Measuring Productivity and the Impact of Prefabrication on Productivity

Marquette University
Mark O. Federle
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ELECTRI Council
ELECTRI International—The Foundation for Electrical Construction, Inc.

As of December 2015

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Executive Summary

Introduction

Field and office productivity and the use of prefabrication in the Electrical Contracting industry are intertwined. This project explored the impact and use of prefabrication within Lean Construction and BIM and VDC. The focus was to untangle and objectively characterize the relationship between productivity and prefabrication. The investigation resulted in a set of best practices that can help Electrical Contractors optimize prefabrication to obtain peak productivity.

To understand how productivity of field and office personnel is measured and to identify the impact of prefabrication on operations, the research team conducted specific “case studies” with 14 leading union and non-union electrical contractors and with leading mechanical contractors throughout the United States. Individual site visits and personal interviews allowed a deeper dive into the changes electrical contractors made to increase their use of prefabrication.

The case studies explored the impact on productivity for field and office operations. These studies provided tactics to guide other electrical contractors who want to increase their prefabrication efforts and understand how they could use prefabrication to increase their competitiveness in the marketplace.

The final investigative report includes the findings from the case studies and provides a series of tactics that may be used by an electrical contractor for implementing prefabrication and measuring its impact on productivity.

The report presents three different levels of tactics for contractors at different stages:
- beginners at prefabrication,
- contractors seeking to dramatically increase their prefabrication efforts,
- advanced prefabricators who can benefit from a few additional tactics.
The research project

The original proposal for this research can be reviewed in Appendix A. During the project, investigators made a number of modifications, both in the approach to the data collection and the focus of the productivity measurement relative to prefabrication.

Per discussions with the ELECTRI Council, researchers decided to seek out both mechanical contractors and non-union electrical contractors to participate in the case studies. Also, during that Council meeting, researchers pursued securing participation in the planned focus groups.

During the course of the project, it became apparent that companies were unwilling to share current and future practices relative to prefabrication with their competitors because these practices were strongly perceived as providing a competitive advantage. This eliminated the possibility of establishing focus groups. In consultation with the ELECTRI staff, the research team decided that four additional case studies would be substituted for these focus groups.

The researchers had also intended to acknowledge those who participated in the case studies. However, a majority of participants specifically asked that names and companies not be shared. For that reason, we have listed the task force members but not the case study participants.

The general demographics of those participating include:

- 2 non-union electrical contractors
- 10 NECA contractors
- 3 mechanical contractors
- About one-half were from the Midwest
- About one-half had very active (and in many cases) large prefabrication areas
- Twenty-five percent were new (in the past year or so) to prefabrication

As part of the survey, researchers asked specifically for details on how contractors measured the impact prefabrication had on their productivity (See Appendix B). For those willing to provide numbers, the range went from fifteen to thirty-five percent labor savings over non-prefabrication. Some savings came from better planning (impacting the entire job, not just those portions prefabricated), and, in some cases, increased material delivery costs were incurred.

Investigators did not have a single participant who indicated the company would decrease the amount of prefabrication based on decreases in productivity or increases in labor costs. In fact, multiple participants very clearly stated that even if prefabrication did not save any labor costs they would still prefabricate as much of the project as possible because of increased safety, the positive impact on schedule, and the reduction in material waste. Based on their experiences, whether your company is new to prefabrication or looking to expand its efforts, their advice was “Get started now!”
The next sections of this report, entitled “Beginners”, targets electrical contractors who have not attempted any prefabrication or have not found an approach that works for them. This section provides specific tactics for an electrical contractor to use to begin implementing a prefabrication strategy.

