An Integrated Quality Management System (QMS) combined with AI/ML Guidelines for the Design and Development of Sustainable Products and Services for IT and Engineering R&D Companies Providing Solutions to Global Mining Organizations

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Abstract

As per Nature[1], AI may act as an enabler on 134 targets (79%) across all Sustainable Development Goals (SDGs), generally through technological improvement and by putting the right processes in place to ensure compliance with applicable regulations, certifications, and standards. As the sustainability and green tech market[2] is expected to grow at 21% CAGR and will reach $73 billion by 2023, it's the best time for IT and Engineering R&D (ERD) companies to strengthen their internal processes to ensure that mining customers are served in a better way. The mining solutions are driven by tightening regulations, shifting customer preferences, and higher compliance requirements. Mining companies must act on many fronts, changing supply networks, manufacturing processes, and business models. Companies are also rethinking how their products are designed, engineered, and used, looking for ways to meet performance and quality requirements while using fewer resources across the full life cycle of everything they make/implement/use. India is a leading software exporter, and many companies are supporting global mining customers across the world. It's now the right time for IT and ERD companies to ensure that mining customers are supported in this fast-changing business and regulatory environment. For sustainable product development/services, companies need to put a strong internal Quality Management System (QMS), ensuring better compliance and usage of AI/ML and tools and related standards/certifications. So, the researcher is proposing a conceptual integrated QMS to support sustainable product development/services which can be used by IT and ERD companies developing mining solutions. The proposed system will provide a high-level view of the required standards, procedures, guidelines, templates etc., which will be compliant with the global sustainability standards/ certifications requirements.

Keywords: *Engineering R&D (ERD), IT Solutions, Mining, Product Development, Green, Sustainability, Quality Management System (QMS)*

1.0 Introduction

Mining is a complex activity and requires a diverse range of processes, products, machines, and solutions to carry out the excavation/extraction efficiently and safely. There are stringent compliance and safety-related requirements. Also, companies must ensure that mining is being carried out sustainably. Sustainable development and mining involve practices that minimize environmental impact, ensure social responsibility, and promote economic

viability. It includes optimal utilization of resources, efficient extraction, reduced environmental impact, safety, and innovation[3]. There is an urgent need to use latest and emerging technologies like AI/ML to meet sustainability related requirements and ensure safe mining operations.

As per nature[1], AI may act as an enabler on 134 targets (79%) across all Sustainable Development Goals (SDGs), generally through technological improvement and by putting the right processes in place to ensure compliance with applicable regulations, certifications, and standards. As the sustainability and green tech market is expected to grow at 21% CAGR and will reach $73 billion by 2023, it is the best time for IT and ERD companies to strengthen their internal processes to ensure that mining customers are served in a better way. The mining solutions are driven by tightening regulations, shifting customer preferences, and higher compliance requirements. Mining companies are required to act on many fronts, with changes to supply networks, manufacturing processes, and business models. Companies are also rethinking how their products are designed, engineered, and used, looking for ways to meet performance and quality requirements while using fewer resources across the full life cycle of everything they use/ make[3,4]. It's now the right time for IT and ERD companies to ensure that mining customers are supported in this changing environment. For sustainable product development/ services, companies need to put a strong internal Quality Management System (QMS), better compliance and usage of AI/ ML and tools and related standards/certifications[3].

Many IT, ERD and product companies work on mining-related projects/solutions and follow a traditional product development life cycle/processes. These companies should adopt integrated systems/processes and ensure that mining customers are supported in better way in this dynamic environment[5,6].

Sustainable product development is essential for mining organizations to support safe and secure mine operations. It helps in balancing the demand for minerals with the need to protect our environment and support local communities.

The researcher is proposing a conceptual integrated QMS to support sustainable product development/ services, which can be used by IT and ERD companies developing mining solutions. The proposed system will provide a high-level view of the required standards, procedures, guidelines, templates, etc., and will be compliant with the global sustainability standards/ certifications requirements.

