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# PRODUCTIVITY TRACKING IN THE HVAC AND SHEET METAL INDUSTRY FOR DESIGN, MANUFACTURING AND INSTALLATION

NEW HORIZONS FOUNDATION
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2019

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# INTRODUCTION & EXECUTIVE SUMMARY

Tracking productivity has been a challenge for HVAC / sheet metal contractors, who are characterized by a high degree of offsite work such as detailing and fabrication that is necessary to build a customer's project. There are few industry standards related to tracking productivity for all facets of HVAC / sheet metal contractor operations – detailing, fabrication, and installation – and because of that, it remains unclear what best practices in effectively tracking productivity apply to these design-driven contractors.

Traditionally contractors have focused on tracking productivity in the field since it is often viewed as the most intensive and riskiest portion of the work. Labor costs typically account for anywhere from 30% to 70% of a project's costs depending on the type of work being performed, so a small improvement in labor productivity can yield substantial increases in profitability. However, there is a growing recognition that productivity tracking for sheet metal contractors should encompass the entire lifecycle of a project from initial detailing through punch list.

**APPENDIX A: EXAMPLE OF IMPROVED PRODUCTIVITY ON PROFITABILITY**
illustrates how a contractor who performs $8,000,000 in annual revenue can double its net profitability with a 10% improvement in labor productivity across all phases (detailing, fabrication, and installation).

The importance of properly allocating time and progress reporting to the correct cost codes cannot be overstated. Companies that accurately analyze their productivity and react appropriately to their trending results are generally more profitable than those that do not analyze productivity. By using a consistent cost code structure to track productivity, companies can identify problems earlier, minimize the impacts, and optimize their work flows to manage productivity.

By tracking productivity earlier and consistently, contractors can monitor progress, reduce issues, forecast costs, and identify profit fade earlier in a project. The steps for successfully tracking productivity are simple:

1. Identify a simple list of activities to be tracked (less is more).
2. Use the estimate to set up a standard cost code structure and a budget for tracking activities.
3. Identify a standard unit of measure for reporting progress that best fits with each cost code.
4. Apply time to those cost codes and report progress using the established units of measure to track and trend performance.
5. Use the measured performance for benchmarking.

These steps are the same for all areas of work performed by HVAC / sheet metal contractors – detailing, fabrication, and installation. For full-service contractors that perform work in all three areas, the typical breakdown of labor hours is:

- 5-15% for detailing
- 20-30% for fabrication
- 55-75% for installation

Establishing an effective methodology to track productivity in each phase is critical to driving process improvements and increased profitability. Industry research suggests that few contractors pay attention to tracking productivity in the detailing phase of the project; and larger contractors tend to track productivity in the fabrication and installation phases while smaller contractors do not.

## About This Study

The primary focus of this study of sheet metal and HVAC contractors was to determine whether the contractors segregate their labor tracking by phase (detailing, fabrication, and installation), to learn

what level of detail they are tracking labor to in each phase and why that detail is significant, to understand how the data is then utilized, and to identify what systems for productivity tracking are in place throughout this process.

We solicited responses from over 100 contractors as part of this process, from all over the contiguous United States. These contractors currently perform work in education, healthcare, manufacturing, industrial, and commercial markets, and represent three different annual revenue classes – which allows us to understand the impact of productivity tracking on revenue:

- Less than or equal to $10,000,000
- Greater than $10,000,000 and less than or equal to $50,000,000
- Greater than $50,000,000.

***This document is organized in the following manner:***

- Stakeholder perspectives and the problems within the industry related to productivity tracking.
- A recommended approach and roadmap for tracking productivity in all three areas of HVAC / sheet metal contracting – detailing, fabrication, and field installation.
- A set of appendices that provide additional background on the findings of the study.
- An appendix that provides a primer on earned value systems and the relationship to productivity tracking.

## STAKEHOLDER PERSPECTIVES

There are several reasons why productivity tracking in the industry has lagged:

- A general lack of familiarity with the impact of productivity on net profitability.
- For many contractors the labor for detailing is considered a necessary step even if unpaid, and the effort to track the work is not viewed as worth the effort, especially for smaller contractors.
- Many contractors view each job as unique and do not break down the activities within detailing and fabrication into standard and consistent sub-activities that can be measured.
- A lack of standard deliverables, reporting processes, terminology, and metrics for measurement between personnel and between projects.
- A view that productivity is driven by the fabrication equipment and not shop labor.

While many contractors have a familiarity or an understanding of earned value analysis and productivity, that knowledge does not typically permeate the organization. Many times, knowledge surrounding earned value resides at a controller or CFO level rather than being pushed down to front line supervisors. For smaller contractors, with their largest contracts in the range of $100,000-$200,000, the effort to track detailing and fabrication productivity may seem counterintuitive.

Productivity tracking starts with setting up the project budget after award. There is an estimate of manhours that has been provided by the estimator, and those hours must be divided into tasks for the areas of detailing, fabrication, and installation. Many contractors do not take the time to properly set up the budget in a way that supports operations. Many will take the estimate, and hand it to the accounting team to create a budget in the job costing system without project input or oversight. Project input is necessary

for the accounting team to create a budget that reflects how the project will be sequenced, detailed, fabricated, and installed.

