

Effective Transition of Electronics Production between Manufacturing Sites

Paul Novak and Monroe Huang
Delphi Electronics & Safety
Kokomo, Indiana

Abstract

“Unprecedented” is a word often used to describe the events caused by the economic downturn and its impact on the automotive electronics industry. The result has been numerous plant closings and plant product portfolio realignments throughout the industry. This paper focuses on how to effectively carry out production line/facility transitions from one manufacturing location to another.

The first part of this paper focuses on how a company’s systems, structures and strategies provide the basis for successful production relocations. Manufacturing Technology Teams (MTTs) are strategic structures within Delphi Electronics & Safety Manufacturing Engineering. These are virtual organizations which network a group of engineering professionals for the interest of technical contribution. The teams are chartered to design and implement common manufacturing systems and process building blocks around the globe. By having the same design standards, equipment sets, process setups and training, moving a production line from Milwaukee, Wisconsin, to Mexico, for example, is more a logistic challenge rather than a technical issue. Strong foundations such as these allowed Delphi Electronics & Safety to conduct over seventy transition projects over an eighteen month period with no customer disruptions.

The second part of this paper covers the mechanics of carrying out production transitions. Particular attention will be paid to the creation of a standard transition template for enterprise-wide use to create achievement plans. Next, the importance of a management steering team will be considered. The charter of such a team is to track progress of all projects, provide a venue for escalation and resolution of problems, and provide a communication vehicle for issues of common interest to all transition teams. The importance of customer communications, both external and internal, will also be stressed. Other often overlooked, but no less critical, topics are covered in this paper such as conducting in-depth workshops at sending sites to uncover “hidden factories,” the adjustment of supplier contracts especially when changing legal entities, understanding and agreeing to validation requirements and freezing product and process changes during the moves.

Introduction

Preparing for and executing one production line relocation project can be a daunting task for many organizations. However, if an organization does not have a strong foundation of common processes, procedures and “building blocks,” executing several relocation projects simultaneously in different regions of the globe can be unachievable. The focus of the first part of this paper has to do with exploring how a company’s structures and strategies provide the means to flawlessly carry out production moves. It shows how the focus on “common” over a period of time can pay off when it becomes necessary to move the production of a product, or products, from one site to another. Key factors in preparing for and executing the production moves will be covered in the second part of this paper. Included in part two will be the development of a standard transition template, the establishment of a steering team, the importance of customer communications and other factors critical to transition project success.

Part 1:

The importance of “common” to the transition process

Transitioning production facilities from one site to another would be a long, difficult process if enterprises do not have strong foundations of common systems. Within Delphi these foundations are established through the structure of Manufacturing Technology Teams (MTTs). MTTs are virtual organizations that consist of a group of functional experts across the product manufacturing locations and design centers for the interest of manufacturing technology development and deployment. The reason that these teams are deemed virtual is that the members maintain direct reporting relationships to local management and MTT activities are only part of their day-to-day activities. The MTT structure has been in place for over 10 years, and it has withstood several major restructurings and a well publicized chapter 11 filing. This has allowed our division to maintain deep technical skills and common structures enterprise-wide over time.

Since MTTs are organized by center of expertise or functional area, there are a number of teams that have been established. A partial list includes: surface mount technology, soldering, assembly, coatings and adhesives, vision technologies, molding and decorating and test. Regardless of the technology utilized, the mission of each MTT is the same. The mission is to

identify the best manufacturing technologies and practices, integrate them into the common global footprint and drive their implementation throughout the enterprise. Each MTT has a universal set of five roles and responsibilities designed to carry out this mission. Chart 1 is a graphical representation of the roles and responsibilities of each MTT. Each role also has a set of deliverables associated with it.

