Kepstrum
INVENTOR OF PRODUCT DNA™
and MODEL-BASED PROGNOSTICS

Oct 3rd, 2023

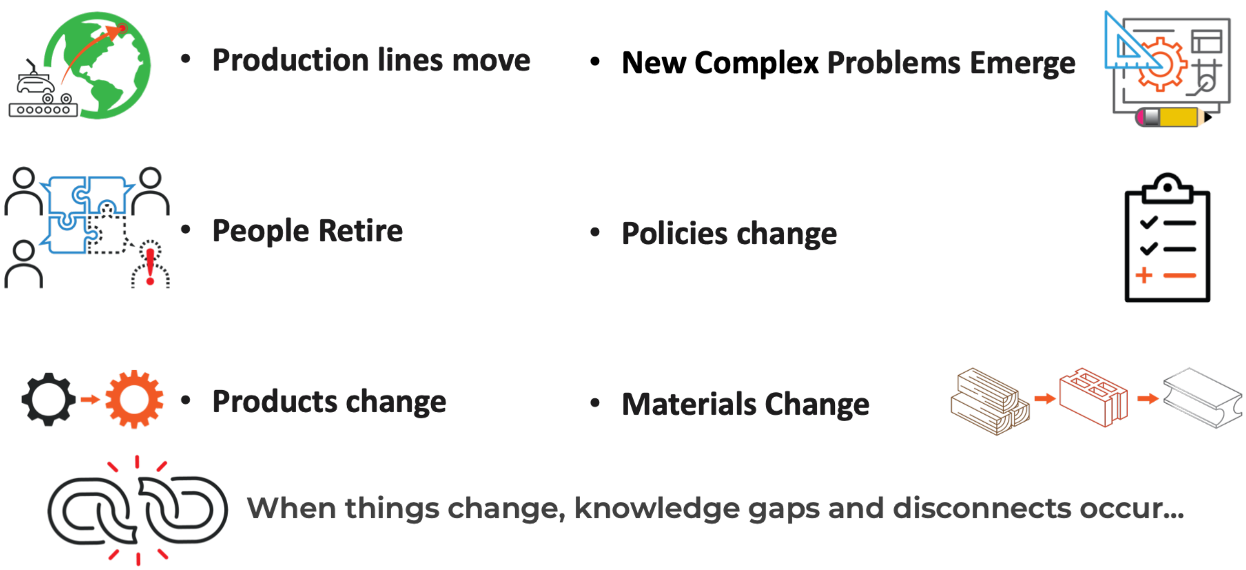
TRACEABLE KNOWLEDGE

DSP's Foundation for Advanced Engineering

Abstract

As engineering industries evolve with technological advancements, changing customer demands, and regulatory shifts, there is an unprecedented demand on engineering organizations to upgrade their existing technologies and develop new ones at break-neck speeds, all while **Original Equipment Manufacturers (OEMs)** are pushing to move to Virtual Validation methods in the near future. To successfully meet these challenges, organizations must employ new methods of converting their members' knowledge and experiences into lasting knowledge assets that are accessible, transferable, and reusable. This shift necessitates overcoming the limitations of traditional file-based knowledge management, risks like organizational silos, opportunity costs of immobilized experience, outdated practices, and challenges in integrating new engineers. Kepstrum's **DNA Structured Platform (DSP)** offers a solution for advanced engineering teams by serving as an integrated knowledge management and virtual system work platform that digitizes knowledge, traces decision rationales, and formalizes a model-based development process built on the use of analytical modeling. This integrated approach provides a stable foundation for Virtual Validation practices by ensuring important information is accessible to the entire organization, empowering engineering teams to reduce testing, shorten development times, and rapidly respond to **requests for quotation (RFQs)**.

Things Change...



DSP's traceable knowledge has the solution!