There is almost NEVER a perfect translation from the estimate to a project budget. There are many reasons why this is the case. One of the primary reasons that the estimate is only a starting point for a project budget is that the way most companies bid a job is not the same way they build a job. The estimate is prepared (usually in a short span of time) in a context of what might or is likely to happen, and will not always result in a winning bid or project.

Further, software systems used for estimating typically do not provide the capability to sequence the project the way it will be built, therefore the estimate must be converted into an operating budget and loaded into the time and cost accounting system. The time and cost accounting system must also utilize rules such as limiting any single labor cost code to a maximum amount of weight (pounds) for fabrication – which allows the project team to more accurately measure the work to be performed, and can provide a meaningful level of detail on that performance.

For contractors who are sufficiently large enough to have estimating separate from operations, there should be a formalized process for handing the estimate off to the project team. After this formalized handoff by the estimator and formalized review by the project team, the operations team can convert the estimate into an operating budget. It is NEVER acceptable to hand the estimate to the accounting team and have them set up the budget without oversight. Budget allocation should be managed by the relevant project manager and/or field manager.

Recall the five-steps to tracking productivity in the approach to follow:

1. Identify a simple list of activities to be tracked, where less is more.
2. Use the estimate to set up a standard budget and cost code structure for tracking those activities.
3. Identify a standard unit of measure that best fits with each cost code.
4. Apply time to those cost codes and report progress to track and trend performance.
5. Use measured performance for benchmarking.

# PRODUCTIVITY TRACKING FOR DETAILING

The term detailing is used to describe the process of developing drawings, with routings and elevations, that can be fabricated. It is important to distinguish detailing from the term “design”. Design is used to describe the stage that includes conceptualization and definition of a system. Since few of the contractors who participated in the study perform design services, design was omitted from the study.

Once a contract has been awarded, sheet metal contractors go through the detailing process which encompasses material selection, modeling, and creation of fabrication documents and materials lists. **Detailing is a fundamental necessity to sheet metal contractors, as it directly supports fabrication and installation**.

## Step 1: Activity Identification for Detailing

The following examples are activities that could be considered part of the detailing process:

- Coordinating the routings and elevations of sheet metal products.
- Creating spool drawings based on client requirements.
- Selecting materials, components, fittings and other items for procurement and/or fabrication.
- Reviewing models and coordinating meetings with other trades.
- Loading spool drawings to the fabrication shop equipment.

The following examples are activities that should be excluded from detailing labor productivity:

- Estimating costs and overhead
- General administrative overhead (administrative or managers salaries)
- Marketing or Business Development

Every contractor should carefully examine, list, and categorize what tasks or activities are performed by its detailing team so that it can create an accurate cost code structure.

## Step 2: Cost Code Setup and Budget Allocation for Detailing

Once the activities that are considered part of the detailing phase have been identified and segregated from other overhead or non-detailing activities, it is important to determine a cost code structure to accurately track detailing.

Cost codes for detailing should be kept to a minimum but used consistently from project to project. There are two forms of cost coding for detailing that contractors should consider:

- Duration-based Codes
- Activity-based Codes

Activity-based cost codes are cost codes where all the tasks and necessary resources are defined to complete an activity. Duration-based cost codes is a more traditional manner of allocating costs based on another factor such as sheet metal weight or machine hours to be utilized. The difference between these two approaches is demonstrated below with two sample products:

- Product A is a low-volume product that is ordered in small batches and therefore requires additional detailing, testing, and setup time with machines.
- Product B is a high-volume product that is ordered in bulk and requires less attention and planning.

In a duration-based system the costs (such as hours of detailing) will be spread across the weight or machine hours for the products. This will result in less detailing costs being allocated to Product A due to the lower volume of fabrication (in weight of material or in machine hours). Product B will be allocated the bulk of the detailing hours due to the higher volume of material or machine hours. This prevents a true measure of the cost, and thus productivity, of the two products.

In an activity-based system costs are assigned to the real detailing activities that exist such as creating detail drawings, machine entry, rework, and coordination meetings. These costs are then assigned to the product those activities supported. In this system the costs and resources associated with the additional detailing, testing, and setup time for Product A are assigned specifically to Product A. Product B, which does not have any of these special or significant activities will be assigned a lesser cost.

Additional or different cost codes for activities at the detailing stage can be determined based on contractor needs; however, as a rule of thumb, **most contractors with revenue under $50 million will find that 3 to 5 cost codes are sufficient at the detailing stage**. An example of a simplified structure that can be used as duration-based or activity-based is provided in *Appendix B*. Once the activities have been identified, and the cost codes created, it is important to allocate the estimate into the budget appropriately.

Many contractors allocate their detailing budgets as a factor of the total installation labor hours or project sheet metal weight. Said differently, they estimate the amount of installation labor or material and then apply a percentage or factor to the labor estimate to obtain their budget for detailing.

At this point in the process, the following has been accomplished:

- Activities or tasks to be performed as part of detailing have been identified.
- A cost code structure to measure those activities has been set up in the time and cost accounting system.
- The estimate has been converted into an operating budget for each of those cost codes in the time and cost accounting system.

