"GEOSPATIAL DEEP LEARNING ENGINEERING ANALYTICS – CLOUD BASED B2B BUSINESS INITIATIVE"

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Abstract:

A pipeline network is the most efficient and economical means of transporting hydrocarbons. Business confidence is driven by the reliability of pipeline network operational safety. Ageing and industrialisation around the network compromise component life. Our industry – any industry! - demands security against failure. Pipeline integrity is a spatial and temporal phenomenon, which demands the continuous monitoring of the network and responsive deployment of preventative measures based on network operational data. An integrity management plan (IMP) and a proactive maintenance schedule is the traditional method of boosting the pipeline network lifespan. Operators gather network performance and preventative methods data through inspection and the use of wired/wireless SCADA systems. Such data is periodically processed in an integrity model to derive optimum mitigation methods. The weakest link in the integrity management system is that, once developed, the integrity model is never refined to incorporate the dynamics of on-the-ground realities. Additionally, such modelling demands highly-skilled resources and advanced computing facilities, placing financial pressure on operating companies. For this reason, some operators may focus on putting integrity compliance in place and maintaining the pipeline network in a traditional way, potentially leading to business and societal risk.

This paper discusses a cloud-based, B2B engineering analytical model setup for pipeline operators to analyse the pipeline integrity using AC overhead lines. The paper also briefly covers B2B business economics and their industry acceptability.

In the advanced deep-learning model, when integrated with the "Data Lake", the top layer of the UPDM data model provides predictive maintenance of all assets deployed on the pipeline. It takes spatial, seasonal and temporal geographical

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Piyush has more than 25 years' experience in digital transformation and engineering Information Solutions for Energy and Utility companies across the globe. He has worked for the top three Oilfield service companies and the top four Oil Majors. He has worked for more than 10 years as a Chief Executive, helping companies to accelerate in the energy sector. Piyush has a proven track record in successful mergers & acquisitions. He knows how to create value in a company and unlock the company worth for investor benefit.

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Uma was recently rewarded best start-up CTO of the year 2017. He has more than 15 years' experience in delivering high-end technical consulting services, including multi-dimensional engineering and

changes into consideration via remote-sensing feeds, and processes the data stack via sets of nonlinear transformation algorithms placed in a hierarchy to create a statistical model covering the selected pipeline network. This results in acceptable levels of integrity within the desired accuracy parameters, using cloud computing. The technology and resources deployed can be shared amongst operators, allowing them to use the most advanced, sophisticated technology at an economic rate. The result is thematically presented over a GIS-based dashboard for easy understanding. **Key Words:** Deep learning, GIS, Integrity, Analytics, Pipeline, B2B, Cloud computing, regressing model, probability of failure, assets life.	scientific data visualisation, engineering information management solutions, business analytics and digital oil field maturity implementations for oil and gas companies. He has an excellent track record in managing distributed resources co-located across the globe, working in multicultural environments. E mail ID: uma.nath@eiceinternational.com Contact: +91 9871895200

Introduction

The convergence of technologies and innovations are forcing industries to think outside of the box. Industries must necessarily migrate from using older technologies to new and innovative solutions, in order to meet business objectives and increase profits. Organisations tend to remain focused on their specialist comfort zones, but customers are now expecting a complete, comprehensive solution via a single window. This demand has opened up new dimensions of data exchange between different specialised solutions and organisations. We observe, however, that data-interoperability between available solutions is far from smooth. The development of a full-scale solution is rarely a financially feasible proposition for any organisation. However, a single-window solution is only possible if the various solution providers collaborate on a single, scalable platform with seamless data exchange ability. Essentially, industry providers want to remain focused on their vertical, while customers are expecting a horizontal solution that cuts across all the required technology / solution verticals.

We suggest that the oil and gas industry customer is looking for a solution based on the equivalent model of e-commerce platforms such as Amazon® and Flipkart®, where a complete range of products, even competitive products, is available. Customers are able to pick and choose based on budget, preference, loyalty or other selection parameters. Similarly, in the oil and gas pipeline industry, a similar solution is expected which can offer a complete, comprehensive engineering solution. An E-commerce platform would be developed for collaborative trading (buying and selling), while an engineering solution platform would focus on the industry lifecycle, where physical, tradable items are replaced by standalone engineering and/or business solutions.