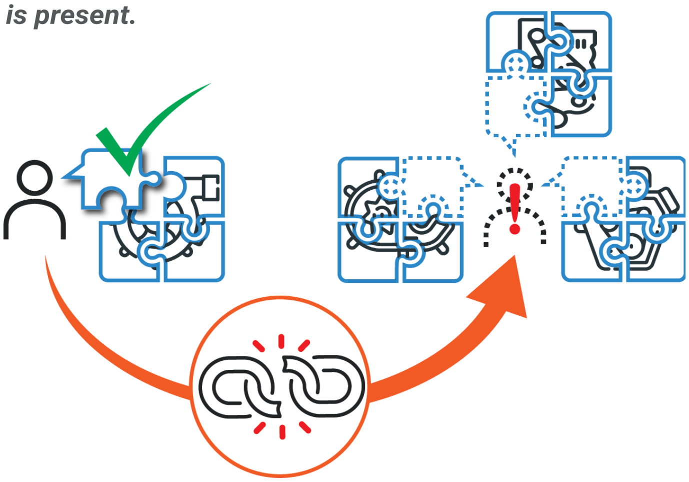
In the modern economy, the transition from resource-based models to knowledge-driven ones is apparent, particularly in sectors like manufacturing and engineering, where knowledge is now the primary driver of innovation and economic growth. While the experience and knowledge of an organization's engineering teams are invaluable assets for developing new technologies and improving existing ones, organizations face challenges in fully harnessing them. At the same time, in a rapidly changing business landscape, solely relying on individual experience can also lead to organizational silos, missed opportunities, challenges in integrating new hires, and inefficiencies that hinder an organization's ability to adapt and achieve consistent growth.

Challenges: The Risks of Relying on Experience

Experience, while important, can become a crutch that inhibits progress and innovation. Reliance on individual experiences can pose substantial risks for engineering companies and impede the broader dissemination of knowledge, resulting in organizational silos and a lack of synergy. There is the risk that experience relevant to multiple organization-wide endeavors can be missed, and valuable insights and expertise that could contribute to diverse projects and initiatives may be overlooked. A narrow focus on individual experiences may inadvertently lead to the exclusion of alternative perspectives and innovative approaches, limiting the organization's ability to explore new avenues and optimize outcomes.

The Opportunity Cost of Immobilized Experience

In Lean Thinking, making use of your employees' talents isn't just a good thing, not making use of them is a bad thing. This problem scales up when you take into account that having an experienced person who is idle is only part of the larger problem of their experience itself being idle at the organization. If the experience of individuals is not harnessed and converted into tangible usable processes, transferable knowledge, or organization-wide understandings, its benefits will only be available to the organization and the individual's immediate peers ***while the individual is present.***

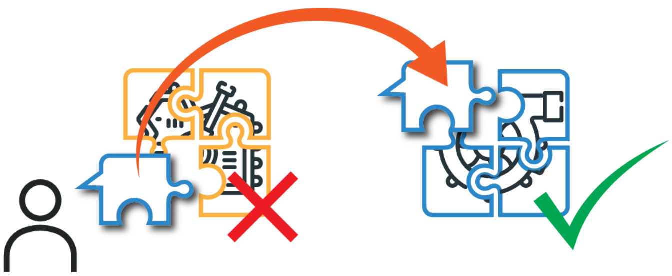


An engineer cannot be in two places at once; their experience may be the missing link for other projects

Outside of the mmediate results that the individual and their team generate, the organization as a whole fails to maximize their benefit from the leveraged experience. When an engineer's experience is contributed to one project, it is essentially unavailable to the rest of the organization until the engineer is available again. project, it is essentially unavailable to the rest of the organization until that engineer is available again. To address these challenges, organizations must adopt a Lean Thinking approach that not only makes use of employees' talents but also avoids the opportunity cost that occurs when their experience is localized.

