This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement number: 642477

Project acronym: ¡VAMOS!
Project title: ¡Viable Alternative Mine Operating System!
Funding Scheme: Collaborative project

D1.4: Sustainable Mining Forum and Advisory Board reports – vs.2 (final)

Due date of deliverable: 31/01/2019
Actual submission date: 22/02/2019
Start date of project: 01/02/2015 Duration: 48 Months
Organisation name of lead contractor for this deliverable: DAM
Participating: SMD, MUL, MIN, MML, EDM, GeoZS, CF, EFG, FZG, FORRV

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### Work Package Deliverable sheet

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<td>DAM</td>
<td>Manager RD&amp;I Development</td>
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<td>Luis Lopes</td>
<td>CF</td>
<td>Project Manager/WP1 Leader</td>
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<td>EFG</td>
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<td>Jeroen van der Linden</td>
<td>Approved(int.&amp;ext.peer reviewed) 21-2-2019</td>
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<td>Technical Manager</td>
<td>Stef Kapusniak</td>
<td>Approved 19-2-2019</td>
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<td>Authorised by Project Coordinator</td>
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| Number of pages: | 54 (incl annexes) |
| Number of annexes: | 5 |
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<th>Description</th>
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<tr>
<td>AB</td>
<td>Advisory Board                                                                A group of external experts providing advice to the project</td>
</tr>
<tr>
<td>GA</td>
<td>Grant Agreement                                                               Generally referring to Grant Agreement 642477 of the ¡VAMOS! project</td>
</tr>
<tr>
<td>MoM</td>
<td>Minutes of Meeting                                                            Report or notes from a meeting</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-governmental organization                                                 An organization that is neither a part of a government nor a conventional for-profit business</td>
</tr>
<tr>
<td>PMT</td>
<td>Project Management Team                                                       Technical, quality and coordination managers of the ¡VAMOS! project</td>
</tr>
<tr>
<td>RTD</td>
<td>Research and Technical (or Technological) Development</td>
</tr>
<tr>
<td>SMF</td>
<td>Sustainable Mining Forum                                                      Online discussion forum for ¡VAMOS!</td>
</tr>
<tr>
<td>USP</td>
<td>Unique Selling Point                                                          Parameter or specification indicating a unique and distinctive feature of a service or product</td>
</tr>
<tr>
<td>WP</td>
<td>Work Package                                                                  Sub-stage and/or sub-plan of Project</td>
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1 Executive Summary

This document presents the activities and findings of the Sustainable Mining Forum and Advisory Board as per Grant Agreement sub-task ST 1.4.1. It outlines and justifies the role, membership, and work schedule of the ¡VAMOS! Advisory Board (AB). The AB forms part of the organizational structure and decision-making processes of ¡VAMOS! as defined in WP7 – Project management. The primary role of the AB is to provide advice on previous progress, current status, and potential future directions of ¡VAMOS! over the 4-year project lifespan. A secondary role is to raise awareness of the ¡VAMOS! activities in other forums, where and when appropriate. The AB consists of stakeholders from outside the ¡VAMOS! project consortium, but covering the most relevant areas: mining, environment and policy. Members come from primary stakeholder groups identified during the initial proposal development and the work from WP1 (Innovation Targets and Stakeholder Engagement) and WP7 (Project Management).

The Advisory Board functioned according to the expectations defined at the beginning of activities. The Project Management Team (PMT) feels that the project has benefited from the external expertise provided by the AB, and have assured that the recommendations were followed up at the appropriate levels of the project organisation. Their recommendations will remain visible for project partners and EU, even after the project lifetime has passed.

The Sustainable Mining Forum (SMF) was established through the online LinkedIn platform, which is still utilised to provide a virtual meeting place of experts, industry and academic stakeholders. It was mainly used as an extension of other means of dissemination. As such, the project benefited from the attention it was given there.
2 Introduction

2.1 The ¡VAMOS! Project

Estimates indicate that the value of unexploited European mineral resources at a depth of 500-1,000 meters is ca €100 billion; however, a number of physical, economic, social, environmental and human constraints have as yet limited their exploitation. ¡VAMOS! will provide a new Safe, Clean and Low Visibility Mining Technique and will prove its Economic Viability for extracting currently unreachable mineral deposits, thus encouraging investment and helping to put the EU back on a level playing field in terms of access to strategically important minerals. Deriving from successful deep-sea mining techniques, the ¡VAMOS! mining solution aspires to lead to: Re-opening abandoned mines; Extensions of open cut mines which are limited by stripping ratio, hydrological or geotechnical problems; and opening of new mines in the EU. ¡VAMOS! will design and manufacture innovative automated excavation equipment and environmental impact monitoring tools that will be used to perform field tests in four mine sites across Europe with a range of rock hardness and pit morphology. ¡VAMOS! will:

1. Develop a prototype underwater, remotely controlled, mining machine with associated launch and recovery equipment
2. Enhance currently available underwater sensing, spatial awareness, navigational and positioning technology
3. Provide an integrated solution for efficient Real-time Monitoring of Environmental Impact
4. Conduct field trials with the prototype equipment in abandoned and inactive mine sites with a range of rock types and at a range of submerged depths
5. Evaluate the productivity and cost of operation to enable mine-ability and economic reassessment of the EU's mineral resources.
6. Maximize impact and enable the Market Up-Take of the proposed solutions by defining and overcoming the practicalities of the concept, proving the operational feasibility and the economic viability.
7. Contribute to the social acceptance of the new extraction technique via public demonstrations in EU regions.
2.2 Deliverable D1.4

2.2.1 Introduction

The use of external experts as advisors to EU funded projects is a common practice since their contribution can be crucial for the smooth implementation of the project. Within the context of a Horizon 2020 project, the Advisory Board (AB) has the role of an external counselling body comprising high-level international experts from different areas of knowledge that meet regularly with the project consortium throughout the project and participate in project meetings and events.

At the outset of the project it was decided to give ¡VAMOS! an even broader base of external opinion and expertise through an Open Forum. By establishing an online environment both Advisory Board members, stakeholders from Industry, NGO’s, Governmental institutions etc, could interact with each other and the project members. The Sustainable Mining Forum has been designed to represent the wider Mining Sector in substantive terms.

In this document the organisation of both platforms will be addressed firstly (Chapter 3) Next, the results are reviewed (Chapter 4;) Finally, in Chapter 5 Conclusions are drawn.

2.2.2 Objectives

The overall objectives of the overarching Work Package (WP1) were set out as (ref. Grant Agreement): “... to set the background for this research, to ensure that research and development is user-driven throughout the project, that the innovation agenda is aligned to the mine sites’ conditions and market needs and to valorise the results and findings to the wider community of stakeholders to ensure maximum impact.”

The specific applicable objective reads as:

“(...) b. Specify inland mining market requirements consolidating requirements from the Sustainable Mining Forum, the Advisory Board, mine sites included in ¡VAMOS! and focused stakeholder roundtables and workshops.

(...)”

The description of D1.4 in the GA is broken down into the following sub-deliverables:

“D1.4 will provide consolidation reports on the views of the SMF and Advisory Board on project progress and potential impact on the mining community. It will also highlight recommendations regarding the activities to be undertaken during the meeting interval periods.”

The tasks (ref. GA ST 1.4.1) associated with expert stakeholder opinion and advise are described as follows:

“(...)The Sustainable Mining Forum (SMF) is important both in guiding the project RTD activities and ensuring that key outputs could be extensively evaluated. A subset of the Sustainable Mining Forum will be organised as an Advisory Board to both support the development of the SMF and to monitor progress in order to identify industry challenges that could be addressed by the project.”
2.2.3 Approach
The PMT is supported by the Sustainable Mining Forum, of which the Advisory Board is a subset, and the Technical Committee.

The AB comprises a well-balanced group of experts representing Institutions, research and business interests, drawn from across Europe and international policy making organisations and embracing the whole range of interests and knowledge of the mineral extraction issues in the broader context of the EU and international extraction sector.

The Sustainable Mining Forum (SMF) was originally formulated as an on-line community, sharing information and views on sustainable mining. Social media would be utilised to provide a virtual meeting place of experts, industry and academic stakeholders. It would be linked to industry associations and technology standardisation bodies. The Advisory Board would serve as the Forum’s meeting place. In practice, the latter was not seen as a useful objective, so the approach was switched to use the SMF as a tool to disseminate the news and results from the project, besides the project website. At the same time, it allowed the members to comment on the achievements reported by ¡VAMOS! or to share ideas.

Requirements validation from physical, economic, social, environmental and safety perspectives would be given by the Advisory Board from the beginning of the project. The synthesis of the Board, would ensure that this validation could be done in a meaningful way. Subsequently, also stakeholder surveys and workshops were to be used to broaden the coverage, which are described in deliverables D1.5 – Stakeholder engagement reports and D1.6 – Dissemination, Web Portal and publication material.

Both the SMF and the AB provided an end-user (mine operators) driven approach throughout the project (shown (Figure 1)), for the design and development of the main project outputs, with the aim of delivering a system solution appropriate to the level of performance they required.

Figure 1; ¡VAMOS! Methodological approach
With reference to the Dissemination Plan (Deliverable D1.6) it can be concluded that almost all stakeholder groups of ¡VAMOS! could participate or benefit from the additional expertise mobilised via the aforementioned instruments:

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<tr>
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<tbody>
<tr>
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<td>Mining and mining exploration companies</td>
</tr>
<tr>
<td>2</td>
<td>Investors and R&amp;D funding organizations</td>
</tr>
<tr>
<td>3</td>
<td>Regulators and policy makers</td>
</tr>
<tr>
<td>4</td>
<td>Research and academic staff</td>
</tr>
<tr>
<td>5</td>
<td>Environmental NGOs</td>
</tr>
<tr>
<td>6</td>
<td>Associations representing the mining community</td>
</tr>
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<td>7</td>
<td>EU commission</td>
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<tr>
<td>8</td>
<td>General Public</td>
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</tbody>
</table>

Table 1 Stakeholder Group definition

¡VAMOS! recruited AB members from groups 1-6. The Sustainable Mining Forum is open to all stakeholders, however it was not intended to explicitly target the General Public via this platform. A large number of project results, experiences and recommendations –including those formulated by the AB– are laid down in public deliverables, for all stakeholders to read.

2.2.4 Timetable

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<td>M33</td>
<td>Intermediate version (MoM of AB feedback session #4 in Lee Moor)</td>
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<td>M45</td>
<td>Intermediate version (MoM of AB meeting #5 in Silvermines)</td>
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<td>M48</td>
<td>Final meeting and Final report including evaluation (this version)</td>
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2.2.5 Deviations

The original time table was to report to the EU in M6, 12, 18, 24, 30, 36.

