

*vision  
future*

# THE IMPACT OF PREFABRICATION ON PRODUCTIVITY

**2017** Prepared By:

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## INTRODUCTION

The productivity of field personnel and the use of prefabrication in the Sheet Metal 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 would enable Sheet Metal contractors to optimize the use of prefabrication to obtain peak productivity. Through a survey, a series of case studies, and the completion of both detailed productivity and prefabrication analyses a number of best practices are presented as tactics other Sheet Metal contractors might use.

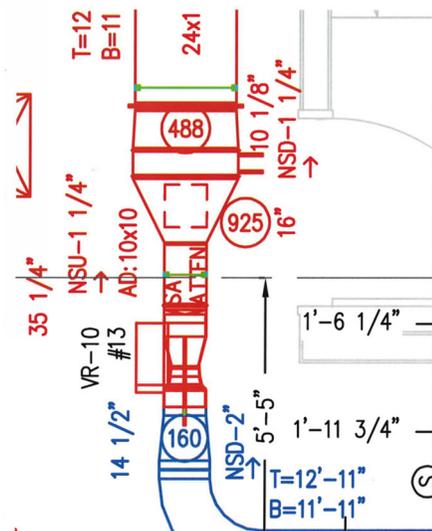
This study sought to understand how productivity of field and office personnel is measured and identify the impact of prefabrication on both field and office operations for Sheet Metal contractors. The impact and use of prefabrication within Lean Construction, BIM and VDC was explored.

### Specific tasks included:

- The research team conducted specific “case studies” with 12 leading Sheet Metal contractors throughout the United States.
- The individual site visits and personal interviews allowed a deeper dive into the changes Sheet Metal contractors have made to increase their use of prefabrication. The case studies sought to understand the impact on productivity for field operations and how they were impacted by prefabrication.
- These case studies provide tactics to guide other Sheet Metal contractors seeking to increase their prefabrication efforts. (note: if the word “either” is kept in, there needs to be another opportunity in here)

This Final Report includes the findings from the case studies and provides tactics for contractors to conduct their own prefabrication efforts. This guide will be a procedural series of tactics that may be used by Sheet Metal contractors for implementing prefabrication. There are three different types of tactics suggested: one for the contractor who is new to prefabrication in the sheet metal shop, one for those seeking to dramatically increase prefabrication efforts, and a few tactics for the advanced prefabricator.

*Lab box assemblies*



## THE RESEARCH PROJECT

The proposal for this research included using focus groups but unfortunately, it became apparent during the course of this project that companies were unwilling to share current and future practices relative to prefabrication with their competitors, as this was strongly perceived as a competitive advantage. Ultimately no focus groups could be established. Upon consultation with the New Horizon's staff it was decided additional case studies would be substituted for these focus groups.

The general demographics of those participating included: 1 Peer Group Meeting, 11 SMACNA Contractors, and 72 Survey Participants.

Additionally, a short survey was developed. It was decided, with consultation of the steering committee, a specific question on how much has prefabrication impacted your field productivity NOT be asked due to the wide variation in the definition of prefabrication by Sheet Metal contractors. It was felt since there was not a common definition there was no way to develop an accurate average of the impact prefabrication has on productivity. The survey results are provided below and the on-line survey is provided in Appendix A.

*30' x 6' x 24" Modular Rack - main duct, VAV boxes, chilled water and electrical cable tray below*



As part of the survey, we asked specifically for details on how contractors measured the impact prefabrication had on their productivity (See Appendix B). For those willing to mention numbers, and not all were, the range was from eight to thirty-three percent of overall labor savings over their definition of non-prefabrication. Some of that savings was found in better planning (impacting the entire job, not just those portions prefabricated), and in some cases increased material delivery costs were incurred. We did not have a single participant who indicated they would decrease the amount of prefabrication based on decreases in productivity or increases in labor costs. Based on their experiences, whether your company is new to prefabrication or looking to expand its efforts, their advice was, "Get started now!" You may choose to join two sections together in your shop or you might put a fitting on a piece of duct while still in the shop – whatever you choose to do first as part of your prefabrication efforts, the important step is to start!

The next sections of this report address the promises made in the research proposal on providing guidance to two sets of entities exploring prefabrication. The following section, entitled "Beginners" is targeted toward Sheet Metal contractors who have not attempted any prefabrication or have not found an approach that works for them. It is written to provide specific tactics for a Sheet Metal contractor to use in implementing a prefabrication strategy.