2.0 Literature Survey on Sustainability, Demand, Market Growth and its Importance in Mining

2.1 Sustainability and its Importance and Market Growth

As per Gartner[7], Sustainability is the foundation for today's leading global framework for international cooperation,

Figure 1. Macro Factors Reshaping Business This Decade (Gartner's view)[7].

the 2030 agenda for sustainable development and its SDGs. Sustainable development is the progress that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability in business refers to a company's plan to lessen the damaging environmental effects caused by its operations in a certain market. Environment, Social, and Governance (ESG) indicators are often used to evaluate an organization's sustainability practices. The report suggests that sustainability is one of the key macro factors, which will reshape business of the future. The report mentions emerging technologies also as one of the key factors as shown in Figure 1.

The above data suggests that sustainable technologies will hold the key in the future and organisations must devise a robust system to ensure that products, solutions and services developed/ offered are in-line with the sustainability requirements of the industry.

Following data[2] suggests that the market for sustainable services and solutions has been growing very fast, so there is a need to propose a better framework/system which can support/ help in sustainable product development and service delivery.

Asia Pacific green technology and sustainability market[5] also growing at a steady pace. It is expected to grow 25% annually as shown below.

In the Asia Pacific green technology and sustainability market[5], mining and exploration also has very significant potential, as shown in Figures 4 and 5.
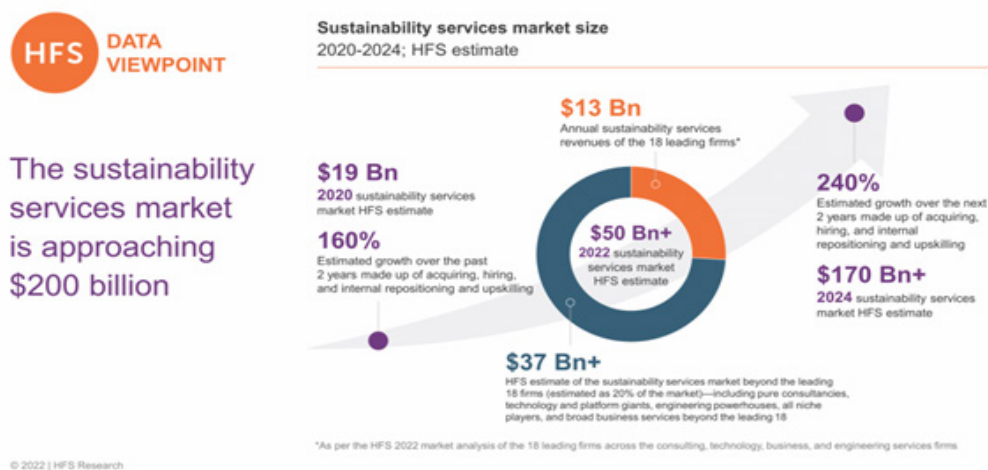

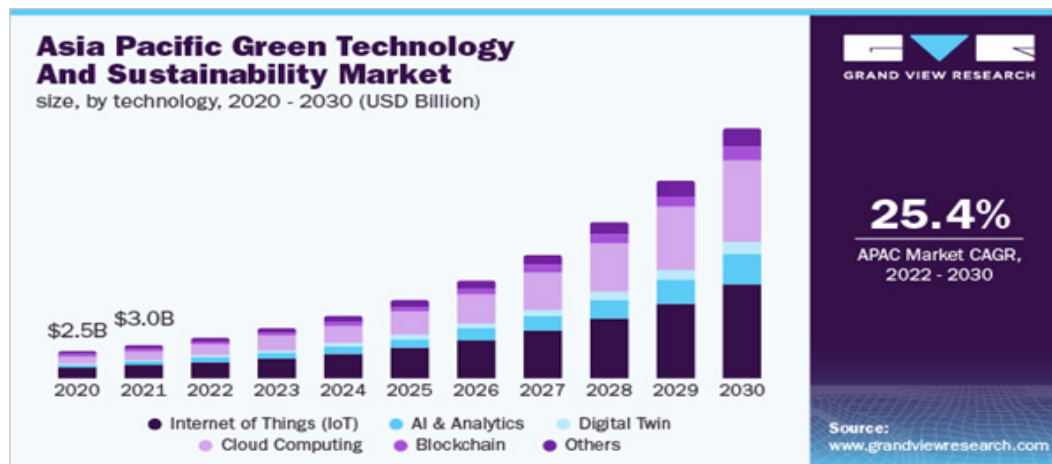**Figure 2.** The Sustainability Services Market[2].

