

MANAGING A PRODUCT CALLED NIF-PLM CURRENT STATE AND PROCESSES*

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Abstract

“Product lifecycle management (PLM) is an integrated, information driven approach... to all aspects of a products life, from its design through manufacture, deployment and maintenance-culminating in the product’s removal from service and final disposal.” [1] The National Ignition Facility (NIF) can be considered one massive product that is made up of millions of individual parts and components (or products). The ability to manage a product of this size consists of controlling the physical definition, status and configuration of the sum of all of these products. This is a monumental undertaking yet critical to the validity of the shot experiment data and the safe operation of the facility. NIF is meeting this challenge by utilizing an integrated approach to implement a suite of commercial and custom enterprise software solutions to address PLM and other facility management and configuration requirements. It has enabled the passing of needed elements of product data into downstream enterprise solutions while at the same time controlling change and minimizing data replication. Strategic benefits have been realized using this strategy and validated the decision for an integrated approach where more than one solution may be required to address the entire product lifecycle management process.

This paper describes how this strategy has been implemented along with a discussion on the successes realized and the on-going challenges.

INTRODUCTION

The National Ignition Facility at the Lawrence Livermore National Laboratory (LLNL) is a stadium-sized structure that contains a 192-beam, 1.8-Megajoule, 500-Terawatt, ultraviolet laser system together with a 10-meter diameter target chamber with room for multiple experimental diagnostics. NIF is the world’s largest and most energetic laser experimental system. NIF’s laser beams are designed to compress fusion targets to conditions required for thermonuclear burn, liberating more energy than required to initiate the fusion reactions.

The advancement of complex software solutions plays a significant role in managing the task of product lifecycle management. Using an integrated approach, NIF has deployed a framework of commercial and custom products that enables the movement of “various aspects of the product record into the necessary enterprise solutions” [2] to achieve a best-in-class software toolset for the diverse and unique challenges facing NIF. To

effectively and safely manage the definition, build, operation, maintenance and configuration control of all components and materials that make up the facility, our strategy was to implement solutions that:

- Capture and maintain an accurate physical description of the system
- Promote a single source of data to reduce the need for replication
- Effectively track changes and understand their impact on surrounding systems
- Provide visibility into what components are installed in a given location at a given time
- Promote a safe environment
- Make full use of vendor-supported and industry standard interfaces

While software plays a significant role in supporting the task of managing a product through change and configuration control, it is important to note that software can only supplement a well-defined and followed configuration management and change control policy.

INTEGRATED SOLUTIONS

This implementation effort was managed and executed with emphasis on several key areas:

- Subject matter experts (SMEs) from all areas were utilized
- Substantial commitment of IT resources
- Common technology base (Oracle DB, consistent mid-tier, Java apps, Windows/Office desktops)
- Close liaison with customer base
- Focused on consensus standards such as EIA-649/GEIA HB-649 [3], industry best practices such as CMII [4], and industry leaders where applicable

The resultant solution has proven to be very effective in meeting the programmatic challenges and adhering to the desired strategies as set forth early in the NIF project. A detailed description of the functions and interactions of three key applications follows.

Physical Definition of NIF

NIF utilizes a suite of commercial Computer Aided Design (CAD), Analysis, and Data Management software applications for the three dimensional virtual definition of the facility. The implementation and utilization of this suite of applications has aided in making the physical NIF a reality.

The process of capturing a virtual design begins by creating a model for each individual component within the facility. These individual models are joined to create