The cloud-based inter-operability engineering solution canvas (i-esc) is a collaborative platform into which each standalone solution provider can plug an application for a Universal Pipeline Data Model (UPDM). A neural network layer places competitive solutions on i-sec, where a customer solution path is determined by the customer's problem statement. i-esc partners get a fair share of the revenue, based on a time log of their solution on a pay-as-you-go model. This business model does not restrict participating solution providers from their existing business outlets.

This paper further posits that a similar, engineering collaborative platform should be developed on a cloud-based ArcGIS server, providing a complete lifecycle solution to midstream (pipeline) oil & gas industry customers. The advanced deep learning algorithm known as "back propagation" is used to define the integrity and predictive maintenance of pipeline assets. i-esc provides an economical solution for pipeline operators and civil contractors to host and collaborate/share their design, survey, testing, maintenance, asset, and other engineering and business data. This offering requires no capital investment. The platform offers a full range of engineering solutions that address the complete lifecycle of a pipeline from planning to construction to operation and eventually abandonment.

Business Model Canvas

The innovative, collaborative implementation of different engineering solutions on a single platform fully addresses the engineering needs of the pipeline industry. The UPDM data model can be modified to address multiphase flow engineering solutions on the pipe network. The inter-operability engineering solution canvas (i-esc) acts as the foundation layer, whereby various engineering solutions are placed side by side. The competitive solutions move upward/downward in their respective solution verticals. Thus, i-esc connects the nXn solution matrix on the single platform as shown in fig 1. i-esc connects the individual solution data model with the UPDM. If the UPDM does not have a placeholder for a specific data set, then provision is made whereby a solution partner can either create an additional table in the UPDM, or store the solution-specific data model in the cloud database. All applications and the database itself have well-defined security policies in place.

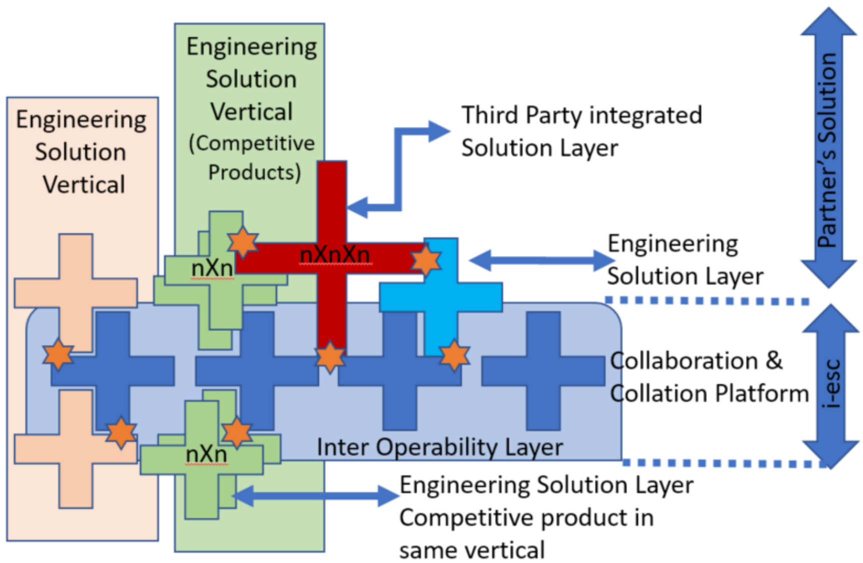


Fig: 1 – Business Model Canvas

i-esc is designed for most data sets currently used in the pipeline industry. The appropriate unit conversion layer is developed to support industry-based and formula-based unit conversion. If a solution partner is using specific imperial values or mathematical constants, then provision is made under the interoperability layer to store application-specific data on the server. Such data would only be accessible to the designated application. The same model is applicable in keeping imperial, curve-based solutions. i-esc also facilitate solution partners in service collaboration, whereby the solution partner collects customer input, processes the request and sends the data back to i-esc for the user to view and download locally. This provides the solution partner with algorithm/ computation protection. The i-esc platform also enables users to host their data in the cloud, where they can run applications on demand.