It was decided to submit the first version of this deliverable after the AB had its first meeting. The foreseen intermediate official releases were cancelled after a project amendment. The meeting reports of the AB can be seen as internal intermediate reference documents. The number of reports/meetings (6) was kept the same. It was more practical and cost efficient to plan these coinciding with other project meetings, which were held at appropriate locations and moments during the project. That’s why the actual release months deviate from the original table.
3 Advisory Board & Sustainable Mining Forum organisation

This Chapter describes the position of the AB and SMF in the managerial structure of the ¡VAMOS! Consortium, the specific role and tasks of the AB, the process of AB member selection, and its final composition.

3.1 Management Structure

This section describes the Project Management structure and decision making process in brief.

An overview of the project management is shown in the figure below.

![Project Management Structure Diagram]

The PMT is supported by the Sustainable Mining Forum, of which the Advisory Board is a subset, and the Technical Committee.

Regarding the decision making process, the principle of subsidiarity is applied in ¡VAMOS! wherever possible. This means that, Work Packages and Tasks are given the necessary decision making power to solve their issues. In the case that is not possible, the Technical Committee has the authority to make all technical decisions in the project. Finally, contract-related decisions are taken by the Partners’ Forum. The PF delegates day-to-day operation to the Project Management Team.

3.2 Role and tasks of the Advisory Board

Within the context of a Horizon 2020 project, the Advisory Board has the role of an external counselling body.

The main tasks of the AB in a Horizon 2020 project, in general, are indicatively the following:

- to provide advice, guidance and recommendations for any project development ensuring high quality and excellence at all project stages and components
- to provide additional quality control and validation of the impact and outreach of the project to give technical and legal guidance to advise on links with relevant groups of interest outside the project consortium
- to propose and encourage the potential interactions of the project with other projects, initiatives and activities
- to provide advice on cooperation opportunities
- to serve as a link between the project and other national/regional activities in the EU
to increase the visibility of project activities and support the dissemination of project results

- to stimulate the discussion between the relevant key players in the EU to extend the market potential of the project.

In the case of ¡VAMOS! the specific activities include:
- Reading and writing reports
- Convene and discuss in meetings
- Initiate and comment on posts via the Sustainable Mining Forum

3.3 Advisory Board Selection and establishment

The membership was finalised in the first months of the project, and confirmed by the partners, ensuring a selection of key players in the field to facilitate the geographical coverage, as well as the thematic coverage, required to adequately address the project objectives.

For the selection of the Advisory Board candidates, the following criteria have been applied:
- Have a longstanding and specific experience in one or more of the following disciplines: Dry mining (underground or open-cut), marine mining or dredging, marine robotics, and in the marine environmental field
- Have an interest in ¡VAMOS!
- Have an helicopter view/bird's eye perspective on the programme
- Provide valuable input on academic level
- Ready to provide honest feedback
- Able to act as a sounding board function
- Is available to attend meetings and keep up-to-date with the project
- Is reliable

In the search and selection, we addressed the desire to have at least 5 experts with operational background as well as in design, research and policy issues. We intended to have a broad geographical spread, not necessarily restricted to Europe. We aimed to have both male and female candidates. Obviously the candidates should come from an organisation not associated to ¡VAMOS!

After a call for candidates amongst the partners, a shortlist of 12 candidates was set up by the PMT. Candidates were approached by phone or through an invitation letter (see Annex A; Invitation letter). A few candidates declined or did not respond. Eventually, 6 candidates were proposed to the ¡VAMOS! partners.

Each AB member has signed an accession (non-disclosure) agreement with the ¡VAMOS! Consortium through its legal representative BMT Group Ltd.

Membership was on a voluntary basis. The AB members were being compensated for their travel and subsistence to meetings only.
### 3.4 Advisory Board members

The ¡VAMOS Advisory Board comprises of the following 6 experts:

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<th>Name</th>
<th>Title, organisation</th>
<th>Biography</th>
<th>Stakeholder Group</th>
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<tr>
<td><strong>Dr. Mike Buxton</strong></td>
<td>Associate Professor / Section Head for Resource Engineering at Delft University, The Netherlands</td>
<td><a href="#">Biography</a></td>
<td>4</td>
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<tr>
<td><strong>Renee Grogan</strong></td>
<td>Independent Environmental consultant, Board Member World Ocean Council, Australia</td>
<td><a href="#">Biography</a></td>
<td>5</td>
</tr>
<tr>
<td><strong>Dipl. Ing. Christian Halbmayr</strong></td>
<td>Independent mining consultant, Austria</td>
<td><a href="#">Biography</a></td>
<td>1</td>
</tr>
<tr>
<td><strong>Dr. Bramley J. Murton</strong></td>
<td>Ass. Head Marine Geosciences Group, National Oceanography Centre, University of Southampton, UK</td>
<td><a href="#">Biography</a></td>
<td>4</td>
</tr>
<tr>
<td><strong>Glen Jones, BSc Mineral Technology, Mining and Mineral Engineering</strong></td>
<td>Technical Services Manager at Nautilus Minerals, Australia</td>
<td><a href="#">Biography</a></td>
<td>1</td>
</tr>
<tr>
<td><strong>Dr. Sander Steenbrink</strong></td>
<td>General Manager Corporate Research and Development at Boskalis, The Netherlands</td>
<td><a href="#">Biography</a></td>
<td>1</td>
</tr>
</tbody>
</table>

1 See Table 1 Stakeholder Group definition
At AB Meeting #5, which was alongside with the 2nd ¡VAMOS! Demonstration Day at Silvermines, a few members were not able to attend. To ensure meaningful discussions at the meeting, 2 other guests were invited to join:

<table>
<thead>
<tr>
<th>Name</th>
<th>Title, organisation</th>
<th>Biography</th>
<th>Stakeholder Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonnie Coxon, MSc</td>
<td>Principal Engineer - Technology &amp; Innovation at Newcrest Mining Ltd, Australia</td>
<td><a href="#">Biography</a></td>
<td>1</td>
</tr>
<tr>
<td>Dir. Ir. Rudy Helmons</td>
<td>Postdoctoral researcher at Faculty of Mechanical, Maritime and Material Engineering of Delft Technical University, The Netherlands</td>
<td><a href="#">Biography</a></td>
<td>4</td>
</tr>
</tbody>
</table>

### 3.5 Sustainable Mining Forum

The ¡VAMOS! project team is supported by the Sustainable Mining Forum, of which the Advisory Board is a subset. The Sustainable Mining Forum (SMF) is formulated as an on-line community, sharing information and views on sustainable mining. The online LinkedIn platform is utilised to provide a virtual meeting place of experts, industry and academic stakeholders. The SMF can also be used to disseminate news and results. The set-up and maintenance was is carried out under sub-task ST1.4.1 and separately reported on in deliverable D1.4.
3.6 Online support

A project website was created, of which the address is: [http://vamos-project.eu/](http://vamos-project.eu/). The website is used as a tool to attracting people to join the AB and SMF. A dedicated menu item and page was created as shown in Figure 4.

The communication went vice-versa, as the interaction with the AB was regularly used in online news, press releases and Twitter messages to promote the project.

![Figure 3: Screendump of Linkedin group front page "Sustainable Mining Forum"

![Figure 4: Screendump of ¡VAMOS! web page “Forum and Advisory Board”](image)
4 Results of the Advisory Board and Sustainable Mining Forum

This Chapter describes the interaction with and by the AB in meetings, written feedback and follow up. Also, it reports on the outcomes of the SMF.

4.1 Meetings

It was deemed practical and cost efficient to plan meetings coinciding with other project meetings, which were held at appropriate locations and moments during the project. At these meetings the AB discussed with the PMT, Technical Manager, WP leaders and other project members where useful:

- First AB meeting, Newcastle, UK, January 12th 2016
- Second AB Meeting, Nijkerk, Netherlands, October 5th 2016
- Third AB Meeting, Porto, Portugal, March 30th 2017
- Fourth AB Meeting incl trial site visit, Lee Moor, UK, October 26th 2017
- Fifth AB Meeting incl trial site visit, Silvermines, Ireland, October 25th 2018
- Sixth AB Meeting –by teleconference- January 25th 2019

A photographic report of the AB in action at visits and meetings can be found in Annex E: Impressions of Advisory Board interaction.

A movie was made to give an impression of the site visit of the AB at the Silvermines field trials on the 24th of October 2019, which can be seen on YouTube here.

4.2 Reporting and feedback

From all meetings, except meeting #4, reports have been made by the task leader. The minutes can be retrieved with the Project Management Team. These reports were sent to all attendees for approval. AB meeting #4 was a feedback session rather than a full meeting. Time did not allow for proper discussion, since the day coincided with the Demo Day held at the field trials in Lee Moor. The comments given by the AB on that occasion were however fed back to the Workpackage leaders and participants, as usual.

One remark which motivated the team is worth mentioning though:

“All in all it looks impressive! Now focus on critical data and integrate”

An action list was maintained, and updated at each AB meeting. The WP leaders were requested to follow up the actions concerning their Work Package, and to update the PMT about their progress.

In addition, after the first and the last meeting, the AB was asked to give their formal responses through Feedback Forms. For both feedback sources goes that not all of the AB responded, however the forms give a sound general idea of the ideas of our experts. They are summarised in the next paragraph. Any feedback from the forms, which required follow up was also communicated by the Task Manager to the PMT.
4.3 Summarised comments of the AB

Three inputs are used in the following table, summarising the recommendations from the AB, and how these were responded to, as per submission date of this deliverable.

- After the initial AB meeting the AB members were asked to give their recommendations. Together with the questions raised at the meeting itself, these were taken into consideration by the team, and fed back to the AB in AB meeting #2. The feedback forms can be found in Annex B; Initial Advisory Board feedback.
- After the last AB meeting the AB members were asked to give their final comments and recommendations. The feedback forms can be found in Annex C; Final Advisory Board feedback.
Throughout the project an action list was kept of all meetings, the action list can be found in Annex C; Final Advisory Board feedback
1. Feedback and recommendations per Workpackage

<Bullets are meant supportive, you may summarize your answer if you like>

**WP1 (Innovation Targets and Stakeholder Engagement)**
- Zero state analysis
  - Policy and regulation
  - Innovation agenda
  - Environmental and geo-hazards
- Stakeholder management
- Dissemination and (scientific) publication

**WP3 (Design and Build prototype equipment)**
- Mining Vehicle Prototype
  - Underwater on-the-fly tool change
  - New cutting technology in real submerged inland mining conditions
  - Remote operation
- LARV
  - Launch and recovery systems
  - Maneuving
  - Power&Control
- Slurry Circuit
  - Slurry pump and system
  - Riser and floating hose systems
  - Density measurement
  - Real time grade control (LUBS)
- Positioning, Navigation and Awareness systems
  - Hybrid AUV/ROV
  - Multi-sensor navigation system
  - Perception system
  - Awareness system
  - Underwater Real Time 3D imaging of the MV
  - Augmented reality representation of the mining environment

The VAMOS prototype mining vehicle, its LARV (deployment system and vessel) were purpose designed and built for the project. The field trials demonstrated both its capability and limitations.