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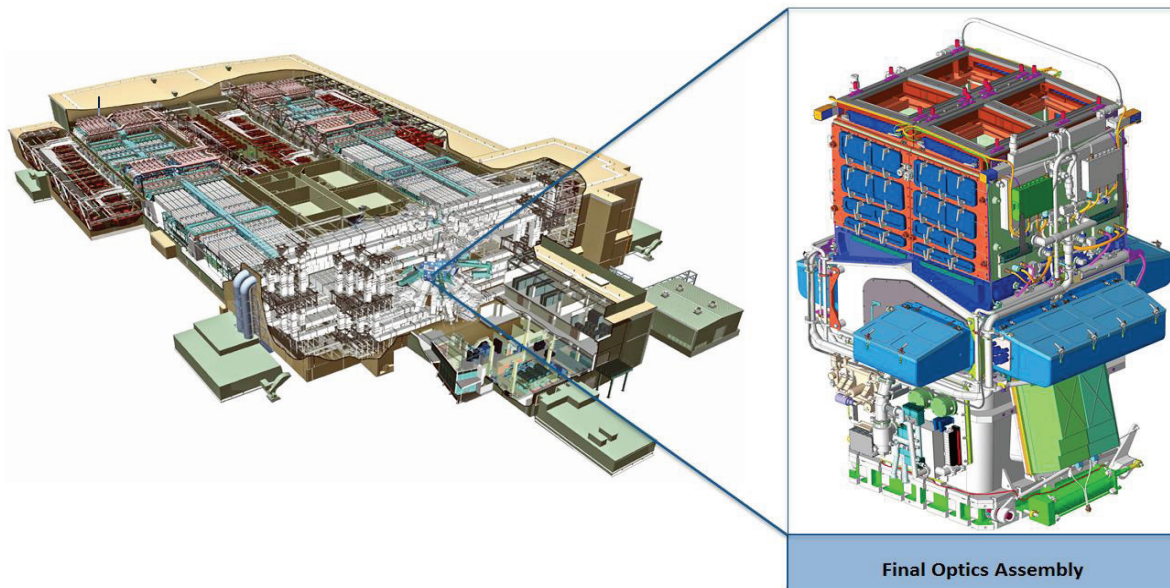


Figure 1: Each of the 48 Final Optics Assemblies contains over 12,000 parts; a fraction of the total NIF part count as shown in this virtual model.

virtual assemblies of all of the NIF subsystems as illustrated in Fig 1. NIF's designers and engineers ensure the fit and function of the millions of objects that make up the facility by using the virtual models to run interference checks. In addition, finite element analysis applications are used to ensure that designs are able to withstand the mechanical and thermal stresses introduced by the operation of the system. A CAD data management application that works in conjunction with NIF's modelling packages enables concurrent design and a single point data storage location. This application manages over 40 million relationships that exist between all of the 3D models and also tracks design iterations and history.

drawing. The CAD model and its associated information becomes the data source for many downstream applications such as the Enterprise Configuration Management System (ECMS) and Enterprise Resource Planning (ERP). Because of this, the integrity and accuracy of this data is of critical importance.

The CAD data management application is integrated with LLNL's institutional Configuration Management system, ECMS. Together they control the creation, approval, release, and revision of every 3D model and drawing associated with NIF.

Data Structure and Formal Change Control

Once the virtual design is finalized and ready for review, approval and release, the individual part information and the BOM is passed electronically from the CAD data management system into ECMS. This electronic data transfer eliminates human intervention and significantly reduces errors thus maintaining the accuracy of the data.

Here, product design information is made available to other NIF groups and functions outside of engineering such as procurement, assembly technicians, production control, NIF operations, etc. for final review and approval. ECMS is also where the 'as designed' configuration is captured through the use of the officially released Engineering Bill of Material (EBOM) [5]. Once the design is approved, it is released for production use. A released design cannot undergo any changes without prior approval.

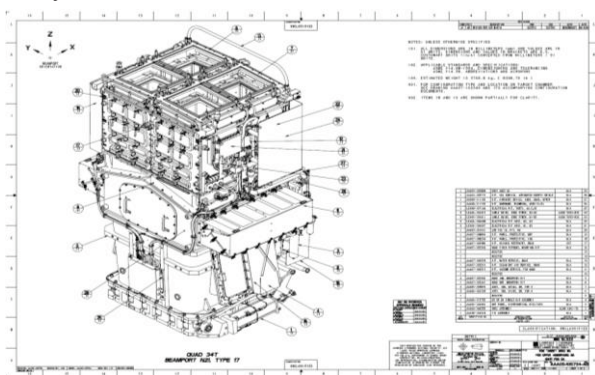


Figure 2: Final Optics Assembly Drawing.

