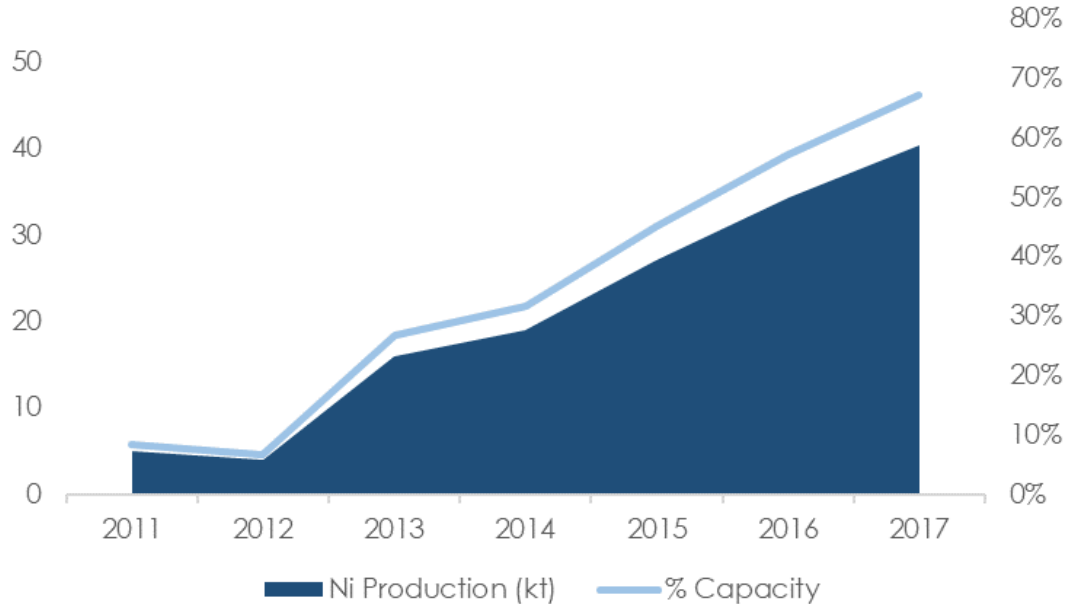


Source: Global Mining Research

# GORO

Long ramp up time has resulted in significant losses

## OPERATING HISTORY

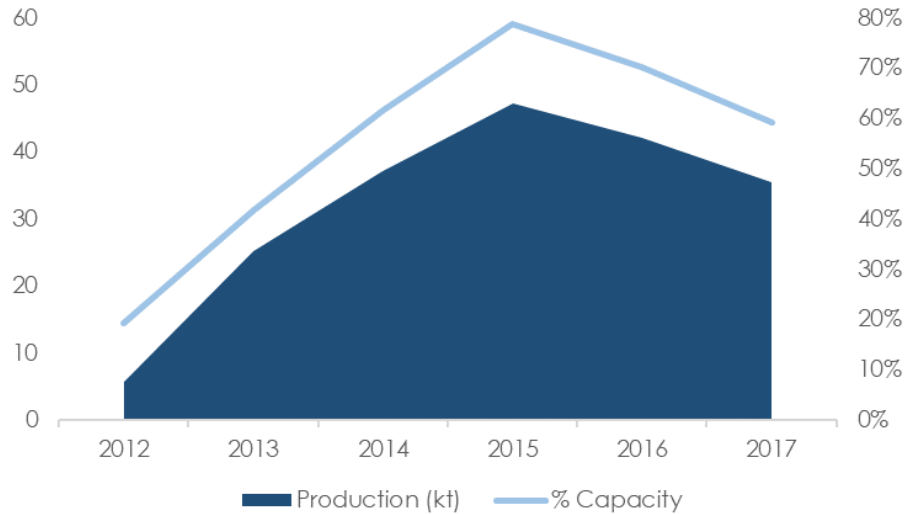


# AMBATOVY

Knock on effects to cost – While Ambatovy was built for US\$5.5B, it has required a further US\$1.7B of working capital during its ramp-up



## OPERATING HISTORY



## NODULE ORE IS DIFFERENT TO CONCENTRATES

Ore coming from the CCZ is not a high value concentrate.

Polymetallic nodules **cannot** be upgraded using physical characteristics to an intermediate product prior to transportation. Rather, polymetallic nodules will need be transferred to another jurisdiction in a RAW FORM.