The Risk of Relying on Outdated Experience

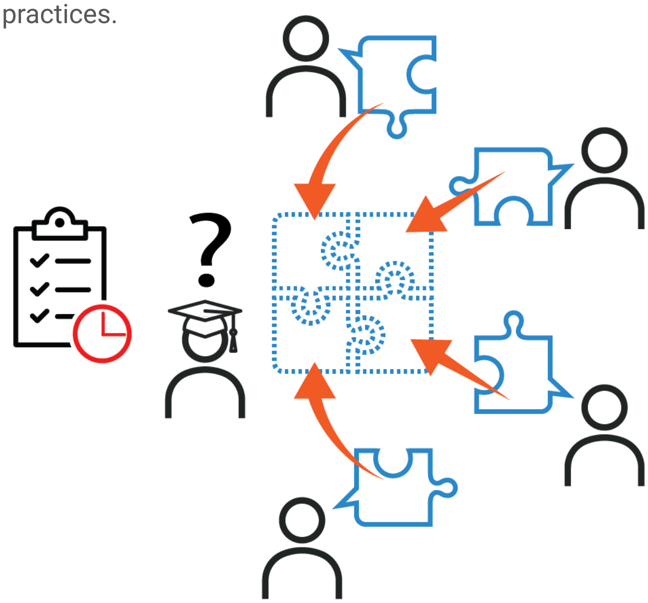
As technology evolves and market demands shift, the opportunity cost of idle experience is compounded by the risks of relying on experience that is outdated or unsuited to specific tasks. Outdated experiences may not align with emerging trends and evolving technological standards, leading to suboptimal solutions and potential setbacks, while experience that is unsuited to the unique requirements of a particular project can result in ineffective problem-solving and inefficient resource allocation. To mitigate these risks, engineering companies must recognize the need to balance experience with continuous learning and the integration of new knowledge. Experience must not only be converted into an easily accessible asset, but an easily interchangeable and amendable one, wherein the experience and knowledge used is always retrieved from an up-to-date collection of all available knowledge, guided by the assessment of its suitability to the task at hand. Organizations must simultaneously strive to eliminate the risk of relying on outdated experience as well as missing out on the use of relevant experience.



Experience that is unsuited to one project may still be helpful to other teams

Integrating the Next Generation of Engineers

Another challenge that organizations face from experience-reliant development processes is the rapid integration of the next-generation of engineers into their ranks. As management hires junior engineers, they are expected to contribute to development processes that are heavily reliant on experience they may not possess, and which can take significant time and effort to acquire. Consequently, training is a dual front task. Firstly, new engineers must familiarize themselves with formalized practices and processes. Secondly, they must bridge the knowledge gaps that exist between them and their experienced peers, particularly in terms of non-standardized problem-solving methods and best practices.

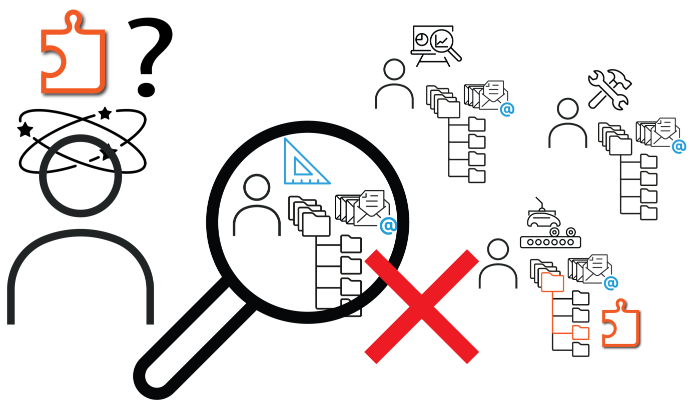


Entry-level engineers need time, and access to multiple colleagues, to fill their knowledge gaps

This two-fold process of ensuring new engineers are effectively trained not only requires significant time and resources, but also exposes them to the aforementioned risks of inadvertently learning outdated or inefficient practices in an environment where the knowledge base is not being proactively managed. Moreover there is a risk that the fresh perspectives and up-to-date physics knowledge of new graduates could be overlooked in favor of continued adherence to established processes and deference to more senior engineers who do not have the means to easily adjust their own practices. To overcome these challenges, there must be a way for entry level engineers to easily access and understand the information in the organization's database, as well as a structural shift that inspires all employees to adopt change by actively using and contributing to an interactive knowledge base.