## Step 3: Establish a Unit of Measure for Detailing Progress

Within the industry there is no prevalent standard for quantifying work completed or productivity for sheet metal contractors during the detailing phase. However, during this study three possible metrics were identified (*shown in Figure 1*) that contractors should consider, that when carefully used, can facilitate a productivity measure for detailing.

**Figure 1: Units of Measure for Detailing**

| Suggested Metric | Advantages | Disadvantages |
|---|---|---|
| Weight (Poundage) per Detailing Hour | Familiarity, as most sheet metal contractors use the weight of the systems to be built as part of their estimating and budgeting process. | Weight of the material can have little to no bearing on the complexity of the work to be detailed and the hours expended in the process. |
| Spool Sheets per Detailing Hour | A metric that more closely correlates to a measurable and desired outcome from the detailing process (drawings). Can assign budgets directly to each spool sheet based on spool complexity, and that budget can be communicated as part of the workflow process to fabrication. | Spool sheet deliverables can be subjective in nature depending on initial design deliverables from clients and what the sheet metal fabrication process requires for production. |
| Detailing Hour per Shop Hour | Can closely correlate effectiveness of Detailing Hour to Shop Labor, for example, can determine how which shop work has a high opportunity cost. Many contractors already estimate detailing as a factor of their field labor hours so there is familiarity. | Suggests that every detailing hour worked is a productive hour and this can be subjective unless there is a specific deliverable or strictly adhered to rule of credit applied. |

***Special Note:*** *For all suggested metrics, additional data and factors must be applied to offset for the size or complexity of each project. Choosing a primary metric and then utilizing secondary metrics along with post mortem data is the most effective way to provide accurate budgets for each task.*

Contractors should select units of measure that best fit the cost code, and be consistent with their selection process from project to project. Consistency between projects will make it easier to provide trending and analysis of the operations.

After step 3 there is now a list of cost codes, with an allocated budget, and a unit of measure for evaluating the performance of that activity (see *Figure 2* on the next page).

