

Enhanced Engineering Decision Making with Digitally Interpreted Knowledge

TCS' PREMAP Integrates Knowledge, Data, and Simulation

CIMdata Commentary

Key takeaways:

- *Product development is increasingly a complex system-of-systems problem requiring effective, efficient decision making to solve.*
- *Knowledge comes from experience, scientific insights, best practices derived from simulation, data, and observations. It is often acquired in an enterprise in various forms besides being in the heads of experienced engineers.*
- *Competitive pressures are driving manufacturers to transform their development strategy and toolsets, making sure all knowledge is considered and applied effectively.*
- *Applications which can deliver knowledge contextually will play a key role in defining the future of business, customer experiences, and product or service behaviors of the agile enterprise.*
- *By leveraging its deep product engineering and manufacturing experiences, TCS has expanded their proven PREMAP digital knowledge curation and algorithmic reasoning capabilities to provide a comprehensive suite of solutions and services for accelerating product and operations decision processes.*

CIMdata's definition of product lifecycle management (PLM) emphasizes the complete lifecycle of a product and all its related data and processes, from requirements to planning and supply chain participation, then mass production, actual in-use performance, product service and upgrades, and finally decommissioning and recycling. Knowledge captured and recorded across products lifecycles is often document-based and not easy to find when needed. Even knowing where to look for the latest insights and putting them into the decision flow is too complicated. Systems engineering accelerates product development and operations by considering broader contexts—including all the operational environments. However, the sources of knowledge and the explosion of empirical data from all stakeholders are overwhelming. Organizing and orchestrating rigorous product decisions requires modern computer-based contextual knowledge delivery tools along with continuous curation of knowledge as it is discovered and refined.

Staying competitive requires the use of computer-based tools beyond design capture, optimization, and simulation for verifications. CIMdata has studied and written about the notion of continuous product performance monitoring enabled by connections to sensors monitoring customer environments and usages. Collecting field data enables faster learning with refined knowledge—but companies need faster ways to manage and apply this newly discovered knowledge (the ability to perform more and better design/performance optimization).¹ Computer based knowledge curation and reasoning algorithms sensitive to varying contexts make knowledge actionable.

Accelerating the best decision-making processes is becoming a competitive differentiator practiced by market leaders. Computer-aided engineering is quickly becoming **computer-accelerated engineering** as companies master techniques to improve their knowledge

¹ Research for this commentary was partially supported by TCS

acquisition, curation, and application. More and more this is done with databases and search engines built with algorithmic interpretable techniques using contextual delivery and execution. Self-service, just-in-time, decision applications are emerging as a necessity to remain competitive. TCS has helped many companies solve large, complex decision processes. PREMAP is the latest example of TCS knowledge, data, and simulation management technology being deployed at their customers to improve many kinds of decisions.

What is PREMAP?

TCS describes PREMAP as an engineering decision automation platform that provides contextual knowledge driven orchestration of data, simulators, and machine learning (ML) models for creating rich no-code applications which can be immediately deployed on the cloud.

PREMAP’s heritage is in determining optimal engineered material products. Determining material properties often involves careful, costly experimentation to discover failure conditions. Using simulation, once correlated, to explore the performance boundaries of a refined material speeds up scientific discovery and understanding. Knowledge guidance plays a key role in making better decisions with higher confidence. Combining historical knowledge with simulations and the most recent laboratory measurements improve the context for materials engineering decisions.



Figure 1—TCS PREMAP Architecture: Analysis and Data Connected to Knowledge Repositories (Courtesy of TCS)

TCS researchers built PREMAP—A Platform for the Realization of Engineered Materials and Products—early in the last decade. It helps engineers and scientists link data acquisition with advance simulations to improve product decisions. Machine learning is used to process data so it can be consumed with digital twins and fed into the knowledge-driven reasoning and decision-making improving speed and quality. The journey to discovery and understanding must follow rigorous scientific methods without constraining the exploration paths. Constant

learning during discovery is key to incorporating new concepts into products and bringing them to market.