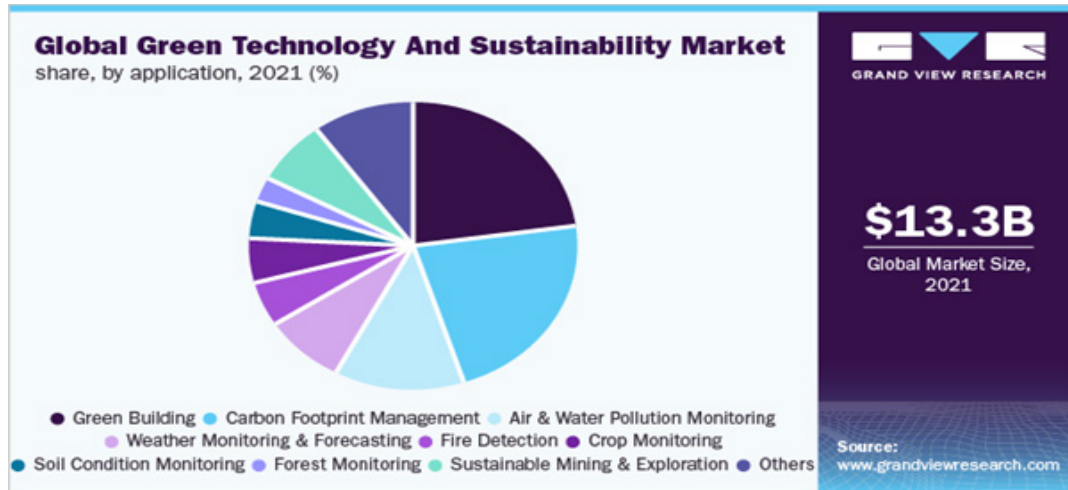**Figure 3.** Asia Pacific Green Technology and Sustainability Market Growth Trend[2].

Figure 4. Asia Pacific Green Technology and Sustainability market size[2].

Figure 5. Green Mining Market Size[2].

Having researched the market demand for sustainable products and services, let's explore sustainability in mining, changing design landscape and needs for sustainable products and services.
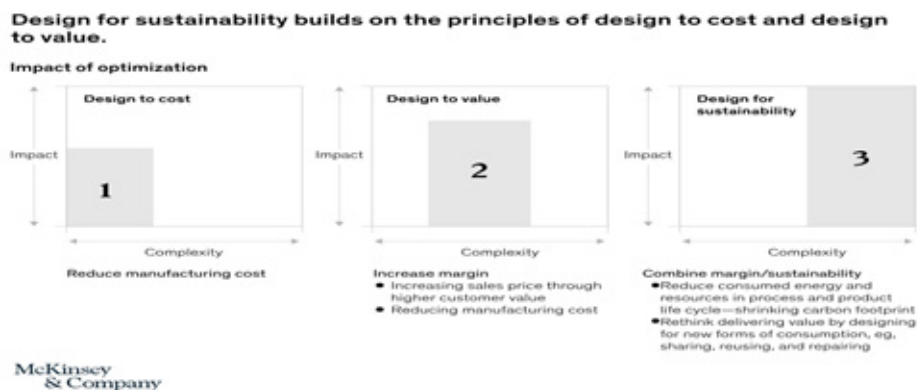
2.2 Mining, Sustainability and Need for Sustainable Product/Services

Most of the resources we use to construct infrastructure and everyday tools, generate vast amounts of electricity, and feed agriculture with fertilizers that enable most of our food to be produced come from mining businesses. Meanwhile, mining is the human activity that has had the most negative environmental effects and is associated with significant social repercussions and

inequities. Despite this, mining is very important to our future[8].