### Tactics

The next several pages discuss the findings of the case studies and separate them into items a beginner might try, items those more advanced might add to their prefabrication efforts, and finally some ideas for those that are more advanced in their prefabrication efforts, which might add to the list of items used to enhance their prefabrication.

### **Beginners**

Sheet Metal contractors who have never attempted a prefabrication effort, or their previous efforts have failed, should consider the tactics listed below. From the case studies, there were specific tactics that someone who is not actively prefabricating (multiple items combined in the shop) should pursue to get started on a path that leads to success.

#### **Tactic 1: Get Started / Start Small**

It seems simple, but many suggested if you are simply trying to get started, find a project that allows you to start small. Perhaps you can connect transitions to straight duct pieces or something similar.

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 this project. As an executive of a Sheet Metal contracting business, it is important 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.

#### **Tactic 2: Clear Space and Connect Pieces of Duct**

Determine if you have, and are willing to devote, space for creating your own prefabricated items. In some cases, contractors reported being able to clear out space in existing warehouses containing old/broken tools, materials returned from jobsites not likely to ever be used again, etc. (note: I really can't figure out how the previous sentence ties into anything, so I would recommend deleting it) Specific to Sheet Metal contractors, you must evaluate the flow of the fabrication

process to look for process improvements. By evaluating the flow and looking for stockpiles of materials that are waiting for the next step in the fabrication process, you should identify opportunities for improvement. It should be noted that some contractors are limited in their ability to prefabricate based on their limited space; others relocated their shops to larger areas to facilitate additional efforts in prefabrication.

Clearly, one of the steps has to be looking at the entire shop and seeking opportunities to improve the flow. Asking yourself, can we handle this piece fewer times before loading it on a truck, or can we add something to the ductwork to reduce our field labor are both very valid questions to ask!

#### **Tactic 3: Organize Space**

Perhaps hiring a student studying industrial engineering, or a consultant (depends on the dollars the contractor would like to spend) will help in determining the best way to organize the space that will allow simpler prefabrication efforts which is key. If you analyze the flow of the shop and determine that too many pieces are handled too many times, you must organize your shop.

It may also be possible to develop custom containers, bins or carts to keep pieces organized and together prior to assembly.

#### **Tactic 4: Explore Lean, use 5S events**

As a corollary to Tactic 3, the sheet metal contractor should explore the use of lean techniques.

Particularly for a beginner, using 5S events to better organize the shop, the tools in the shop and the flow of materials is critical to any prefabrication efforts. The entire effort should be focused on reducing the overall number of steps or touches required for a piece. This should have a dramatic impact on improving productivity in the shop and in the prefabrication efforts.

There are many opportunities to tie prefabrication efforts and using the concepts of Lean Construction to improving overall operations and productivities. One opportunity that many of the case study participants reported using is what Lean calls 5S events. A video describing how a mechanical contractor has used 5S to improve operations can be found at <http://www.grunau.com/lean-construction.php>, look for the video – *Grunau Construction 5S*. By following the steps outlined in this video, a Sheet Metal contractor should be able to improve not only field operations (think of how often sheet metal workers look for tools, materials, and information), but also implement the 30-second timeframe to improve field productivity. A helpful presentation on how a Sheet Metal 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>. “When in Doubt, throw it out” and organizing your shop’s tools, equipment and material storage will greatly enhance the ability to do in-house prefabrication.

### **Tactic 5: Use your best personnel**

Put the best field foreman (or at least the best 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 seeking opportunities to also 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 reduced. 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

### ***Box assembly with piping subassemblies mounted and piped on terminal boxes***



worksite, and allowing the company to be more competitive, thus increasing the number of Sheet Metal workers one would employ.

### **Tactic 6: Measure**

The old adage of “What gets measured gets managed” applies to prefabrication productivity as well. When starting out, the case study participants suggested that one decide on a standard between the two methods in Tactic #7 to track prefabrication hours.

### **Tactic 7: Track**

To keep tracking as simple as possible, review the total labor hours in the estimate, review those items one plans on prefabricating or purchasing already prefabricated and shift the appropriate number of hours from the field labor to a new “prefabricated” category. Most suggested simply 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 a sheet metal worker to reduce the number of field hours. This tactic was made 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 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.

Clearly, it is important to measure and have “apple to apple” comparisons, therefore it is suggested that prefabrication hours are 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. Next, 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 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 (remember 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 providing budgeted hours to both the prefab shop and the field forces based on the total number of expected hours rather than estimated hours, which is a more sophisticated approach. 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.