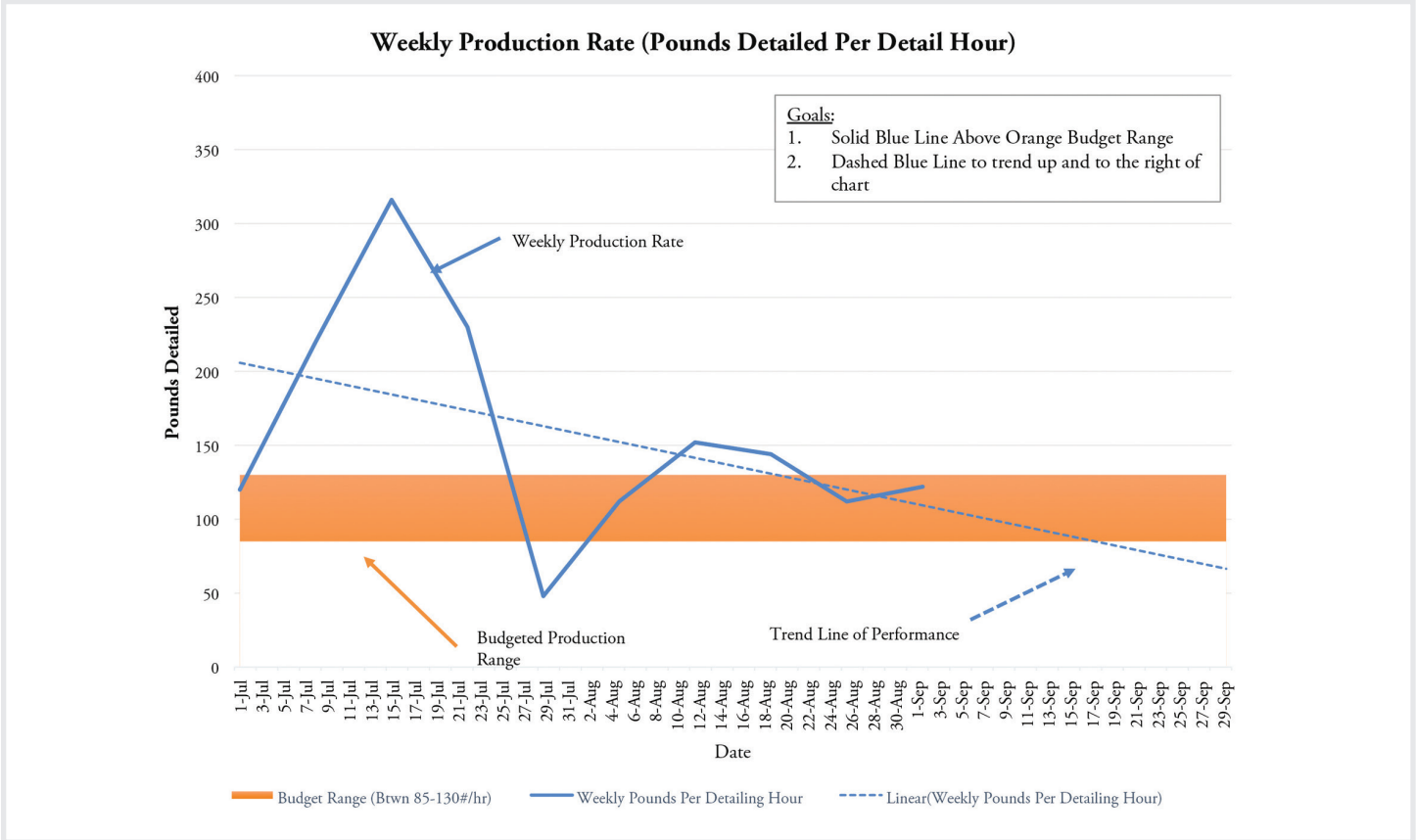
**Figure 2: Detailing Budget Setup**

| Cost Code | Cost Code Description | Units of Measure | Quantity | Budgeted Hours | Budgeted Dollars |
|---|---|---|---|---|---|
| 0100.02 | Detailing | Pounds per Hour | Pounds from Estimate | Allocated from estimate | Allocated from estimate |

## Step 4: Tracking and Trending Productivity in Detailing

Once a unit of measure has been chosen, it is important for contractors to track their hours expended on each cost code and report progress using the units of measure. By tracking the time and progress reported, and then comparing it to budget, it becomes easier to forecast project fade, identify issues, and forecast costs. *Figure 3* demonstrates an example of tracking by sheet metal weight per detailing hour on a weekly basis.

**Figure 3: Weekly Production Rate for Detailing**




In figure above, the weekly production rate fluctuates compared to the budgeted rate, indicating whether current production is more productive than the budgeted rate, less productive than the budgeted rate, or equal to the budgeted rate. The trend line in this example also shows that the production rate is continuing to decrease, and that steps should be taken to improve productivity.

### Step 5: Benchmarking and Estimating Future Projects

The data gathered in steps 1-4 helps the project manager or field manager manage the production on a project. The key next step is to return the captured production data to the estimating team for future projects. By tracking the data in a job cost system and feeding it back into an estimating system, more accurate estimates for bidding work can be created. By understanding the correlation between detailing and fabrication, contractors can also perform enterprise planning and predict how much staffing and equipment is required to support their backlog.

The process for tracking detailing productivity is relatively straight forward. The most important tasks are the segregating of activities for detailing from general overhead, allocating them to standard cost codes, and establishing what the unit of measure or project deliverable is for that cost code.

## PRODUCTIVITY TRACKING FOR FABRICATION

Within the fabrication process, sheet metal contractors also face the same challenges in tracking and improving productivity. Contractors must define their activities, standardize their reporting structure, identify relevant metrics, and establish reporting and benchmarking processes.

### Step 1: Activity Identification for Fabrication

One important consideration is that while many contractors calculate the production capacity of their equipment, they often ignore any calculation of shop labor productivity. It is important to recognize how both the shop labor and the equipment itself can impact productivity. A typical sheet metal contractor performs the following activities in their fabrication facility:

- Uncoiling
- Punching
- Laser Cutting
- Forming
- Roll Forming
- Welding
- Packaging

### Step 2: Cost Code Setup and Budget Allocation for Fabrication

Many contractors utilize equipment which can perform one or more of those operations simultaneously and should consider that when setting up their cost codes structure. However, in these operations the outcome are definable products such as rectangular straight duct, fittings, elbows, etc. These different products should be considered when building a fabrication cost code structure, and a suggested cost code structure that takes products into account is provided in *Figure 4*:

**Figure 4: Fabrication Cost Codes**

| 0200 | Fabrication Cost Codes |
|---|---|
| 0200.01 | Rectangular Straight Duct / Coil Line Duct (Full Lengths) |
| 0200.02 | Rectangular Duct Fittings and non-full pipe lengths (considered fittings) |
| 0200.03 | Welded |
| 0200.04 | Round Pipe and/or fittings |
| 0200.05 | Assemblies/Spools/Manifolds |
| 0200.06 | Internal Duct Liner on Rectangular Duct |

Like detailing, there are different approaches to allocating budget for fabrication. Fabrication budgets can be set up as a factor of total sheet metal weight or by piece count. Other factors to consider when setting up project budgets are fitting sizes and types. These are not classified as uniformly by weight as sheet metal types are. Depending on the shop size there may be a specific employee (or set of employees) who make up

most of the fittings for the shop, and are responsible for stockpiling patterns and tracings on standard fittings used for sheet metal duct systems.