For Beginners

There are electrical contractors who have never attempted a prefabrication effort, or whose previous efforts have failed. For this group, the case studies reveal a number of tactics that might get one started on a path that leads to success. If one needs some convincing before getting started, consider these benefits to contractors, as reported by Graybar in http://www.graybar.com/manufacturers/tnb/efab-online-prefabricated-rough-in-solution:

- Labor savings of up to 50% on in-wall, rough-in installation costs.
- Material savings of up to 40%.
- Reduced material handling and inventory costs by building (or ordering) based on the quantities needed for the job and the ability to supply the labeled assemblies in exact quantities.
- Reduced on-site packaging and waste by identifying specific locations on the job to deliver prefabricated materials, thus allowing utilization of palletized assemblies.

Tactic 1:

To get started, find a project that allows you to start small.

Look for a project that has a few items that could be prefabricated prior to sending them out to the field. This could be as simple as:

- Wiring Devices
- Electrical Assemblies
- MC Cable Whips
- Temporary Power / Distribution
- Temporary Lighting
- Bending larger sizes of conduit

The key to this tactic is to start with a review of a project that has willing participants both in project management and in-field supervision. You must have the commitment of both to determine what makes sense for the project. It is important for the executive of an electrical contracting business to provide support to the project manager and lead foreman. Therefore, it is extremely unlikely a prefabrication implementation will be successful if it is forced upon them. Picking a project and forcing the project manager and foreman to implement prefabrication when they are uninterested will NOT work.

There are two approaches in determining which items will be prefabricated. One is to purchase already manufactured items from a supplier and then simply install what is provided. One case study participant identified potential suppliers who have a presence at NECA’s Annual Convention. Their items are directly shipped to jobsites in boxes or containers with specific identifiers regarding where in the project these specific materials would be installed. This, in effect, reduces the amount of handling on each project. Typically, these produces include information on drawings and labels, showing exactly where each item should be installed.
The second approach is to create space in the contractor’s existing warehouse (more on that later) to allow the prefabrication manager to supervise the fabrication of these components in the contractor’s own shop. It is important to have someone with a passion for prefabrication and excellent communications skills leading this effort. Quite possibly, the individual can supervise multiple groups of workers, hired at a lower wage rate than journeyman scale on the jobsite, to prefabricate these materials. Again, experienced contractors strongly encourage that the materials not be shipped out in one large container, but should be organized based on room or area. At the extreme, one contractor shipped out everything, even consumables like screws, per room. This same contractor also indicated a belief in the highest amount of labor savings due to prefabrication. In fact, there were some specific tasks for which the hours saved were identified as a seventy-five percent reduction over items completely field built.

**Tactic 2:**

*Determine if you have space, and are willing to dedicate it, to creating your own prefabricated items.*

In some cases, contractors reported being able to clear out space in existing warehouses that housed old/broken tools, materials returned from jobsites not likely to ever be used again, etc. There are two possibilities for ways to reduce space that materials are taking up in the warehouse. It may be possible to sell some of those materials back to a supplier, who will likely pay cents on the dollar compared to the original purchase price. This is still a better option than NOT starting your prefabrication efforts. It may also be possible to donate the materials to Habitat for Humanity’s Restore program or some other charity. In either case, your commitment has to be to stop storing materials that are simply consuming space.

**Tactic 3:**

*Contact vendors.*

If space is not available, or if purchasing prefabricated materials is preferred, contact vendors (“Google” prefabricated electrical assemblies) who can provide prefabricated materials.

**Tactic 4:**

*Attend the NECA Trade Show and visit with vendors.*

At the trade show, it is quite likely that one will identify additional vendors who can provide ideas regarding what a contractor might prefabricate or alternatively provide those items.

**Tactic 5:**

*Consider standardizing specific materials, whether boxes, mud rings, or cable whips.*

The case study participants acknowledged that materials costs may increase by selecting a more expensive box that works in all situations for multiple customers. Nevertheless, view this decision as one that provides significant benefits when purchasing or issuing a purchase order for the total planned quantity needed for the year rather than ordering specifically to a project. An additional advantage is a likely increase in crew productivity because they will have better materials that are familiar to install. Certainly, the increase in material costs is insignificant relative to the labor savings generated.
Tactic 6:

**Review the materials stored in your warehouse. Then ask and answer these questions:**

1. What did it cost in labor hours to bring these materials back into the warehouse and keep them organized?
2. What is the annual cost to store, insure and track the inventory for these items?
3. What is the oldest material in the warehouse?
4. How much labor is lost looking for items stored somewhere in the warehouse?