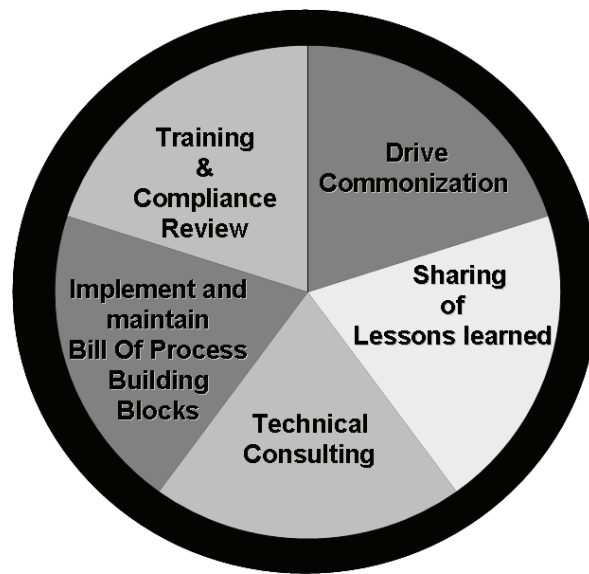


Figure 1 – MTT Roles and Responsibilities

Role 1. Drive Commonization across Sites and Business Units

Moving a product with surface-mounted components, as an example, from one site to another is much easier if the placement equipment is the same at each site than if it is not. Establishing a common set of equipment that each site can implement is one of the key deliverables of each MTT. A common equipment footprint across all manufacturing sites, in essence limiting machine proliferation, allows for rapid redeployment of assets. This is a key enabler for effective and timely site-to-site product transitions. The MTTs are also responsible for the product and process design standards that apply to their respective center of expertise. For example, the surface mount and soldering MTTs “own” the circuit board design standards, and the molding MTT is responsible for the molding design standards. Establishing a universal set of principles allows products to be manufactured on a common set of equipment using proven technology regardless of the location.

Changing a product’s manufacturing location involves sharing knowledge about how the product is manufactured, not just transferring equipment, tooling or programs. A common equipment set and a common set of standards facilitates the transfer of lessons learned between sites via deep-skilled experts. Limiting equipment proliferation also results in a common set of maintenance procedures and spare parts throughout the enterprise. This means that expensive or unique spare parts do not become obsolete when equipment is moved.

A common equipment set that is developed once and redeployed repeatedly improves engineering productivity since site support engineers can focus on deploying the manufacturing system without having to spend time writing unique statements of work, evaluating multiple equipment alternatives or obtaining quotes. These are all factors in significantly lowering the lead time for procuring equipment.

Role 2. Share Lessons Learned

All the knowledge in the world is of no particular use if it is not effectively shared with the rest of the enterprise. MTT members share lessons learned within the organization using various methods. One activity called “Drill Deep/Drill Wide” involves using a formal tracking chart (called a look across chart) and other tools to ensure that the resolution of a production issue in one site is carried out in all the sites. Baseline Process Failure Modes and Effects Analyses (PFMEAs) are another deliverable provided by the MTTs and another means of sharing lessons learned. These PFMEAs include failure modes and causes common to virtually every site and manufacturing line and are used as a starting point for product specific PFMEAs, thus eliminating redundancy and supporting lean engineering.

Role 3. Technical Consulting

MTT members are often called upon to assist with the resolution of production issues at sites anywhere in the world. Sometimes these issues require a level of expertise or access to test equipment that may not be available at every site. Quick problem resolution is often essential to keeping transition projects on track, so having a network of colleagues already established supports this MTT role.

Another method of technical consulting employed by the MTTs involves developing technology roadmaps that are aligned with the product plans of the design centers. These roadmaps are used to identify manufacturing technology gaps (which processes need to be developed and when they are needed) and for planning engineering resource needs.

Role 4. Implement and Maintain Bills of Process and Building Blocks

Process building blocks that include specifics of man, machine, material, method, measurement and mother nature (commonly called the 6M's) are yet another deliverable provided by the MTTs. These building blocks include everything from equipment statements of work, operator work instructions, processing materials specifications, facilities specifications, process monitoring documents and preventative maintenance procedures. The purpose of these building blocks as it relates to production transitions is to commonize the manufacturing processes across the sites. The benefit is to copy the proven quality of existing processes from product-to-product and site-to-site. Organizing process building blocks into standard bills of process (or process flows) is another MTT deliverable. Again, it would be very difficult to move production between sites if the processes used to produce a product were not organized in a common flow from site-to-site.

Role 5. Training and Compliance Review

The core members of a given MTT are seasoned technical veterans with deep skills in their particular area of expertise. These members are called upon to share this knowledge formally by developing and carrying out training classes. These classes are part of a curriculum of internally taught classes designed to enhance the knowledge of the entire enterprise. MTT members are also called upon to conduct line side reviews focused on their particular process focus. These reviews are held on the production floor, and they are designed to ensure compliance to process design standards. A completed production line transition move is an excellent time to conduct these on-site reviews.

