Respuesta de AMIRA International
Desde el Cobre a la Innovación:
*Roadmap Tecnológico 2015-2035*

29 September 2016
Presentation in 4 Parts…

PART A
Overview of AMIRA International

PART B
Response: Pillar 1: Data, information & technology

PART C
Response: Pillar 2: Corporate development, innovation & implementation

Joe Cucuzza
Joe Cucuzza
Robert Flynn
PART A  An overview of AMIRA International
AMIRA International: in brief

- AMIRA International is a private sector, not-for-profit, member-based organisation
- We are a facilitator, developer and manager of collaborative projects designed to address industry challenges and needs: both technical and non-technical
Our members include explorers, producers and equipment, technology and service suppliers from around the world.

We are independent, not tied to any research institution nor any government agency. This means we can engage with solution providers throughout the world and ensure that local partners are part of the team.
AMIRA International: in brief

- We have **global reach** with a physical presence in the USA, Chile and South Africa, and a head office in Australia

- We have a 57 year **history of success**, with support from Chilean industry since 1990
Delivering solutions through collaboration

We develop, coordinate and deliver a broad range of collaboration-based solutions for data, information & technological centred challenges on one hand and enterprise development, innovation and implementation on the other.

Supporting the global mining industry via our two service-delivery pillars.
AMIRA International’s collaborative models

Co-opetition Model
(Collaboration with peers who could be direct competitors)

Non-competitor Collaborative Model
(Collaboration with peers who are not direct competitors)

One-on-one Collaborative Model (includes managing existing proprietary projects for our members)
AMIRA International’s modus operandi: 57 years of experience

Gate 1: Should AMIRA work on the idea?
Gate 2: Should Idea → Expression of Interest (EOI)?
Gate 3: Should EOI → Proposal?
Gate 4: Should Proposal → Circulation?
Gate 5: Commencement?

Project Pipeline

Project ideas / Concepts from industry & researchers

Delivering solutions through collaboration
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AMIRA International’s modus operandi: 57 years of experience

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Gate 1 → Admittance of the Idea
Key requirements for progression:
• It does not duplicate current activity
• Appropriate resources can be allocated
• Will the idea have the potential to ‘turn the dial’ in the short term in respect of productivity gains, decrease water & energy usage, reducing the mining footprint, enhancing social license to operate, efficient management of operations, reducing Capex &/or Opex, processing of complex ores, effectiveness of exploration, and faster cheaper smarter anything?

Gate 2 → Preparation of EOI
Key requirements for progression:
• Positive feedback (informal) from at least three trusted contacts in industry who have domain knowledge and are competent to comment on the idea

Gate 3 → Preparation of full proposal
Key requirements for progression:
• Demonstration that a sufficient number of companies have expressed interest in supporting the project and to be involved in preparing the proposal to allow the project to start at a minimum programme level

Gate 4 → Circulation for Marketing/selling
• Positive internal review via Project Checklist form
• MD sign off

Gate 5 → Start
Key requirements for progression:
• Has minimum funding been secured?
• Who will be accountable to oversee project?
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<th>Mining</th>
<th>Mineral processing / metallurgy</th>
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<td>P1037 – Optimisation of Stope Design and Stope Layouts</td>
<td>P9P – Optimisation of Mineral Processing Circuits</td>
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AMIRA International's Technology focused projects span from TRL 1 to 7

Delivering solutions through collaboration
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AMIRA International’s projects span the minerals value chain

Roadmaps:
- Alumina, Copper, Drilling, Exploration
- Undercover, In-situ extraction, Heap-leach

Sustainability: HSC&E, Licence to Operate; Enterprise development, innovation & implementation
Project: **P9P - The Optimisation of Mineral Processes by Modeling & Simulation**

Project aim: The enhancement of performance of mineral processing operations through the use of predictive unit process models & circuit simulation.
The AMIRA Collaborative model in action: Example of Pillar 1

Example of a “co-opetition” collaborative project

Sponsor A
Sponsor B
Sponsor C
.....etc

Researcher A
Researcher B
Researcher C
.....etc

Project:  

P9P - The Optimisation of Mineral Processes by Modeling & Simulation

Project aim:
The enhancement of performance of mineral processing operations through the use of predictive unit process models & circuit simulation.