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 due to working in a more controlled environment, the improved quality, and other benefits both tangible and intangible.

**Outline of thoughts for the beginner:**

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 space that is well lit, well planned and in an area others can see.
3. *Make it voluntary* – success will not come from forcing participation.
4. *Organize the shop using 5S events* – a poorly organized area used in prefabrication will dramatically (and negatively) impact the likelihood of success.
5. *Put the best people in the prefab shop* – this demonstrates your commitment to the process.
6. *Manage prefab as a bucket* – specifically identify how many hours are moved from the field and put in 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. You may need to add something in here for a summary of Tracking.
8. *Use Apprentices* in the prefab shop (reduce your hourly rate).

**In your own shop:**

If further convincing is needed, look at the materials stored in the warehouse, and ask and answer these questions:

1. What is the cost for “blue wrapping” individual pieces of duct work?
2. What did it cost in labor hours to wrap and dispose of the plastic?
3. What is the oldest material in the warehouse?
4. How much labor is lost looking for all the parts that must be installed at the same time?

## For those looking to increase their prefabrication efforts

### **Advanced Tactic 1: Devote more time to planning**

Those contractors who were active in pre-planning with their project team and their field operations found much more to prefabricate than those who involved fewer people. Even involving the General Contractor / Construction Manager in allowing larger access points or more open areas will enhance the prefabrication efforts.

### **Advanced Tactic 2: Improve the flow in the shop**

Studying the flow in the shop and making sure that pieces move efficiently between work stations is a simple way to improve the productivity in the shop. In particular, look for times the metal is handled or sorted on multiple occasions. Some Sheet Metal contractors have created custom material handling carts to make sure the amount of sorting and handling is reduced.

### **Advanced Tactic 3: Packaging materials into bins by area/room**

One should identify specific locations on the job to deliver prefabricated materials, thus allowing utilization of palletized assemblies and reducing on-site packaging and waste.

One clear indicator of more advanced prefabrication efforts were those made packaging into bins by area/room. Some contractors chose to use re-usable bins, others chose to have one-use cardboard boxes, and each had made the determination of what was best for his/her own prefabrication approach based on multiple trial and error attempts. The Sheet Metal contractor should try a number of different containers and labeling efforts to see what works best for them.

*Modular Exhaust Stack - built frame to support all exhaust ducts as one unit versus in separate pieces*



It was suggested developing a color or numbering scheme that makes it visually apparent where that particular container or box should be delivered. In one case, we observed multiple colors of plastic wrap where the color specifically identified to which floor that particular pallet should be delivered.

As one seeks more opportunities to prefab, one must 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 his/her prefabrication efforts. Seeking projects that allow for pre-planning, or working with the GC/CM to ensure the focus is on completing the work efficiently in the field (rather than simply showing a lot of activity on the project) should increase the amount of prefabrication which can be completed on the project. Recall that many of the case study participants specifically identified they would 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 Sheet Metal contractor creates that level of understanding within the project management staff of the GC/

CM. It should also be observed that 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 installation can occur due to proper planning and significant prefabrication is the key.

### **Advanced Tactic 4: Transparency**

Whether it is called open-book management or transparency, based on the conversations in the case studies, it was clear that a key to success was the Sheet Metal contractors' willingness to share labor information with your lead field foremen.

### **Advanced Tactic 5: Design the truck / shipping to maximize size of prefabricated materials**

One limitation that some contractors have not overcome is figuring out how to use their trailers and or material delivery carts to maximize their prefabrication. By customizing trailers to support ductwork with additional elbows or other items already attached, rather than worrying about how to increase the overall tons/trailer, some contractors have dramatically increased their overall prefabrication efforts

### **Advanced Tactic 6: Reduce Waste (blue plastic)**

The more advanced one is in prefabrication efforts; one should also work to dramatically reduce the amount of packaging and trash that ends up on the jobsite.

While this might be captured as material handling costs, a Sheet Metal contractor should recognize, specifically, how much time and effort is spent in removing materials from boxes, attaching and removing blue plastic, carrying the boxes to the dumpster, and paying the waste hauler to remove

those dumpsters. It is our sense that 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 7: Track waste reduction**

From the case study interviews, it is the contractor who dramatically increases prefabrication efforts who will see the amount of material waste on a job reduced from five to ten percent down to less than two percent. There were a couple of case study participants who reported reducing the waste for specific items from having filled a dumpster to now only filling a five-gallon bucket!