## Step 3: Establish a Unit of Measure for Fabrication Progress

Like the detailing stage, a consistent unit of measure should be chosen for the shop operations. Three suggested metrics are provided in *Figure 5*:

**Figure 5: Suggested Metrics for Tracking Fabrication**

| Suggested Metric | Advantages | Disadvantages |
|---|---|---|
| Weight (Poundage) per Shop Hour | Familiarity, as most sheet metal contractors use the weight of the systems to be built as part of their estimating and budgeting process. | Weight of the material can have little to no bearing on the complexity of the work to be fabricated. |
| Footage (can be linear foot or square foot) per Shop Hour (apply to linear/flat panel products) | Correlates closely with the total volume of material handled by the shop, which can have a significant effect on labor productivity in the shop. | Most contractors do not estimate in this manner and are not necessarily set up for it. |
| Each or Piece per Shop Hour | Correlates well with specific pieces of equipment to be fabricated. | Not applicable for all activities. Best for fabrications which can be 'counted' easily. |

***Special Note:*** *For all suggested metrics, additional data and factors must be applied to offset for the size or complexity of each project. Choosing a primary metric and then utilizing secondary metrics along with post mortem data is the most effective way to provide accurate budgets for each task.*

Contractors should select units of measure that best fit the cost code for tracking the work, and be consistent with their selection process from project to project.

At this point in the process, similar to what was covered in the detailing phase, the following has been accomplished:

- Activities or tasks to be performed as part of fabrication have been identified.
- A cost code structure to measure those activities has been set up in the time and cost accounting system.
- The estimate has been converted into an operating budget for each of those cost codes in the time and cost accounting system.

An example of these steps is shown in *Figure 6*.

**Figure 6: Budget Setup for Fabrication**

| Cost Code | Cost Code Description | Units of Measure | Quantity | Budgeted Hours | Budgeted Dollars |
|---|---|---|---|---|---|
| 0200.01 | Rectangular Straight Duct / Coil Line Duct (Full Lengths) | Pounds per Hour | Pounds from Estimate | Allocated from estimate | Allocated from estimate |
| 0200.02 | Rectangular Duct Fittings and non-full pipe lengths (considered fittings) | Pounds per Hour | Pounds from Estimate | Allocated from estimate | Allocated from estimate |
| 0200.03 | Welded | Pounds per Hour | Pounds from Estimate | Allocated from estimate | Allocated from estimate |
| 0200.04 | Round Pipe and/or fittings | Pounds per Hour | Pounds from Estimate | Allocated from estimate | Allocated from estimate |
| 0200.05 | Assemblies/Spools/Manifolds | Pounds per Hour | Pounds from Estimate | Allocated from estimate | Allocated from estimate |
| 0200.06 | Internal Duct Liner on Rectangular Duct | Pounds per Hour or by Square Foot | Pounds from Estimate | Allocated from estimate | Allocated from estimate |

## Step 4: Tracking and Trending Productivity in Fabrication

When trending productivity in fabrication, it is important to avoid a silo mentality. Because material flows from one station to the next, focusing on productivity of just one task can often cause other upstream or downstream impact. For example, a logistics or shipping manager might schedule infrequent deliveries or shipments to minimize freight costs, but may impact the overall fabrication process within the shop. For that reason, managers should look at trending fabrication productivity as an entire process rather than just one particular task or activity.

*Figure 7* demonstrates an example of tracking by productivity in the shop by product type. Contractors can input their budgets from the estimate and can determine their variances weekly. In this figure, each product has an associated labor and material cost. That actual cost is then compared to a budget that was established.

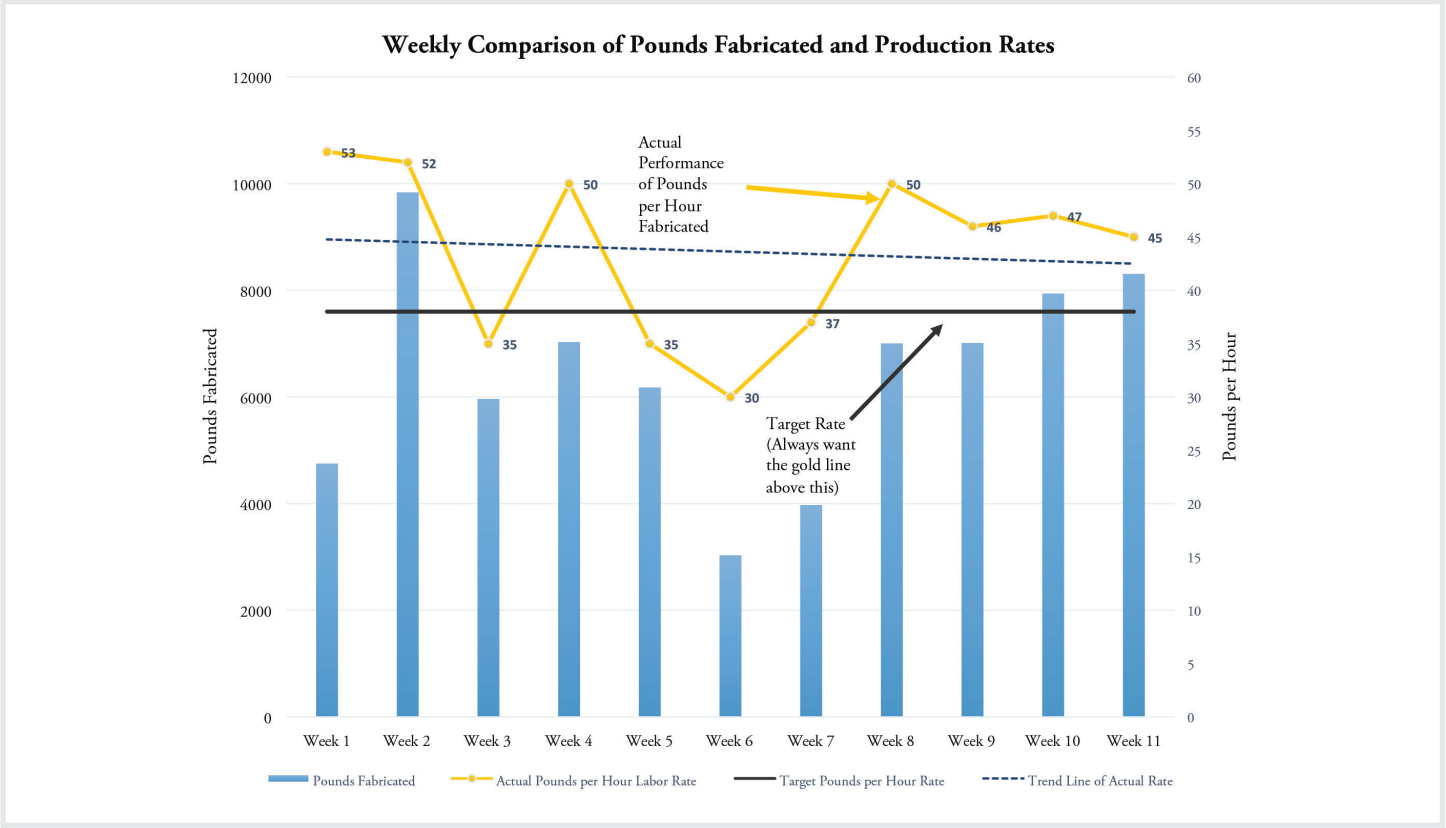
## Figure 7: Fabrication Productivity Example