Sponsors:
Alcoa, Anglo American, AngloGold Ashanti, Barrick Gold, BHP Billiton, Glencore, Teck Resources, LKAB, Lonmin, Newmont, MMG, Newcrest, Rio Tinto, and Vale
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FLSmidth Minerals, Magotteaux, Metso, Outotec, Polysius, Russell Mineral Equipment, Senmin, Tenova Bateman, and COREM
The Research Partners of the P9P project

- Chalmers University of Technology (Sweden)
- Hacettepe University (Turkey)
- Universidade Federal do Rio de Janeiro (Brazil)
- University of Cape Town (South Africa)
- University of Queensland (Australia)
AMIRA International: in summary

Independent
Non-aligned
No vested interest
Globally connected
PART B Pillar 1 – data, information and technology centered activities
SUPPORTING THE GLOBAL MINING INDUSTRY VIA OUR TWO SERVICE-DELIVERY PILLARS

PILLAR 1
DATA, INFORMATION & TECHNOLOGY CENTRED COLLABORATIVE SOLUTIONS

PILLAR 2
ENTERPRISE DEVELOPMENT, INNOVATION & IMPLEMENTATION

Delivering solutions through collaboration
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WE OFFER SOLUTIONS FOR SOME OF THE KEY TECHNOLOGY CHALLENGES IDENTIFIED IN THE ROADMAP

HELPING TO ENHANCE THE PRODUCTIVITY OF THE CHILEAN MINING INDUSTRY
2015 - 2035
Desde el cobre a la innovación - Roadmap Tecnológico 2015-2035

2035
- Producción de 8,5 millones de toneladas
- 80% de la producción en primeros cuartiles de costos de la industria a nivel global
- 250 empresas proveedoras de clase mundial
- US$4.000 millones en exportaciones de bienes y servicios

NÚCLEOS TRACCIONANTES
- Relaves
- Fundición y refinería
- Operaciones y planificación minera
- Concentración de minerales
- Hidrometalurgia

NÚCLEOS HABILITADORES
- Capital humano
- Proveedores e innovación
- Minería inteligente
Our Proposal for Tackling the Technical Strategic Priorities

1. Development of Large Scale Deep Mining
2. Improving the Competitiveness of Smelting and Refining
3. Mine Tailings: Dealing with Increased Scarcity of Space & Minimization of their Impact
4. Improving Productivity Of Open-Pit Mines: Moving Large Volumes for Long Distances
5. Strengthening Exploration Activity in Chile
6. Enabling the Development of Intelligent Mining
7. Development of Human Capital in line with Industry's Current and Future Needs
Tackling the Technical Strategic Priorities

RATIONALE

To successfully **achieve the vision** outlined in the *Desde el cobre a la innovación - Roadmap Tecnológico 2015-2035* will require a **coordinated effort** between industry, SMET sector, researchers and government.

Some of the major challenges will no doubt be addressed through proprietary behavior of miners and SMET suppliers but many will require **collaboration**.
Tackling the Technical Strategic Priorities

RATIONALE

To successfully **achieve the vision** outlined in the *Desde el cobre a la innovación - Roadmap Tecnológico 2015-2035* will require a **coordinated effort** between industry, SMET sector, researchers and government.

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PROGRAM DELIVERY

Via existing research consortiums and by building new consortiums of world class solution providers partnering with Chilean METS suppliers, miners and government agencies.

**AMIRA International, as a totally independent organisation, will coordinate the design, development, and management of projects delivering on the key needs.**
Development of Large Scale Deep Mining

**PURPOSE**

Through collaboration address components: a) remote operation of equipment for preparatory and operational phases of u/g mining; b) development of autonomous equipment for preparatory and operational phases of u/g mining; and c) to undertake R&D in geosciences to better understand the rock formation.