Manufacturing Technology Network

With a mission to identify the best manufacturing technologies and practices, integrate them into the common global footprint and drive their implementation throughout the enterprise, the manufacturing technology network is a hierarchical structure depicted in Chart 2. The various entities within this structure and their respective functions are described in detail below.

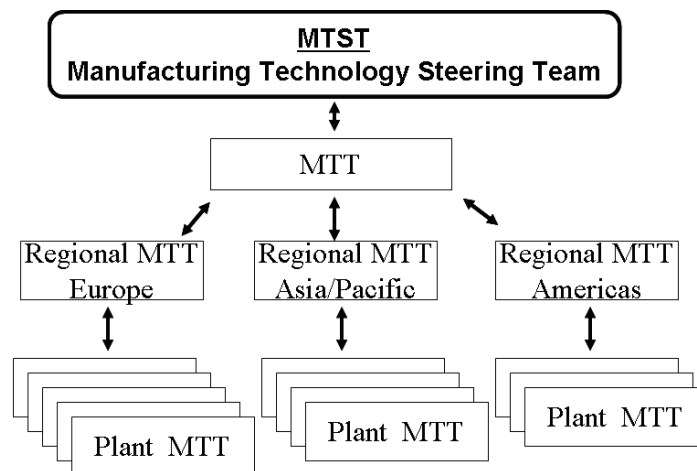


Figure 2 – Manufacturing Technology Network

Manufacturing Technology Steering Team (or MTST)

The MTST serves three major functions. First, it provides the direction for manufacturing technology roadmaps. These roadmaps were described earlier in this paper. Next, the MTST sets the priority for manufacturing technology development. And third, it provides resources and resolves roadblocks.

Global Manufacturing Technology Teams (or MTTs)

The global MTTs are at the heart of the MTT structure. These teams are chartered with developing, maintaining and deploying process building blocks, as well as, product and process design standards. Second, they provide training, conduct audits, initiate Drill Deep and Drill Wide activities and share lessons learned. Additionally, they identify systemic gaps for development and provide technical resolution to production problems.

Regional MTTs

For large organizations with many manufacturing sites, regional MTTs can provide a bridge between the global MTTs and plant MTTs. Specifically, regional MTTs identify needs and provide feedback to global MTTs. Regional MTTs also execute implementation plans, implement building block development projects and provide training to the local manufacturing locations. The regional MTTs can also provide a line of defense for problem resolution. A regional network of experts can provide timely resolution of urgent issues due to their proximity to the site.

Plant MTTs

Plant MTTs function is where the “rubber meets the road.” They are set up to identify the needs of a specific plant site and provide feedback to the global and/or regional MTT. Additionally the plant MTTs execute the implementation plans and assist in providing training to the plant site personnel.

Part 2: Mechanics of the Move

Template Development

The mechanics of carrying out production line and facility transitions are the focus of the second part of this paper. One of the first actions taken when faced with a large number of pending transitions was the development of a standard transition template. The purpose of this template was to gather the collective knowledge of transition experts instead of relying on the intuition or memory of any given individual. And what one person may consider insignificant may be essential to the success of a project, so a standard approach is warranted. The first step in creating a template was holding a workshop attended by representatives of every discipline in the enterprise. The attendees were members of the following departments: operations, manufacturing engineering, validation, project management, production control, industrial engineering, customer satisfaction, product engineering, purchasing and sales. It was important that the attendees had significant experience with carrying out transitions or facility moves since the first task in the workshop was to list all the activities required to carry out transitions. A half day was allocated to this task, and it was carried out in brainstorming fashion. The next day and a half of the workshop was spent putting the activities in sequential order, determining which activities could be done in parallel and assigning activities to disciplines.

Although the detailed template is a proprietary document, the major sections of the template will be discussed. The first section comprehends the selection of site transition leaders, the identification of team members and holding the first team meeting. The second section of the template involves determining the scope of the project. Tasks in this section include obtaining current value stream maps and generating future state maps, developing a project schedule and obtaining a list of part numbers (both OEM and service) that will be transitioned to the new site. Some less obvious but no less important tasks in this section include determining the need for bank (or bridge) builds, defining the communication plans with customers and between the sending and receiving sites and developing the validation test plan, including obtaining customer approval of the validation plan. The next section is focused on conducting audits at the sending and receiving sites. Beyond just hosting site visits, specific tasks in this section include documenting “hidden” factories like rework loops, verifying cycle times and equipment capabilities, finalizing equipment lists, developing logistics plans for moving equipment to the receiving site and collecting documentation including language translations, if necessary. One of the primary goals of this section is to ensure that the manufacturing systems of the sending and receiving sites are compatible. If they are not compatible, any additional action items need to be identified and resources assigned at this time.