Mining activities shall be intertwined with sustainable development goals to ensure that present and future generations will have resources or alternative means to satisfy their basic needs of food, water, and energy. This implies that we need to put a very strong and enduring sustainability framework in place. Planning for the future is an approach used by many organizations, communities, and businesses to direct their development, allocate resources, and assist in decision-making[5,6,8].

As per McKinsey report[9], there is an overall shift in the product/service design approach, we can observe the shift from "Design to Cost" to "Design to Value" to "Design for Sustainability" as shown in Figure 6.

Design for sustainability builds on the principles of design to cost and design to value.

Impact of optimization

Design to cost

1

Impact

Complexity

Reduce manufacturing cost

Design to value

2

Impact

Complexity

Increase margin
- Increasing sales price through higher customer value
- Reducing manufacturing cost

Design for sustainability

3

Impact

Complexity

Combine margin/sustainability
- Reduce consumed energy and resources in process and product life cycle—shrinking carbon footprint
- Rethink delivering value by designing for new forms of consumption, eg, sharing, reusing, and repairing

McKinsey & Company

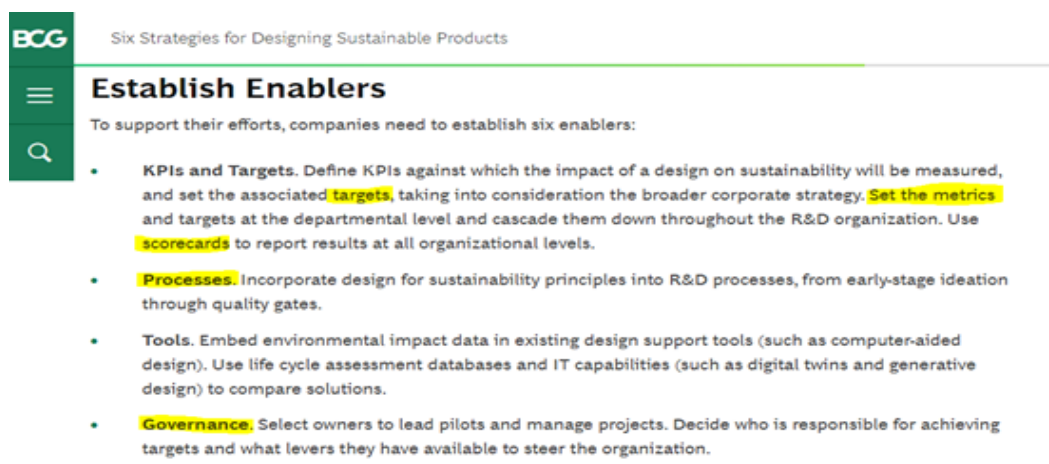**Figure 6.** Design for Sustainability Principles[9].

Now, because of the ever-changing energy landscape and the increasing importance of ESG considerations, mining firms need to explore and implement new technologies/products/services. Companies should also focus on the automation and sustainability of the supply chain and other key operations.