Figure 1 shows how information can be combined from digital twins, machine learning, IoT devices, formulae and rules, tacit knowledge, correlated simulations, and optimization to enable decisions. Connecting these elements requires an all-encompassing ontology² which is a semantic broker amongst these knowledge domains. CIMdata believes a significant benefit of this approach is that automation becomes significantly enhanced with contextual knowledge delivery with or without a human in the loop. Rather than searching for relevant documents in libraries, specific knowledge is delivered when needed for the next decision.

While the original PREMAP solution was developed to support the materials engineering domain, similar algorithmic techniques can be applied to the broader product development realm enabling all kinds of product decisions across the complete lifecycle and these are being applied to multiple engineering industries including oil and gas, pharmaceuticals, automotive, aerospace, etc. TCS has received many patents for PREMAP in the last decade.³ Applications built on the PREMAP platform allow users to build decision aids as their knowledge grows and is refined.

TCS PREMAP Platform Expands to all Decision Makers

TCS recognizes that all core business processes for all product disciplines must make effective, timely decisions. Based on their proven methodologies and experience, they have developed a platform, PREMAP, which lets engineers and leaders build decision specific applications. The order and depth of decisions will keep changing as knowledge about products and the engineering processes evolve, and PREMAP enables continuous incorporation of this new knowledge into existing applications. Knowledge curation and refinement becomes continuously enabled through an evolving ontology with a semantic knowledge modeling framework. The refined knowledge may come from various sources including empirical observations from the data. This means knowledge, derived from any of the sources identified in Figure 1, is served proactively as and when decisions need to be made.

As TCS' PREMAP success within the engineering community demonstrated, PREMAP helps leaders organize and orchestrate decisions using simulation, evaluations, and relevant knowledge to improve their depth while likely reducing the number remediation change cycles. Reasoning automation helps explore knowledge databases proactively that will accelerate engineering decision making. Cloud deployment enables easy sharing. Applications developed on the PREMAP platform, constructed by the users themselves, help orchestrate timely decisions by providing easy access to relevant knowledge, whether it is fundamental or recently discovered. By delivering contextual knowledge, simulation exploration, and the latest customer experiences as the decisions are made, TCS helps organizations accelerate all phases of product development, manufacturing, and service.

By combining simulation, digital twins, and analytics capabilities with effective data management and knowledge repositories, TCS's PREMAP platform improves knowledge driven orchestration as noted in Figure 2.

² [Web Ontology Language - Wikipedia](#)

³ US20170039298A1, WO2016051338A1, WO2017175080A1, US11023507B2, WO2021191933A2, EP4064076A1

Technologies & Products

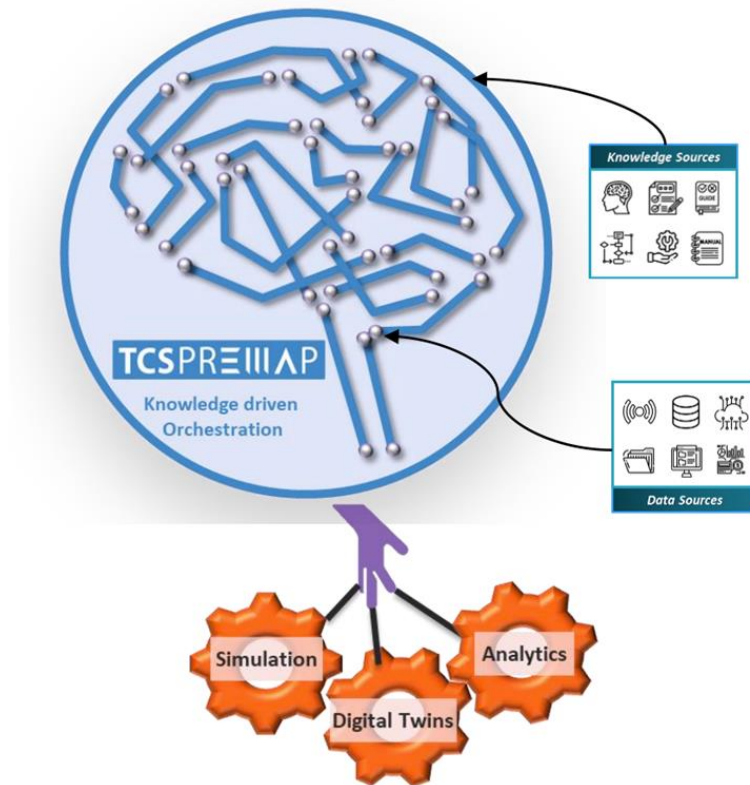


Figure 2—Empowering Leaders & Engineers with Knowledge-Driven Orchestration
(Courtesy of TCS)