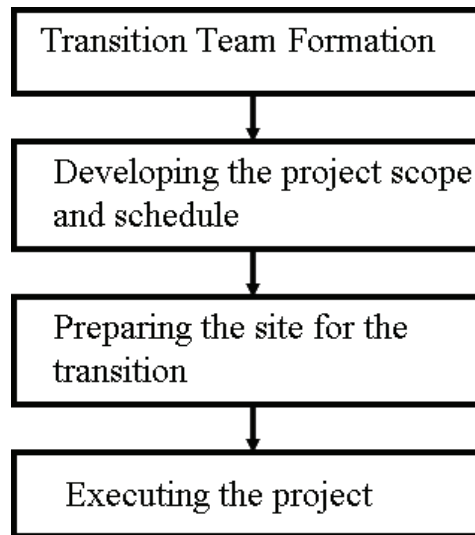


Figure 3 – Transition Project Stages

The last section of the template details the actual execution of the move. There are various tasks to be accomplished here such as: building any required inventory banks, building validation samples and conducting validation testing, conducting run-at-rate builds to verify line rates and site readiness and hosting customer on-site audits. All these tasks need to be completed before the first day of full volume production. Chart 3 graphically depicts the main stages of a transition project.

Management Steering Team/Oversight Board

Resources, particularly human resources, are limited in every organization. This fact coupled with the time-sensitive nature of transition projects creates the need for a management oversight board, especially in large organizations. One of the first things that an oversight board should do is create a tool (perhaps a simple spreadsheet) to keep track of all the transition projects, large and small, within the company. A list of items to include in the tracking spreadsheet includes the name of the project, the project manager, the sending and receiving site owners, scheduled completion dates, who the end customer is, whether or not customer approval has been granted, etc. A reason for using a tracking spreadsheet is that you can sort on any attribute so attention can quickly be focused on, for example, a particular site or projects with completion dates in the near future. The end goal is to find issues before they become problems.

Another reason for creating an oversight board is to provide a communication vehicle for sharing common issues among various transitions teams. It is natural for transition team leaders to focus on the tasks at hand and not have the time to contact leaders at other sites to share lessons learned; this is where an oversight board is essential. More than one customer has been disappointed at having to be the communication channel between factions of the same organization. Having an oversight board in place can help prevent such situations. A third reason for chartering an oversight board is to track expenditures associated with restructuring projects. Since transition projects are sometimes associated with corporate restructuring events, expenditure tracking is critical since this expense can be written off in many cases. Careful accounting while transition events are occurring will provide invaluable records for the future.

Onsite Workshops

It is virtually impossible to document every facet of a manufacturing system on paper. Traveling to a site to observe a system first hand has proven to be invaluable in every case. One way to formalize such visits is to conduct workshops with counterparts from the sending and receiving sites as participants. These participants should include machine operators and equipment maintenance personnel, as well as engineers and managers. It is important that as much time as possible be spent on the production floor during these workshops. This is the opportunity to find “hidden factories” (for example, rework processes) that may not be fully documented. It is also the opportunity for sending and receiving site operators to share information, good or bad, about processes and procedures. As a note of caution, a certain level of care and compassion needs to be expressed since in many cases the sending site may be in midst of being shut down permanently. This fact can create some tension during onsite visits and workshops.

Supplier Contract Adjustments

When changing manufacturing locations it is important that your suppliers are formally notified early in the process, not by the engineering group but by the purchasing and logistics departments. The purchasing department must be involved because

legal documents, especially contracts, need to be changed to reflect the new manufacturing (or for the supplier, the ship-to) locations. Next, the participation of the logistics department is critical so that shipping schedules are changed appropriately. If this is not done properly, a manufacturing location can find itself without raw materials, or a gap in shipments. The latter could be caused when the new manufacturing location is further away from the supplier's location than the old manufacturing location. Additional shipping costs can be incurred from the suppliers if the shipping distances increase.