While designing sustainable products and services, more focus should be on the design phase/ stage. There is an understanding that the design phase is often the most effective and economical point to address the resource footprint of future products and services, which is the second factor contributing to increased focus on design sustainability. Companies have long recognized that most of the product's manufacturing, operating, and maintenance expenses are determined by design choices. Sustainability follows the same reasoning. According to data[7], R and D affects up to 80% of a product's resource footprint while contributing no more than 5% of the entire cost of the product. The sustainability of a product
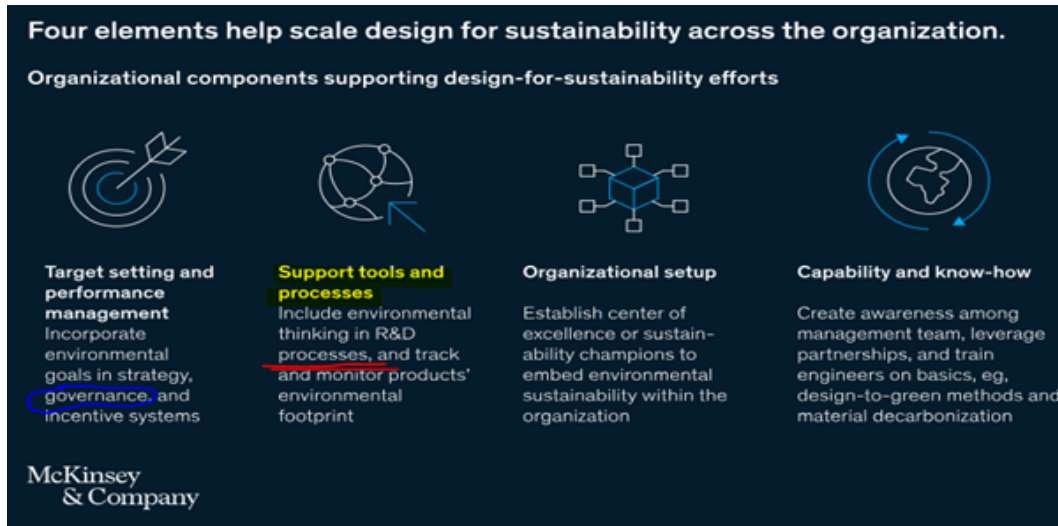
is impacted by design in various ways. Greenfield designs for sustainability may utilize less material or use recycled or biologically based materials for high-footprint virgin ones. By concentrating the energy and inventiveness of their R and D teams on the need for product sustainability, leading organizations already see significant outcomes. However, for many R and D activities, a major difficulty is figuring out how to balance the ongoing need to reduce costs, satisfy new client expectations, and set their goods apart from those of their rivals with the need for increased sustainability. There must be continuous efforts towards building a sustainable systems/ framework for sustainable product development[1,5,10-12].

3.0 Research Gap and Necessity of New Framework

Looking at the available data and trends, there is a lack of a robust system/framework which can support sustainable

BCG — Six Strategies for Designing Sustainable Products

Establish Enablers

To support their efforts, companies need to establish six enablers:

- **KPIs and Targets.** Define KPIs against which the impact of a design on sustainability will be measured, and set the associated targets, taking into consideration the broader corporate strategy. Set the metrics and targets at the departmental level and cascade them down throughout the R&D organization. Use scorecards to report results at all organizational levels.

- **Processes.** Incorporate design for sustainability principles into R&D processes, from early-stage ideation through quality gates.

- **Tools.** Embed environmental impact data in existing design support tools (such as computer-aided design). Use life cycle assessment databases and IT capabilities (such as digital twins and generative design) to compare solutions.

- **Governance.** Select owners to lead pilots and manage projects. Decide who is responsible for achieving targets and what levers they have available to steer the organization.

Figure 7. Six strategies for Designing Sustainable Products[13].

Figure 8. Elements helping in design for sustainability across the organization[9].

product development. As per BCG[13], organizations need to establish enabling mechanisms like processes, systems, and governance to ensure sustainable product/ service design, development and implementation. Organizations also need to put key enabling mechanisms like a project management office, Center of Excellence (CoE) and knowledge management system in place to ensure that sustainable product development requirements are met.