*Multiple sections of ductwork prefabricated in the shop prior to transport to the project site*



## **Highly Advanced Tactics**

With a fairly active prefabrication effort, one might consider some of the following tactics, as they build off those that have been previously listed:

### **Highly Advanced Tactic 1: Increasing precision in drawings/models**

One of the common themes heard from the advanced prefabricators during the case studies

was the use of Bluebeam (or some other technology) to specifically identify those items that can be assembled into larger pieces.

Some contractors have leveraged their modeling efforts to go beyond what was contractually required. The observations these companies provided was they purposefully used their 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: Move to Spiral Duct**

Work with the design engineers to use more spiral duct – this should allow you to fabricate to exact lengths (using a BIM model) and enhance your prefabrication efforts.

### **Highly Advanced Tactic 3: Seek or create opportunities to modularize components**

While modularization has been around since the 1960's, it is clear that the current efforts to reduce labor hours expended on the jobsite and 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 these efforts will only look to expand into additional markets. Especially for those Sheet Metal contractors who also have Mechanical (and in some cases Electrical) capabilities, creating multi-trade racks and installing them in longer pieces has led to a significant increase in field productivity.

### **Highly Advanced Tactic 4: 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 5: Manage productivity at the task level**

To ensure the company is making data driven decisions regarding prefabrication and productivity, it is important that there is a 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, rather 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, as 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, depending on how much time, effort and energy a Sheet Metal contractor is willing to put into prefab, use of an outside consultant was highly recommended. It is quite possible that prefabrication efforts will be improved through the use of outside consultants and it is suggested that one seek someone who understands not only Sheet Metal contracting but also has 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 SMACNA, the Lean Construction Institute (<http://www.leanconstruction.org/>) and the AGC ([www.agc.org/LCEP](http://www.agc.org/LCEP)). As part of this effort, one should, perhaps with outside assistance, complete 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.

### **Highly Advanced Tactic 8: Manage by facts and collect data**

This would require developing prefab cost codes to match job cost codes. After those have been developed, there can be a discussion between the prefab manager and the project manager on each project as to 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 of the case study participants was this effort should be focused on outputs rather than inputs and not simply moving hours from one cost code to another - carefully analyzing how many hours it takes to prefabricate each component.

It was also suggested as the company becomes more sophisticated in its prefabrication efforts there should be an attempt 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 of those participating in the case study were adamant that the SMACNA 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: Significantly increase the level of planning prior to job starts**

This planning should be used to drive coordination with other trades, perhaps bringing the GC/CM on board. Regardless, the participants noted that working with other trades is an important step in prefabrication efforts. One participant noted, “Develop a plan; execute the plan.” They 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. It may be possible to dramatically increase the length of the duct being installed through careful planning with the GC/CM. A common length of installed ductwork in these situations was 20’, with some cases of 40’ lengths being installed at one time.

### **Other thoughts provided by the participants**

- 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
- Coordinate multi-trade racks

*Entire box assembly with piping subassemblies mounted and piped on terminal boxes*



## CONCLUSION

The tactics that were provided above will work best when Sheet Metal contractors specifically develop their plan for prefabrication as part of their overall strategic plan. Thoughtful consideration on what best fits the culture of an individual organization and increases the likelihood of a successful implementation should be the chosen actions.

Recognize many of the quantitative benefits of prefabrication will only come from changes in the method of estimating and tracking costs. There are many benefits of prefabrication that go beyond labor savings and will manifest themselves in better plans, safer jobsites and decreased construction schedules.

## Big Idea

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 is being used by at least a couple of mechanical contractors already. There are web-enabled devices that allow the operator to login, see the piece to be constructed, and then automatically track the hours to prefabricate. While an individual piece may be too granular for a Sheet Metal 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 this was not seen in any Sheet Metal contractor's shop.

## APPENDIX A: SURVEY MONKEY SURVEY RESULTS

The survey was specifically kept very short (and is provided in Appendix B). Two of the questions sought to better understand whether contractors measure productivity in the shop or the field. It may not be surprising that 78% (56/72) of the respondents measure shop productivity. In fact, even in some of the largest sheet metal fabrication jobs there was no measure of shop productivity. In effect the shop foreman was told to “make sure your shop workers are efficient.” Typically, in those shops there was also little evidence of Lean construction techniques being employed in the fabrication area. We also determined that only 87% of respondents measured field productivity (62/71 = 87%). Clearly to best understand the impact that prefabrication is having on overall productivity, some measure of productivity must be established. It is worth noting that in many (perhaps even most) cases, the typical measures of productivity were lbs/day in the shop and lf/hour in the field.