The main problem with the mining vehicle is its ability to cope with heterogeneous rock material. The host rock in which ore material is embedded is heterogeneous in terms of hardness, macro-

Advisory Board Feedback Form, iVAMOS! project, GA number: 642477
structure (veins) and fractures. This results in extremely variable fragmentation of the outcrop leading to subsequent clogging of the transfer mechanism of the ore to the collector. Vehicle maneuverability is subject to the conditions of the substrate with muddy or clay deposits causing problems with the vehicle tracks.

The remote operation and visualization in real time of the cutting operation was very good and absolutely required in turbid conditions where optical visibility is poor. Likewise the underwater positioning. The AR display was also very good at guiding the operation as well as the launch and recovery operations.

The LARV proved to be a reliable and capable system with fixed point moorings allowing stable and yet high-precision maneuverability. Future consideration will require thought about vessel to shore ore transfer and whether the floating pipe system is adequate for ease of maintenance etc, blockage clearing, and how the shore-side configuration can be designed to enable further ore separation and tailings control.

Real-time grade control was not demonstrated in situ, as planned, but it was demonstrated adequate for off-line analysis. The use of double pulse laser illumination of the target ores was particularly useful for saturated samples. It is not clear whether the LIBS system has significant advantages for off-line analysis over other methods such as XRF, which produces analyses from a larger and hence more representative volume of sample. The potential value of LIBS lies in the in situ analysis of grade, but this has yet to be demonstrated in the active part of the mining cycle.

**WP5 (Integration, Field Testing and Evaluation)**
- Site selection and pre-survey
- Planning & site [preparation](#)
- Commissioning & Operation
- Testing procedures
- Environmental measurements
- Evaluation
- Safety

Site selection for the first trial was hindered by the nature of the rock. Being clay, this limited visibility, the substrate was non-optimal in terms of heterogeneity with boulders clogging the collector system, and was slippery for the collector vehicle traction system.

Site planning and execution of the trials was good, with plenty of outreach and local support.

Environmental monitoring during the testing was, as far as I am aware, not undertaken at the first test site.

Safety issues were well attended to.
**WP6 (Feasibility, Viability and Market Up-Take)**
- Economic feasibility
- Accessibility of minerals and industrial viability
- Environmental Impact
- Technology exploitation
- Policy
- Future research

The technical feasibility of the concept was well tested during the project. However, the economic feasibility is yet to be demonstrated.

There remains uncertainty about the effectiveness of the cutting and collecting processes. Environmental monitoring was not well trialed, and I would like to have seen more done with the in situ environmental data esp regarding sediment plume and noise generation being quantified.

The technology is cutting edge with the general approach being well thought through, and much of the implementation being effective.

The results of the project should be assessed in terms of policy, and an estimate of the potential resource now made accessible and available were underwater mining of existing open-cast deposits to be exploited in Europe. What effect would that have on the value chain and the impact of new supply of raw materials on European demand?

**WP7 (Project Management)**
- Schedule
- Risk management
- Quality System
- Progress reports

Overall the project was well managed. Problems with test sites were overcome in a timely way, the public were engaged proactively, and the various stages of the build and demonstration of the various technologies were delivered well.

The Risk register was kept up to date and mitigations employed where required, e.g. the re-siting of the second test site.

The overall quality of the project was high with many innovations being developed and tested. The aims of the project were extremely ambitious, especially the autonomous underwater monitoring and the VR or enhanced reality visualization of the system in operation.

Progress reports were mainly on schedule and the advisory board was kept updated on the project as it progressed, including being asked to comment and advise where changes were necessary e.g. changes in test site.
2. General

1. What is your current view on the iVAMOS! project, its relevance for industry and research, its significance for EU Raw Materials policy, its objectives vs results, and the approach that was chosen, etc? Please include strategical, technical and management aspects.

Overall, the VAMOS project was an ambitious and imaginary attempt to enhance recovery of mineral resources in areas that had already seen extraction. The concept is very promising, and has significant environmental advantages to opening new mines or operating existing ones in subseabed conditions.

I would recommend further work in this area, given the strategic need for security of supply of raw materials to European industry. The demonstration proved the concept, identified problems, and laid the groundwork for further development and improvement in the concept.

2. Your recommendations for the upcoming period, after project closure:

I would like to see the prototype system being applied to together in areas of interest beyond mining. There is opportunity in dam construction, servicing and development in hard rock areas, as well as maritime harbor development in rocky areas, which is especially relevant to small island developing states.

The concept could also be developed for underwater marine mining, especially in shallow areas where mineral deposits continue offshore but are too shallow for underground mining.

I would also like to see the concept being publicized more widely to attract other innovative applications including those outside of mining.

3. Your notes on the organisation and functioning of the AB:

The interaction between the project team and the Advisory Board was excellent. The AB was kept informed of developments outside of the annual AB meetings, were invited to tests and demonstrations and their opinion sought especially when the project did not go as planned. The AB constituted expertise from a broad range of areas, making it able to input positively and assess progress across the range of project work packages.

4. Other

As a member of the AB, I was very impressed with the professional way VAMOS was executed. This was always an ambitious project, and the fact that it was able to integrate so many new technologies together, build a substantial prototype system and test it in a number of challenging field environments is testament to the excellent organization and capability of the team.

Signature:

Advisory Board Feedback Form, iVAMOS! project, GA number: 642477
Advisory Board Feedback Form

Name AB member : [redacted]
Date : 30 January 2019
Meeting/date : AB meeting #6 (telcon), 25 January 2019
1. Feedback and recommendations per Workpackage

<Bullets are meant supportive, you may summarize your answer if you like>

**WP1 (Innovation Targets and Stakeholder Engagement)**
- Zero state analysis
  - Policy and regulation
  - Innovation agenda
  - Environmental and geo-hazards
- Stakeholder management
- Dissemination and (scientific) publication

**WP3 (Design and Build prototype equipment)**
- Mining Vehicle Prototype
  - Underwater on-the-fly tool change
  - New cutting technology in real submerged inland mining conditions
  - Remote operation
- LARV
  - Launch and recovery systems
  - Maneuvering
  - Power & Control
- Slurry Circuit
  - Slurry pump and system
  - Riser and floating hose systems
  - Density measurement
  - Real time grade control (LIBS)
- Positioning, Navigation and Awareness systems
  - Hybrid AUV/ROV
  - Multi-sensor navigation system
  - Perception system
  - Awareness system
  - Underwater Real Time 3D imaging of the MV
  - Augmented reality representation of the mining environment
Within the given budget and timeframe certainly a good outcome of the project. I guess to pull such a complex system together and get it to through a prototype test is certainly a great achievement. The concept which is built from a combination of known technologies from very different areas (excavation, haulage, hydraulic pumping, underwater positioning and navigation, control and awareness systems...) has merit. Unfortunately due to some constraints on MV (power/weight, material gathering system, size control...) machine could not be tested out to get confident data on longer term performance levels.

**WP5 (Integration, Field Testing and Evaluation)**
- Site selection and pre-survey
- Planning & site preparation
- Commissioning & Operation
- Testing procedures
- Environmental measurements
- Evaluation
- Safety

Second testing site was not really suitable for the weight class of machine in the prevailing geology - causing severe problems with vibrations. Excessive vibrations are a clear sign the machine is lacking stability (weight, power, more effective stabilizing system...) and if you put it permanently into overload condition you will get it into self-destruction mode adding operating and maintenance cost. I think most of the vibration/stability problems described in the test report would disappear with a right sized machine.

In hard rock mining you find usually a fair spread of rock strengths and you would need to focus your design parameters on the harder conditions you want to handle. The downside of this is: One size does not fit all conditions and this machine may not be very well suited to soft conditions.

The size of cut material or presence of silt can heavily influence your loading performance which is again influenced by the chosen cutterhead design, cutting speeds and pick type. So in order to perform in a variety of geotechnical conditions you either have to have a modular system where you can adopt different loading and cutting systems or alternatively, if the size of project allows you could use more than one machine which are then adjusted to a different set of conditions.

With the limited testing not a great deal of experience for future machine designs could be gained and entering into new projects ahead would still require a lot of designing and testing in order to get a highly productive and reliable system.

Is there going to be more EU funds available to take this to the next step and/or who would make this call on an adjusted system specification?

**WP6 (Feasibility, Viability and Market Up Take)**
- Economic feasibility
- Accessibility of minerals and industrial viability
- Environmental impact
- Technology exploitation
- Policy
- Future research

Advisory Board Feedback Form, IVAMOS! project, GA number: 642477
I would certainly revisit the Specific Energy relationship as described in D5.6 Financial Viability Section 3.2.1.1. Underwater adjustments Figure 2. If this would be reality then this would be a distinct advantage as we would see a significant reduction in specific energy. This means for a given cutting power installed substantially more volume per time unit could be cut. Since we are working in shallow waters one would not expect this to have such an impact. Is there any evidence for this phenomenon in deep sea mining or trenching operations? If this effect would come from “wet” versus “air” this would not go unnoticed in roadheader applications where machines work in water saturated rock.

**WP7 (Project Management)**
- Schedule
- Risk management
- Quality System
- Progress reports
2. General

1. What is your current view on the iVAMOSI project, its relevance for industry and research, its significance for EU Raw Materials policy, its objectives vs results, and the approach that was chosen, etc? Please include strategical, technical and management aspects.

I think that you need to go through a more extensive learning curve since you have to expect more teething and adjustment problems before you can confidently push the system into a commercial application. The area of collecting material and reducing the oversize to achieve trouble free hydraulic pumping of material can become quite a challenge. A crushing unit could certainly be beneficial but space requirements could force you to put a throat into the machine and pick up material further back. It seems there will be different solutions to different geotechnical situations which could be thought of before taking this a step further. System uptime and productivity is what will count when you enter into production mode.

2. Your recommendations for the upcoming period, after project closure:

3. Your notes on the organisation and functioning of the AB:

4. Other
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under
Grant Agreement number: 642477

Project acronym: ¡VAMOS!
Project title: ¡Viable Alternative Mine Operating System!
Funding Scheme: Collaborative project

Advisory Board Feedback Form

Name AB member: [REDACTED]
Date: 29 January 2019
Meeting/date: AB meeting #6 (telcon), 25 January 2019
1. Feedback and recommendations per Workpackage

<Bullets are meant supportive, you may summarize your answer if you like>

"WP1 (Innovation Targets and Stakeholder Engagement)"
- Zero state analysis
  - Policy and regulation
  - Innovation agenda
  - Environmental and geo-hazards
- Stakeholder management
- Dissemination and (scientific) publication

Comments were made in the AB meeting that the stakeholder engagement particularly was very well handled by the project team.