Tactic 7:

**Contact the material vendors and ask which materials they will purchase back.**

Among the case study participants, most have sold back old materials to vendors and now keep a limited amount of inventory in the warehouse. The best-in-class contractors keep no inventory except for standard items. In some cases, these standard items are re-stocked by the vendor rather than ordered by the contractor (more on that later).

Tactic 8:

**Tie prefabrication efforts and using the concepts of Lean Construction to improve overall operations and productivities.**

One opportunity that many of the case study participants reported using is what Lean calls 5S events. A video titled Grunau Construction 5S describes how a mechanical contractor has used 5S to improve operations. It can be found at [http://www.grunau.com/lean-construction.php](http://www.grunau.com/lean-construction.php). By following the steps outlined in this video, an electrical contractor should be able to improve field operations (think of how often electricians look for tools, materials, and information) and implement the 30-second timeframe to improve field productivity. A helpful presentation on how an electrical contractor might go about improving its warehouse areas and create needed space can be found at [http://www.leanconstruction.org/media/docs/chapterpdf/chicago/2012-11-15-lci-chicago-meeting.pdf](http://www.leanconstruction.org/media/docs/chapterpdf/chicago/2012-11-15-lci-chicago-meeting.pdf). “When in Doubt, throw it out” and organizing your shop’s tools, equipment and material storage will greatly enhance your ability to do in-house prefabrication.

Tactic 9:

**Put the best field foreman interested in prefabrication in charge of the prefab shop.**

Make participation voluntary. By placing the best person in the position, his/her organizational influence will likely lead to others also seeking opportunities to prefab. If the company is relatively small, especially when it comes to manpower, perhaps identifying items that a single person can start prefabricating can be used as a springboard to influence other tradespeople into considering prefab. This is especially worthwhile when considering the reaction from labor over hours being taken away. In this case, one is simply moving hours into an environment that will help labor be more productive, allowing them to work in better conditions (assuming your warehouse is a better workplace than a project worksite), and allowing the company to be more competitive, thus increasing the number of electricians one would employ.
Tactic 10:

*Select a standard to track prefab hours.*

The old adage of “What gets measured gets managed” applies to prefabrication productivity as well. When starting out, the case study participants suggested the importance of selecting a standard to track prefabrication hours between the methods described in Tactics #11 and #12.

Tactic 11:

*Keep tracking as simple as possible.*

To keep tracking as simple as possible, review the total labor hours in the estimate, review those items one plans to prefabricate or to purchase already prefabricated. Shift the appropriate number of hours from the field labor to a new “prefabricated” category. Most suggested shifting the number of hours used in prefabrication to the new category if self-performing the prefabrication. If purchasing prefabricated materials, calculate the increase in material costs and divide by the burdened hourly cost of an electrician to reduce the number of field hours. This tactic was suggested in an effort to keep the tracking simple. It will also provide a very easy way to determine if there were labor savings on this project. It was suggested that one not worry about whether one could determine if this savings was due to prefabrication or other reasons. Assuming there are savings, it is likely that one is building the case, internally, for more employees to be interested in prefabrication.

It is important to note that more than one of the case study participants indicated even if there were absolutely no labor savings, they would still prefabricate because of the ability to meet schedule, the enhanced safety from working in a more controlled environment, the improved quality, and other tangible and intangible benefits.