Competitive Solution Canvas

The competitive solutions in a vertical business space are connected though a "Predictive Model". The selection of the right model amongst competitive solutions is scrutinised by an expert system, based on data input from the user. The competitive business model works on a scaled down version of i-esc, catering to specific solution verticals as shown in figure 2. The competitive model is a vertical solution of the 1Xn matrix. It is designed in such a way that any solution provider can use the input-output data model layer to integrate its own solution with i-esc. The expert system recommends the best fit solution path to the user; the selection can be interactively refined later, based on the users' recommendations and ratings.

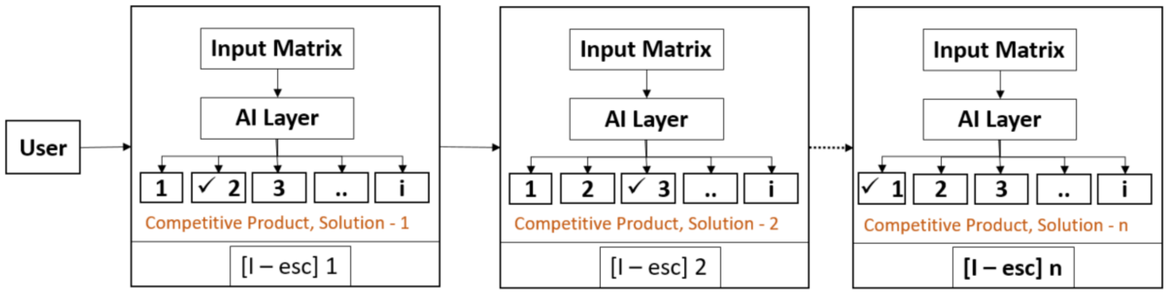


Fig: 2 – Competitive Solution Canvas

The following solution vertical modules are developed on i-esc, and are now open for competitive solution providers to plug-in their application:

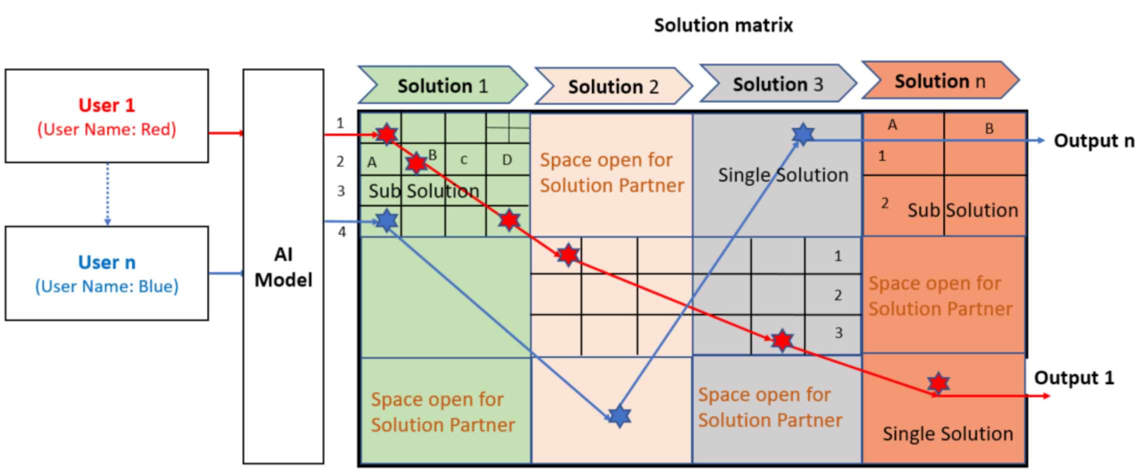
- **Pipeline Data Model:** keep engineering, operational and assets data online
- **Pipeline Route Selection:** enables the user to interactively decide the route to the best solution. Multiple options can be saved based on various design criteria
- **Pipeline Material Selection:** helps the user to select rigid, flexible or composite materials based on design parameters, field data, fluid property, material cost or transportation cost. It generates a BOQ (Bill of Quantity) and costs of materials
- **Pipeline Corridor Planning:** facilitates layout of the centreline, develops the buffer and decides the best corridor based on selection criteria
- **Pipeline Alignment Sheet Generator:** develops alignment on the GIS map and provides the alignment sheets and plan layout (X, Y)
- **Pipeline Stress Calculator:** calculates different stress profiles based on alignment and design/operating parameters
- **Pipeline Wall Thickness Design:** pipe thickness is designed based on Internal Pressure, MAOP, Burst model, Propagation model, local buckling and the buckle propagation model
- **Anchor Design:** assists in designing the support anchor on bends
- **Pipeline Foundation Design:** enables the design of anchor foundations for pipe supports as well as the foundations for any other standalone structures deployed in corridor, such as solar panels etc. It also provides pipeline on-bottom stability design, secondary stabilisation such as concrete blocks, geo textiles, rock dumping etc.
- **Pipe Design:** assists in designing diameter, thickness, and materials, based on design parameters
- **Pressure Distribution in Network:** calculates the pressure distribution in the network using operating parameters, material properties and age etc.
- **Coating Design:** designs corrosion coating, insulation coating, concrete weight coating and field joint coating
- **Corrosion Model:** used in corrosion analysis, proposes methods for mitigating corrosion