Bank (or Bridge) Builds

Many production moves require that a bank of products be produced prior to the production line being shut down at the sending site. This is particularly true if excess capacity does not exist at the new (or receiving) site or if unique equipment or tooling is needed and duplicating these pieces is cost or time prohibitive. Planning for a bank build is one of the first tasks that needs to be completed during a transition project. One reason for this is that suppliers of raw materials need a certain amount of lead time to produce the extra parts needed to build the bank of products. This new requirement is above and beyond the raw material that they are already supplying. The next reason is that it takes time to build the actual bank of products. For example, if a facility is already working two shifts (16 hours per day) and a third shift is used for building the bank; it will take 2 weeks to build 1 week's worth of products. In a real life example, twelve weeks of lead time was needed for our suppliers to produce enough raw materials for the bank build. An additional twelve weeks was needed to build the bank during night shifts and weekends. That means roughly six months was needed from the start of the project until the production line could be shut down, dismantled and moved to the new site. Another factor to consider when planning for a bank build is the size of the bank itself. The bank must be large enough to bridge the time required to dismantle the production line, crate it, move it to the new site, reinstall the line, build any required validation parts and conduct the validation testing. This is why it is critical that the achievement plan timeline is followed religiously because depleting the product bank will leave the customer without parts which will not be taken lightly nor forgotten easily by any customer.

No Changes During the Move

Freezing product and process changes during transition projects was another factor in carrying out successful moves. One reason is to put the customer at ease. Changing production sites already causes some level of customer anxiety, so there is no need to heighten it with changing other factors. Also, customers have agreed to limited validation schedules (as we will discuss below) based on an emphasis that the only thing changing during a move is the actual physical location. If a product bank is required, restricting product changes is even more critical. The reason is that predicting how much of each version of the product (new vs. old) to build for the bank is difficult and getting this wrong can be disastrous. A benefit of moving a product without changes to a new site with the same manufacturing footprint as the old site is that direct comparisons of manufacturing metrics can be made. A transition team can validate the transition when metrics like first time quality, throughput, and scrap are equal to or better at the new site than at the old site.

Customer Move Procedures

Customers, especially large corporations, may have specific procedures established to handle customers' production location changes. These procedures often include obtaining approval of the transition plan from a "change board" before any activities can begin. This approval process can be lengthy and/or iterative. The sooner the customer is notified of the transition plans and the change process initiated with the customer, the better. This is especially true if the closure or the sale of a facility is at stake.

A key issue to discuss with the customer early in the move process is what validation testing, if any, will be required before production can start at the new location. When discussing this issue, some customers will relax testing requirements or even only require equipment repeatability studies if no changes are made to the product or the process. This can save a company money, or often more importantly, time during the move process. This fact reinforces the discussion regarding eliminating or limiting changes during the move process and the importance of commonality across the enterprise. Also, it is important that validation requirements are formally agreed upon in writing, so there are no questions later.

Equipment Functionality

Ensuring that equipment being sent to a new site is fully functional prior to the move is essential to a successful transition project. The project timeline will be derailed if it becomes necessary to obtain unexpectedly missing parts or spend time bringing equipment back to working order once it is received at the new site. A way to prevent such occurrences is to move equipment off site, especially if there will be a time lag before the move. This will avoid the temptation to remove parts to keep other equipment in the sending factory working. Another way to ensure functionality is to conduct any long term preventative maintenance procedures before the move. For complex or expensive equipment, it is also advisable to have the original equipment manufacturer assist with the crating of the equipment. Lastly, it is essential that the shipping method matches the manner in which the equipment is packaged. For example, if a crate is destined to be shipped by sea and it is not sealed properly, the equipment inside may rust which would potentially render it useless or at the very least cause expensive and lengthy repairs.

Environmental Permits

A chemical used legally at the original manufacturing location may not be able to be used at the new manufacturing location. This can be true when moving from one state to another and even more likely when moving from one country to another. A company must also consider not just which chemicals are used, but how much of a given chemical is used and how much of the chemicals are emitted into the air. So a company, even a large one with an environmental engineer or engineers on the staff, may need to hire a consultant to ensure compliance with environmental laws. Dealing with governmental entities can be time consuming, so this is another process that must be initiated very early in the product move process.