"WP3 (Design and Build prototype equipment)"
- Mining Vehicle Prototype
  - Underwater on-the-fly tool change
  - New cutting technology in real submerged inland mining conditions
  - Remote operation
- LARV
  - Launch and recovery systems
  - Manoeuvring
  - Power&Control
- Slurry Circuit
  - Slurry pump and system
  - Riser and floating hose systems
  - Density measurement
  - Real time grade control (LIBS)
- Positioning, Navigation and Awareness systems
  - Hybrid AUV/RDV
  - Multi-sensor navigation system
  - Perception system
  - Awareness system
  - Underwater Real Time 3D imaging of the MV
  - Augmented reality representation of the mining environment

Comment made that I was particularly impressed with the PNAS progress – in terms of the delivery of a prototype system that provides a high accuracy positioning solution in turbid water. This presents extremely beneficial outcomes for both mine planning and environmental management.

Advisory Board Feedback Form, iYAMOS! project, GA number: 642477
WP5 (Integration, Field Testing and Evaluation)

- Site selection and pre-survey
- Planning & site preparation
- Commissioning & Operation
- Testing procedures
- Environmental measurements
- Evaluation
- Safety

The amount of environmental data collected was to some extent disappointing, however I understand there are numerous learnings to be taken from the experiences of the two test trials. I indicated it would be good to see some recommendations on revised monitoring strategy (different equipment, different locations of monitoring points) for future projects, as I believe there are numerous learnings to be taken from the project that are not immediately obvious in the draft reports as they currently stand.

WP6 (Feasibility, Viability and Market Up Take)

- Economic feasibility
- Accessibility of minerals and industrial viability
- Environmental impact
- Technology exploitation
- Policy
- Future research

Due to the relatively limited environmental data available, there is little analysis of environmental impacts. In some ways this is because there were limited impacts observed which is a positive outcome, however I would like to see more analysis of the dewatering retention strategy, as the report indicated the TSS was not significantly altered by the retention ponds – it seems like this is an opportunity for suggesting amendments to the dewatering strategy for future projects.

WP7 (Project Management)

- Schedule
- Risk management
- Quality System
- Progress reports

It was disappointing that the environmental reports took so long to come, and that full drafts were not available before the final Advisory Board meeting.
2. General

1. What is your current view on the JVAMOSI project, its relevance for industry and research, its significance for EU Raw Materials policy, its objectives vs results, and the approach that was chosen, etc.? Please include strategical, technical and management aspects.

I think the VAMOS team should be extremely proud of their efforts – they have produced a prototype vehicle that could be extremely significant for the EU Raw Materials policy, and have shown that a high accuracy, bespoke system can be designed, constructed and integrated within a reasonably short time frame. The team has worked well together and there are significant learnings from this project that could be taken further with relative ease given the technology advancement already demonstrated, to make submerged mining a reality as part of a low-impact mining strategy in future.

2. Your recommendations for the upcoming period, after project closure:

3. Your notes on the organisation and functioning of the AB:

The most productive AB meetings were those were all parties were able to attend, and this did not happen often. Also, the last AB meeting was timed such that there was relatively little (if any) time for AB comments to be addressed in the final documents, which was a shame. In future it would be good if AB travel were compensated in full, rather than a cap on travel stipend contributions, to encourage AB members to attend in person.

Other

Signature:

[signed]
<table>
<thead>
<tr>
<th>ID</th>
<th>Recommendation</th>
<th>Follow up / Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Revisit the gathering/loading device (auger), submerged load test on surface with differentiated size distribution of muck (simulate blocky ground….)</td>
<td>It is anticipated that due to nature of the abandoned mines and periods they have been unused, there will be a range of materials. This will provide ample opportunity to test the auger.</td>
</tr>
<tr>
<td>2</td>
<td>Review calculation of safety factor of cutter power w.r.t. MV stability</td>
<td>Increased peak cutter power to 150kW. Added variable torque control/limiter. Start at low torque on each site, increase gradually and monitor MV inclination.</td>
</tr>
<tr>
<td>3</td>
<td>Activation of gathering device (pushed to the ground) for stability while slewing</td>
<td>Implemented including dozer blade at rear of MV. FEM analysis of cutter boom finished. The limitation in cutting will be given by the weight of the machine. Max. applicable slewing force approx. 15kN</td>
</tr>
<tr>
<td>4</td>
<td>Control of particle size intake</td>
<td>This will be fixed - defined by inlet size. There will be some overspill and re-handle.</td>
</tr>
<tr>
<td>5</td>
<td>Match riser vertical transport capacity to the particle size being cut</td>
<td>Not anticipated and proven to be a problem; critical flow velocity to prevent blocking is higher than anticipated settling velocity of largest particles</td>
</tr>
<tr>
<td>6</td>
<td>Ensure continuous use of integration register</td>
<td>Register is in shared environment and maintainable for everyone, and discussed in WP3 and 4 meetings</td>
</tr>
<tr>
<td>7</td>
<td>Analyse applicability of LIBS opposed to X-ray for measuring sulphides. Analyse fitness for underwater use?</td>
<td>Applicability for sulphur was validated with the Silvermines samples. InescTEC have demonstrated precisely that it is possible to map the sulphur contents from the LIB’s spectra alone, and that it correlates very well with the XRF information. In addition, they will be looking into some sulphide samples provided by the Portuguese Geology Dpt, that should give insight on the possibility of sulphur masking other elements of interest. Process time low enough to initially test at surface. Submerged testing is optional.</td>
</tr>
<tr>
<td>ID</td>
<td>Recommendation</td>
<td>Follow up / Comment</td>
</tr>
<tr>
<td>----</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Compare USBL vs fixed long baseline navigation accuracy and precision</td>
<td>SBL/iUSBL is used in preference to LBL because of operational advantages (fast and less logistics in the deployment or re-positioning of the transponder to get a good coverage of the open pit) and some localization advantages (increase the measurement rates by using both the iUSBL and SBL; capable of providing orientation measurements updates due to the iUSBL; better support for the simultaneous positioning of multiple underwater vehicles).</td>
</tr>
<tr>
<td>9</td>
<td>Identify goals for user-machine interface and environmental mapping (3D visualisation)</td>
<td>Goal was to provide a virtual view – including off-machine views as well as key machine diagnostics. Environmental mapping was before during and after trials – whatever we can pick up and affected by what AUV/HROV could carry and power on board – and on site character</td>
</tr>
<tr>
<td>10</td>
<td>Evaluate different acoustic imaging systems including acoustic cameras</td>
<td>Variety of equipment used in Bejanca survey, and trials at Lee Moor and Silvermines</td>
</tr>
<tr>
<td>11</td>
<td>Define at early stage which parameters need to be monitored during field testing, to be able to obtain results.</td>
<td>Was defined within the project trials plan, that was be drafted and circulated to all relevant partners before testing commenced.</td>
</tr>
<tr>
<td>12</td>
<td>Run pre-bathymetry before entering test site preparation.</td>
<td>Bathymetric surveys are planned for all sites prior to testing – unless there is a recent final pit survey – in which case the survey may be done just before testing.</td>
</tr>
<tr>
<td>13</td>
<td>The AB recommends to ensure that the history of each risk is captured and recorded, so any changes to probability or impact scoring are not lost.</td>
<td>Was done, see Risk Register in D7.4</td>
</tr>
<tr>
<td>14</td>
<td>Add a classification column to the risk register – eg Commercial, Technical, Political</td>
<td>Assigning risks to Work Package was done, which will deliver similar possibilities to filter, see Risk Register in D7.4</td>
</tr>
<tr>
<td>15</td>
<td>List water waste rehabilitation opportunities as a USP</td>
<td>Was done in WP1 and 6</td>
</tr>
<tr>
<td>16</td>
<td>Do not mention ¡VAMOS! as being a stepping stone towards deep sea mining as a USP</td>
<td>Considerated in WP1. There’s a report D5.7 however on the topic of offshore use, which is marked Public from the start of the project</td>
</tr>
<tr>
<td>ID</td>
<td>Recommendation</td>
<td>Follow up / Comment</td>
</tr>
<tr>
<td>----</td>
<td>--------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>Emphasize the advantage for submerged mining against open cut mining in</td>
<td>Was done in WP1 (leaflets for instance, plus public deliverables) and WP6 (public</td>
</tr>
<tr>
<td></td>
<td>communication</td>
<td>deliverables)</td>
</tr>
<tr>
<td>18</td>
<td>Create awareness with the public, not only top-down, but also bottom up, e.g. by</td>
<td>Several partners employed students at various stages. And presentations were made on the project to students in universities</td>
</tr>
<tr>
<td></td>
<td>involving student of local universities</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Seek contact with relevant projects, to learn from their experiences w.r.t.</td>
<td>Inter-project collaboration is described in deliverable D1.6</td>
</tr>
<tr>
<td></td>
<td>sustainability and communication with stakeholders</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Add environmentally biased presence to the AB</td>
<td>Renee Grogan joined the AB from AB meeting #2</td>
</tr>
<tr>
<td>21</td>
<td>Make list of potential spin-off techniques</td>
<td>Was done in WP6, see D6.4 and D6.6 and presentation at AB meeting #2</td>
</tr>
<tr>
<td>22</td>
<td>Update Risk Register with all comments incl AB ones</td>
<td>A column was added, enabling filtering on “input from AB”, see Risk Register in D7.4</td>
</tr>
<tr>
<td>23</td>
<td>Run turbidity test in a tank</td>
<td>Done prior 2nd field trial by InescTEC at low turbidity</td>
</tr>
<tr>
<td>24</td>
<td>Produce mine plan for Lee Moor</td>
<td>Done by WP5 team. For 1st trial modified during tests, due to higher than anticipated silt levels. For 2nd field trial laid down more detailed into Field Test Document</td>
</tr>
<tr>
<td>25</td>
<td>List environmental parameters to be measured</td>
<td>Was done approaching field trials and during site selection investigations and sent to Renee Grogan. Listed in D4.2 – Environmental Impact Monitoring System</td>
</tr>
<tr>
<td>26</td>
<td>Inform all partners of liability/insurance conditions during transport and</td>
<td>Done by Damen prior to field trials (WP5)</td>
</tr>
<tr>
<td></td>
<td>testing</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Be aware that any site has a variety of rocks, so machine needs to be versatile</td>
<td>Comment made in AB#6</td>
</tr>
<tr>
<td>ID</td>
<td>Recommendation</td>
<td>Follow up / Comment</td>
</tr>
<tr>
<td>----</td>
<td>--------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 28 | Recommendation for future generation of the equipment would be: interfacing of components requires more attention. | Comment made in AB#6  
During (pre) feasibility study of a project this could be highlighted. |
| 29 | Give practical advise to end users for implementing for environmental monitoring systems | Comment made in AB#6, and see also Annex C; Final Advisory Board feedback  
Will be included in final D6.3, section “Lessons Learned” |
| 30 | Focus future research on improving reliability and predictability to convince investors, mine owners and contractors | Comment made in AB#6.  
During (pre) feasibility study of a project this could be highlighted. |
| 31 | Recommend further investigation into the application of the concept in the area of opening new mines or operating existing ones in subaerial conditions. | Taken from final feedback form, see Annex C; Final Advisory Board feedback |
| 32 | Promote the prototype system being applied to in areas of interest beyond mining. There is opportunity in dam construction, servicing and development in hard rock areas, as well as maritime harbor development in rocky areas, which is especially relevant to small island developing states. The concept could also be developed for underwater marine mining, especially in shallow areas where mineral deposits continue offshore but are too shallow for underground mining. | Taken from final feedback form, see Annex C; Final Advisory Board feedback |
| 33 | Publicize the concept more widely to attract other innovative applications including those outside of mining. | Taken from final feedback form, see Annex C; Final Advisory Board feedback |
| 34 | In order to perform in a variety of geotechnical conditions of a hard rock mine you either need to have a modular system where you can adopt different loading and cutting systems or alternatively, if the size of project allows, you could use more than one machine which is then adjusted to a different set of conditions. | Taken from final feedback form, see Annex C; Final Advisory Board feedback |
### Recommendations