Land based sulphide ores (e.g. from copper and nickel sulphide deposits) can be upgraded relatively simply to a product for sale to a smelter. E.g. through **CRUSHING, GRINDING AND FLOTATION** a copper or nickel sulphide ore can be upgraded to a high grade concentrate product.

**This is not the case with polymetallic nodules which are oxide deposits where the metals like copper and nickel are not in discrete particles that can be separated physically from the rest of the ore. Rather, all of the polymetallic nodule ore needs to be processed (e.g. hydro/pyro metallurgy), which is far more costly and capital intensive than less complex physical separation.**



Froth flotation

Grinding Mill





## NODULES ARE DIFFERENT TO CONCENTRATES

Because polymetallic nodule ore cannot simply be upgraded close to the mine site it will be shipped as a raw material, and as such is more analogous to a bulk commodity such as coal or iron ore. The royalty rate should take account of this and reflect the fact that:

- shipping nodules in raw form results in higher transport costs per tonne of metal produced; and
- processing nodules is far more costly and complex than physically upgrading terrestrial ores to intermediate products

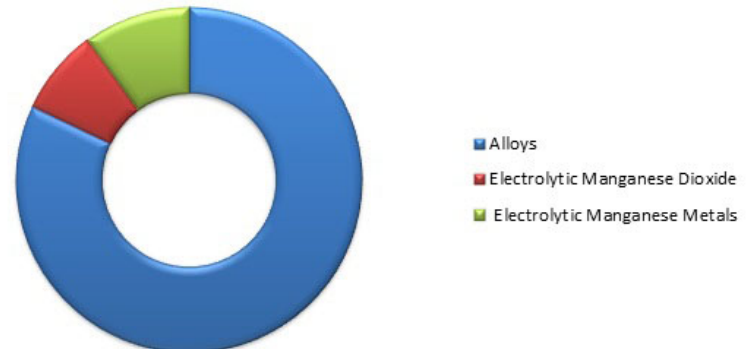
## WHICH METALS TO APPLY ROYALTY

- Ni, Cu, Mn and Co, ... ?
- There may be some by-product materials that can be extracted from the ore and sold for no profit or a small loss to ensure it reduces the waste from the processing plant. However, if the Contractor was charged a royalty for the sale of that by-product then there would be little incentive to find a market to sell into and rather it may be left as waste
- At this point in time it is difficult enough to produce the main pay metals at nameplate capacity before worrying about the recovery and sale of other by-products
- Benefits to humankind beyond the royalty:
  - These metals are critical to economic and social development
  - Recyclable and will be available for future generations to use and benefit from

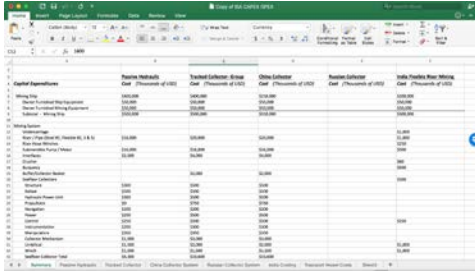
# MANGANESE

- 4<sup>th</sup> most used metal in the world
- EMM is only a small fraction of the manganese market
- An essential alloy that helps convert iron into steel. Cannot make steel without manganese (and without steel the world stops).
- USGS has deemed manganese a “critical mineral” because:
  - Essential to the economy
  - most of the world’s manganese is produced by just a few countries
  - significant risk of incurring supply interruptions

**Global Manganese Mining Market Share (%) -  
By Application - 2016**



## TIMING IS IMPORTANT



The image shows a screenshot of an Excel spreadsheet with multiple columns and rows of data. The columns are labeled with various financial metrics and categories. The data is organized into several sections, with some rows highlighted in blue. The spreadsheet appears to be a detailed financial statement or budget.

- 40 years since first trial harvesting in CCZ
- UNCLOS Article 151 contained uncommercial terms – removed in 1994 Agreement
- **Chennai Workshop 2008** - Meeting of Contractors to discuss status of mining and processing technology
- Suggest we are not looking to come up with the final payment regime, merely the payment regime that is applicable to the First Movers. Irrespective of which processing route is selected, the First Movers will be taking on the greatest technological risk and highest cost of capital.
- Consider erring on the side of caution and develop a royalty rate for First Movers that incentivizes the industry to make such large investments in the first place, after which benefits will flow to humankind for generations.