- **Heat Loss Design:** computes the heat loss and changes in fluid properties. Required for heated pipelines management
- **CP Design:** designs the CP system, rectifier, anode bed and bond box (for crossing) of network
- **Expander Design:** designs thermal and pressure expansion safe relief joints
- **Data Model:** supports the UPDM and POD data model. The data can be exported in any GIS or CAD format
- **Unit Conversion:** converts the engineering and scientific units used in the oil and gas industry
- **Hot Tap:** designed to connect existing operating lines with another section of pipe, without disturbing the existing operation
- **HDD**: calculates the stress that a pipe segment will experience whilst being pulled through an HDD curve conduit. The application also designs the bore path curve to make it easy to install HDD conduits based on sub-soil parameters

Note: The solution canvas is not yet complete as it does not cover several aspects of the pipeline: for example, "free span analysis" ILI module etc. This will be completed in due course.

Solution framework

The solution framework is mostly developed by maintaining a simplistic approach whereby the user provides a problem statement. For example, the user requires mitigation for high voltage AC lines. The problem statement defines the input requirements. Some of the input would be available from the user in the form of GIS data (eg; route shape files) and any remaining input may be entered via GUI. The application enables the user to import GIS data and tables to the UPDM. Some of the data which is critical for analysis could be public in nature, for example the current layout of AC transmission lines. The system takes this as map data and uses it for analysis. The output is saved in the user database and the result can be generated via geo-visualisation. The user can instruct the system to check the data regularly with respect to public feed and ensure compliance. For example, a user wants to ensure the integrity of a pipeline with respect to seasonal changes and flooding announcements from the USGS in USA.



User Red Output = {Solution: 1 (1.1.A+1.2.B+1.4.D) + Solution 2 (2.1.A) + Solution 3 (2.3.B) + Solution n(3)}
Blue User Output = {Solution 1 (1.4.A) + Solution 2 (3) + Solution 3(1)}

Fig: 3 – Solution Architecture

Competitive Solution Engagement

In this case the final solution could be derived from the combination of two or more applications. In such a case, the system provides a user dashboard to select available solutions. The user is also able to define additional solutions if required. The system automatically schedules the input/output sequence based on the selection and produces the output as shown in Fig 3.