As per McKinsey[9], multiple elements will help in the scaled design of sustainable products in the organization. It will include governance, processes, training, partnerships, organizational set up (including CoE and sustainability champions) and many more as shown in the below figure.

As per McKinsey[9], the following are the findings/ gaps in the organizations involved in product design:

- Only 22% of the organization considers sustainability as a key component of their product design process.
- Only 12% of the organization considers and incorporates system thinking while developing sustainable products and services.

The above data shows that there is a need for a system to ensure that sustainable products and services are developed and that key requirements are met/satisfied by designing a sustainable solution. Mining software solution providers must also ensure that sustainability requirements are met while developing products and services. Sustainability requirements also need to be mandatorily complied with by products/services

companies. Many businesses are implementing new initiatives/frameworks to increase productivity, customer satisfaction, processes, and quality to satisfy sustainability-related requirements. However, there is a need to have a comprehensive framework/system to specifically support such products development and services[14].

An innovative system and new framework are needed to develop sustainable products, services, and processes. The framework must include practices/procedures related to safety, sustainability, and compliance[1,15].

4.0 Objectives of the Study

Sustainable product development is a new area where many organizations/companies are trying to establish themselves and contribute to the growth of the industry where there is a need to provide sustainable solutions, services, and processes. As we move towards achieving the sustainability development goal SDG, there is a need to provide products and solutions which can help organizations achieve the target of net zero and sustainable growth[16].

The mining industry has made considerable efforts in numerous sustainability issues such as climate change, pollution, land degradation/ rehabilitation, mine closure, health and safety and human rights. Mining companies have been trying to use best practices and tools to ensure sustainable management and mining through mining solutions providers/IT companies[17].

This paper aims to propose a new framework for sustainable product development. It suggests using a framework to design and develop sustainable products, processes, and services. This framework will help IT and ERD companies in planning, monitoring, and tracking the development of sustainable products/services for mining organisations.

5.0 Methodology

The researcher relied upon secondary data available from different industries to build the new framework. There are multiple frameworks used by IT companies including CMMI, ISO9001:2015 and others. The researcher also studied the existing product management processes and frameworks and their usage by IT and product development organizations.

The researcher used IT-based quality management systems' practices and sub-practices to define a new integrated framework for managing sustainable product/ service design and development.

The new framework will include processes, practices, and sub-practices that must be followed while executing a sustainable product design and development project/ program. It will be supported by a database of required standards, certifications, and AI/ ML design guidelines. To handle complicated sustainable product/solution design and development, the framework also has integrated governance, life cycle management, collaboration,

product management, reusability system, responsibility matrix, Program/Product Management Office (PMO), partnership system, vendor management, etc.

6.0. An integrated QMS combined with AI/ML Guidelines for the Design and Development of Sustainable Products and Services

Based on the above discussion and data points, we are suggesting a new integrated approach to sustainable product/service design and development. The proposed framework will consist of QMS procedures, processes, forms, templates, and guidelines. We suggest adding a database of required standards, certifications, and AI/ ML design guidelines. It also includes processes and guidelines for adaptive product design. The framework is duly supported by a risk management systems and module for compliance assurance.