Conclusion

Many people may think that moving a product's manufacturing location is as simple as moving equipment from point A to point B and restarting the production line. However, there are many things to consider in preparation for a transition event. A factor not always considered is how an enterprise implements common structures and systems can have a large impact on the potential success of production line relocations. This focus on "common" is not something that can be a short-term initiative; it must be a long-term way of doing business. Many factors are involved in the planning for the actual transition of the production facility. A key to planning is creating transition templates or achievement plans with solid, achievable dates because the customer's satisfaction and trust is at stake. With the proper focus and attention to detail, a company can carry out flawless production moves, and even simultaneous moves, at sites around the globe.



Effective Transition of Electronics Production Between Manufacturing Sites

Paul Novak and Monroe Huang

Delphi Electronics & Safety

Kokomo, Indiana

Transition Experience

- Moved 78 surface mount lines globally over an 18 month period
- Represents an annual volume of over 9 million products of various complexity
- No customer disruptions throughout transition period

- Key Factors for Effective Production Transitions to New Sites
 - Strong foundation of common processes and procedures
 - Standard approach to transition mechanics throughout the enterprise

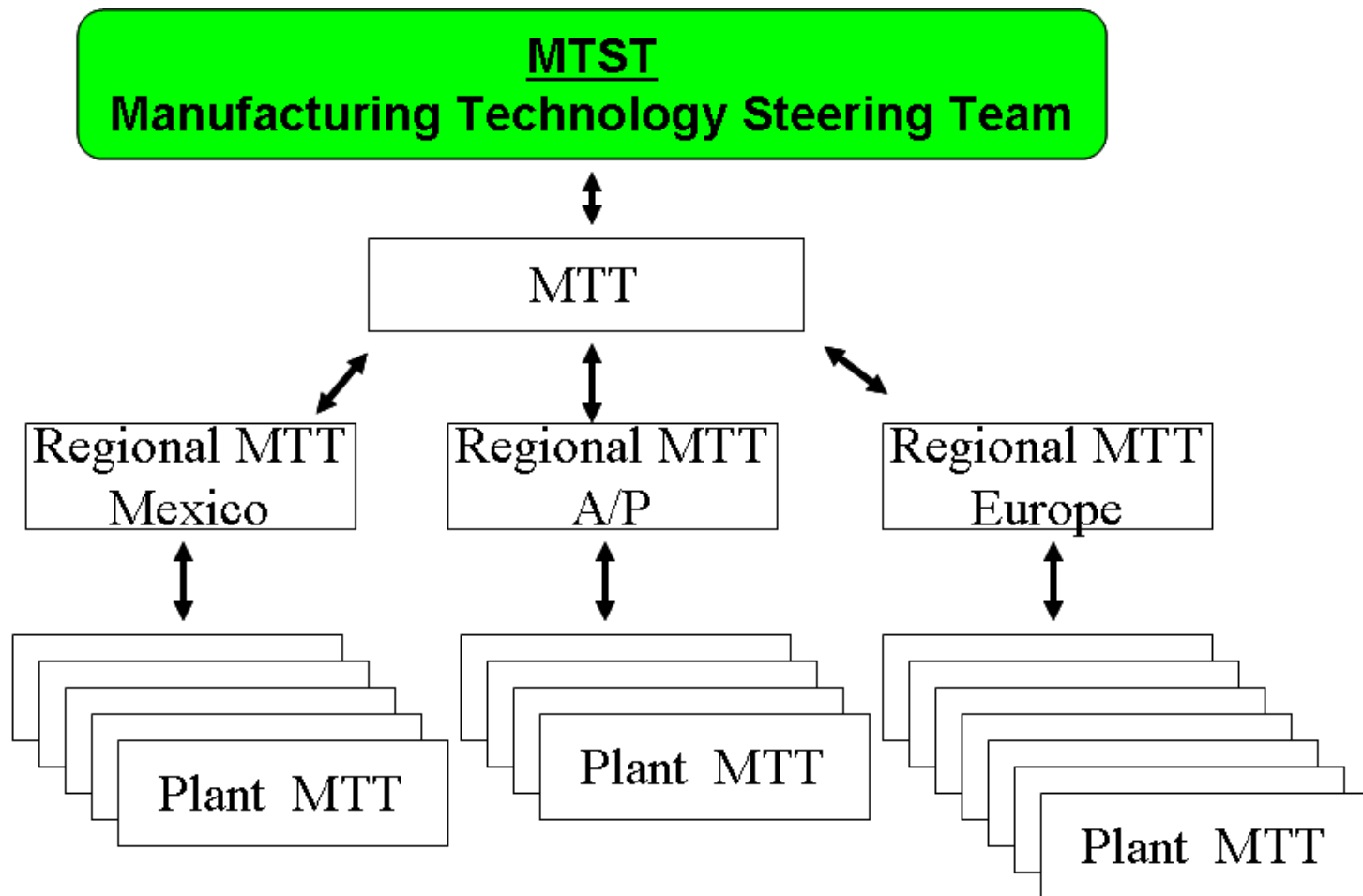
Manufacturing Technology Teams (MTTs)