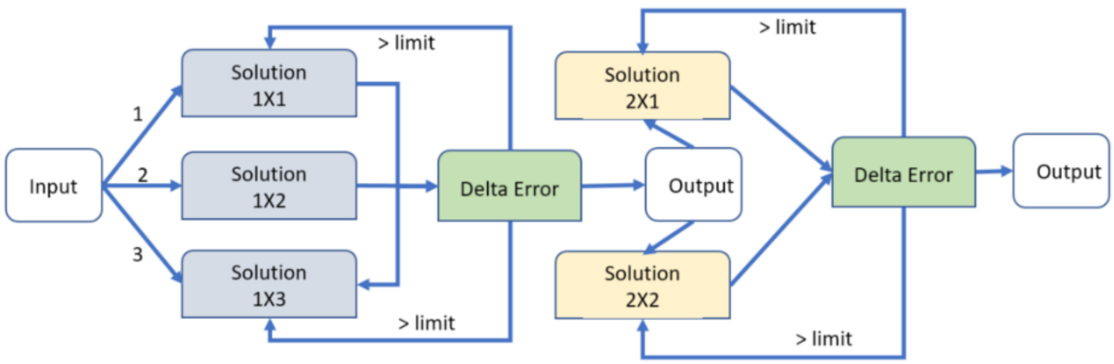


Fig: 4 – Comprehensive Competitive Solution Engagement

The application becomes complex when competitive products are also available, and the user wants to test results using the best solution, but is unsure which solution to choose. In this case the input matrix passes the data to multiple solutions available on i-esc. Every solution output is compared and an interactive feedback mechanism (delta error) is passed to the input training matrix. This process is iterated until the desired accuracy is <u>not</u> achieved. Provision is made whereby the user may allocate confidence weighting to the solution and the application produces the output accordingly. The iterative solution diagram is shown in fig 4. Solution compartments are connected though non-linear functions (as per input need) so that the composite system can take multiple inputs simultaneously.

Inter-operability engineering solution canvas (i-esc)

The customer expectation is for a complete solution, but organisations can no longer fund the development of proprietary solutions. Allowing the organisation to focus on its own area of expertise and participate in a digital solution-based marketplace, is the best way to retain customer loyalty.

The Inter-Operability Engineering Solution Canvas (i-esc) is the solution. It is designed to encourage small solution providers, university researchers and experienced, retired subject matter experts who have brilliant computational solutions but are struggling to gain wider visibility. Plugging their application into i-esc will give them access to a larger user base, higher visibility and additional revenue streams, without impacting on their current business practices and schemes. The system transparently tracks the use of all solution partners' applications (using internal licensing and a token policy), and the revenue is accordingly shared between participants.
i-esc is a cloud-based platform which provides engineering solution partners (B2B) with the ability to plug in their products with minimal reprogramming. i-esc uses the modified UPDM model hosted on a cloud-based SQL server. The UPDM is modified to accommodate temporal and spatial engineering, business, sub-surface geology, cartographic, surface geology, social, environmental, operational and maintenance data. Generic GIS navigation and Geo-processing services are made available to solution partners whilst developing or porting their application on i-esc. Most solutions that address complex engineering problems are non-GIS in nature. Such solution partners are using GIS web services and featured services interactively to take the input and present

the result thematically on GIS. This has added value to solution partners without any investment required. Modelling of the pipeline network and tagging assets with centreline was a major challenge. The UPDM analysis layer takes the real-time input from a SCADA system and computes the result. For example, CP data is being collected automatically from the field via a SCADA feed. The pipeline owner can simply connect the real-time SCADA feed to the system and see that the pipeline network property is protected. Such results are visualised on a GIS thematic-based dashboard. The system is also designed to take input from public feeds such as flooding, forest department boundary changes, road rights of way, weather, new transport network data etc. This data is regularly processed in the system and provides vital information to the pipeline operators.

