DELIVERING ON THE PROMISE OF GLOBAL GROWTH

CUMMINS INC.

CASE STUDY ON ENGINEERING AND MANUFACTURING BUSINESS INFRASTRUCTURE DECISIONS IN SUPPORT OF CORPORATE BUSINESS GROWTH PLANS

Whitepaper by: Dr. Michael Grieves

Executive Summary

Today's organizations are wrestling with a number of common issues. These issues include moving to integrated Product Lifecycle Management (PLM) systems from internally developed legacy product and engineering systems, replacing a diverse set of manufacturing applications that have proliferated over the years in facilities strung out across the globe with a common Manufacturing Execution System (MES) platform, and integrating these systems with each other and with transactionally-oriented Enterprise Resource Systems (ERP).

While the attention to the technology aspect is critical, equally important is an attention to the change issues affecting people and the activities they perform, which are their processes and practices. The impact of these changes affects everyone in the organization, from executives to factory workers on the plant floor. While executives expect to be involved, if done correctly, these initiatives can unlock knowledge resources possessed by every worker.

This case study describes how a leading industrial organization, Cummins Inc., is approaching these issues. The case study explains how Cummins is organizing itself for managing change, and how it is collaboratively involving factory workers in its efforts to improve productivity and quality, while encouraging innovation. The case study identifies the dramatic benefits Cummins is already realizing, but also pinpoints potential issues Cummins will need to be vigilant about as their initiative progresses.

Background

Cummins Inc. is a premier manufacturer, headquartered in Columbus, Indiana. Founded in 1919 by Clessie Lyle Cummins, Cummins Inc. has grown from humble beginnings to being a global power leader as one of the premier diesel and natural gas engine manufacturers in the world. The company has weathered the current economic period well, reporting global 2011 revenues of $18 billion and $1.85 billion in earnings. This was an increase over 2010 revenue of 36% and an increase over 2010 earnings of 85%. Cummins employs over 40,000 people and has presence in 190 countries.

Cummins has four business units: Engine Business Unit (EBU), Power Generation Business Unit (PGBU), Components Business Unit (CBU), and Distribution Business Unit (DBU). Cummins complementary business units design, manufacture, distribute and service engines and related technologies, including fuel systems, controls, air handling, filtration, emission solutions and electrical power generation systems.

Diesel engines and natural gas engines, which can be found in mobile and stationary applications, are Cummins' best known products,. Diesel and natural gas engines in mobile applications range from the popular Cummins engine found on Dodge Ram pickup trucks to heavy duty engines in long haul freight trucks to massive engines in giant mine trucks. Stationery diesel and natural gas engines often drive Cummins Power Generation units, which range from small generators for personal use to massive generators for commercial, industrial, and medical use. Cummins engines range in size from 31 to 5,000 horsepower and from 1.4 to over 120 liters. Power generation sets range from 2.5 to 2,700 kilowatts.

From a manufacturing perspective, Cummins has over 85 plants worldwide, located on all continents except Antarctica. From a product perspective, Cummins has a highly proliferated product portfolio made up of almost 2 million parts in a large number of product lines supporting an almost incalculable number of product configurations.

Positioning for Growth

Cummins has an aggressive plan for growth over the next few years. However, management realizes it needs to be both efficient and effective if it is to grow successfully. Being efficient means taking unnecessary costs out of the business in order to provide needed resources for future growth.

Being effective means that Cummins will have tighter integration between engineering and manufacturing, and, within manufacturing, will have consistent processes throughout its manufacturing plants. Achieving this level of effectiveness will provide an infrastructure that not only supports the corporate growth plan, but delivers new-found levels of operational agility capable of addressing business needs that are yet to be defined.

At the overall organization level, Cummins will need a better and more modern product information system to move products from the design to the fully manufactured stage. This means that Cummins will move from the in-house developed mainframe-based product information system that has served them for decades to a comprehensive Product Lifecycle Management (PLM) solution.

Cummins has selected the PTC Windchill product and is in the process of implementing it. Cummins is currently defining their consolidated product definition infrastructure and tackling many of the definitional questions about 'where to draw the lines' of product data ownership and authority in an highly integrated product engineering – manufacturing world.