The proposed framework is a combination of standards, certifications, a database of information related to sustainability, processes and guidelines for modelling. It will also include Global Reporting Initiatives (GRI), Business Response and Sustainability Reports (BRSR), carbon disclosure project, greenhouse gas protocols, ISO 14044 and other global standards. There are additional key dimensions including data intelligence,
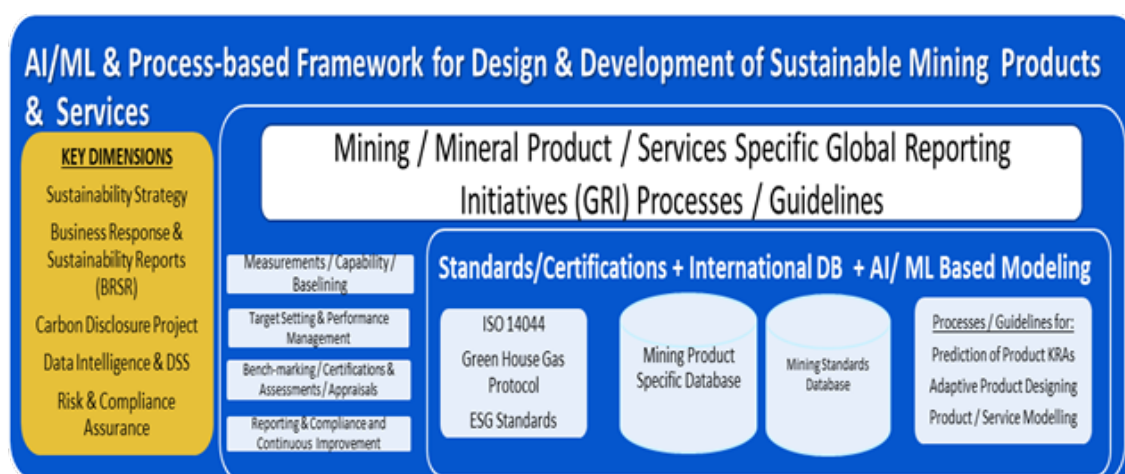
Figure 9. AL/ML and Process-based Framework for Design and Development of Sustainable Mining Products and Services by IT and ERD companies.
(Source: Research and Self-study)
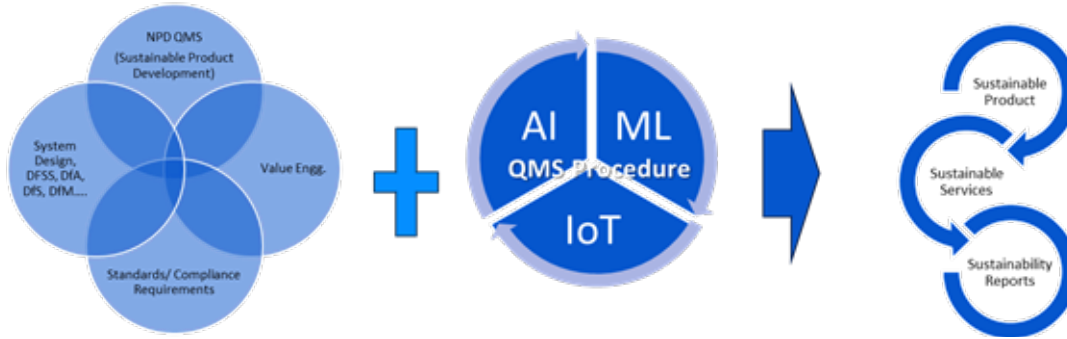
Figure 10. AL/ML and Process-based Framework for Design and Development of Sustainable Mining Products, and Services.
(Source: Research and Self-study)

Figure 11. Integrated Framework for Design and Development of Sustainable Mining Products and Solutions.
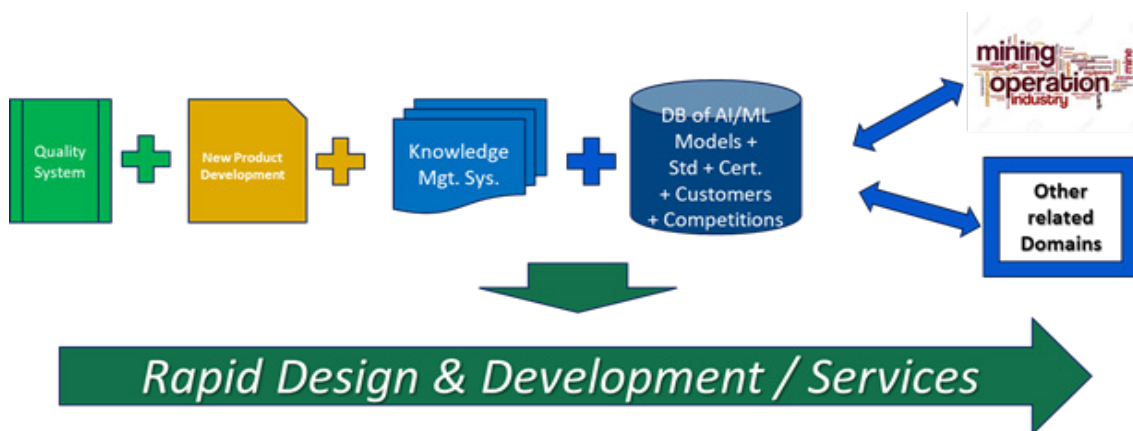
(Source: Research and Self-study)