<table>
<thead>
<tr>
<th>ID</th>
<th>Recommendation</th>
<th>Follow up / Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Cater for additional designing and testing in order to get a highly productive and reliable system when entering into new projects.</td>
<td>Taken from final feedback form, see Annex C; Final Advisory Board feedback</td>
</tr>
<tr>
<td>36</td>
<td>Revisit the Specific Energy relationship as described in D5.6 Financial Viability, Section 3.2.1.1. Underwater adjustments, Figure 2.</td>
<td>Taken from final feedback form, see Annex C; Final Advisory Board feedback</td>
</tr>
<tr>
<td>37</td>
<td>Cater for an extensive learning curve since you have to expect more teething and adjustment problems before you can confidently push the system into a commercial application.</td>
<td>Taken from final feedback form, see Annex C; Final Advisory Board feedback</td>
</tr>
<tr>
<td>38</td>
<td>Perform more analysis of the dewatering retention strategy, as the report indicated the TSS was not significantly altered by the retention ponds – it seems like this is an opportunity for suggesting amendments to the dewatering strategy for future projects.</td>
<td>Taken from final feedback form, see Annex C; Final Advisory Board feedback</td>
</tr>
<tr>
<td>39</td>
<td>In future it would be good if AB travel were compensated in full, rather than a cap on travel stipend contributions, to encourage AB members to attend in person.</td>
<td>Taken from final feedback form, see Annex C; Final Advisory Board feedback</td>
</tr>
</tbody>
</table>

### 4.4 Results of the Sustainable Mining Forum

Initially, the Sustainable Mining Forum was set up as a LinkedIn Group. The owner of this Group is the previous Project Coordinator. At the end of 2017 the WP1 team decided to create a new forum on the basis of functionality, as a LinkedIn Company. This made it possible to better comment and share posts among members while reaching more stakeholders. It was not feasible to change the functionality of the forum, and migrate the (then 175 members) within LinkedIn itself. The members of the existing forum were asked to subscribe to the newly created forum, which most of them did. Over time the number of participants grew. At the time of writing this final deliverable, the Forum had a total number of members of 227. The Forum was maintained by the ¡VAMOS! Dissemination team, which is a sub-set of Workpackage 1 participants. See also deliverable D1.6 for more details.
Out of the six AB members, three were active on the LinkedIn platform. The visitors analytics show an average of approx. 100 page views and 35 unique visitors per month.

The following graphs (Figures 5 and 6) show analytical data of the forum over the last 12 months as per release date of this deliverable. The peaks in the graphs can be related to the dates of the Demo Days and articles and/or News items published online.

![Page view analytics of ¡VAMOS! Sustainable Mining Forum](image1)

*Figure 5: Page view analytics of ¡VAMOS! Sustainable Mining Forum*

![Visitor analytics of ¡VAMOS! Sustainable Mining Forum](image2)

*Figure 6: Visitor analytics of ¡VAMOS! Sustainable Mining Forum*

The demographics data (as seen in following Figures 7 and 8) show that followers mainly come from the Mining & Metals or Oil & Energy industry, and also to a large extent from Research institutions. They originate mainly from the EU, as can be seen in the figures. It suggests that the stakeholder impact via LinkedIn was mainly realised in target groups 1, 4 and 6.
The messages which were posted on this platform originate mainly from the ¡VAMOS! Dissemination team. The interaction was limited to liking and sharing the (intermediate) achievements that were published, which happened approx. 50-100 times. So, we can conclude that the feedback from the SMF is not “steering towards requirements” (as originally planned), but rather “confirming the development path” of ¡VAMOS!.

In addition to the standard discussion capabilities of LinkedIn, we also used the group to execute a digital survey, in order to intensify the feedback from outside the consortium. In Q2-2017 members of the forum (plus other known contacts) were approached directly with a market research survey in Google Forms. The results of this enquiry were reported on before in deliverable D1.2 – Innovation Agenda, which was submitted on 31st July 2017. They will not be repeated here, because they were not solely sourced from the SMF; however the recommendations were followed up by the Project Management Team in a similar fashion as was done for the AB ones. One of the recommendations was to hold a demonstration of the equipment, open for all stakeholder groups. This was indeed organised during both field trial programs in October 2017 (Lee Moor, UK) and October 2018 (Silvermines, Ireland).
5 Conclusions

This Chapter aims to evaluate the effectivity of the Advisory Board and Sustainable Mining Forum.

The ¡VAMOS! PMT has installed a well-balanced and knowledgeable amount of expertise, which was able to comment on all aspects of the submerged mining concept. The PMT is satisfied with the functioning of the Advisory Board and feels that the project approach was supported by external expertise. It has assured that the AB recommendations were addressed, and fed back to the project partners during the design and test phases. Some of their comments have been integrated into the final deliverables of ¡VAMOS!.

It can be said that the project plan has been fine-tuned by the discussions and recommendations from the Advisory Board. In addition the recommendations give directions for both project partners and EU strategy for future research strategy and implementation of the ¡VAMOS! technology.

The Sustainable Mining Forum has acted differently than foreseen. If the Forum was intended to act as planned, it would have involved highly intensive moderation and posting, as is the case for any online Forum. Still, the SMF contributed to the involvement of stakeholders of the ¡VAMOS! concept through posting news about the project, and sourcing respondents for a marketing survey.
Dear Mr/Mrs …..

I have the pleasure of inviting you to join the Advisory Board of the ¡VAMOS! project of which I am [the Project Coordinator], [the Technical Manager], [the participants’ representative of my organisation] – use as appropriate.

¡VAMOS! will provide a new Safe, Clean and Low Visibility Mining Technique and will prove its Economic Viability for extracting currently unreachable mineral deposits, thus encouraging investment and helping to put the EU back on a level playing field in terms of access to strategically important minerals. Deriving from successful deep-sea mining techniques, the ¡VAMOS! mining solution aspires to lead to: Re-opening abandoned mines; Extensions of opencut mines which are limited by stripping ratio, hydrological or geotechnical problems; and opening of new mines in the EU. ¡VAMOS! will design and manufacture innovative automated excavation equipment and environmental impact monitoring tools that will be used to perform field tests in four mine sites across Europe with a range of rock hardness and pit morphology. VAMOS will:

1. Develop a prototype underwater, remotely controlled, mining machine with associated launch and recovery equipment.
2. Enhance currently available underwater sensing, spatial awareness, navigational and positioning technology.
3. Provide an integrated solution for efficient Real-time Monitoring of Environmental Impact
4. Conduct field trials with the prototype equipment in abandoned and inactive mine sites with a range of rock types and at a range of submerged depths.
5. Evaluate the productivity and cost of operation to enable mine-ability and economic reassessment of the EU's mineral resources.
6. Maximize impact and enable the Market Up-Take of the proposed solutions by defining and overcoming the practicalities of the concept, proving the operational feasibility and the economic viability.
7. Contribute to social acceptance of the new extraction technique via public demonstrations in EU regions.

Further information can be also found in www.vamos-project.eu.

In order to involve experts and end-users from outside the consortium, ¡VAMOS! will set up an Advisory Board, which will comprise a well-balanced group of experts representing Institutions, research and business interests, drawn from across Europe and international policy making organisations and embracing the whole range of interests and knowledge of the Minerals extraction issues in the broader context of the EU and international extraction sector. The Advisory Board will be the heart of the consensus building exercise among the main stakeholders on the final solution, being crucial for successfully promoting the ¡VAMOS! project.

Your acceptance of our invitation to become a member of the Advisory Board will mean that you will be regularly informed about the progress and some of the Deliverables of the project, and you will be asked to participate to a small number of meetings during the project’s lifetime in which you will listen to speakers from the project and other invited speakers on a subject related to inland or deep sea mining, and you will be asked to express an opinion on the progress and status of the project. We foresee that there will be 5 such meetings over the next 3 years, the first one expected to take place late November or beginning of December 2015, in Newcastle, UK.

It will be an honour for us if you would support us with your expertise and advice by joining the ¡VAMOS! Advisory Board. If you accept, a contract including a confidentiality agreement will be drawn up.

Please advise at your earliest convenience and preferably by 31st September 2015. If you have any more questions, we will be glad to elaborate.

Yours Sincerely,
Annex B: Initial Advisory Board feedback

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement number: 642477

Project acronym: ¡VAMOS!
Project title: ¡Viable Alternative Mine Operating System!
Funding Scheme: Collaborative project

Advisory Board Feedback Form

Name AB member: [Redacted]
Date: 16 February 2016
Meeting/date: AB meeting #1, 12 January 2016
1. General opinion (What is your current view on the ¡VAMOS! project, its fit to the EU Raw Materials policy, its objectives and the approach? Please include both strategic technical and management aspects)

VAMOS has the potential to significantly enhance recovery from land-based opencast mines that are now flooded and would otherwise offer an unviable resource both economically and environmentally. One of the more significant impacts of the innovation is the reduction of environmental foot-print: by containing mine waste water, reducing dust and noise, and extending the use of existing infrastructure. As such, VAMOS clearly meets the EU H202 Raw Materials agenda.