The Limits of File-Based Knowledge Management

The value of an individual's experience cannot be understated, but experience is a personal phenomenon, with its value to the individual and to the organization depending on their mutual ability to apply and learn from it. In building a healthy knowledge base, organizations face the challenge of effectively harnessing an organization's wealth of experience while mitigating the risks associated with overreliance on that experience. However, it is not sufficient to merely accumulate knowledge, in haphazard forms, in sprawling and disconnected repositories, as this can lead to confusion and disorganization.



It can be difficult to find the right answers amongst files, e-mails, and disconnected knowledge repositories

A file-based and unstructured approach to knowledge management can result in a number of problems. Files are as personalized as experience, with naming conventions and locations of files being left to individuals. Inconsistent terminology and inadequate document tagging on the part of individuals can impede information retrieval, and the lack of a structured system can make it challenging to efficiently search for specific information. Furthermore, as changes are made and files are passed from one person or team to the next, it becomes increasingly difficult to keep track of the most up-to-date information between the multiple versions that are scattered across the organization.

Ironically, in this context, experience is required to navigate the knowledge base, and sometimes the only way to find important information is to already know where it is located. If the individuals who know what a file was named, where it was placed in the repository, and whether or not it is the most current version happen to leave, that knowledge will be hard to access thereafter. This is in addition to the knowledge gap that is created by the departure of that individual whose experience, in terms of knowledge and practices, may not have been well documented or converted into formalized practices.

In the same way an individual's experience is localized, critical information in files may become isolated within specific departments or teams. Without a well structured central repository, duplicated efforts may occur unknowingly, and managing access to sensitive documents becomes problematic. Additionally, documents often lack context or decision-making rationale, making it challenging for all employees regardless of seniority, to understand past decisions. Changes in regulations or industry standards pose a risk as well, as outdated documents may lead to non-compliance and legal issues. All of these limitations underscore the importance of adopting a structured and comprehensive knowledge management system.

Building a Healthy Knowledge Base

Addressing these challenges requires a shift in both development processes and knowledge management methods, where they become integrated with one another. Furthermore, in the context of solving engineering problems and making engineering know-how transferable and accessible, the development process must be structured around the use of physics-based models.

In order for an engineer's experience to be transferable, it must be transformed into knowledge that can be understood and accessed by all engineers in the organization. There are two fundamental dimensions to any engineer's experiential knowledge:

1. The engineering know-how that encapsulates their understanding of a product's function, mechanisms and material properties.
2. The process know-how that encapsulates their understanding of how their team makes decisions and executes tasks related to designing, modeling, testing, and manufacturing a product.

To capture an individual's engineering know-how, the content of the development process they partake in must be based on the use of physics-based models, while their experience and knowledge that falls outside of the realm of physics based-understandings should be captured and integrated into a digital framework that aligns with the development process itself. An effective knowledge base must be integrated into the development process, not stand outside of it. This necessitates the use of a **Model-Based Systems Engineering (MBSE)** platform that manages a physics-based development process in a virtual environment while serving as a centralized knowledge repository that links the various kinds of knowledge and data used to the steps of the process in which they are used.

Kepstrum's DNA Structured Platform (DSP) is an enterprise-level MBSE platform that embodies this integrative and physics-oriented approach. DSP serves as a centralized knowledge management and virtual system work platform that ensures important information is accessible to the entire organization and not localized to individual engineers.