Once modelled, the design with its components and sub-assemblies are documented through the use of engineering drawings as shown in Fig. 2. Engineering drawings provide a visual definition of the design and include a list or Bill of Material (BOM) of the components that make up the design. The relational nature of the software maintains a one to one relationship of the modelled assembly and the (BOM) found on the

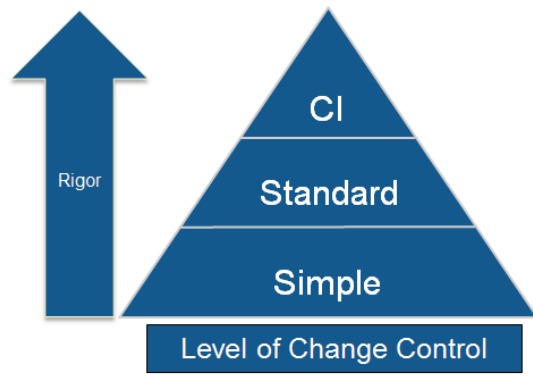


Figure 3: A Graded Change Approach.

Change control is a key function of ECMS and the system has been configured to allow for different levels of change control rigor depending of the level of impact. See Fig. 3. A Simple change typically has no functional or systematic impact and therefore requires no formal review prior to revising the data. A Standard change has impact on the form, fit or function of the system. This requires the initiation of a formal change request where the proposed change is documented and reviewed for functional impact. Once change approval is obtained, the modification to the design can be implemented. A Configuration Item (CI) change proposal requires an additional level of analysis and review. CI's are systems whose failure could have negative impact on surrounding environment, equipment or worker safety and thus requires a higher level of scrutiny when changes are proposed. The need for increased rigor during impact analysis and review is systematically imposed such that individuals responsible for the configuration and control of the CI must be included in the change approval process.

When change approval is obtained and implemented, the updated design is released in ECMS. Upon release, part and EBOM information is transferred into the NIF ERP system.

Tracking the System Assembly and Installation

The NIF ERP system is a software application used to manage the assembly, installation, and maintenance of specialized laser and diagnostic equipment. The product lifecycle in NIF ERP begins with a plan that includes product definitions and installation dates. These are used to create demand in the form of planned orders in ERP. The next phase in the product lifecycle is product definition, which begins with ECMS creating parts and assemblies in ERP via the production release process. Upon release from ECMS, information is transferred electronically to the ERP system.

Production Control Engineers begin their part of the product lifecycle with the released EBOM from ECMS and add intelligence required for the assembly and installation of end products resulting in a Manufacturing Bill of Material (MBOM) [6]. MBOMs are created by adding labor and machine resource information required

for assembly. Specific parts and subassemblies in MBOMs are flagged for tracking by assigning a serial number based on safety significance, operational significance, and calibration and maintenance requirements as shown in Fig. 4 below.

Actions	Serial / Lot	Part	Rev	W/O	Type	Location
	NEEDCTSN1	AAA06-100008	AA	PCT&T96862		
	28344900	AAA10-118196	AA			TC090-015-SHIELD
	28344857	AAA10-118197	AA	DCTT99385		
	28344856	AAA10-118197	AA	RCTT98692		
	28344855	AAA10-118197	AA	RCTT98570		
	28344854	AAA10-118197	AA	RCTT98438		
	28344853	AAA10-118197	AA	RCTT98549		

Figure 4: Serialized Parts.

Next, a Master Production Schedule (MPS) is run on a daily basis to create and schedule assembly and subassembly work orders. Following completion of product assembly, NIF ERP tracks the finished items through installation at specific facility locations. Most serialized parts are labelled with a barcode. The barcode allows for rapid, error free capture of the movement of parts and the exact installation location. Following installation, ERP work orders are used to manage the final testing of each assembly, subsystem, and system.

