Integrating and Continuously Improving Design Process with KollabNet DesignMap

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KollabNet Studio supports a fast-moving environment, linking people with shared knowledge across a broad set of tools and assorted information sources. This environment promotes speed and accuracy of decision making by offering more complete insight into problems, and above all by reusing knowledge – a scarce resource in the increasingly competitive manufacturing arena.

In the face of relentless competitive pressure to improve performance in terms of speed and quality, the priority rises continuously to migrate away from sequential process flows that are often sub-optimal. Design organizations must meet the needs of all market and customer requirements, while the handoff to manufacturing involves precise and complex details that must be fully validated for performance, quality, and manufacturability.

Fully integrated concurrent engineering practices accelerate design efforts while still maintaining precision and quality. They rely on parallel threads of activities in the design process, aimed at slashing risks by increasing knowledge as rapidly as possible regarding features, functions, performance, and quality. At the same time, parallel efforts address program risks of development related to schedules and budgets. Once the high risks factors are resolved in the early stages of development, the process then follows a more predictable fashion to define and distribute product information to those who will approve vendors, plan and procure materials, manufacture the product, and position and launch the offering.

In design, a large number of multi-disciplinary professionals engage in a lively and sometimes very frantic collaboration. As a very creative endeavor, design must solve challenging technical and business problems that may include hundreds of contradictory criteria. Myriad requirements, test cases, functional and design artifacts of the physical product, as well as thousands of parameters ascribed to these artifacts need to be conceptualized, analyzed, and synthesized to define the final configurations of the product. The knowledge generated, captured, shared, and reused during the design process creates a tremendous asset not just for the company leading the design, but for all involved in the extended value chain.

A particular challenge, many processes in design are neither predictable nor sequential. Moreover, different approaches are needed to serve the stages of design when risks and variances are relatively high. To manage design, organizations need to first understand the nature of the processes involved and train professionals to navigate them with the tools that identify the fastest approaches for eliminating the underlying risks. Then, they need to measure and control the execution to spot any early signs of trouble that may require alternative approaches on the fly. Lastly, they need to ensure rapid information sharing to fully leverage every man-hour available for producing useful knowledge and deliverables. All the while, they must synchronize the efforts of the entire team properly to avoid unnecessary rework.

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KollabNet DesignMap visually maps design artifacts and dependencies at any level of granularity, down to detailed parameters. Relationships and dependencies may be classified, grouped, and managed with the toolkit. Once they are captured in the KollabNet solution, an analysis may clarify and size the impact of risks that cascade through downstream steps in the design process.

Three Phases of Process Optimization

These challenges call for a comprehensive solution that addresses three very different phases for process optimization involving many aspects unique to design:

1. **Visualize**: Because the exact information flow cannot be predicted upfront, design management needs to explicitly define dependencies and map them accurately to design artifacts. Simple, intuitive maps need the flexibility to match logical relationships involving different contexts for design. For example, the maps may have to specifically address the visualization of design requirements or design artifacts, design variables or trade-off criteria, and rules or constraints. The map should then clearly indicate the knowledge required to eliminate the critical risks facing development. The sequences for risk elimination can be visualized with the help of the mapping. The clear visual display of dependencies dramatically facilitates the identification of the best alternative, once the risks are recognized.
2. **Analyze:** Design management has to clearly delineate critical paths to the fastest reduction in risk. Engineers can create several what-if scenarios to determine the most feasible sequences for the optimal generation of knowledge, to cut the design risks as fast as possible. Their analysis may unearth hidden root causes, expose more dependencies, or point to additional issues and program risks. Facilitated by the maps of dependencies, analysis needs to provide a solid understanding of the underlying detailed work breakdowns and help to develop a consensus on the course of action.
3. **Connect and Execute:** Design management must promote the fast propagation of alerts and information throughout the entire design chain regardless of where the design artifacts are stored and authored. The execution engine then needs to connect dependant tasks, and to execute the flow assigned to the dependencies.

KollabNet Visualization and Execution

KollabNet DesignMap provides particularly strong capability in visualization, which in turn facilitates analysis without involving any specialized templates or wizards. In addition, the KollabNet execution engine effectively implements the proposed solutions.

With the visualization, the explicit model displays all the elements involved. Design engineers can then quickly search the entire space of their design problem and possible solution,

regardless of where the information resides. They can easily navigate through the complexity of the information whether that involves requirements, previous designs, manufacturing constraints, cost and weight constraints, material properties, geometry considerations, assembly considerations, spatial bill of materials, or configured bill of materials.

While the payoff with DesignMaps flow immediately as the design is completed, the knowledge stored also provides leveraged benefits. Once the information has been collected and organized, it also serves as a ready source of reference for future efforts. With a new product, the designers should first search for other similar efforts completed earlier. Already acquired knowledge should represent the starting point for every new design to maximize reuse. New efforts should stimulate a systematic review of results from earlier designs.

Initial programs may target a relatively narrow scope involving a small number of people. Their success then accelerates the adoption by others, and spreads the efforts for systematic knowledge management. The more knowledge captured, the more the momentum reinforces the increase in new knowledge acquisition. As the process gains credibility, more and more participants contribute to new knowledge. The added capability then reinforces the cycle as the initiative grows on its own, and reuse builds and compounds the momentum. Facilitated by well-rounded and easy-to-use solutions like KollabNet, design management dramatically improves its focus, gaining credibility and momentum with intuitive process scenarios that expose and organize knowledge not captured previously.

KollabNet execution components mask much of the complexity from the end user. They connect to the information sources through intuitive plug-ins and reference links stored in the design map. Once the execution starts, the KollabNet engine evaluates the conditions for linking information, and passes that data on as prescribed in the process map. With all information elements linked and modeled, the execution of the design process may smoothly propagate from source to consumer, regardless of where the authoring takes place or by whom.