- Virtual Organizations
 - Consist of functional experts
 - Located throughout the world-wide enterprise
 - Maintain local direct reporting relationship
 - Enabler for maintaining deep technical skills
- Sample of established teams

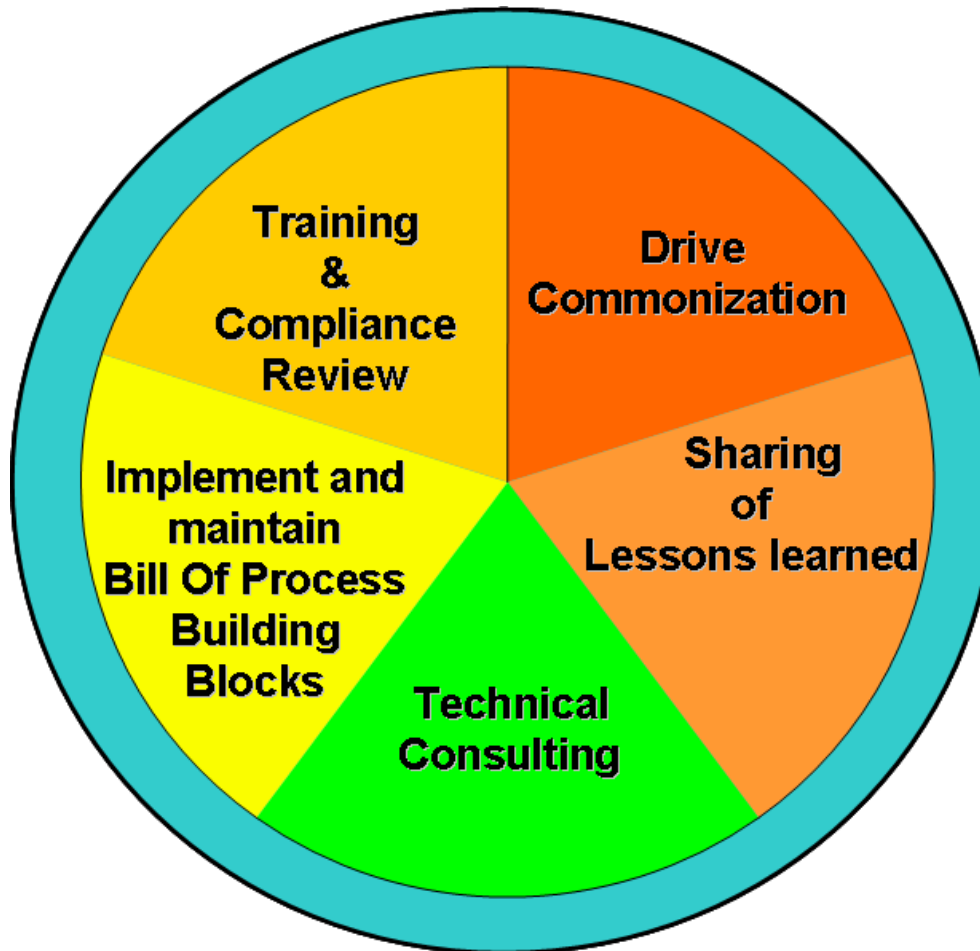
Surface Mount	Soldering
Coatings & Adhesives	Assembly
Molding	Vision Technologies
Test	Welding

Manufacturing Technology Network

Mission - Identify the best manufacturing technologies and practices, integrate them into the common global footprint and drive their implementation throughout Delphi Electronics and Safety Systems.