Actions	Serial / Lot	Part	Rev	Type	Location	BIN	Beamline	Status	Da
	NEEDCTSN1	AAA06-100008	AA	PCT&T96862				WIP	20
	28344900	AAA10-118196	AA		TC090-015-SHIELD			Installed	20
	28344857	AAA10-118197	AA	DCTT99385				WIP	20
	28344856	AAA10-118197	AA	RCTT98692				WIP	20
	28344855	AAA10-118197	AA	RCTT98570				WIP	20
	28344854	AAA10-118197	AA	RCTT98438				WIP	20
	28344853	AAA10-118197	AA	RCTT98549				WIP	20
	28344852	AAA10-118197	AA	RCTT98349				WIP	20
	28344450	AAA06-106100	AA		TC090-015			Installed	0
	28344401	AAA06-107400	OC		TC090-239			Installed	0

Figure 5: Serialized Parts Tracked in a Specific Location.

NIF ERP is also a resource for detailed records of as-built and as-maintained hardware configuration over time. This hardware configuration data provides visibility into the location and status of key components. This information is used to assess system readiness by enabling comparison of the equipment installed and available versus the equipment required for a given experiment.

The hardware configuration data also enables historical analysis of equipment performance by providing a record of the specific items of equipment used in any given experiment in the facility.

NIF ERP is the primary data hub from which many other applications and reporting tools requiring visibility into the location and status of key components access that information. (Fig. 6).

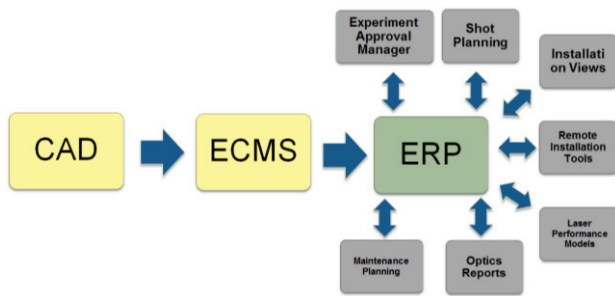


Figure 6: PLM Data Flow.

CONCLUSION AND LESSONS LEARNED

Overall, NIF has realized the strategic benefits of using an integrated approach to implement a suite of commercial and custom PLM enterprise solutions to manage the entire lifecycle the product called NIF. The integrated application toolset has been a significant asset for ensuring data integrity and promoting the concept of a single system of record. It has enabled the program to move needed aspects of the product data into the necessary enterprise solutions while at the same time minimizing data replication. While this approach has worked well overall, it has not been without challenges and shortcomings.

One challenge is that a “version/interoperability” trap is significant when integrating many software tools. Application and operating system compatibility constraints sometimes result in being out of date with the latest versions of certain COTS products. Upgrades of enterprise applications can be a significant resource and cost consideration. It is important to acknowledge that solutions with large numbers of integrated COTS applications make it difficult to deploy new releases. Maintaining awareness and planning ahead by developing a product roadmap can help manage this issue.

A closely related issue is that a high level of application integration drives the need for coordinated releases. Often a release to modify functionality in one application can be interdependent on corresponding capabilities in another. Design reviews and a cross team release planning process can greatly enhance the quality and success of a product release. Appropriate allocation of resources to conduct a comprehensive testing program is important when multiple integrated applications are affected.

High levels of integration can lead to data driven system issues. If data is problematic in the system of record, that same problem can be propagated throughout the enterprise. Recovery and clean-up in certain cases can be a significant effort. Prevention of problematic data using mechanisms such as data validation and strong data typing* can mitigate the initiation of problem data. Recognizing that problematic data will occur, development of data management tools and processes specific to correcting data should be considered.

* A data type is a classification identifying one of various types of data, such as real-valued, integer or Boolean, that determines the possible values for that type.

With the use of COTS products, organizations are confronted with the question of using the application “out of the box” and modifying business processes around built-in capabilities or applying customizations to support the automation of program specific data processing needs. [7] Redesigning business processes around COTS tools is not well accepted in a research culture yet customizing will increase the cost of ownership by increasing the complexity of maintaining and upgrading the product. NIF has chosen a hybrid approach to meet both business requirements and keep the cost of ownership under control. The use of a steering committee or change control board provides the forum for scrutinizing enhancement requests to make an informed decision enabling a reasonable balance between business needs and cost of ownership.

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