Design engineers can stay in their native authoring environment during the execution of the entire process. The KollabNet solution provides simple plug-ins for sharing the data which can be applied like any other menu item in the native user interface.

KollabNet enables the high-fidelity modeling of the real design process, as well as promoting the optimum execution of the information flows underneath. Execution of the process is fully traceable, supporting a data pedigree and traceability reports. Performance metrics may be registered as the process flows through various iterative loops. Users do not leave their native environment. They can quickly identify their position in the process, and find the knowledge needed to accomplish their task. Because the process flow is captured, the metrics can be defined and supported that

steer users towards a more streamlined process flow next time. The process can be monitored and measured for continuous improvement.

Overall, businesses facing accelerated development cycle times and margin pressures require scalable and repeatable design management. They also need to ensure that the most creative resources are most effective in spending their time on value added tasks – design problem solving. KollabNet provides the tools for migrating an entire organization from the sequential process flows that are often sub-optimal. The solution supports a fast moving knowledge sharing environment that links people to knowledge artifacts across many tools and assorted information sources. This capability promotes the speed and accuracy of decisions by providing more complete insight into the problems. Above all, the approach promotes the reuse of knowledge of the design process – the most valuable resource in the increasingly competitive manufacturing arena.

Early Decisions at NASA

NASA engineers rely on KollabNet to capture problem-solving approaches for robotics systems design. According to Sam Miller, Project Engineer at NASA Langley Research Center's Robotics and Intelligent Machines Lab, a precise map of dependencies facilitates the assessment of system design tradeoffs. The mapping accelerates the speed of obtaining the information and assures that the complete set of data is available to meet the needs for decisions early in conceptual design. These decisions significantly impact the rest of the project downstream. The ability to review and understand the context and potential for reducing technical risks translates into significant savings in time and resources. Satisfied with the results to date, NASA engineers are now considering the broad formalization of the process of knowledge capture and reuse. That move would more fully capitalize on KollabNet's ability to organize disparate snippets of knowledge scattered across multiple authoring environments into a comprehensive context for decision making. The tools track and capture the design artifacts and relationships for reuse on other programs facing similar challenges.

Effective Knowledge Engineering Targeting Risk Reduction

Design management must directly address the need to reduce development risks as quickly as possible. Risks arise from both the unknown, and from the perceived knowledge of a system that will change. The only effective way to reduce risk is to increase the store of knowledge and to correct any misperceptions.

The first phase targets the critical tradeoffs that are not known, and concentrates on validating the circumstances that may trigger changes in requirements. Resolution of tradeoffs and timely confirmation of the scope of requirements reduces risks. The associated effort involves significant challenges, and often requires the aid of tools embedded in the design process.

As experienced by NASA and other early adopters, the key to effective knowledge management depends upon mapping the design problem and detailing the series of dependencies linking otherwise isolated artifacts. Considered by themselves, design artifacts and deliverables provide limited insight – even when fully formed in their final version. Knowledge management gains little by automating the creation of isolated artifacts. While that may substitute sophisticated programs for qualified and expensive expert work, it does not directly cut the risks early in the program – by far the biggest challenge. Design management must capture and reuse knowledge in the context of the critical program tradeoffs and dependencies between artifacts to reduce both technical risks involving performance, quality, and functionality, and business risks in terms of schedules and budgets. The most valuable knowledge resides in the full context defined by the relationships between design artifacts, not in the individual artifacts themselves. Effective knowledge engineering gains its greatest leverage by capturing and reusing the knowledge embedded in relationships between artifacts in the context of design problem solving.

The Benefits of Fully Developed Design Management

As the understanding of the design scope widens and deepens, the knowledge must be managed and displayed effectively. Clear displays with intuitive, easy-to-navigate maps of dependencies help design engineers quickly visualize the entire domain of all tradeoffs. Tools such as those from KollabNet benefit design management in several ways:

- The *complexity of dependencie*s covering tradeoffs that may involve hundreds of variables from dozens of design artifacts mushrooms. All need to be linked in a map of the complete system design. The dynamic nature of the relationships compounds the challenge, making it impossible for humans to continuously capture, monitor, and control the knowledge base to optimally manage the process without the help of information repositories.

- *The right information must be available to the right person at the right time* for effective decisions. Even when a system effectively captures and organizes critical dependencies and their context, they still need to be exposed to the right engineers at the right time. KollabNet solves this problem with the propagation of events every time critical changes and updates are triggered within any native authoring environment. Then, the map of dependencies guides engineers through a fast analysis of the impact that the changes entail. KollabNet supports an explicit and agreed-upon definition of roles, events, and rules for the reconciliation of changes that is linked to the maps of dependencies. A simple and friendly rule builder helps define the conditions.

- *The full documentation of design decisions in DesignMaps, including rejected alternatives, provides complete background for future reviews*. Alternatives that were rejected on earlier cycles may become the best option under different circumstances.

- *The linking of design maps to requirements* is particularly important to closely link design management with the overall process of requirements management. Changes in requirements may impact multiple dependencies at various levels of system design that all need to be reconciled without losing sight of any important limitation, constraint, or assumption.
- *Design artifacts are scattered across silos.* Moreover, specialized engineering solutions with their workflow engines often support independent databases that need to be linked. Electrical, mechanical, software, and system content may all reside in heterogeneous information systems. As the maps of design dependencies are established and incorporated in the process and supported with the clear definition of roles, events, and management rules, the linking of information across all engineering automation environments can cover MCAD, ECAD, CAE, CAT, or PDM.