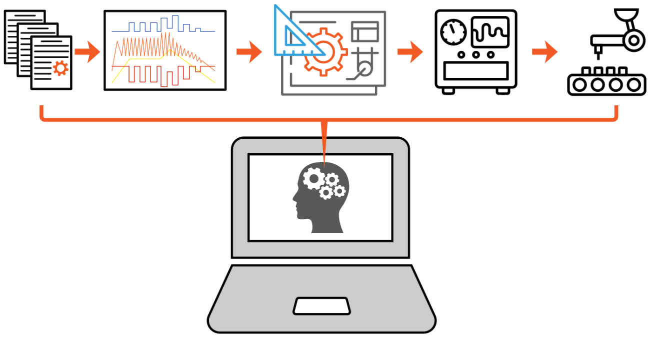
What is MBSE?

Model Based Systems Engineering is "a formalized methodology that uses models as the center of system design, as opposed to document-centric engineering. It supports the requirements, design, analysis, verification, and validation associated with the development of complex systems."[1] A mature MBSE environment provides a platform for collaborative virtual system work, enabling an organization to create and manage a single **digital thread**, "a data-driven architecture that links together information generated from across the product lifecycle and is envisioned to be the primary or authoritative data and communication platform for a company's products at any instance of time"[2].

A digital thread helps to overcome many of the previously mentioned issues with file-based knowledge management and "connects traditionally siloed elements in manufacturing processes and provides an integrated view of an asset throughout the manufacturing and product lifecycle."[3] A robust digital thread is the basis for

1. Shevchenko, Nataliya. "An Introduction to Model-Based Systems Engineering (MBSE)." Web log. Carnegie Mellon University, Software Engineering Institute's Insights Dec. 2020
2. Singh, Victor, and K. E. Willcox. "Engineering Design with Digital Thread." AIAA Journal, vol. Volume 56, no. Number 11, 2018, pp. 4515-4528.
3. Diann, Daniel "Definition: Digital Thread" https://www.techtarget.com/searcherp/definition/digital-thread.

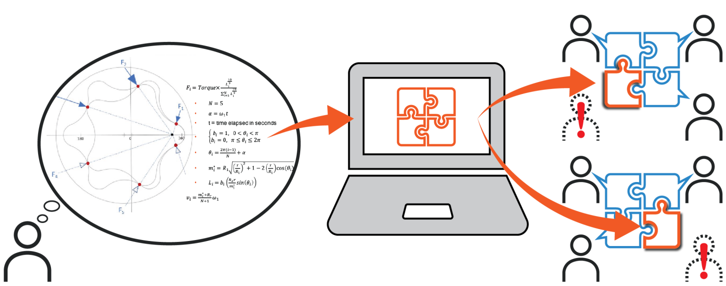
making information more accessible, and processes and decisions in a product's life cycle more traceable. What distinguishes DSP from typical MBSE platforms is the integration of physics-based models as the basis of the virtual system work that the system facilitates.



A digital thread connects all aspects of product development in one virtual platform

Capturing Engineering Know-how

To successfully capture an individual's engineering know-how, product designs must be broken down in terms of the underlying application of physics and understanding of material properties that together define the product's function and limitations. DSP empowers engineers to use scientific and engineering principles to solve problems and develop new processes, products, and technologies. DSP empowers engineering teams to consolidate their expertise into new physics-based models, while also providing a platform to document, manage, and integrate these models into their development process. When this central use of physics-based models is formalized and built into the virtual systems they use, engineers will inherently express their decisions and designs in terms of the first principles they are using. With this analytical approach, not only will an organization be able to convert their engineer's knowledge into physics-based models that can be flexibly utilized across the organization, it will also be able to successfully employ virtual validation methods that necessitate the use of physics-based modeling in order to enhance simulation and reduce costly testing.



DSP digitizes an engineer's know-how, making it accessible organization-wide, even when the individual isn't available

DSP's Knowledge Management Structure

Lastly, to make organizational knowledge, including both dimensions of engineers' experiential knowledge, accessible organization-wide, the knowledge repository must be integrated into a structured development process. This ensures that relevant knowledge is accessible at the point at which it is used, or captured at the point at which it is generated. An organization's development process corresponds to the day-to-day operations of its members, mapping out where and when specific types of knowledge are used and generated. Therefore, if the knowledge management system is structured around the development process rather than being a separate file-based repository, all engineering know-how, process know-how, and other forms of technical data can be systematically documented in relation to the aspect of the development process to which they are related.