Focusing on manufacturing, Cummins needs to replace the wide variety of local applications that it has in the manufacturing plants. In many cases, these applications are homegrown and very difficult

to maintain. Even if this was not the case, the fact that these are all different applications means that there are major difficulties in having standardized and common processes throughout the plants. In addition, there is no ability for Cummins to collect and maintain longitudinal manufacturing data that can both help identify problems and provide feedback into new manufacturing processes. Cummins has instituted a project called Next Generation Manufacturing Execution System (NGMES), and has selected Apriso's FlexNet to provide the Manufacturing Execution System (MES) software technology. Cummins foresaw the need for a new manufacturing paradigm and supporting infrastructure several years ago and started the NGMES project. After a number of global deployments within the last 18 -24 months, Cummins is now preparing for a rapid and sizeable deployment of their NGMES manufacturing platform throughout the enterprise over the next 2-3 years.

The drivers of Information Systems (IS) in general and Product Lifecycle Management (PLM) and Manufacturing Execution Systems (MES) in particular with their comprehensive and product-centric view are: productivity, innovation, quality, and collaboration. Cummins will need incremental and consistent productivity gains in engineering and manufacturing to free up needed resources for growth and innovation. In order to stay ahead of its competitors and attract new segments of business, Cummins will need to innovate both its products and its processes and produce those products with continually increasing quality. Finally, Cummins will need to collaborate both across functional areas and with their suppliers in order to accomplish productivity, innovation, and quality. The Cummins' NGMES initiative supports all of these drivers.

People, Process/Practice, and Technology

The elements of any information system are: people, processes/practices, and technology. Together, these elements come together to provide people with the right information when they need it. The failure to address any one of the elements results in an information system that is, at best, suboptimal and, at worst, nonfunctional. For manufacturing, the NGMES initiative addressed each of these areas.

Technology

Technology is not the solution to information needs, but it is a key enabler. Without computing and communications technology to capture, organize, and communicate, the ability to provide people with the right information when they need it becomes inefficient and expensive.

In the Cummins case, it selected the Apriso FlexNet system because it met the criteria better than competing applications. These criteria included: flexibility of processes, advanced functionality, ability to share processes globally, and a technology partner with a primary focus on manufacturing.

Processes/Practices

Processes are set, repeatable routines that are intended to deliver efficiency. Practices, on the other hand, are activities to create methods in order to solve problems or produce innovative results that have not been obtained before. In the manufacturing area, performing a process that is proven to give the same result over and over again is the key to consistent productivity and quality. The manner in which to create and enhance that process is practice. Cummins has effectively used both process and practice in the NGMES initiative.

Affecting both quality and productivity, a problem in the past has been that the work instructions for a product that came down to the factory floor had

exceptions that were undocumented. This required tribal knowledge on the part of the factory workers in order to understand that, while the process plan may have called for one thing, they knew that they needed to do something else because of their experience with the product. This was fine if the workers remembered this exception, but, because of worker replacements, time pressures, or simply forgetfulness, errors would be made as workers followed the exact instructions.

This leads to the second point in that, even though the workers would provide corrections to the processes, these corrections were never able to be incorporated into the build process. The NGMES implementation allows for feedback from the workers to be easily incorporated into the processes. This moves Cummins from relying on tribal knowledge to having institutional knowledge of the processes, so that newer workers, who may be unfamiliar with the specific build process, are given the appropriate instructions for the specific product at the right point in time.

As important as these improvements are, they are intra-factory improvements. For Cummins to reach its growth goals, it needs to leverage its single factory improvements across the entire organization. Having each factory discover the same process improvements is inefficient and time-consuming. However, making a process improvement and extending it across all factories improves productivity and quality in a consistent standardized method.

A common MES system that supports this kind of improvement sharing is exactly what Cummins looked for in their NGMES initiative.

Cummins also addressed the practice side in order to ensure that it could innovate and problem solve as part of the NGMES initiative. In order to do that they created a Core Team group (Figure 1) that included global manufacturing engineering, corporate IT manufacturing systems, and a manufacturing application development and support center (ADSC). The manufacturing IT systems team members are the business application "subject matter experts" and staff what is commonly referred to as the "Center of Excellence" or COE. In addition to their internal groups, Cummins also included selected consultants, including their software supplier, Apriso.