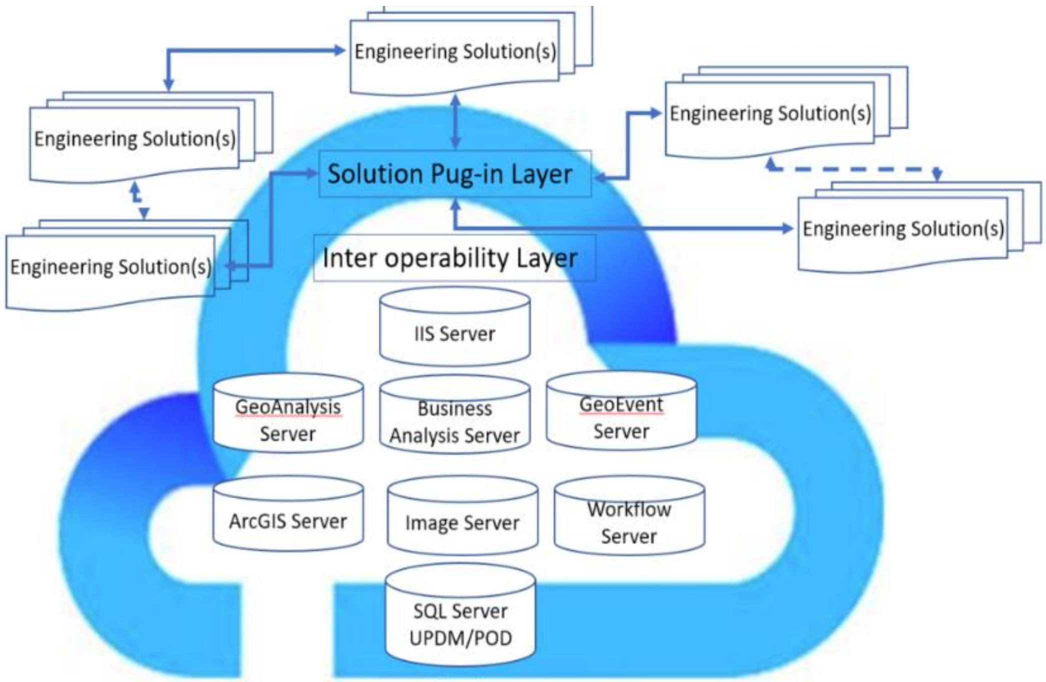


Fig: 5 - Inter-operability engineering solution canvas (i-esc)

Predictive Maintenance of Asset

The biggest challenge in the oil and gas pipeline industry is ensuring asset reliability. The ultimate objective for a pipeline operating company is to move from reactive to proactive maintenance. The aim therefore is to increase asset reliability, improve performance, reduce asset downtime, and reduce overall maintenance costs. Ultimately this will result in increased profitability for the organisation.

Asset reliability becomes critical if a pipeline passes through environmentally sensitive areas and/or urban populations. An organisation cannot afford asset failure and must therefore aim for proactive maintenance of all assets. Prediction times are critical. If maintenance is predicted and carried out too early, it reduces the lifetime of the asset, and if predicted too late there is the significantly increased probability of unexpected failure. Predictions should also be synchronised with the purchase system, ensuring minimal storage shelf-time.

Machine-learning is the most effective, perhaps the only solution. A normalised data layer is built on top of the UPDM, providing a feed to a machine-learning system. The right machine-learning model is determined based on the relationship between dependent and independent engineering variables. The life of an asset is defined as the multiplication of “Likelihood of Failure (LOF)” and “Consequence of Failure (COF)”. LOF further depends on internal or external corrosion, third-party events, design, material geology, ground conditions, operating conditions, stress corrosion cracking, past maintenance, skill of team involved in past repair etc., while COF is greatly dependent on social, political, environmental and meteorological data parameters. All such data has placeholders in the UPDM and once the machine-learning model is implemented, the organization will get greatly improved predictive asset reliability data. The system matures over time as the training matrix matures. i-esc facilitates multiple users in hosting their data on a single platform. This results in faster learning by the training matrix. This collaboration helps the even the smallest pipeline operator proactively to predict their asset maintenance schedule accurately, even with a smaller set of historical data. In this way, AI is addressing the problem of gaining insight based on the cleaned and structured data pulled out from the UPDM. This data is organised as input to the machine learning algorithm. The pipeline asset model is designed currently based on four sub models as listed below:

Regression Model to Predict the Remaining Service Life: based on just one type of path of failure, generally provided by the manufacturer or based on past historical industry records

Probability of Failure of Assets Within Remaining Life Span : predicts the probability of failure based on LOF parameters. Probability increases exponentially based on time scale

Prediction of Anomalous Pattern: this is mostly based on field observation. An algorithm is designed to establish the relation between the field spectrum of observations and likelihood of failure

Prediction of Failure Probability: this model focus on prediction of failure, taking into account past maintenance and COF data.

The final prediction of assets is based on the logical combination of above four sub models. The biggest advantage to the user is that asset reliability and predicative analytics can be done without engaging experts and requiring capital investment.

Conclusion

We live in a connected world, working in highly-specialised areas but functioning in silos. The biggest challenge is to reap the benefits of fellow subject matter expert and collaboratively provide a comprehensive solution to the customer. The cloud-based B2B engineering solution model is a unique business proposition, enabling small to medium solution providers to dissolve the silos. This business model facilitates users in acquiring the right solution from a single window on a “pay-as-you-go” model without any capital investment. The collation of engineering solutions is the best business model, enabling individuals, experts, consultants and universities to publish their innovative solutions, providing revenue without market complications. The current system is developed for the oil and gas pipeline industry, but similar solutions could be developed for other engineering sectors. This is the ideal marketplace, providing an ecosystem for technology, talent and time. Optimum value will be derived when the system operates with the collaboration of both human and machines, retaining viable economic security at its centre.

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