Tactic 12:

*Measure and have “apple to apple” comparisons.*

This suggests that prefabrication hours be tracked at the same level of detail that field hours are tracked. Many cost codes used in the field to track hours should be easily converted to a series of prefabrication cost codes. Determine the level of effort required and shift an appropriate amount of hours from the field labor cost code to the prefabrication cost code.

The best practices from the case study participants indicate that when beginning this effort, simply track the number of hours spent in prefabrication and reduce the total number of field hours as the best first step (remembering to put one of the best people in charge of prefabrication). Once the company has built up a cost code history on the savings being generated by prefabrication, then explore a more sophisticated approach by providing budgeted hours to both the prefab shop and the field forces based on the total number of expected hours rather than estimated hours. The best practices from the case study participants indicate when beginning this effort, shifting based on a percentage of total hours is a likely second step.
Summary for the Beginning Implementer:

1. **Start small** – pick a project that has a strong likelihood of success. Put measures in place to determine the level of success and then tell others in the company about it.

2. **Devote space** – preferably visible space that is well-lit and well-planned.

3. **Make it voluntary** – success will not come from forcing participation.

4. **Put the best people in the prefab shop** – this demonstrates your commitment to the process.

5. **Organize shop using 5S events**; a poorly organized prefab area will dramatically -- and negatively -- impact the likelihood of success.

6. **Manage prefab as a bucket** – specifically identify how many hours are moved from the field and put into the prefabrication efforts. Then measure how many hours are used in the prefab, return the remaining hours back to the field and see how they do. The key is to be transparent with the hours and share the success.

7. **Use Apprentices** in your prefab shop (or CWs if allowed) to reduce your hourly rate.

For those who want to increase their prefabrication efforts

**Advanced Tactic 1:**

**Package into bins by area/room.**

One clear indicator of the more advanced prefabrication efforts was organizing packaging into bins by area/room. Some contractors chose to use re-usable bins; others chose to have one-use cardboard boxes. Each had determined what was best for his/her own prefabrication approach based on multiple trial and error attempts. The electrical contractor should try a number of different containers and labeling efforts to see what works best. Participants suggested developing a color or numbering scheme that makes it visually apparent where that particular container or box should be delivered. In one case, researchers observed multiple colors of plastic wrap that specifically identified to which floor that particular colored pallet should be delivered.

**Advanced Tactic 2:**

**Separate material handling from electrician’s installation.**

To better identify and manage installation costs, an electrical contractor must start separating the costs associated with material handling from those associated with installation. Better planning should allow one to develop crews that focus on doing one or the other. Clearly, material handling labor costs can be dramatically less than the scale for a union electrician. At the same time, start measuring the reduction in trash and packaging that comes from increased prefabrication (see tactic below).
Advanced Tactic 3:  

**Work to reduce significantly the amount of packaging and trash that ends up on the jobsite.**

While this might be captured as material handling costs, an electrical contractor should recognize specifically how much time and effort get spent in removing materials from boxes, carrying the boxes to the dumpster, and paying the waste hauler to remove those dumpsters. Those costs are usually much higher than estimated or expected and most are likely hiding in the labor hours for each particular installation.

Advanced Tactic 4:  

**When seeking more opportunities to prefab, increase the amount of time provided to the lead foreman to plan the prefab for the project.**

If all the planning and work for a project is reactionary, it is doubtful that one can grow in prefabrication efforts. Seek projects that allow for pre-planning or work with the CM/GC to ensure the focus is on completing the work efficiently in the field (rather than simply showing a lot of activity on the project). This should increase the amount of prefabrication that can be completed on the project.

Recall that many case study participants specifically identified their intent to prefabricate even if there were no labor savings simply because of the positive impact prefabrication has on reducing the number of items on the critical path.