Figure 1

This core team has both a strategic and tactical focus. From a strategic perspective, they have a Change Control Board (CCB) led by the business process owner that will both evaluate and prioritize change requests to address both innovative opportunities and problem-causing threats.

On the tactical side, the Change Implementation Board (CIB) is responsible for managing implementation issues. The CIB sets priorities for problem reports. If the issue generates a change request, it then makes the decision to refer to the CCB.

While the movement of information is the process, the problem-solving, idea generation, and prioritization are practices that require the combined expertise of Cummins management, functional area leadership, subject matter experts, and consultants collaborating in order to produce results that Cummins desires. This produces productivity, innovation, and quality.

People

In any information system, people are the most important element. They are the source of productivity, innovation, and quality. Only people can collaborate. However, in the manufacturing area, people are often considered to be temperamental equipment. They are expected to be programmed once and perform flawlessly thereafter. Unfortunately, that is not a successful approach.

With the NGMES initiative, Cummins realized that their factory workers are their most valuable resource. As a result, they have designed their systems to augment their factory personnel and not simply treat the factory workers as a type of machine. In return, the factory workers have seen this as an opportunity to become more engaged in the manufacturing process. They see NGMES as a way to improve productivity and quality in a way that does not burden the workers.

Three areas where this system has improved factory floor operations are in fail-safing, feedback, and visual presentation of information.

Fail-safing, or as the Japanese refer to it, poka-yoke, is the use of systems and procedures to eliminate even the ability to make a mistake. Fail-safing improves both productivity and quality. It improves productivity by ensuring that the right operations, the right parts, and the right equipment come together each and every time. In NGMES, operators must be certified for a particular station before they can operate it. Since the system knows exactly what parts must be installed at what operation, bin lights illuminate only on those bins whose parts are required at a particular station. Operators do not need to remember what parts the build process calls for, because the system prompts them.

Since operators are the experts in performing their function, it only makes sense that their feedback should be incorporated in improving their processes. The FlexNet system is set up to incorporate improvement suggestions immediately, so that the operator can see on the next build of that type that his or her suggestion has been incorporated. Not only does this prevent errors by making sure that the right process is being done, but it gives the operators a sense of ownership over those processes.

The third aspect is that the NGMES system provides the operator with visual images of the product he or she is tasked with building. Rather than a having to rely on 2-D blueprints and documents, the operator can see a full three-dimensional image and understand the sequences necessary to create a product that matches that image. As products become more complex, this visualization becomes a requirement.

Innovation plays a part even on the manufacturing floor. Factory workers, who are engaged in the manufacturing processes as they are at Cummins and who are encouraged to share their ideas and knowledge, are the source of innovations that leads to both productivity increases and quality improvements. This will be key factor to Cummins future growth.

MES/PLM/ERP Integration

While the NGMES initiative is specifically focused on the global deployment of Apriso's manufacturing execution platform, PLM and Enterprise Resource Planning (ERP) systems integration must also be addressed in order to provide the necessary product information and processes. Determining the relationship of MES, PLM, and ERP can best be illustrated graphically by positioning them against the functional areas they support and the domains of knowledge that they deal with. As shown in Figure 2, the intersection between product information and production or manufacturing is a critical one. Manufacturing needs to have timely, complete, and

accurate information on what product to build, its geometry and specifications of that product, and the detailed operations necessry to realize that product.