MTT Roles & Responsibilities



MTT Role 1: Drive Commonization Across Sites and Business Units

- Common equipment footprint at manufacturing sites
 - Limits machine proliferation
 - Allows rapid redeployment of assets as needed
- Common Process Building Block elements
 - Proven technology
- Common knowledge base
 - Deep-skilled experts in all regions
 - Lessons learned are transferable
- Common Maintenance/Spare Parts worldwide
- Long term corporate purchase approval
 - Engineering productivity improvement
 - Do not need to return to sourcing table for each purchase
 - Reduced order lead time

MTT Role 2: Share Lessons Learned

- Effectively share knowledge throughout the enterprise
 - Drill Deep/Drill Wide
 - Ensure universal application of problem resolution
 - Formal tracking system – look across chart
 - Baseline PFMEAs
 - Used as a basis for product specific PFMEAs
 - Includes fail modes & causes common to many sites and manufacturing lines
 - Reduces redundancy and supports lean engineering

MTT Role 3: Technical Consulting

- Resolution of production issues world-wide
 - Members possess high level of expertise
 - Access to specialized tools or test equipment
 - Quick problem resolution – keeps transition projects on track

- Technology roadmaps
 - Align process technology development with future product plans
 - Which technologies are needed?
 - When are they needed?
 - Plan engineering resource needs

MTT Role 4: Implement and Maintain Building Blocks & Bills of Process

- Process Building Blocks include specifics of:
 - Man: work instructions, operator training, maintenance training
 - Machine: statement of work, preventive maintenance, spare parts
 - Material: material specifications, material safety data sheets
 - Method: baseline PFMEA, design standards, line side review checklist
 - Measurement: capability studies, process monitoring sheets & methods
 - Mother Nature: facilities requirements, environmental controls
- Commonize processes across the sites
 - Proven quality product-to-product and site-to-site
- Bills of Process
 - Building blocks organized into common process flows
 - Facilitates movement of products between sites

MTT Role 5: Training and Compliance Review

- Develop and carry out training classes
 - Internally taught courses are organized into process-specific curricula
 - Enhance the knowledge of the enterprise
- Conduct “Line Side Reviews”
 - Held on the production floor
 - Ensure compliance to process design standards
 - Product and production transitions are appropriate times to conduct line side reviews

Same Equipment
Same Design Standards
Same Setups
Same Training

Leads To ...

Production Transitions – More Logistics
Challenge Than Technical Issue

Now We Will ...

Focus On Mechanics Of
Production Moves

Standard Transition Template

- Gather the collective knowledge of transition experts
- Use as a basis for transition project achievement plans
- Developed by representatives of:

Operations	Manufacturing Engineering
Validation	Project Management
Production Control	Industrial Engineering
Customer Satisfaction	Product Engineering
Purchasing	Sales

Transition Project Stages

Transition Team Formation



Developing the project scope
and schedule



Preparing the site for the
transition



Executing the project

Management Steering Team/ Oversight Board

- Track simultaneous transition projects across the organization
 - Develop and use tracking tools, even simple ones
 - Focus attention on developing issues before they become problems
- Share common issues among transition teams
- Track project spending
 - Provides valuable records for later use

Onsite Workshops

- First hand observation of manufacturing system at sending site
- Participants to include operators, maintenance personnel and engineers from sending and receiving sites
- Uncover “hidden factories” and share information

Supplier Contract Adjustments

- Notify suppliers early in the transition process
- Contracts need to be changed to reflect new manufacturing location
- Need to ensure no gaps in supply of raw materials
- May incur additional shipping costs if distances increase

Bridge (or Bank) Builds

- May be required prior to shutting production line down
- Needed if:
 - Excess capacity does not exist at receiving site
 - Not possible or practical to reproduce unique equipment
- Long lead times often needed for vendors to supply extra volume of raw materials
- Time to build the bank can be lengthy and expensive – using off-shifts and weekends
- Need to ensure quality and quantity of banked material

No Product or Process Changes During the Moves

- Reduces customer anxiety
- Customer may agree to reduced validation testing
- Nearly essential if bank builds are required
- Allows comparison of metrics before and after the move

Customer Move Procedures

- Customers may have “change boards” and specific procedures
- Involve customers early since approval process can be lengthy
- Obtain validation plan agreement up front
 - Extensive validation testing can drive project timing

Conclusion

- Transitioning manufacturing from one site to another involves many factors that are often overlooked.
- An organization's focus on "common" plays a key role in successful transitions.
- Careful planning and staying on track are keys to customer satisfaction.