It is imperative that the electrical contractor creates that level of understanding within the project management staff of the CM/GC. Most GCs/CMs should understand this point if they think about the mechanical trades and the amount of prefabrication done in ductwork and piping. Ensuring they understand the speed at which the electrical installation can occur due to proper planning and significant prefabrication is the key. One case study participant explained that prefabricating the main conduit runs in a hotel’s hallways reduced the number of electricians used for that task. They were able to keep up with the drywallers and mechanical trades, drop from a typical ten-worker job down to two electricians, and demonstrate to the GC/CM, who were doubters at the start of the project why the planning and prefabrication efforts were justified.

Advanced Tactic 5:  

**Attend the NECA trade show each year to learn more about opportunities.**

The research team contacted a number of different vendors who made it clear that the vendor community is seeking opportunities to help electrical contractors in prefabrication efforts. It is important that yearly efforts be made, as each year there are new offerings from vendors.

Advanced Tactic 6:  

**Explore longer-term purchasing agreements with vendors.**

In some cases, the electrical contractor has turned over the materials management activities for specific items to a single vendor based a purchase order ranging from one to three years. There are minimum and maximum quantities that are identified, but the vendor is the one usually responsible for managing and owning the inventory.
Advanced Tactic 7:

*Be willing to share labor information.*

Whether it is called open-book management or transparency, based on the conversations in the case studies, it is clear that one key to success is the electrical contractors’ willingness to share labor information.

This must be the actual data, not a percentage. Participants noted that the right people will be excited about the savings and the wrong people will coast which, to participants, was very clearly a management not a prefab issue.

Advanced Tactic 8:

*Track waste reduction.*

From the case study interviews, one can conclude that the contractor who dramatically increases prefabrication efforts will see the amount of material waste on a job reduce to less than two percent from five to ten percent. Several case study participants reported reducing the waste for specific items from having filled a dumpster to now only filling a five-gallon bucket.

**Summary for Those Increasing Prefab Efforts:**

1. Package into bins by area/room.
2. Separate material handling from electrician’s installation.
3. Work to reduce significantly the amount of packaging and trash that ends up on the jobsite.
4. Increase the amount of time provided to the lead foreman to plan the prefab for the project.
5. Attend the NECA trade show each year to learn more about opportunities.
7. Be willing to share labor information.
8. Track waste reduction.

**For Those with Significant Prefab Operations in Place**

**Highly Advanced Tactic 1:**

*Increase precision in drawings/models.*

Advanced prefabricators leverage modeling efforts to go beyond what was contractually required. These companies purposefully used modeling efforts in a manner that allowed them to explore more and more prefabrication options. This may require an increased investment in the modeling department but should open up opportunities to explore modularization across trades.
Highly Advanced Tactic 2:

Seek or create opportunities to modularize components.

While modularization has been around since the 1960s, current efforts to reduce labor hours expended on the jobsite and to reduce the number of activities on the critical path have greatly expanded the interest and efforts surrounding the use of prefabrication to support modularization efforts. It seems clear that these efforts will only look to expand into additional markets.

Highly Advanced Tactic 3:

Prefabricate to remove activities from the critical path.

Similar to the efforts in modularization, it is important to look at prefabrication efforts that take items off the critical path allowing faster project completion times.

Highly Advanced Tactic 4:

Use prefabrication efforts to expand market share.

Some advanced users of prefabrication specifically note that prefabrication has allowed them to not only compete but also win market share back from those with a lower electrician hourly cost. By reducing the total number of hours needed on a project, they indicate that significant market share could be regained.

Highly Advanced Tactic 5:

Manage productivity at the task level.

To ensure the company is making data driven decisions regarding prefabrication and productivity, it is important to focus on managing productivity at the task level. Some contractors who participated in this study had not changed their methods of tracking productivity to help them understand the time required to prefabricate specific items. Instead, they relied upon their Prefabrication Manager to know when employees were working to their utmost capability. This clearly is not the best way to manage work, since developing productivity measures for both the field and the prefabrication crews is critical to tracking success.

Highly Advanced Tactic 6:

Seek out experts.