| Description | Labor Est (Hrs) | Labor Est ($) | Labor Actual (Hrs) | Labor Actual ($) | Labor Variance (%) | Labor Variance ($) | Material Est ($) | Material Actual ($) | Material Variance (%) | Material Variance ($) | Total Variance ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sleeves | 160 | 9,600.00 | 138 | 8,418.00 | -12% | (1,182.00) | 8,000.00 | 6,500.00 | -19% | (1,500.00) | (2,682.00) |
| Couplers | 250 | 15,000.00 | 289 | 17,051.00 | 14% | 2,051.00 | 7,500.00 | 8,200.00 | 9% | 700.00 | 2,751.00 |
| 45 Degree Elbows | 80.5 | 5,246.00 | 58 | 3,751.50 | -28% | (1,494.50) | 2,267.00 | 3,000.00 | 32% | 733.00 | (761.50) |
| End Caps | 35 | 2,100.00 | 34 | 1,972.00 | -6% | (128.00) | 498.00 | 375.00 | -25% | (123.00) | (251.00) |
| *Subtotal for Week* | 525.5 | 31,946.00 | 519 | 31,192.50 | -2% | (753.50) | 18,265.00 | 18,075.00 | -1% | (190.00) | (943.50) |
| | | | | | | | | | | *Variance from Previous Week* | 3,800.00 |
| | | | | | | | | | | *Change from Previous Week* | (4,743.50) |

## Step 5: Benchmarking

*Figure 8* shows production and productivity in one example chart. In this chart the weight of material fabricated (blue column bars), the budget unit rate (solid black line), the actual unit rate (solid gold line), and a trend line of the actual rate over time (dashed black line) are all displayed in one location. Managers can then make decisions on how much quantity to produce and how much manpower is necessary to achieve a budgeted unit rate, and can look at historical records to see what factors achieved those rates in the past.

## Figure 8: Comparison of Production and Productivity



# PRODUCTIVITY TRACKING FOR FIELD INSTALLATION

There are additional activities to consider if a sheet metal contractor performs other field work such as HVAC systems and plumbing; however, conceptually the process by which a contractor tracks productivity remains the same:

1. Identify a simple list of activities to be tracked, where less is more.
2. Use the estimate to set up a standard budget and cost code structure for tracking those activities.
3. Identify a standard unit of measure that best fits with each cost code.
4. Apply time to those cost codes and report progress to track and trend performance.
5. Use measured performance for benchmarking and estimating future projects.

As with the detailing and fabrication stages, it is also important to define and standardize cost codes and activities for the field installation.

## Step 1: Activity Identification for Installation

The activities a sheet metal contractor typically performs include (but are not limited to):

- Installation of Hangers / Supports
- Rough-in of ductwork
- Installation of air distribution and trim
- Installation of dry side equipment
- Installation of risers
- Installation of supply ducts
- Installation of return ducts
- Installation of RGD's

Contractors should further define other "soft" costs such as shipping and punch-list, and determine where these belong in terms of cost codes. Avoid activities without a quantifiable metric for measuring progress.

