Nickel, Cobalt & Manganese

History and Factors Affecting Future Demand
Difficulties of Projecting Demand

- Metal Demand is subject to unpredictable factors, both transient and transformational
- Four examples from the mid-1970s demonstrate the difficulty: USGS Medium and Low Projections, Wassily Leontief, and Wilfred Malenbaum
Forecasting Demand is a Risky Effort

<table>
<thead>
<tr>
<th>Year</th>
<th>Nickel</th>
<th>Copper</th>
<th>Cobalt</th>
<th>Manganese</th>
</tr>
</thead>
<tbody>
<tr>
<td>USGS-Med.</td>
<td>1705</td>
<td>19,500</td>
<td>79.7</td>
<td>22,100</td>
</tr>
<tr>
<td>USGS-Low</td>
<td>1290</td>
<td>14,700</td>
<td>57.8</td>
<td>20,000</td>
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<tr>
<td>Leontief</td>
<td>2833</td>
<td>31,300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malenbaum</td>
<td>1446</td>
<td>18,523</td>
<td>63.3</td>
<td>18,503</td>
</tr>
<tr>
<td>Actual</td>
<td>1290</td>
<td>13,300</td>
<td>37.9</td>
<td>6,960</td>
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</tbody>
</table>
Rating the Projections

Copper - 2000

Nickel - 2000

Cobalt - 2000

Manganese - 2000
Nickel, Cobalt and Manganese Prices (2005 Dollars)
Demand Projections based on Recent Trends

![Graph showing demand projections for Copper, Cobalt, Manganese, and Nickel from 2000 to 2010. The graph includes lines for each metal with corresponding growth rates: Copper growth 4.0%, Nickel growth 4.25%, Cobalt growth 6.0%, and Mang. Growth 1.0%. The y-axis represents Thousand Tonnes Copper and Manganese, and the x-axis represents Year from 2000 to 2010.]
Nickel

- Component in most Stainless Steels
- Element in some Steel Alloys
- Plating
- Batteries (Ni-MH) are a small but growing use of Nickel
- 2005 Mine production: 1.5 Million Tonnes
- Reserves: 62 Million Tonnes
Western World Nickel Use in 2000

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.
2005 Nickel Production
(Thousands of Tonnes)
Nickel and Stainless Steel
Demand Growth

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.
Nickel Demand in China

![Graph showing nickel demand in China from 1990 to 2000. The graph indicates a significant increase in demand over the years, with a notable rise in primary nickel demand and nickel in imported stainless steel.]
Nickel Reserves

Australia
Russia
Cuba
Canada
Brazil
New Caledonia
South Africa
Indonesia
China
Philippines
Colombia
Dominican Republic
Venezuela
Botswana
Greece
Zimbabwe
Other countries
Cobalt

• Essential Metal for Advanced Economies: Superalloys, Carbides, Batteries, Tool Bits and Surface Treatments
• Nickel Can Substitute for Cobalt in Some Applications, but not all
• Generally Cobalt is a by-product of Nickel or Copper Production
• 2005 Mine Production: 52,400 Tonnes
• Reserves: 7,000,000 Tonnes
Uses of Cobalt

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.
2005 Cobalt Production (Tonnes)

- Congo: 15,000 tonnes
- Zambia: 9,000 tonnes
- Australia: 7,000 tonnes
- Canada: 6,000 tonnes
- Russia: 5,000 tonnes
- Cuba: 4,000 tonnes
- Morocco: 1,000 tonnes
- New Caledonia: 1,000 tonnes
- Brazil: 1,000 tonnes
- Other countries: 2,000 tonnes
Cobalt Reserves
(Thousands of Tonnes)
Manganese

- Primary use is in steel production
- Specialty steel and aluminum alloys
- 200 Series Stainless Steel
- Batteries: Conventional Alkaline and Advanced Lithium-Ion
- 2005 Production: 9,790 Thousand Tonnes
- 2005 Reserves: 430,000 Thousand Tonnes
2005 Manganese Production
(Thousands of Tonnes)
Manganese Reserves
(Thousands of Tonnes)
Potential Demand Change: Automobile Design

- Rising Fuel Costs are promoting innovations in automobile design
- Major Competing Technologies are Advanced Diesel Engines and Hybrid and Electric Vehicles.
- Current and projected designs of hybrid and electric vehicles use batteries based on metals from nodules and crusts
- Changes in SLI systems (12 volt vs 36 volt)
US Sales of Hybrid Cars by Month
Nickel and Cobalt in Batteries for Hybrid Vehicles

<table>
<thead>
<tr>
<th>Metal/ Battery Type</th>
<th>Battery Weight, 3 kwh battery (Kg)</th>
<th>Metal Content 3 kwh battery (Kg)</th>
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</thead>
<tbody>
<tr>
<td>Nickel/ NiMH</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Cobalt/ Lithium Ion</td>
<td>22.65</td>
<td>4.08</td>
</tr>
<tr>
<td>Lead/Lead Acid</td>
<td>85.71</td>
<td>60</td>
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Implications of Battery Choice

- Annual World Production exceeds 55 Million Automobiles/year
- 10% Penetration by Hybrid Vehicles could require 66,000 tonnes of Nickel or 16,500 tonnes of Cobalt (4.5% or 31% of current world production respectively)
- Alternative Lithium-Ion batteries could use Nickel, a Nickel/Cobalt combination or Manganese
Battery Design Continues to Evolve: Manganese Li-Ion
Some Factors Affecting Nickel, Cobalt and Manganese Supply

• Supply
  – Russian Export vs Domestic Consumption of Nickel
  – Development and Expansion of Major Nickel Deposits (Vosey’s Bay, Goro)
  – Improved application Pressure Acid Leach processing for Laterites
Factors Affecting Nickel, Cobalt and Manganese Demand

- Economic Growth in China and other Developing Countries
- Use of 200 Series Stainless Steel in place of Nickel-based Stainless
- Adoption of Hybrid and Electric Automobiles with High-Capacity Batteries
Implications for Seabed Production

• Land based reserves of Cobalt, Nickel and Manganese can need demand, so metals from the seabed must compete for market
• Economic growth in China and Russia, followed by India and Brazil, will increase need for new sources of nickel and cobalt
• By-product relationships are advantage for seabed minerals
• Long term contracts for production of specialty products (electrolytic manganese, nickel and cobalt for batteries) could reduce risk and improve economic outlook