The survey also asked respondents how much of their overall hours were in the field versus shop. The average percentage was 41% of the hours were in the shop. Additionally, 68% of those responding indicated that they were expending more hours in the shop than they had previously, with 20% indicating it was the same as before and 12% indicating they were expending less time in the shop.

We also asked “What is the percentage increase in the shop hours (per lb of steel, or lf of duct):” and received these responses

- Less than 5% - 4 respondents
- Between 6 and 10% - 25 respondents
- Between 11 and 20% - 8 respondents

- Greater than 20% - 10 respondents
- Approximate Average 12.3% increase in number of hours

From the survey, respondents indicated at 84% (57/68) that they had seen an increase in productivity, with 47% of the increase being attributed to prefabrication. Through the interview process (Appendix C), we learned that productivity was estimated (and in some cases measured) to have improved between 15% and 33%. It is fully expected that similar productivity gains will be common for other Sheet Metal contractors.

We also provided the opportunity to comment on why Sheet Metal contractors were choosing to prefabricate more. A few of the responses included:

- Controlled environment, less set up time, better tooling
- Lower cost with increased productivity by preassembly in the shops in a controlled environment; compressed schedules, to reduce jobsite weather issues. Increased system quality by working in a controlled environment.
- Better productivity in our controlled environment, and the speed of projects does not allow all of the duration for an activity to happen on the project site. Loss of qualified journeymen over the past few decades.
- Saves labor, saves time unloading in the field, saves field labor, and provides better quality control.
- Field labor productivity, compressed schedules
- Projects go smoother in the field.
- Variables in the shop are more controllable than the field.
- We get 7 hours production in shop, compared to 6 in field.

- 1)Quality of workmanship is better in a controlled environment. 2)Reduces the total number of personnel, on site man hours and durations in executing the work. 3)Reduces your footprint on the job site - less lay down area or floor space consumption requirements. 4)Promotes a significant improvement in pre-planning and execution on site. 5)You are moving and handling less pieces of material on site. This reduces many exposures including health, safety, scheduling, craft interference and overall coordination.
- Overall project more productive. Shop assembly is a more controlled environment. Helps with aggressive field schedules
- To reduce field labor, eliminate covered ends of duct, and be more competitive.
- Shorter duration schedules, more efficiency utilizing equipment and assembly standards, less overall material handling
- We are looking for an advantage against our competition and to assist in meeting the construction schedules.
- Controlled conditions
- To minimize field crew size while meeting shortened projects duration and overall cost reductions with more work being performed in a controlled environment.
- More control over man power; fabrication is more productive in the shop environment; less waste of time and material.
- Working conditions are always better in a shop environment

*PVC coated sub-assemblies*



Survey Monkey Survey

**Prefabrication in Sheet Metal Contracting**

**This survey is part of a study conducted for the New Horizons Foundation seeking to better understand the impact of pre-fabrication on Sheet Metal Construction**

1. My definition of pre-fabrication in Sheet metal is:

2. Do you measure shop productivity?

Yes

No

3. Do you measure field productivity

Yes

No

4. What is the percentage of overall labor expended in the shop as compared to the field?

0 hours spent in the field (all in the shop)	Half hours spent in both	100 % of hours spent in field
-------------------------------------------------	--------------------------	----------------------------------

5. Are you expending more time in the shop pre-fabbing as compared to 10 years ago?

Yes

No

Same as before

6. If yes, what is the percentage increase in the shop hours (per lb of steel, or lf of duct)

Less than 5%

Between 6 and 10%

Between 11 and 20%

Greater than 20%

NA

## Survey Monkey Survey, *continued*

7. Have you seen an overall increase in your overall productivity

Yes

No

8. If you are prefabricating more, why (please list all reasons)

9. Has prefabrication impacted your overall productivity, if so indicate the increase or decrease you attribute to increased pre-fab?

-100 (cut productivity in half)      No Impact      100 (doubled productivity)

## APPENDIX B: MEASURING PRODUCTIVITY AND THE IMPACT OF PREFABRICATION ON PRODUCTIVITY

### Case Study Questions

1. What should concern a Sheet Metal 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 a Sheet Metal Contractor to initiate prefabrication efforts?
19. What resources are required for a Sheet Metal 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?