## Step 2: Cost Code Setup and Budget Allocation for Installation

When setting up cost codes and allocating budgets for field installation activities it is best to consider the means and methods of installation and group them by the order of installation in the field. These activities are usually installed in passes. For example, a contractor will install all the hangers in a given area of a project, then proceed with the medium pressure ductwork, then low pressure, and so forth. A typical task progression is shown below:

- Hangers
- Medium Pressure Ductwork (spiral or rectangular) that may include Fire Dampers, VAV's, and other equipment within the flow
- Low Pressure Supply Air
- Low Pressure Exhaust Air
- Risers
- Set Equipment (Air Handling Units, Fans)
- Finish Items (RGDs)

*Figure 9* shows an example of a cost code structure, keeping in mind the installation approach of completing tasks in passes.

**Figure 9: Installation Cost Codes**

| 0300 | Sheet Metal Installation Cost Code |
|---|---|
| 0300.01 | Install Hangers / Supports |
| 0300.02 | Rough in Duct |
| 0300.03 | Rough in Spiral Round |
| 0300.04 | Rough in Duct Rectangular |
| 0300.05 | Rough in Grease Duct |
| 0300.06 | Air Distribution and Trim |
| 0300.07 | Dry Side Equipment |
| 0300.08 | Risers |
| 0300.09 | Supply Ducts |
| 0300.10 | Return Ducts |
| 0300.11 | Exhaust |

These cost codes can be segmented by project, phase, and area to signify work location. Contractors can set up a series of special codes that are set aside for non-standard work, however the emphasis should be on the 20% of codes that manage 80% of the work. The cost codes should be segmented in a meaningful quantity and budget such as how much work can be accomplished or installed within a time frame of a week or a month or a maximum amount of weight to be installed. However, they should not be so small that the effort of tracking outweighs any observed data (such as how much work can be accomplished within a single day).

The cost code structure below shows areas added to the cost codes:

| 0300 | Sheet Metal Installation Cost Code |
|---|---|
| A.0300.01 | Area A Install Hangers / Supports |
| A.0300.02 | Area A Rough in Duct |
| B.0300.01 | Area B Install Hangers / Supports |
| B.0300.02 | Area B Rough in Duct |

In the above the areas are defined as Area A and Area B, but the cost codes are still the same. This adds a straightforward way to determine the areas of work and track the cost code consistently.

## Step 3: Establish a Unit of Measure for Fabrication Progress

While contractors tend to prefer sheet metal weight as their unit of measure for budgeting installation work, many contractors also use sheet metal footage and equipment pieces to set their installation budgets.

*Figure 10* shows these three suggested basic units of measure for field installation activities.

## Figure 10: Suggested Metrics for Tracking Installation

| Suggested Metric | Advantages | Disadvantages |
|---|---|---|
| Weight (Poundage) per Field Hour | Familiarity, as most sheet metal contractors use the weight of the systems to be built as part of their estimating and budgeting process. | Weight of the material can have little to no bearing on the complexity of the work to be installed. |
| Footage per Field Hour | Correlates closely with the total volume of material handled by the field, which can have a significant effect on the ability to handle the material. | The footage of the material installed may not reflect the complexity of the estimated installation. |
| Each per Field Hour | Correlates well with specific pieces of equipment to be installed. | Not applicable for all activities. Best for installs which can be 'counted' easily. |

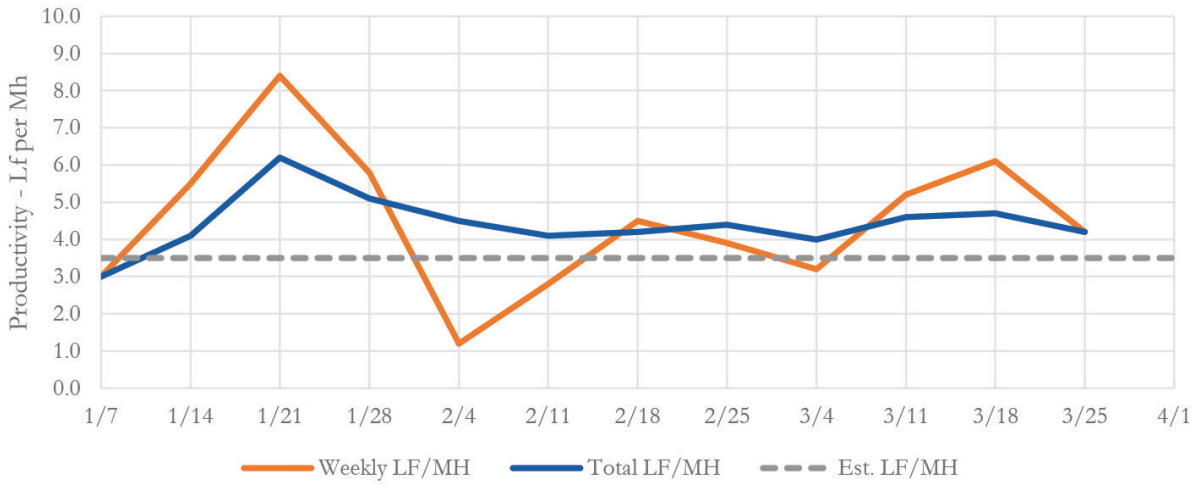
***Special Note:*** *For all suggested metrics, additional data and factors must be applied to offset for the size or complexity of each project. Choosing a primary metric and then utilizing secondary metrics along with post mortem data is the most effective way to provide accurate budgets for each task.*

With a standard cost code structure, a defined unit of measure, and accurate time and quantity reporting, contractors can establish trend reports for productivity.

| Cost Code | Cost Code Description | Units of Measure | Quantity | Budgeted Hours | Budgeted Dollars |
|---|---|---|---|---|---|
| 0300.01 | Install Hangers | Each per Hour | Quantity from estimate | Allocated from estimate | Allocated from estimate |

*Figure 11* below is a graphical representation of a productivity chart for installing sheet metal in the field. A manager or superintendent can review the red and blue trend lines and see that at times productivity is above estimate or below estimate, and can then take appropriate actions to correct or celebrate.