One might argue this could also be a basic tactic. Based on how much time, effort and energy an electrical contractor is willing to put into their efforts, using an outside consultant was highly recommended. It is quite possible that prefabrication efforts will be improved through the use of outside consultants, particularly those who understand not only electrical contracting but also have expertise in Lean Construction and Supply Chain Management.
Highly Advanced Tactic 7:

*Apply Lean Construction principles to increase prefabrication.*

When organizing the prefabrication area and, for that matter, when organizing your processes and warehouses, learn and follow Lean Construction principles. There is a wealth of information available from ELECTRI International (www.electri.org) from the Lean Construction Institute (http://www.leanconstruction.org/) and from the AGC (www.agc.org/LCEP). As part of this effort, consider (perhaps with outside assistance) completing Value Stream Mapping of office and field processes. Start with items that will provide the most “bang for the buck” and simplify ordering of materials, setting up job trailers, etc.

An additional result of Value Stream Mapping could be the exploration of products which become the company standard. The focus of these decisions should be on the benefits that come from:

- On-line forms to order prefab materials
- Decreased order times
- Increased knowledge of materials used in installation
- Decreased warehouse costs

Another part of the decision-making could focus on how to develop and use on-line forms to order prefab materials. As one looks for those opportunities, bring in preferred vendors and start exploring strategies for vendor managed tools, materials, hardware and perhaps even making commitments for purchases through the use of yearly contracts.

Highly Advanced Tactic 8:

*Manage by facts and collect data.*

Develop Prefab cost codes to match job cost codes. Once this has been accomplished, there can be a discussion between the prefab manager and the project manager on each project how best to re-allocate hours between the prefab shop and the field labor. Obviously, there should be a correlation between the two. One caution, provided, as an example from some case study participants was that this effort should be focused on outputs rather than inputs and not simply moving hours from one cost code to another. Carefully analyze how many hours it takes to prefabricate each component.

It was also suggested as a company becomes more sophisticated in its prefabrication efforts, there should be an effort to set company goals for Prefabrication. Perhaps:

- 1/3 of hours in prefab
- 1/3 in installation
- 1/3 in time savings (this may be treated like contingency or savings to the project)

Some participants in the case study were adamant that the NECA contractor not discount hours due to prefab. The exceptions noted were during those tight markets where the use of prefabrication might provide a competitive advantage.

Highly Advanced Tactic 9:

*Increase the level of planning significantly prior to job starts.*

Planning should be used to drive co-ordination with other trades, perhaps bringing the CM/GC on board. Participants noted that working with other trades is an important step in prefabrication efforts. One participant noted, “Develop a plan; execute the plan”. That firm experienced eight hours of field labor savings for every hour of planning.
As their planning grew in sophistication, they began to include vendors in the planning process. This allowed them to determine ways to use deliveries made by their vendors for shipping prefabricated items.

**Highly Advanced Tactic 10:**

*Consider establishing prefabrication shops on the jobsite.*

Very large projects, or those with sufficient space, may have the need or opportunity to build a prefab shop on the jobsite. Particularly for projects where there are long shipping distances and large mass (duct banks). Recognize that, for most contractors (perhaps all), labor is the risk, not transportation.

**Other thoughts from participants:**

- Stay out of the storage business
- Only have materials on the job for the next week
- Reduce the number of touches
- Visit with the design engineers to identify prefabrication opportunities
- Pick what you DON’T want to do in the field
- Eliminate trash / packaging
- Remove benders from the field
- Coordinate multi-trade racks

**Observations at two Mechanical Contracting Businesses:**

Develop software that those working on prefabrication can use to track the exact amount of time used to prefabricate a single item or group of items. This approach is already in use by a number of mechanical contractors. Web-enabled devices allow an operator to log in, see the piece to be constructed, and then automatically track the hours to prefabricate. While an individual piece may be too granular for an electrical contractor, it is easy to discern where having a set of like prefabricated materials all tracked under a single code would be beneficial. It should be noted that using this type of software was not observed in any electrical contractors shop.