2. Feedback per Workpackage
   - WP1 (Innovation Targets and Stakeholder Engagement, in progress)
     VAMOS appears to making a good start with mine wast limitation targets and engagement with locals in the test sites.
   - WP2 (System Specification and Architecture, completed)
   - WP3 (Build Innovative Mining System Prototype, in progress)
   - WP4 (Positioning, Navigation and Awareness System, in progress)
     ... VAMOS needs to compare USBL vs fixed long baseline navigation accuracy and precision
   - WP5 (Integration, Field Testing and Evaluation, in progress)
   - WP6 (Feasibility, Viability and Market Lip-Take, in progress)
   - WP7 (Project Management, in progress)
     ... Use of a matrix of integration is a very good idea.

3. Your recommendations for the upcoming period:
   ... VAMOS needs to assess:
   (i) whether LIBS is appropriate for underwater use
   (ii) if the cutter can control particle sizes
   (iii) match riser VT capacity to cutter particle size
   (iv) identify goals for user-machine interface and environmental mapping (3D visualisation)
   (v) evaluate different acoustic imaging systems including acoustic cameras

4. Your notes and additions on the Risk Register:
   ... none specifically

5. Your notes and additions on the Quality System:
   ... none specifically

6. Your notes and additions on the KPI/USP Register:
   ... none specifically

Advisory Board Feedback Form, ¡VAMOS! project, GA number: 642477
7. Your notes and additions on the functioning of the AB:
   ... Future AB’s should start by recapping the objectives for the reporting period, and summarise the deliverables and their progress.
   This could be followed by an update of the risk register and an analysis of the integration matrix. There should be room for discussion about new challenges and how to approach them.

8. Your notes and additions on the organisation of the AB meeting:
   ... Future AB’s should include a social ‘icebreaker’ before the meeting – e.g. in Newcastle we gathered for an informal dinner. This was useful to get to know the team and discuss peripheral issues.

9. Other
   ...

...
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement number: 642477

Project acronym: ¡VAMOS!
Project title: ¡Viable Alternative Mine Operating System!
Funding Scheme: Collaborative project

Advisory Board Feedback Form

Name AB member: [redacted]
Date: 23 February 2016
Meeting/date: AB meeting #1, 12 January 2016
1. General opinion (What is your current view on the [VAMOS! project, its fit to the EU Raw Materials policy, its objectives and the approach? Please include both strategic technical and management aspects)

I believe this project fits into the EU Raw Material policy to boost exploitation of strategic minerals with the aim to reopen some of the old mining operations within the EU or starting up new mines by using more environmental friendly, less visible mining techniques. At a first glance we are dealing with previous surface mines (I guess most of them were operating in Drill & Blast mode), now flooded, with the benefit of operating at steeper sidewall angles, reducing overburden ratios but with the challenge of remote mining.

It is a practical approach to put a “scalable” mining system together and operate/test the system components at four already identified mining locations. Size of the prototype is dimensioned according to funds available and mobility constraints to move system components on public road infrastructure.

My concerns are that roadheader cutting technology has up to now not made it into standard opencut operations and only drum-type surface miners had some success in more uniform soft to medium hard geology.

Remote mining has the challenge that every breakdown or maintenance activity not performed in situ will add substantial time to recover and re-launch a system component and will detract substantially from the system uptime.

From the management aspect I see a good mix of expertise on the table to deal with existing and new technologies including the knowledge of subsea equipment and hydraulic transport. What I would also like to see (even if it is only for the four test sites) is a more detailed description of geology, expected rock types and strengths distribution and a ball park figures for acceptable mining cost or production rates. This would allow a better assessment to what size the system has to scale up and if adequate performance levels are within reach.

2. Feedback per Workpackage

- WP1 (Innovation Targets and Stakeholder Engagement, in progress)
- WP2 (System Specification and Architecture, completed)

This comment refers to 3.4 Cutting force due to torque against vehicle mass

I do not think the safety factor calculated here is meaningful. This calculation is done with omission of reaction forces to the cutting forces! As soon as you start cutting (e.g. the head is on top of the bench and cuts down or is cut in already and moves in horizontal direction) your cutting force (32 kN) induces a reaction force (=Normal Force as per Figure 20 which is about 3 times your cutting force) and you get a Resulting Force in the magnitude of 100 KN. The y-component of this Resulting Force will be > 32 KN depending on the force direction. In Figure 20 this y-component is e.g. 88 kN at an angle of ~60 deg. If you use this force in your equation your safety factor goes down to 1,3.

Should the force direction get flatter e.g. ~40 deg, your y-component would get smaller but the x-component pushing your machine out of the face will increase (> 51 kN) which needs a reaction force consisting of weight force of machine times friction factor.
Side forces by the slewing of the cutter boom should not be neglected either and roadheaders have rear stabilizers and the loading apron down to compensate for this twisting moment. Not sure if active forces can be applied by the planned front gathering device?

**Cutting Forces for cutter attached to Prototype Mining Vehicle - Vertical Cutting**

New consider MA500 cutter mounted to VAMOS prototype mining vehicle:

![Diagram of mining vehicle](image)

- **Cutter Pick Force**: 
  \[ \text{Force}_{\text{MA500}} = 9.6 \text{ kN} \]

- **Mass of Vehicle in Air**:
  \[ \text{Mass}_{\text{VAMOS, air}} = 27000 \text{ kg} \]

- **Mass of Vehicle Submerged**:
  \[ \text{Mass}_{\text{VAMOS, submerged}} = 0.85 \cdot \text{Mass}_{\text{VAMOS, air}} = 22950 \text{ kg} \]

- **Distance from Pivot to C of G**:
  \[ L_1_{\text{VAMOS}} = 1090 \text{ mm} \]

- **Distance from Pivot to Cutter**:
  \[ L_2_{\text{VAMOS}} = 822 \text{ mm} \]

- **Force available at cutter**:
  \[ F_{\text{VAMOS}} = 5 \cdot \text{Mass}_{\text{VAMOS, submerged}} \cdot \frac{L_1_{\text{VAMOS}}}{L_2_{\text{VAMOS}}} = 1118 \text{ kN} \]

- **Factor of Safety**:
  \[ \text{FOR}_{\text{VAMOS}} = \frac{F_{\text{VAMOS}}}{\text{Force}_{\text{MA500}}} = 35.4 \]

An issue raising discussion is cutter power versus service weight of a mining machine.

![Graph of Cutter power vs. Weight of vehicle](image)

Roadheaders have been initially developed to cut entries/tunnels in underground mining and in order to attack a face the cutter head has been put on an outrigger (and turret) to have a certain...
reach in width and height (and on tracks to have mobility). The cutting forces are generally taken by the machine weight (see calculations in D2.1 System architecture). To advance a tunnel face you need to create a horizontal slot in the face (sump-in process) and once you have reached the desired depth you start cutting the rest of the face by cutting up/down. In the case of surface mining this sump-in is avoided by putting the head on top of the bench (comprised to tunnelling you have an additional free face) and cut at an end position down to create a certain span and move the cutterhead across the face, cut down again for the next span and move in the opposite direction and so on. This leads to a rather complicated cutting process with the advantage that harder material can be cut because during your slewing phase only a very limited number of picks is engaged allowing high specific forces - although the cutting rate will drop quite significantly with increased rock strength (Figure 21 in D2.1 System architecture).

When you look at drum type miners e.g. the Wirtgen, much higher installed cutting power is feasible with a given machine weight (factor of 1.5 – 2.5 in the graph) compared to roadheaders. Reason for this is that the cutting forces in y-direction are taken straight by the machine weight (if you put the cutting system near the centre of gravity) and the cutting forces in x-direction have to be induced by the crawler tracks. So you cut with the drum engaged at a certain depth and just control the cutter motor load with your travelling speed. The disadvantage is that a drum has typically more picks engaged and the strength of material which can be cut at similar installed cutting power levels will be lower compared to a pineapple head. This effect is partially compensated by increased installed cutting power compared to roadheaders. To limit the number of picks engaged drum type miners only take bench heights up to a third of the drum diameter.

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**Cutting performance for the Wirtgen Surface Miner 2200 SMA**

![Cutting performance graph for the Wirtgen Surface Miner 2200 SMA](image)

- Rock: with an unconfined compressive strength < 70 MPa can only be cut under moderate conditions.
- Please contact Wirtgen.

---
If you take a surface miner S2200 with 50 ton service weight you have about 550 kW cutter power available and you can cut with a 2,2m wide drum up to 50 MPa with a performance of about 100 bcm/hr. (the graph below taken from a Wirtgen brochure is not up to Sandvik’s detail)

If you compare this with the MA520 hydraulic cutterhead rated 100 kW with a mining vehicle service weight of 27 ton it can cut 50 Mpa as well (extended range) but the cutting rate will be in the range of 10-15 bcm/nch (net cutting hour). It is not spelled out in Wirtgen’s brochure if the cutting rate is per operating hour (they do not use a net cutting rate definition) but if you take 0,5 nch/operating hr from Sandvik the cutting rate per operating hour will be diluted further.

Fact is that the drum type surface miner mode of operation is intriguingly simple as you have a continuous cutting process with a set cutting depth (=bench height), a drum rotational speed and a variable advance speed controlled by the tracks to use the installed cutting power.

Level control and directional control of the machine is also quite simple as you have four tracks with adjustable height and ability to steer the machine. Material collection is also easier as the drum sits in the centre of the machine and the cuttings (and fines) are collected in a space around the cutter drum avoiding spill. Size distribution of cut material would be nice to have!

Since the workable bench height with this drum type concept will be much lower compared to a roadheader, the travel distance to cut a set volume will be much longer but the hydraulic haulage system should have enough flexibility to follow the machine when moving around in the pit.

To start an operation in rugged terrain with a drum type machine could be a challenge but if we move into historic opencut operations this could be manageable.

To be able to compare both systems more geotechnical data and expected performance data are required to make a call. This question will present itself when the scale up of the current system will be discussed.

I am not an agent for a drum type surface miners or anything else but I just want to flag this because if a drum type machine can handle the prevailing rock strength I see a distinct advantage in the simplicity and ease of operation, in the automation of the mining process and in the performance level. Also equipment capital cost per mining capacity should be more favourable.
Roadheaders are certainly more flexible when it comes to changing geology and rock properties but this is a trade off with a quite complex cutting process and substantially reduced cutting rates when cutting is in the extended and limited cutting range (see Figure 21 D2.1 System Architecture). Another issue exists in layered and blocky ground when the cutting head tends to rip out large rocks which cannot be handled by the gathering and conveying system which likely leads to more operational delays. I have to raise some concerns, that the collecting system proposed for the roadheader may not be effective in blocky ground.

In my career I have seen a few roadheaders fail in opencut situations as they were simply unable to meet productivity and cost targets.