When decisions are made in a virtual environment built around a single digital thread that links data directly to the interface where those decisions, designs, and protocols are managed, knowledge is automatically captured and readily accessible to anyone involved in the process. This elevates experience to a lasting and shareable asset while eliminating communication and comprehension gaps that typically arise when changes occur in an environment with a disjointed knowledge management process.

DSP's knowledge management tools allow organizations to transition from using traditional file-based knowledge repositories to employing knowledge "maps". Within the platform, existing knowledge and files can be effortlessly uploaded and linked to the specific steps in the development process where they are used. DSP has a built-in version control system, enabling

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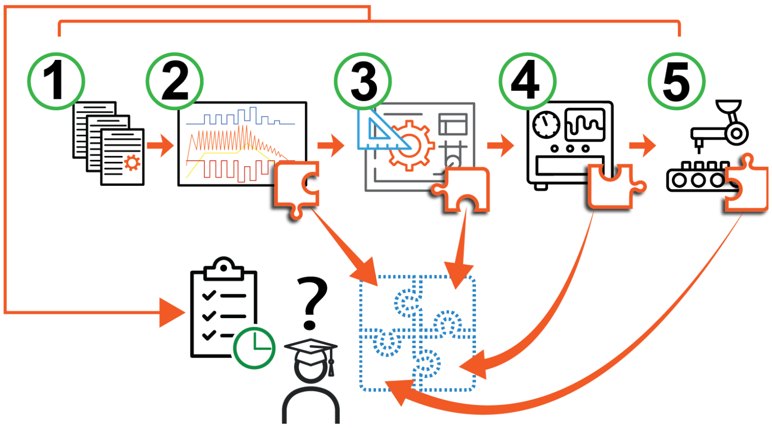
constant updates to the files linked to the development process. Previous versions are easily accessible, and the rationales for changes are logged. Furthermore, all data, pages, and files in DSP can be interlinked to reveal relationships that might otherwise be overlooked. Previously, these relationships might only have been understood by those with the relevant experience and those who they explained them to in a specific in-person or e-messaging communication chain. To document such relationships would require generating another file that could be easily lost or forgotten over time, and valuable scientific insights that might be useful to other projects would remain localized.

Using DSP's knowledge management tools, all information can be correlated and presented within an intuitive network, offering an unprecedented level of traceability for decision-making rationales, while scientific knowledge and physics-based understandings can constantly be documented in a globally accessible physics library, eliminating knowledge silos between departments and teams and allowing for new and existing physics-based understandings to be seamlessly employed by any teams that stand to benefit from it. With this framework, new team members can seamlessly integrate into the organization, leveraging a foundation rooted in applied physics, and all of the organization's members can access knowledge precisely where it's needed at different stages of the development process.



Entry-level engineers can use DSP's digital thread to intuitively access all the process and engineering know-how they need to fill their knowledge gaps

Conclusion

In engineering, individual experience is important for problem-solving and project success. However, organizations struggle with effectively leveraging this experience without being overly reliant on it. Organizations must adopt processes that transform an individual's knowledge and experience into lasting assets that can be used across the entire organization, even when that individual is not available. Moving beyond file-based knowledge repositories, a robust MBSE platform with integrated knowledge management is needed—one that captures valuable experience while ensuring it is easily accessible, transferable, and scalable.

Capturing engineering know-how in the universal language of physics is fundamental for transferability, while linking this knowledge directly to a digitized development process ensures its accessibility. Kepstrum's DSP addresses both of these requirements by formalizing a model-based development process built on a foundation of using physics-based models (that embody the organizations' collective engineering know-how) and also serves as a centralized knowledge management platform that links data to the steps of the process that use it, and traces decisions made in the development process to the underlying knowledge that informed them. This ensures that engineering physics & principles are retained, transparent, traceable, and globally accessible, making them transferable across generations of engineers and products.