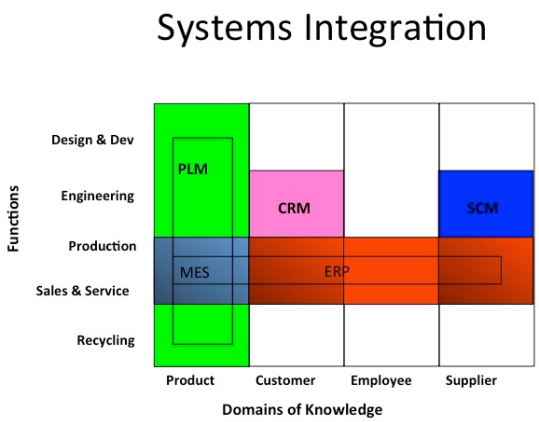

Figure 2

Cummins is currently in transition in this area. Some business units are moving from a legacy mainframe system that, while technically not a PLM system fulfills some of those functions by having product information such as Bill of Materials, shop orders, engine software, engine data plate information, regulatory information, etc. all in one place. This system is scheduled to be turned off in 2015. Other business units are moving from a newer PDM system. Cummins is replacing these legacy systems with PTC Windchill, which is a PLM system. On the ERP front, Cummins utilizes various ERP systems; primarily Oracle, but also IMS, QAD, Movex and Mapics. Projects are also underway to standardize these ERP solutions to a more common footprint.

As mentioned above, with respect to MES applications, Cummins had a large number of individual manufacturing systems, many self-developed. These applications are expensive to support, have dated functionality, and differ from each other. Cummins has implemented Apriso's FlexNet in five plants and will methodically replace the individual plant MES systems with Apriso's FlexNet over a 3 year period.

As shown in Figure 2, the MES application is the enterprise solution that is positioned between the product oriented PLM system and the transactionally oriented ERP system in a global organization. The role of the MES application is both as a repository for manufacturing knowledge and as a granular transactional system for controlling and monitoring the product as it moves from station to station on the factory floor. While ERP systems sometimes claim this functionality, the reality is that they deal at a much less granular level and are not well suited for the step-by-step functions on the factory floor.

The interface between PLM and MES requires well thought out coordination and communication. In Cummins case, the high-level Bill of Processes (BOPs), which are the routings and instructions for the manufacturing process, will be developed and held in the PLM system. These BOPs will be considered prototypical, because they will form the basis for the factory-specific executable BOPs that will be tailored for the individual plants in the MES application.

This adds a level of complexity that is a potential source of problems. The true test of a BOP is whether it will produce the required part to the required quality. If not, the BOP will need to be modified immediately to prevent poor quality parts. However, those changes will need to be conveyed back to manufacturing engineering in order to change the prototypical BOP. Failure to incorporate these changes will result in a deficient BOP being sent out to the factories with the next product release.

Additionally, the ability to globally institute changes in BOPs is a critical requirement that Cummins has addressed in their NGMES project.

Outside of NGMES, Cummins' BOP change management is often paper-based because they do not have a common MES for their plants. This means that changes have to be evaluated, tailored for each plant, and translated for that MES. The advantage provided by the NGMES deployment is that changes to BOPs can be immediately disseminated and incorporated in all plants.

While that appears to be a major efficiency, this could have unintended consequences because of plant differences. Even if changes are sequestered at each plant until they are approved, the ease of accepting changes versus having to translate changes for different systems requires higher diligence than Cummins may anticipate. With global BOP change capability, problems can be transmitted through the plants as quickly as efficiency gains. This requires extra diligence be provided within the governance framework of the centralized BOP controlling authority.

An additional issue is that the specific data integration requirements between PTC Windchill PLM system and Apriso's FlexNet MES has yet to be fully defined. Ideally, this should be a system to system interface, Windchill to FlexNet. Additionally, this should be a two-way interface to allow BOP changes discovered on the factory floor to be propagated back into the PLM system. This will require strong and active coordination between Apriso and PTC.

At the end of the PLM and NGMES initiatives, Cummins will have a standardized corporate MES system, Apriso FlexNet, a corporate wide PLM system, PTC Windchill, and increasingly standardized ERP systems. Since Cummins has joint ventures in addition to its own factories, it may not be able to standardize on a single ERP system. FlexNet has the flexibility of interfacing to multiple ERP systems.

NGMES Benefits

Cummins has already reaped substantial benefits from its initiative. In the manufacturing area 1% or 2% increase efficiency is considered to be excellent. Cummins has recorded an outstanding 25% improvement in initial implementations. On that metric alone, Cummins would completely justify their NGMES initiative.