**Summary for Those with Significant Prefab Operations in Place:**

1. Increase precision in drawings/models.
2. Seek or create opportunities to modularize components.
3. Prefabricate to remove activities from the critical path.
4. Use prefabrication efforts to expand market share.
5. Manage productivity at the task level.
6. Seek out experts.
7. Apply Lean Construction principles to increase prefabrication.
8. Manage by facts and collect data.
9. Increase the level of planning significantly prior to job starts.
10. Consider establishing prefabrication shops on the jobsite.
Conclusion

The tactics detailed above will work best when electrical contractors specifically develop their plan for prefabrication as part of their overall strategic plan. Each contractor will need to determine what best fits the culture of an individual organization and increases the likelihood of a successful implementation.

Many of the quantitative benefits of prefabrication will only come from changes in the method of estimating and tracking costs. Many benefits of prefabrication go beyond labor savings and will manifest themselves in better plans, safer job sites and decreased construction schedules.
Appendices

Appendix A

The Proposal

Introduction

The productivity of field and office personnel and the use of prefabrication in the Electrical Contracting industry are intertwined. This project sought to untangle and objectively characterize the relationship between productivity and prefabrication. The goal of this project was to develop a set of best practices that could enable Electrical Contractors to optimize the use of prefabrication to obtain peak productivity.

There are a number of previous reports that provide a great amount of detail on how and why and electrical contractor could go about increasing the amount of prefabrication they use in completing their electrical installations, this project was not intended to duplicate nor confirm those efforts. For those interested in learning more about prefabrication in electrical contracting, please refer to these reports published by Electri. The focus of many of these reports is:

Prefabrication can help improve (Moore 2014):

- Safety
- Reliability
- Predictability
- Productivity
- Composite Rates
- Crew Mix of the Jobs

Other resources would include:


2. Exploring the Opportunities for Applying Lean Principles to Electrical Prefabrication - (Yang, Yizhe, Lee, Hyun Won and Shakouri, Mahmoud,) The Electrical Contracting Foundation, 2014.

Current Conditions & Practices in the Electrical Contractor Industry The current conditions in the Electrical Contractor Industry require contractors to continuously seek to improve their competitiveness by increasing productivity. Without concrete evidence to identify the optimal use of prefabrication, it is impossible for Executives to make sound decisions to positively impact their productivity. Many electrical contractors have simply entered into prefabrication based on faith or that it was the right thing to do, or alternatively chosen not to pursue a prefabrication strategy due to the lack of hard data to support the investments required to implement a modest of full-blown prefabrication workplace. This study sought to analyze how both might be accomplished.
Action Needed to Address these Issues.

Working with the task force and members at the Electri Summer meeting, it was decided to use 14 face-to-face interviews to examine the following questions:

■ How do various contractors measure and track productivity on their jobsites and in their shops? (It will be important to separate measures of production from measures of productivity; much of this will build off the work previously completed on productivity and captured in ASTM Standard E2691-09.)
■ How do contractors make the decision to prefabricate, and how do they evaluate the impact that has on the shop and the field?
■ How do productivity and production measures change based on the amount of prefabrication completed?

a. Goals and Objectives

Purpose of the Project.

The purpose of this project was twofold: 1) analyze how leading Electrical Contractors measure field and office productivity and 2) analyze how Electrical Contractors document and measure the impact of prefabrication on the productivity of their field and office personnel.

b. Work Plan

Deliverables and Timeline for Completion.

This study sought to understand how productivity of field and office personnel is measured and identify the impact of prefabrication on both field and office operations for electrical contractors. The impact and use of prefabrication within Lean Construction and BIM and VDC was explored. Specific tasks included:

Task 1: Review the literature available on measuring productivity, the ASTM Standard, and prefabrication in the electrical contracting industry. Evaluate and identify the methods and models used within the industry and develop a series of questions for the focus groups and case studies.