- WP3 (Build Innovative Mining System Prototype, in progress)
  Would at least revisit the gathering/loading device, submerged load test on surface with differentiated size distribution of muck (simulate blocky ground...) Can the gathering device be activated (pushed to the ground) to add some stability to handle slewing forces
- WP4 (Positioning, Navigation and Awareness System, in progress)
  ...
- WP5 (Integration, Field Testing and Evaluation, in progress)
  Gather as much geotechnical and operational information of the four test sites as possible
- WP6 (Feasibility, Viability and Market Up-Take, in progress)
  ...
- WP7 (Project Management, in progress)
  ...

3. Your recommendations for the upcoming period:
   Updates on progress on a more frequent basis.

4. Your notes and additions on the Risk Register:
   ...

5. Your notes and additions on the Quality System:
   ...

6. Your notes and additions on the KPI/USP Register:
   Access to KPI register and risk log?

7. Your notes and additions on the functioning of the AB:
   I think it is a good forum with quite diversified experts to discuss with the ¡VAMOS! Project team

8. Your notes and additions on the organisation of the AB meeting:
   ...

9. Other
   Pick central locations for AB meetings to avoid extensive travelling time

Signature:

Advisory Board Feedback Form, ¡VAMOS! project, GA number: 642477
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under
Grant Agreement number: 642477

Project acronym: ¡VAMOS!
Project title: ¡Viable Alternative Mine Operating System!
Funding Scheme: Collaborative project

Advisory Board Feedback Form

Name AB member : [REDACTED]
Date : 13 April 2016
Meeting/date : AB meeting #1, 12 January 2016
1. General opinion (What is your current view on the IVAMOS project, its fit to the EU Raw Materials policy, its objectives and the approach? Please include both strategic, technical and management aspects)
   The project has taken off well, and according to plan. There is a clear technical plan. Further

2. Feedback per Workpackage
   - WP1 (Innovation Targets and Stakeholder Engagement, in progress)
     As per MoM of meeting #1
   - WP2 (System Specification and Architecture, completed)
     As per MoM of meeting #1
   - WP3 (Build Innovative Mining System Prototype, in progress)
     As per MoM of meeting #1
   - WP4 (Positioning, Navigation and Awareness System, in progress)
     As per MoM of meeting #1
   - WP5 (Integration, Field Testing and Evaluation, in progress)
     As per MoM of meeting #1; It is recommended to define at an early stage which parameters need to be monitored during field testing, to be able to obtain results needed for the required performance analysis, e.g. cutter power. Regarding the environmental viability of the concept it is strongly recommended to use a widely accepted Environmental Impact Assessment method, linking activities to ecosystem components via “pressures”. An example worth mentioning is the generic framework CUMULEO, as applied in maritime cases.
   - WP6 (Feasibility, Viability and Market Up-Take, in progress)
     As per MoM of meeting #1
   - WP7 (Project Management, in progress)
     As per MoM of meeting #1

3. Your recommendations for the upcoming period:
   ...

4. Your notes and additions on the Risk Register:
   Uncertainties seem to be managed well and transparent. It is recommended to address the defined risks more into detail on a next AB meeting.

5. Your notes and additions on the Quality System:
   ...

6. Your notes and additions on the KPI/USP Register:
   ...

7. Your notes and additions on the functioning of the AB:
   ...

8. Your notes and additions on the organisation of the AB meeting:
   A socialising event prior to the meeting itself may be useful next time.

Advisory Board Feedback Form, IVAMOS project, GA number: 642477
Annex C; Final Advisory Board feedback

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under 
Grant Agreement number: 642477

Project acronym: [VAMOS!]
Project title: [Viable Alternative Mine Operating System]
Funding Scheme: Collaborative project

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**Advisory Board Feedback Form**

<table>
<thead>
<tr>
<th>Name AB member</th>
<th>[redacted]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>28 Jan 2019</td>
</tr>
<tr>
<td>Meeting/date</td>
<td>AB meeting #6 (telcon), 25 January 2019</td>
</tr>
</tbody>
</table>
1. Feedback and recommendations per Workpackage

<Bullets are meant supportive, you may summarize your answer if you like>

**WP1 (Innovation Targets and Stakeholder Engagement)**
- Zero state analysis
  - Policy and regulation
  - Innovation agenda
  - Environmental and geo-hazards
- Stakeholder management
- Dissemination and (scientific) publication

**WP3 (Design and Build prototype equipment)**
- Mining Vehicle Prototype
  - Underwater on-the-fly tool change
  - New cutting technology in real submerged inland mining conditions
  - Remote operation
- LARV
  - Launch and recovery systems
  - Maneuvering
  - Power & Control
- Slurry Circuit
  - Slurry pump and system
  - Riser and floating hose systems
  - Density measurement
  - Real time grade control (LIBS)
- Positioning, Navigation and Awareness systems
  - Hybrid AUV/ROV
  - Multi-sensor navigation system
  - Perception system
  - Awareness system
  - Underwater Real Time 3D imaging of the MV
  - Augmented reality representation of the mining environment

The VAMOS prototype mining vehicle, its LARV (deployment system and vessel) were purpose designed and built for the project. The field trials demonstrated both its capability and limitations.

The main problem with the mining vehicle is its ability to cope with heterogeneous rock material. The host rock in which ore material is embedded is heterogeneous in terms of hardness, macro-
structure (veins) and fractures. This results in extremely variable fragmentation of the outcrop leading to subsequent clogging of the transfer mechanism of the ore to the collector. Vehicle maneuverability is subject to the conditions of the substrate with muddy or clay deposits causing problems with the vehicle tracks.

The remote operation and visualization in real time of the cutting operation was very good and absolutely required in turbid conditions where optical visibility is poor. Likewise the underwater positioning. The AR display was also very good at guiding the operation as well as the launch and recovery operations.

The LARV proved to be a reliable and capable system with fixed point moorings allowing stable and yet high-precision maneuverability. Future consideration will require thought about vessel to shore ore transfer and whether the floating pipe system is adequate for ease of maintenance e.g. blockage clearing, and how the shore-side configuration can be designed to enable further ore separation and tailings control.

Real-time grade control was not demonstrated in situ, as planned, but it was demonstrated adequate for off-line analysis. The use of double pulse laser illumination of the target ore was particularly useful for saturated samples. It is not clear whether the LIBS system has significant advantages over other methods such as XRF, which produces analyses from a larger and hence more representative volume of sample. The potential value of LIBS lies in the in situ analysis of grade, but this has yet to be demonstrated in the active part of the mining cycle.

**WP5 (Integration, Field Testing and Evaluation)**
- Site selection and pre-survey
- Planning & site preparation
- Commissioning & Operation
- Testing procedures
- Environmental measurements
- Evaluation
- Safety

Site selection for the first trial was hindered by the nature of the rock. Being clay, this limited visibility, the substrate was non-optimal in terms of heterogeneity with boulders clogging the collector system, and was slippery for the collector vehicle traction system.

Site planning and execution of the trials was good, with plenty of outreach and local support.

Environmental monitoring during the testing was, as far as I am aware, not undertaken at the first test site.

Safety issues were well attended to.
**WP6 (Feasibility, Viability and Market Up-Take)**
- Economic feasibility
- Accessibility of minerals and industrial viability
- Environmental impact
- Technology exploitation
- Policy
- Future research

The technical feasibility of the concept was well tested during the project. However, the economic feasibility is yet to be demonstrated.

There remains uncertainty about the effectiveness of the cutting and collecting processes. Environmental monitoring was not well trialed, and I would like to have seen more done with the in situ environmental data especially regarding sediment plume and noise generation being quantified.

The technology is cutting edge with the general approach being well thought through, and much of the implementation being effective.

The results of the project should be assessed in terms of policy, and an estimate of the potential resource now made accessible and available were underwater mining of existing open-cast deposits to be exploited in Europe. What effect would that have on the value chain and the impact of new supply of raw materials on European demand?

**WP7 (Project Management)**
- Schedule
- Risk management
- Quality System
- Progress reports

Overall the project was well managed. Problems with test sites were overcome in a timely way, the public were engaged proactively, and the various stages of the build and demonstration of the various technologies were delivered well.

The Risk register was kept up to date and mitigations employed where required, e.g. the re-siting of the second test site.

The overall quality of the project was high with many innovations being developed and tested. The aims of the project were extremely ambitious, especially the autonomous underwater monitoring and the VR or enhanced reality visualization of the system in operation.

Progress reports were mainly on schedule and the advisory board was kept updated on the project as it progressed, including being asked to comment and advise where changes were necessary e.g. changes in test site.
2. General

1. What is your current view on the [VAMOS] project, its relevance for industry and research, its significance for EU Raw Materials policy, its objectives vs results, and the approach that was chosen, etc? Please include strategical, technical and management aspects.

Overall, the VAMOS project was an ambitious and imaginary attempt to enhance recovery of mineral resources in areas that had already seen extraction. The concept is very promising, and has significant environmental advantages to opening new mines or operating existing ones in subaerial conditions.

I would recommend further work in this area, given the strategic need for security of supply of raw materials to European industry. The demonstration proved the concept, identified problems, and laid the groundwork for further development and improvement in the concept.

2. Your recommendations for the upcoming period, after project closure:

I would like to see the prototype system being applied to together in areas of interest beyond mining. There is opportunity in dam construction, servicing and development in hard rock areas, as well as maritime harbor development in rocky areas, which is especially relevant to small island developing states.

The concept could also be developed for underwater marine mining, especially in shallow areas where mineral deposits continue offshore but are too shallow for underground mining.

I would also like to see the concept being publicized more widely to attract other innovative applications including those outside of mining.

3. Your notes on the organisation and functioning of the AB:

The interaction between the project team and the Advisory Board was excellent. The AB was kept informed of developments outside of the annual AB meetings, were invited to tests and demonstrations and their opinion sought especially when the project did not go as planned. The AB constituted expertise from a broad range of areas, making it able to input positively and assess progress across the range of project work packages.

4. Other

As a member of the AB, I was very impressed with the professional way VAMOS was executed. This was always an ambitious project, and the fact that it was able to integrate so many new technologies together, build a substantial prototype system and test it in a number of challenging field environments is testament to the excellent organization and capability of the team.

Signature:

Advisory Board Feedback Form, VAMOS! project, GA number: 642477
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement number: 642477

Project acronym: ¡VAMOS!

Project title: ¡Viable Alternative Mine Operating System!