This approach helps to facilitate greater collaboration, continuous learning for all teams, increased organizational knowledge retention and traceability, and the faster training and mobilization of new graduates, who have fresh and up-to-date understandings of physics-based models. A healthy digital ecosystem with a robust knowledge base and a physics-based approach to virtual system work is a necessary foundation for successfully employing virtual validation methods to reduce testing, shorten development times, and rapidly respond to requests for quotation (RFQs).

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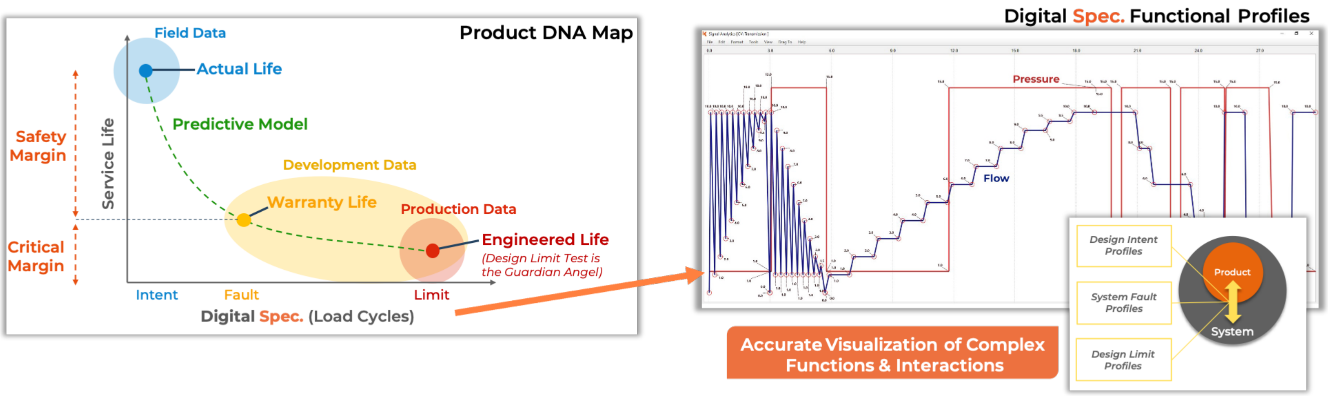
About Kepstrum:

Kepstrum is the inventor of **Product DNA** (**Design Limit, Nature of Failure, Actual Life**). With core competencies in engineering physics and software engineering, it is the patent holder of deterministic risk reduction methodologies and technologies to map Product DNA, through its innovative software platform, named Kepstrum's DSP.

Kepstrum's DSP (**DNA Structured Platform**), is an enterprise-level collaborative software with a revolutionary digitalization approach. DSP replaces files with maps, and words with profiles to generate digital specifications (**Digital Spec.**) that are used as inputs to its engineering analytics to configure product mechanisms and predict failure-life models (**Product DNA**).



DSP empowers Advanced Engineering Teams to use scientific and engineering principles to solve problems and develop new processes, products, and technologies. DSP ensures that Model-Based solutions are retained, transparent, traceable, globally accessible and transferable to the **new generations of engineers and products**. DSP revolutionizes the traditional transformation of "Applications to Product Functions" using the "Digital Spec. to Digital DNA" process. DSP enables R&D engineers to predict the concept's DNA, in less than 8 weeks, as the fundamental step to meet OEM's new **Virtual Validation** demands. DSP provides organizations with a significant analytical bandwidth to compete in this agile market shift using limited resources.

Kepstrum's mission is to advance **Model Based Systems Engineering** (**MBSE**) by commercializing **physics-based analytics** and is an advocate for the adoption of **deterministic design** processes (by removing random features at the conceptual level) for new developments without history over traditional experience-based and probabilistic design methods.

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