Decision Support Systems (DSS), sustainability strategies etc.

The framework is designed to be modular and can be used/implemented as per the product profile and sustainability related recommendations/requirement of target mining organization depending on the geographic location/country of operations. It would ensure that the proposed product/solutions meet the local as well as global standards.

The proposed framework can be further customized with the addition of New Product Development (NPD) QMS, guidelines of design for sustainability, value engineering systems, standard/compliance requirements etc.

We are also proposing another integrated system which can include systems for governance, life cycle management processes, team/stakeholders' collaboration, product management, rapid prototyping, reusable system, responsibility matrix, Program/Product Management Office (PMO), partnership system, vendor management, innovation processes etc. as presented below in Figure 11. The PMO will be central control point ensuring uniform standardization and governance across the width and breadth of the product development organization. It will also provide required support to team by providing them resources, funding and strategic direction.

Figure 12. Proposed System for Rapid Product/Service Design and Development.

(Source: Research and Self-study)

By integrating all the above frameworks, we also proposing a system for rapid product/service design and development including a knowledge management system, central database and systems as depicted below:

The proposed system/framework can be used by IT and ERD companies of any size that provide services and develop mining/mineral products/solutions. The framework is very flexible and modular, which can be implemented as per the organizational need and requirements.

7.0 Conclusion

Increasing compliance requirements, changing consumer demands, and tighter laws are the driving forces behind new innovative mining solutions. Mining businesses have to act on several fronts, altering their business strategies, manufacturing processes, and supply networks. Additionally, companies are reconsidering the engineering, design, and use of their products to achieve quality and performance standards while utilizing fewer resources throughout the whole life cycle of everything they produce or consume. The moment has come for IT and ERD firms to guarantee that their mining clients are supported in this evolving landscape. India is a top software exporter, and its businesses serve clients in the mining industry worldwide. Prominent IT and ERD firms make substantial money from the services they create for multinational mining corporations. So, the

new framework is being proposed/developed to support sustainable growth.

The best practices of available QMS frameworks are used to define an integrated AI/ML-guidelines-based QMS framework, which mining product organizations and IT & ERD companies can use to monitor and track the product/solutions design and development. The proposed integrated system includes QMS, AI/ML guidelines, a knowledge management system, a CoE Framework, a Program/Product Management Office (PMO), database of standards/certifications, etc. It will support an end-to-end product development process and ensure sustainable product development as per the requirements of mining organizations.

The framework should be customized as per the organizational context and product management requirements.

8.0 Limitations and Future Direction

The proposed framework is based on the available literature related to mining, sustainability, green energy, quality systems/certifications etc. This conceptual framework needs to be validated by IT, Engineering, mining product/process/service companies and product designers. In the future, best practices and frameworks like Green Product Development, PMP-PMI-related processes can be added to make the proposed framework

more practical, acceptable, and robust. The framework can be experimented with the sustainability related tools and standards used/followed in mining organizations.

Finally, researchers and practitioners may look at introducing new product management tools, Quality Function Deployment (QFD), Design of Experiments (DoE) and other related approaches/concpets into the framework for better product life cycle management.

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