Task 2: Plan and conduct 4 focus groups for the electrical contracting industry to identify the key forces and directions in prefabrication for the electrical contracting industry and the potential market areas. This workshop would also examine the needed education and training for the EC Owner, Project Management Staff, Field Management Staff, and for the GC / CM (or client). Additionally specific requirements – such as those for technology / space will be identified. Participants in the workshop will come from all segments of the electrical contracting industry— both line and commercial construction.

Task 3: Plan and conduct 10 individual case studies with leading electrical contractors who have a fully implemented prefabrication operation in their shop. Determine how they measure and track productivity both in the field and office and how they measure success of their prefabrication efforts.

Task 4: Document the results and provide a short seminar at the annual NECA Convention (and webinar series if desired) on prefabrication and productivity.

The research team conducted specific “case studies” with 14 leading contractors – both union and non-union electrical contractors as well as leading mechanical contractors throughout the United States.
The individual site visits and personal interviews allowed a deeper dive into the changes electrical contractors have had to make to achieve increase use of prefabrication. The case studies sought to understand the impact on productivity for field and office operations and how they were impacted by prefabrication.

These case studies will serve as a guide to other electrical contractors either seeking to increase their prefabrication efforts or seeking to understand how they could use prefabrication to increase their competitiveness in the marketplace.

This Final Report includes the findings from the case studies and provides a guide for contractors to conduct their own prefabrication efforts. The guide will be a step-by-step procedure for implementing prefabrication and measuring its impact on productivity. There will be two sections, one for the beginner at prefabrication, one for those seeking to dramatically increase their prefabrication efforts.
Appendix B

Measuring Productivity and the Impact of Prefabrication on Productivity

Case Study Questions

1. What should concern an electrical contractor about prefabrication?

2. How do you use prefabrication today?
   a. When did you start to prefabricate?
   b. Why did you start?
   c. What resources were required?
   d. Is there anything that you have tried to prefabrication and stopped?

3. How quickly was the initial investment recovered?
   a. Is there a minimum number of projects / volume that is required?

4. How have you avoided potential risks of using a prefab process?

5. Do you outsource any of the prefabrication?
   a. What are the benefits of out-sourcing the construction of assemblies?

6. What special equipment/tools do you use in your prefabrication shop?

7. Does project location/region impact the use of prefabrication due to transportation costs?

8. What time savings are attributed to prefabricated assemblies?

9. What cost savings are attributed to prefabricated assemblies?

10. What specific assemblies do you prefer to prefabricate first? How do you prioritize what you choose to prefabricate? Why? Do you do a cost / schedule analysis as part of the decision making?

11. Is there a specific market sector that uses prefabrication assemblies over others?
   a. If so, why?
   b. How can those concepts be used in the market sectors with lower frequencies of prefabricated assemblies?

12. Is there a contract value that a project reach before considering prefabrication?

13. Is there a correlation with a project size and amount of prefabrication on it?

14. Are there any exceptions to using/considering the use of prefabrication on a project?

15. What tactics do you have to see a higher use of prefabrication on a project?

16. How do you measure and track productivity on your jobsites and in your shops?

17. How does anticipated productivity impact make the decision to prefabricate, and how do you evaluate the impact that has on the shop and the field?

18. What resources are required for an Electrical Contractor to initiate prefabrication efforts?
19. What resources are required for an Electrical Contractor to move beyond initial prefabrication efforts towards a model where the bulk of the project is prefabricated?

20. How do productivity and production measures change based on the amount of prefabrication completed?

21. What measures of project success do you use to evaluate your projects?

22. How has prefabrication impacted your planning and scheduling processes during the past three years? How did you measure the impact of the changes?

23. How has prefabrication impacted your project management processes?

24. How has prefabrication impacted your office staffing/support processes?

25. How has prefabrication impacted your field staffing/support processes?
References


