Digital Standards for the Advanced Manufacturing Enterprise

Executive Summary

Manufacturing is plagued by a tower of babel. There are hundreds of data formats with thousands of flavors. Many are compromised for performance reasons that no longer apply. The DigMan project will replace them with two digital manufacturing standards: the STEP-NC standard for model based programming; and the MTConnect standard for machine tool, client server interfacing.

The two standards are being tested by industry as input and output interfaces for the next generation of manufacturing machinery. The DigMan project will show how to orchestrate a flexible manufacturing cell using these interfaces. A laboratory will be built at the DMDII that includes additive, subtractive and measurement machines. The machines will be serviced by robots and will include other ancillary equipment such as tool pre-setters. The manufacturing cell will allow students to quickly and efficiently manufacture interesting products, such as swarms of fighting robots, with the minimum of programming and the maximum of safety

In three six month phases, the DigMan project will design protocols that make the new cell safe to use, fast to program and easy to change.

1. In the first phase, DigMan will validate machining actions in real time. Today an operator is required to make machining safe using the big red button. Many operators are reluctant to support 5-axis machining because of the difficulty of predicting collisions from codes. The first phase of DigMan will create software to monitor the manufacture of a product in a cell using coordinated 3D models of the product, processes and machines.
2. In the second phase, DigMan will orchestrate the operation of concurrently executing machines. Different resources will be prioritized and scheduled according to availability. The DigMan will show how solutions can be programmed quickly and easily when the inputs and outputs are described by models whose constraints are defined by the PMI.
3. In the third phase, the DigMan will show the dynamic replacement and enhancement of machining resources. The project will show how a schedule can be adjusted to make optimal use of new resources and processes when they are modeled as open data shared by a network.

DigMan will achieve its goals by deploying the framework shown in Figure 1. Manufacturing is represented as a series of stage models that meet the PMI requirements set by design. A set of resources is available for each stage and those resources are dynamically validated to be compatible with the requirements of the process. They may include additive machines, subtractive machines, measurement machines, robots and ancillary equipment such as tool pre-setters.

The inputs and outputs of each stage are defined by the STEP and MTConnect standards. STEP will be extended to include Universally Unique Identifiers (UUIDs) anchored into standardized data, connected by URL's and made safe using digital signatures and fingerprints. This will be managed by deploying the Part 21 Edition 3 extension to STEP whose draft has been approved by ISO. The MTConnect standard will

be extended to reference the STEP resources as the machining actions take place, ensuring simulations are kept up to date, and enabling subsequent analysis in big data systems.

Protocols will be developed to drive communication between machines. Examples are shown above each adaptor. As a machine completes a face it requests validation by a measurement device. As a robot moves the pieces it requests the placement of a fixture. As a CMM measures a workpiece it requests the face whose tolerance must be validated. Each command is requested and delivered using MTConnect and contains content defined by STEP. Simulators make everything safe, and cloud services help optimize the models. Digman will complete and deliver this set of protocols, and create educational instruments that allows the next generation of engineers to be trained in plug and play control for traditional and advanced manufacturing applications.

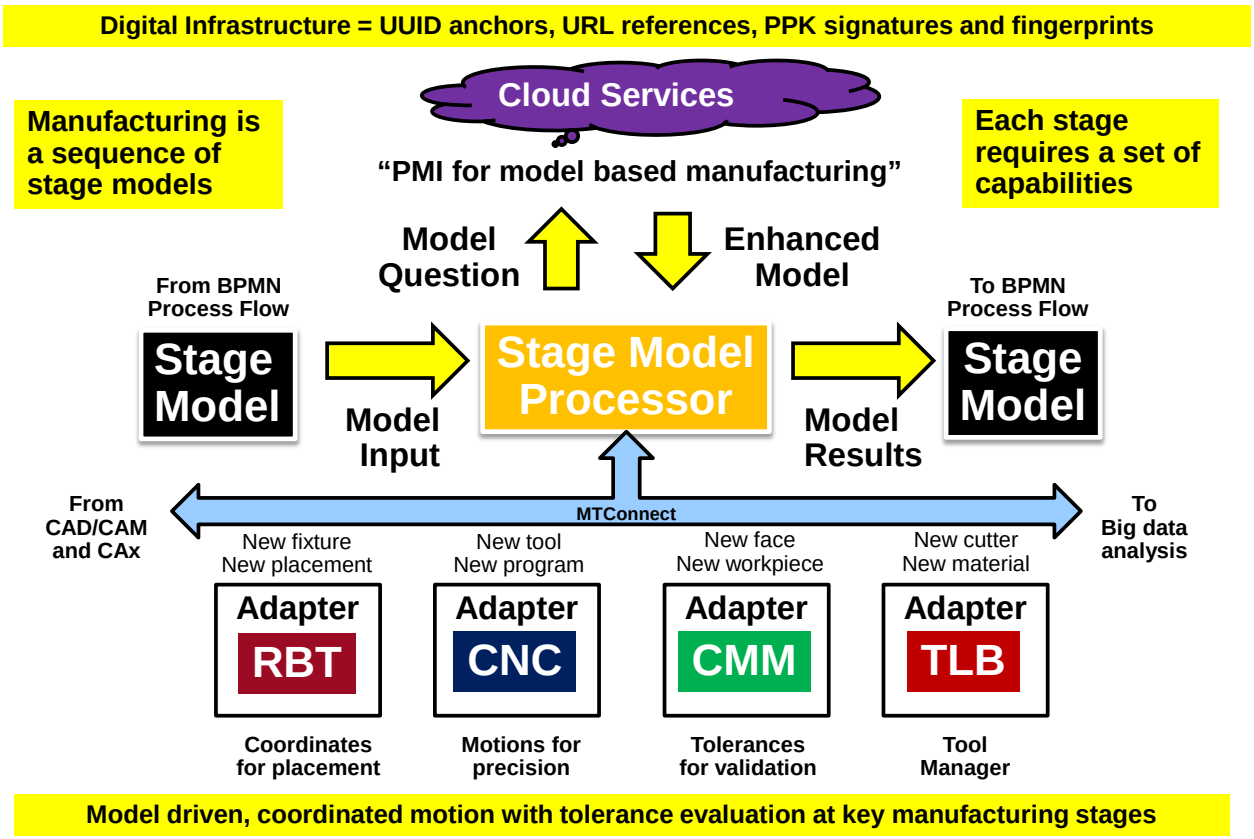

Figure 1 the DigMan Framework for Orchestrating Manufacturing

DigMan will create an advanced manufacturing environment that can be replicated across industry. The new framework will make manufacturing faster, safer and more flexible. It will be faster because many new optimizations will be enabled, on and off the machine, using cloud services and adaptive programing. It will be safer because software on the control will check and validate all actions using models. It will be more flexible because protocols will allow new machines and solutions to be replaced using plug and play. The difficulties and compromises caused by the babel of localized solutions and post processors will be eliminated.