**CURRENT & POSSIBLE ACTIVITIES**

| Requirement for interoperability, frameworks and standards to allow machine to machine and human to machine interaction. | Requirement for interoperability, frameworks and standards to allow machine to machine and human to machine interaction. | Requirement for interoperability, frameworks and standards to allow machine to machine and human to machine interaction. |
|---|
| P1025 & P1025A - Interoperability | P1187 – Multi-spectral GPR | In-situ fracturing of ore |
| Rock characterization |

**PROGRAM RATIONALE**

- The system that will be developed is predicted to provide data that will characterise geological materials undercover with an increased detection range, & better resolution.
- Revisiting the possibility of cost-effective electrofracturing of ROM material.
- Better understand the rock formation. Undertake a SOTA of the characterization of ore and rocks via in-situ and laboratory measurements.
Development of Improving competitiveness of smelting and refining

PURPOSE
Through collaboration address components: a) adaptation of emerging technologies for continuous conversion of white metals to the conditions of national smelters; and b) development of instrumentation and expert systems for operational control of bath smelting furnaces

CURRENT & POSSIBLE ACTIVITIES
- Chemical conversion of Cu concentrates
- P705C – Eletrowinning
- Rock characterization

PROGRAM RATIONALE
- Exploring new technologies to convert copper concentrate into copper cathodes by hydrometallurgical processes
- Developing low temperature technology for Cu electrowinning to reduce acid mist, extend anode lifetime, minimize organic degradation and improve energy consumption
- Better understand the rock formation. Undertake a SOTA of the characterization of ore and rocks via in-situ and laboratory measurements
Dealing with Mine Tailings

**PURPOSE**

Through collaboration address components: a) Intelligent dam: Monitoring of mine tailings; b) Treatment of tailings to recover valuable metals; and c) Develop instrumentation for online physical-chemical monitoring and measurement of leakage produced in dam operations

**CURRENT & POSSIBLE ACTIVITIES**

- **P1182 Roadmap for “Clean Mine” futures**
- **P1192 – Industrial uses of flotation tailings**
- **P1184 – SmartDam**

**PROGRAM RATIONALE**

- Build a vision, set of goals and a plan that will lead us to a future in which everything that is taken out of the ground is converted into a value-added product
- Separation of values and toxic components from fresh flotation Tailings for further uses or better disposal
- Develop instrumentation for online monitoring and measurement of leakage produced in dam operation that will address the stability question
Improving Productivity of Open-Pit Mines: Moving Large Volumes for Long Distances

PURPOSE

Through collaboration address components: a) Implement the use of autonomous trucks that operate continuously; and b) management of blasting to facilitate continuous transportation.

CURRENT & POSSIBLE ACTIVITIES

- Mining value not waste
- P1167 – In-situ metal recovery Roadmap
- P9Q – Optimization of Mineral Processing by Modeling & simulation

PROGRAM RATIONALE

- Build a vision, a set of goals and a plan that will lead industry into a future in which everything that is taken out of the ground is utilized or converted into a value-added product.
- In-situ metal recovery has the potential to be a key enabling technology in the minerals industry. A roadmapping initiative is being proposed to identify the key obstacles and articulate the necessary steps towards achieving viable in-situ mining for a range of commodity metals.
- The enhancement of performance of mineral processing operations through the use of predictive unit process models & circuit simulation.
Strengthening Exploration Activity in Chile

PURPOSE

Through collaboration address component: Improving public pre-competitive geological information.

CURRENT & POSSIBLE ACTIVITIES

- Isopach map of post mineralisation cover

PROGRAM RATIONALE

The easy deposits have largely been found. The future is undercover. New and improved geophysical technologies will comfortably see to >250 metres however, there is a need to know where post-mineralisation cover is within the range of this technology to improve exploration targeting
BUT ITS NOT JUST ABOUT THE TECHNOLOGY

UPTAKE/IMPLEMENTATION OF TECHNOLOGY IS A "Core Enabler"
UPTAKE/IMPLEMENTATION OF TECHNOLOGY IS A “Core Enabler”

Technology + implementation = value created
PART C  Pillar 2 – enterprise development, innovation and implementation
SUPPORTING THE GLOBAL MINING INDUSTRY VIA OUR TWO SERVICE-DELIVERY PILLARS

PILLAR 1
DATA, INFORMATION & TECHNOLOGY-CENTRED COLLABORATIVE SOLUTIONS

PILLAR 2
ENTERPRISE DEVELOPMENT, INNOVATION & IMPLEMENTATION
WE OFFER PROSPECTIVE SOLUTIONS RELATING TO TWO OF THE THREE ‘CORE ENABLERS’ IDENTIFIED IN THE ROADMAP

CONTRIBUTING TO THE STRATEGIC DEVELOPMENT OF THE CHILEAN MINING INDUSTRY ECO-SYSTEM 2015 - 2035
Via a carefully composed consortium of world-class mining industry specialists and adult educators, AMIRA International will coordinate the design, development, and implementation of a leadership program entitled:

**LEADERSHIP EDGE 21**

**PURPOSE**

To build highly specific management-leadership capability and skills across the Chilean minerals eco-system, with particular reference to the SME sector.
Our Response to the HUMAN CAPITAL ‘Core Enabler’

Via a carefully composed consortium of world-class mining industry specialists and adult educators, AMIRA International will coordinate the design, development, and implementation of a leadership program entitled:

**LEADERSHIP EDGE 21**

**CURRICULUM TOPICS (Potential)**

- Strategic Planning
- Life of Mine Planning
- Big Data Analytics
- Organisation Design
- Community Engagement
- Risk Mitigation
- Collaboration & Innovation
- Mine Management
- HRO-Safety
- Sustainability
- Intelligent Mining
- Funding & Capital Markets
Via a carefully composed consortium of world-class mining industry specialists and adult educators, AMIRA International will coordinate the design, development, and implementation of a leadership program entitled:

**LEADERSHIP EDGE 21**

No matter what level of technological sophistication is available, and no matter what kind of economic conditions are prevailing, the ultimate driver of high-level enterprise performance resides in the **QUALITY OF JUDGEMENT & DECISION-MAKING** being exercised by those in leadership roles.
Our Response to the HUMAN CAPITAL ‘Core Enabler’

Via a carefully composed consortium of world-class mining industry specialists and adult educators, AMIRA International will coordinate the design, development, and implementation of a leadership program entitled:

LEADERSHIP EDGE 21 (LE21)

Via Fundación Chile-accredited TLE consultant-educators based in Chile, assisted by specialist contributions from leading international sources.

The pedagogic model will be *Blended Learning.*
Our Response to the METS Sector ‘Core Enabler’

Via a consortium led by AMIRA International, and with contributions by Minovex and METS Ignited, we will design and develop a CUSTOMISED BLUEPRINT for the strategic advancement of the Chilean METS Sector during the period 2015 – 2035.

PURPOSE

To ensure the Chilean METS Sector reaches and maintains a standard of world-competitive performance, such that:

1. It best serves the needs of the Chilean minerals eco-system in the 21st century ‘VUCA’ environment.

2. Its capacity to generate export earnings is substantially enhanced, with at least 250 companies involved in export trade.
Our Response to the METS Sector ‘Core Enabler’

CUSTOMISED BLUEPRINT
for the strategic advancement of the Chilean METS Sector during the period 2015 – 2035.

**KEY TOPICS FOR INVESTIGATION**

- Fostering collaboration to accelerate participation of the Chilean METS sector in global supply chains.

- Establishing platforms for collaboration, both within the METS sector and between METS companies and the wider eco-system, to jointly solve problems and implement solutions.

- Developing the capacity of senior leaders in METS companies to engage with capital markets in order to fund innovation and growth.

- Developing an *Open Innovation Platform* whereby the METS sector, and wider eco-system, will benefit from new ideas from all potential sources, including other industries.
Customised Blueprint
For the strategic advancement of the Chilean METS Sector during the period 2015 – 2035.

Rationale for the Blueprint
The possibility for transformative improvement of the Chilean METS sector will be greatly enhanced if the process is being systematically driven by a government-supported sector development scheme, such as that presented in this Customised Blueprint.

Activation of the Blueprint
This will be achieved via the efforts of a government agency dedicated to its successful implementation. These will be carried out through a series of carefully selected initiatives, delivered by a combination of government specialists and suitably accredited consultants, both Chilean and international.
In Conclusion……

- As an independent and non-aligned facilitator and manager of projects, AMIRA International is open to collaboration with government agencies and industry to address the big challenges facing the Chilean mining sector; whether technical or non-technical.

- We are a global organisation but we act local by addressing local issues:
  - By engaging local solution providers and, as appropriate, facilitate partnerships with overseas solution providers,
  - Industry/government funds largely stay local; and in the process help to enhance local research capacity and help to nurture a more vibrant culture of collaboration.

- We are well connected with broad networks in industry and academia and have many years of experience on how to build collaborative partnerships between industry, solution providers and government.
Gracias

Con la Colaboración
Grandes Cosas Resultan

Collaboration
Great Things Result

Delivering solutions through collaboration