However, Cummins has realized additional major benefits. In the area of quality, Cummins has seen a ten (10) times improvement (decrease) in customer defects. In some cases, they have recorded zero defects to some customers over extended periods.

On the innovation front, they have reused over 85% of their core code from factory to factory. Their learning curve in one factory can be immediately transferred to another factory, eliminating the need of that second factory to experience preventable problems.

However, as mentioned above, Cummins will need to take care that unintended consequences from this rapid dissemination do not occur.

From a collaboration perspective, Cummins has engaged their factory workers in capturing and transmitting knowledge that previously remained as tribal knowledge on the factory floor. In addition, workers are seeing immediate feedback of their improvement suggestions. This encourages them to provide continuing improvement suggestions as they see that their engagement produces visible results.

Cummins will also require collaboration between their MES and PLM vendors. Cummins implementation requires active information sharing of BOPs between the PLM system and MES. This is not a one-time issue. As both vendors enhance their systems, constant collaboration needs to occur so that changes to one system to not cause a loss of interchange capability.

Delivering on the Promise of Global Growth

Cummins ability to deliver on the promise of global growth will play out over the next few years. Cummins is in the early stages of transitioning from legacy product information applications to a commercial PLM system. This will be a change in technology, processes/practices, and people. Any one dimension of change is difficult. Changing all three dimensions will require careful planning, an ability to detect and react to the inevitable issues that will arise, and reliance on and oversight of their PLM vendor. Accomplishing these objectives while keeping costs under control will be Cummins' challenge.

Since NGMES has already had successful implementations, the challenge here is less daunting. Cummins has had both experience in implementations and has reaped major benefits from these implementations. However scaling from a few implementations to all 85+ plants will present its own problems. The implementation team will need to have continuity of individuals who are experienced in both manufacturing and MES. Cummins has proven out the technology of the Apriso FlexNet system. However, Cummins needs to be prepared for cultural and people differences at plants that have historically had their own idosyncratic systems.

Finally, the ability of Cummins to manage their internal transitional changes and their ability at the same time to manage their external technology vendors is the key to future growth. The success of this initiative requires seamless integration between Apriso and PTC. Cummins will need to devote constant attention to this effort.

Initial indications are promising. Certainly, the NGMES benefits are impressive and, if scaled, will dramatically improve productivity and quality. Cummins has seasoned leadership driving these initaives and their Core Team organization enables effective collaboration. Cummins has engaged their technology vendors and has emphasised the importance of continuous collaboration between them.

In short, Cummins has prepared well the promise to deliver on future growth. Their challenge will be in constant attention to that delivery.

About the Author

Dr. Michael Grieves is a world-renowned expert in Product Lifecycle Management (PLM). Dr. Grieves has published the seminal book on the topic: *Product Lifecycle Managent: Driving the Next Generation of Lean Thinking*. Dr. Grieves lectures world wide on PLM, Systems Engineering, manufacturing, and other related areas.

Dr. Grieves has over 40 years executive experience in a wide range of fields. He currently divides his time between industry and academia and has appointments as a professor at the University of Iowa Tippie College of Business, the Florida Institute Technology College of Engineering, and Italy's Consortium Institute of Management and Business Analysis (CIMBA). He consults with selected leading organizations, including NASA, on manufacturing, engineering, and product support and serves as a board member for both public and private firms.

Dr. Grieves' recently published book on PLM is: *Virtually Perfect: Driving Innovative and Lean Products through Product Lifecycle Management*

About Apriso Corporation

Apriso is a software company dedicated to helping its customers transform their global manufacturing operations. It does so by enabling manufacturers to achieve and sustain manufacturing excellence while adapting quickly and easily to market changes. Apriso's FlexNet is a BPM platform-based software solution for global manufacturing operations management. Apriso supports global continuous improvement by delivering visibility into, control over and synchronization across manufacturing and the product supply network. Apriso serves nearly 200 customers in 40+ countries across the Americas, Europe and Asia. Customers include GM, Volvo CE, Honeywell, L'Oréal, Trixell, Lockheed Martin, Bombardier, Textron Systems, MBDA, Saint-Gobain and Essilor. Learn more at: www.apriso.com.