Funding Scheme: Collaborative project

Advisory Board Feedback Form

Name AB member: [redacted]
Date: 30 January 2019
Meeting/date: AB meeting #6 (telcon), 25 January 2019
1. Feedback and recommendations per Workpackage

<Bullets are meant supportive, you may summarize your answer if you like>

WP1 (Innovation Targets and Stakeholder Engagement)
- Zero state analysis
  - Policy and regulation
  - Innovation agenda
  - Environmental and geo-hazards
- Stakeholder management
- Dissemination and (scientific) publication

WP3 (Design and Build prototype equipment)
- Mining Vehicle Prototype
  - Underwater on-the-fly tool change
  - New cutting technology in real submerged inland mining conditions
  - Remote operation
- LARV
  - Launch and recovery systems
  - Manoeuvring
  - Power&Control
- Slurry Circuit
  - Slurry pump and system
  - Riser and floating hose systems
  - Density measurement
  - Real time grade control (LIBS)
- Positioning, Navigation and Awareness systems
  - Hybrid AUV/ROV
  - Multi-sensor navigation system
  - Perception system
  - Awareness system
  - Underwater Real Time 3D imaging of the MV
  - Augmented reality representation of the mining environment
Within the given budget and timeframe certainly a good outcome of the project. I guess to pull such a complex system together and get it to/through a prototype test is certainly a great achievement. The concept which is built from a combination of known technologies from very different areas (excavation, haulage, hydraulic pumping, underwater positioning and navigation, control and awareness systems...) has merit. Unfortunately due to some constraints on MV (power/weight, material gathering system, size control...) machine could not be tested out to get confident data on longer term performance levels.

**WP5 (Integration, Field Testing and Evaluation)**
- Site selection and pre-survey
- Planning & site preparation
- Commissioning & Operation
- Testing procedures
- Environmental measurements
- Evaluation
- Safety

Second testing site was not really suitable for the weight class of machine in the prevailing geology - causing severe problems with vibrations. Excessive vibrations are a clear sign the machine is lacking stability (weight, power, more effective stabilizing system...) and if you put it permanently into overload condition you will get it into self-destruction mode adding operating and maintenance cost. I think most of the vibration/stability problems described in the test report would disappear with a right sized machine.

In hard rock mining you find usually a fair spread of rock strengths and you would need to focus your design parameters on the harder conditions you want to handle. The downside of this is. One size does not fit all conditions and this machine may not be very well suited to soft conditions. The size of cut material or presence of silt can heavily influence your loading performance which is again influenced by the chosen cutterhead design, cutting speeds and pick type. So in order to perform in a variety of geotechnical conditions you either have to have a modular system where you can adopt different loading and cutting systems or alternatively, if the size of project allows you could use more than one machine which are then adjusted to a different set of conditions.

With the limited testing not a great deal of experience for future machine designs could be gained and entering into new projects ahead would still require a lot of designing and testing in order to get a highly productive and reliable system.

Is there going to be more EU funds available to take this to the next step and/or who would make this call on an adjusted system specification?

**WP6 (Feasibility, Viability and Market Up Take)**
- Economic feasibility
- Accessibility of minerals and industrial viability
- Environmental impact
- Technology exploitation
- Policy
- Future research

Advisory Board Feedback Form, IVAMOS! project, GA number: 642477
I would certainly revisit the Specific Energy relationship as described in D5.6 Financial Viability Section 3.2.1.1. Underwater adjustments Figure 2. If this would be reality then this would be a distinct advantage as we would see a significant reduction in specific energy. This means for a given cutting power installed substantially more volume per time unit could be cut. Since we are working in shallow waters one would not expect this to have such an impact. Is there any evidence for this phenomenon in deep sea mining or trenching operations?

If this effect would come from “wet” versus “air” this would not go unnoticed in roadheader applications where machines work in water saturated rock.

**WP7 (Project Management)**

- Schedule
- Risk management
- Quality System
- Progress reports
2. General

1. What is your current view on the iVAMOS! project, its relevance for industry and research, its significance for EU Raw Materials policy, its objectives vs results, and the approach that was chosen, etc? Please include strategic, technical and management aspects

I think that you need to go through a more extensive learning curve since you have to expect more teething and adjustment problems before you can confidently push the system into a commercial application.

The area of collecting material and reducing the oversize to achieve trouble free hydraulic pumping of material can become quite a challenge. A crushing unit could certainly be beneficial but space requirements could force you to put a throat into the machine and pick up material further back. It seems there will be different solutions to different geotechnical situations which could be thought of before taking this a step further. System uptime and productivity is what will count when you enter into production mode.

2. Your recommendations for the upcoming period, after project closure:

3. Your notes on the organisation and functioning of the AB:

4. Other

Signature: 

Advisory Board Feedback Form, iVAMOS! project, GA number: 642477
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under
Grant Agreement number: 642477

Project acronym: ¡VAMOS!
Project title: ¡Viable Alternative Mine Operating System!
Funding Scheme: Collaborative project

Advisory Board Feedback Form

Name AB member: [Redacted]
Date: 25 January 2019
Meeting/date: A8 meeting #6 (telecon), 25 January 2019
1. Feedback and recommendations per Workpackage

<Bullets are meant supportive, you may summarize your answer if you like>

4 WP1 (Innovation Targets and Stakeholder Engagement)
- Zero state analysis
  - Policy and regulation
  - Innovation agenda
  - Environmental and geo-hazards
- Stakeholder management
- Dissemination and (scientific) publication

Comments were made in the AB meeting that the stakeholder engagement particularly was very well handled by the project team.

WP3 (Design and Build prototype equipment)
- Mining Vehicle Prototype
  - Underwater on-the-fly tool change
  - New cutting technology in real submerged inland mining conditions
  - Remote operation
- LARV
  - Launch and recovery systems
    - Maneuvering
    - Power&Control
- Slurry Circuit
  - Slurry pump and system
  - Riser and floating hose systems
  - Density measurement
  - Real time grade control (LBS)
- Positioning, Navigation and Awareness systems
  - Hybrid AUV/ROV
  - Multi-sensor navigation system
  - Perception system
  - Awareness system
  - Underwater Real Time 3D imaging of the MV
  - Augmented reality representation of the mining environment

Comment made that I was particularly impressed with the PNAS progress – in terms of the delivery of a prototype system that provides a high accuracy positioning solution in turbid water. This presents extremely beneficial outcomes for both mine planning and environmental management.

Advisory Board Feedback Form, iVAMOS! project, GA number: 642477
WP5 (Integration, Field Testing and Evaluation)
- Site selection and pre-survey
- Planning & site preparation
- Commissioning & Operation
- Testing procedures
- Environmental measurements
- Evaluation
- Safety

The amount of environmental data collected was to some extent disappointing. However, I understand there are numerous learnings to be taken from the experiences of the two test trials. I indicated it would be good to see some recommendations on revised monitoring strategy (different equipment, different locations of monitoring points) for future projects, as I believe there are numerous learnings to be taken from the project that are not immediately obvious in the draft reports as they currently stand.

WP6 (Feasibility, Viability and Market Up-Take)
- Economic feasibility
- Accessibility of minerals and industrial viability
- Environmental impact
- Technology exploitation
- Policy
- Future research

Due to the relatively limited environmental data available, there is little analysis of environmental impacts. In some ways this is because there were limited impacts observed which is a positive outcome, however I would like to see more analysis of the dewatering retention strategy, as the report indicated the TSS was not significantly altered by the retention ponds – it seems like this is an opportunity for suggesting amendments to the dewatering strategy for future projects.

WP7 (Project Management)
- Schedule
- Risk management
- Quality System
- Progress reports

It was disappointing that the environmental reports took so long to come, and that full drafts were not available before the final Advisory Board meeting.
2. General

1. What is your current view on the [VAMOS] project, its relevance for industry and research, its significance for EU Raw Materials policy, its objectives vs results, and the approach that was chosen, etc? Please include strategic, technical and management aspects

I think the VAMOS team should be extremely proud of their efforts – they have produced a prototype vehicle that could be extremely significant for the EU Raw Materials policy, and have shown that a high accuracy, bespoke system can be designed, constructed and integrated within a reasonably short time frame. The team has worked well together and there are significant learnings from this project that could be taken further with relative ease given the technology advancement already demonstrated, to make submerged mining a reality as part of a low-impact mining strategy in future.

2. Your recommendations for the upcoming period, after project closure:

3. Your notes on the organisation and functioning of the AB:

The most productive AB meetings were those where all parties were able to attend, and this did not happen often. Also, the last AB meeting was timed such that there was relatively little (if any) time for AB comments to be addressed in the final documents, which was a shame. In future it would be good if AB travel were compensated in full, rather than a cap on travel stipend contributions, to encourage AB members to attend in person.

Other

Signature:

[signed]

Advisory Board Feedback Form, ¡VAMOS! project, GA number: 642477
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<tr>
<td>A01</td>
<td>Direct RG to reports on WP1</td>
<td>FB</td>
<td>Damen</td>
<td>&lt;AB#3</td>
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<td>A02</td>
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<td>A04</td>
<td>Provide BM and SS with specifications of USBL system</td>
<td>ES</td>
<td>Inese</td>
<td>&lt;AB#3</td>
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<td>A05</td>
<td>Make list of potential spin-off techniques</td>
<td>All</td>
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<td>A06</td>
<td>Circulate slide “Exploitation Opportunities”</td>
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<td>A07</td>
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<td>List of foreseeable scientific publications &gt; WP1</td>
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<td>Q3-17</td>
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<td>A09</td>
<td>Run turbidity test in Inese Teg lab tank &gt; TM</td>
<td>ES</td>
<td>Inese</td>
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<td>A10</td>
<td>Explain sulphide masking issues in Li85 &gt; AB</td>
<td>PS</td>
<td>Inese</td>
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<td>A12</td>
<td>Include surface sound measurement results in final deliverables</td>
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<td>A13</td>
<td>Produce mine plan for Lee Moor &gt; WP5</td>
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<td>La Palma</td>
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<td>inform all partners of liability/insurance conditions</td>
<td>FB</td>
<td>Damen</td>
<td>&lt;May 17</td>
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<tr>
<td>A17</td>
<td>Send final technical reports and deliverables, incl D1.4 Advisory Board Reports</td>
<td>FB</td>
<td>Damen</td>
<td>Jan’19</td>
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<td>A18</td>
<td>Propose date and location for last AB meeting</td>
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<td>Send in final comments and recommendations as per template (for inclusion in D1.4)</td>
<td>AB members</td>
<td>-</td>
<td>Jan’19</td>
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Annex E; Impressions of Advisory Board interaction

Figure 9; First AB Meeting, SMD, Newcastle

Figure 10; Third AB Meeting; Witnessing the build of EVA at the lab of InescTEC, Porto

Figure 11; Second AB Meeting; Slurry pump FAT test explained at Damen, The Netherlands

Figure 12; AB and visitors at Demo Day in Lee Moor, UK

Figure 13; Visitors and AB being demoed on LARV and at Control Cabin in Silvermines

Figure 14; Fifth AB Meeting at Silvermines, Irela