The nodes on the blue paths are decision points which need insights, evidence, and knowledge. Insights come from simulation, analytics, and digital twins. Evidence comes from field data and experiences. Knowledge comes from learning, reasoning, and discovery. Many parallel paths occur as products are engineered—some for specific components and others for subsystems integration. Switching from one path to the next or an alternative is how skilled engineers makes decisions. By providing a decision dashboard which automates the collection and display of knowledge as it is learned, PREMAP is aiding the orchestration of knowledge driven decisions. Earlier discovery helps accelerate concurrent engineering. CIMdata believes that TCS' PREMAP will enhance flexible, agile, decision making across PLM lifecycles.

TCS has customers using PREMAP for different types of applications within different industries. In commercial aerospace it was used to orchestrate and confirm skin-stringer design by automating the client's complex analysis methods requiring more than 30,000 load cases, hundreds of configurations, and multiple safety criteria resulting in hundreds of millions of evaluations. PREMAP improved traceability between the knowledge and data sources with the skin-stringer design interface. It also reduced design verification time by over 50%. At the other end of the lifecycle, PREMAP is also used by TotalEnergies, builders and operators of large oil and gas refineries, to predict impending failures. Mr. Nicolas Ranchet of TotalEnergies explained how they validated the use of PREMAP within their online FMEA system for risk

management and planning component replacements before they fail, which improved their “on” time maintenance.⁴ Contact TCS for more insights on their growing PREMAP customer base.⁵

Concluding Remarks

TCS evolved their PREMAP invention for developing new material products into a much broader platform that supports product decisions based on and sensitive to knowledge and experiences to be applied to diverse products and operations across industries. Assuring safety by applying trusted, shared knowledge relying on models that learn from expansive product sensing during operation is now possible. Building trust in virtual models of an operational environment requires constant evaluation of customer real-world scenarios. Leveraging real-world measurements to correlate virtual model-based scenarios using digital twins with digitally interpretable tacit knowledge to help assess complex operational anomalies will make product upgrades and operations enhancements safer and more reliable, thereby fostering societal trust. Constant learning and adaptation keep product and process models relevant and trustworthy. Doing this in near real-time keeps them well correlated and therefore more useful as applied knowledge.

Automating decision making brings consistency and speed to product development, operations, and service. Teams working collaboratively in parallel while using the same trustworthy models will develop enhancements and/or investigations from different expert contexts. Considering multiple decision-making contexts is possible when knowledge derived from actual usage patterns is readily accessible to decision-makers when needed. Product engineering has always focused on what customers value—safety, fun, luxury, and lifestyles. TCS’ PREMAP is better than many knowledge management solutions—which often manage only documents, because it can provide understanding in actionable ways and facilitate algorithmic reasoning over curated knowledge. CIMdata expects that product developers using TCS’ PREMAP platform will improve their use of simulation, machine learning and knowledge management leading to better products. Development processes will evolve as the order of decisions changes based on agile, knowledge driven orchestration—keeping actual product usage understanding visible. Comprehensive, efficient product engineering remains a competitive advantage and decision process innovations will be transformed with TCS’s PREMAP.

CIMdata recommends that companies evaluating their need for improved, agile decision making consider TCS’s PREMAP. As pervasive computing and sensing grows in all products, TCS’ PREMAP provides a platform for adaptive decision making as knowledge is discovered.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise’s ability to design, deliver, and support innovative products and services by identifying and implementing appropriate digital initiatives. For nearly forty years, CIMdata has provided industrial organizations and providers of technologies and services with world-class knowledge, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) solutions and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs

⁴ <https://www.aiche.org/academy/conferences/european-conference-on-process-safety-and-big-data/2020/proceeding/paper/knowledge-driven-online-fmea-system-risk-management-petroleum-refinery>

⁵ <https://www.tcs.com/what-we-do/research/driving-engineering-decisions-through-digital-transformation>

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