**Figure 11: Installation Productivity Example**




Companies that accurately analyze their productivity and react appropriately to their trending results are generally more profitable than those that do not analyze productivity.

Having an efficient process in place that is enabled by technology allows contractors to perform work and report their time and progress consistently into a system – and will yield a measurable outcome.

## CONCLUSION

Contractors agree that tracking productivity is a key component of profitability. Companies with a strong mindset toward tracking productivity are typically much more profitable than those that lack that mindset. Pushing productivity tracking from the highest level management through the rest of the organization is critical to successfully managing productive operations as contractors grow.

By focusing on proper reporting of quantities and time to appropriate cost codes, receiving timely and consistent information, and then analyzing trends, companies can identify issues earlier and optimize their productivity strategies in pursuit of profitable work.

# APPENDIX A – AN EXAMPLE OF PRODUCTIVITY AFFECTING PROFITABILITY

In the example below, a typical contractor has about 30% of its direct costs in labor (across all three areas of detailing, fabrication, and installation). By making minor improvements in productivity the net profitability of the entire company can be drastically improved.

**Figure 12: Example of Improved Productivity on Profitability**

| | | | |
|---|---|---|---|
| ANNUAL SALES | $ | 8,000,000.00 | % OF SALES |
| DIRECT COSTS | | | |
| LABOR | $ | 2,400,000.00 | 30.0% |
| MATERIALS | $ | 2,320,000.00 | 29.0% |
| SUBCONTRACTS | $ | 1,680,000.00 | 21.0% |
| EQUIPMENT | $ | 800,000.00 | 10.0% |
| TOTAL DIRECT COSTS | $ | 7,200,000.00 | 90.0% |
| GROSS PROFIT | $ | 800,000.00 | 10.0% |
| OVERHEAD | $ | 560,000.00 | 7.0% |
| **NET PROFIT (BEFORE TAXES)** | **$** | **240,000.00** | **3.0%** |

| % CHANGE IN LABOR PRODUCTIVITY | NEW NET PROFIT % | $ CHANGE IN NET PROFIT | % CHANGE IN NET PROFIT |
|---|---|---|---|
| 10% | 6% | $ 240,000.00 | 100% |
| 5% | 5% | $ 120,000.00 | 50% |
| 2% | 4% | $ 48,000.00 | 20% |
| 0% | 3% | $ - | 0% |
| -2% | 2% | $ (48,000.00) | -20% |
| 5% | 2% | $ (120,000.00) | -50% |
| -10% | 0% | $ (240,000.00) | -100% |

# APPENDIX B – SIMPLIFIED STRUCTURE FOR COST CODE AND TRACKING

Most smaller contractors do not have in place the systems, tools, and organization to support productivity tracking that larger organizations have. The value for smaller contractors arises then from having a simplified structure that can be flexible enough to meet the unique needs of each project and consistent enough to provide trending at all, yet provide enough detail for meaningful trending and analysis. Having too many codes and tracking a small number of hours will be counter-productive, and it is helpful to put rules in place to define tracking – for example only field track items greater than 8 hours.

In the example below, the contractor is tracking the entire floor as a percentage of weight detailed (24,900lbs), fabrication by their batch size (1,005lbs), and field installation by percentage of shop drawings (8,986lbs, 1 of 3 sheets for the floor).

- Detailing – by entire floor
- Shop fab – Cost codes by:
  - Coil duct
  - Rectangular fittings

  - Round fittings
  - Welded duct
  - Lining
  - Pre-fab
  - Track by pounds from download batch #
- Field – Cost codes by system (S/A High side, S/A low side, R/A, E/A, Welded duct)
  - Track by batch number and by lbs. installed
  - The only time we track hangers is when we insert. Other than that, we install hangers with the duct.
  - We have a code to track seismic hangers
  - Field coordination is tracked by percentage

The level of detail to be tracked, and how many cost codes are to be used, is then decided and agreed to between estimating, project management, supervision, and field foremen at the start of the job.

# APPENDIX C – SURVEY OF THE CURRENT STATE OF THE INDUSTRY

This section reviews the findings of the survey of the current state of productivity tracking in the sheet metal industry. Study participants spanned the entirety of the contiguous United States and operated in a variety of markets – Healthcare, Industrial, Manufacturing, Commercial, and Retail – and were split into three annual revenue categories of less than $10M, between $10M and $50M, and greater than $50M.

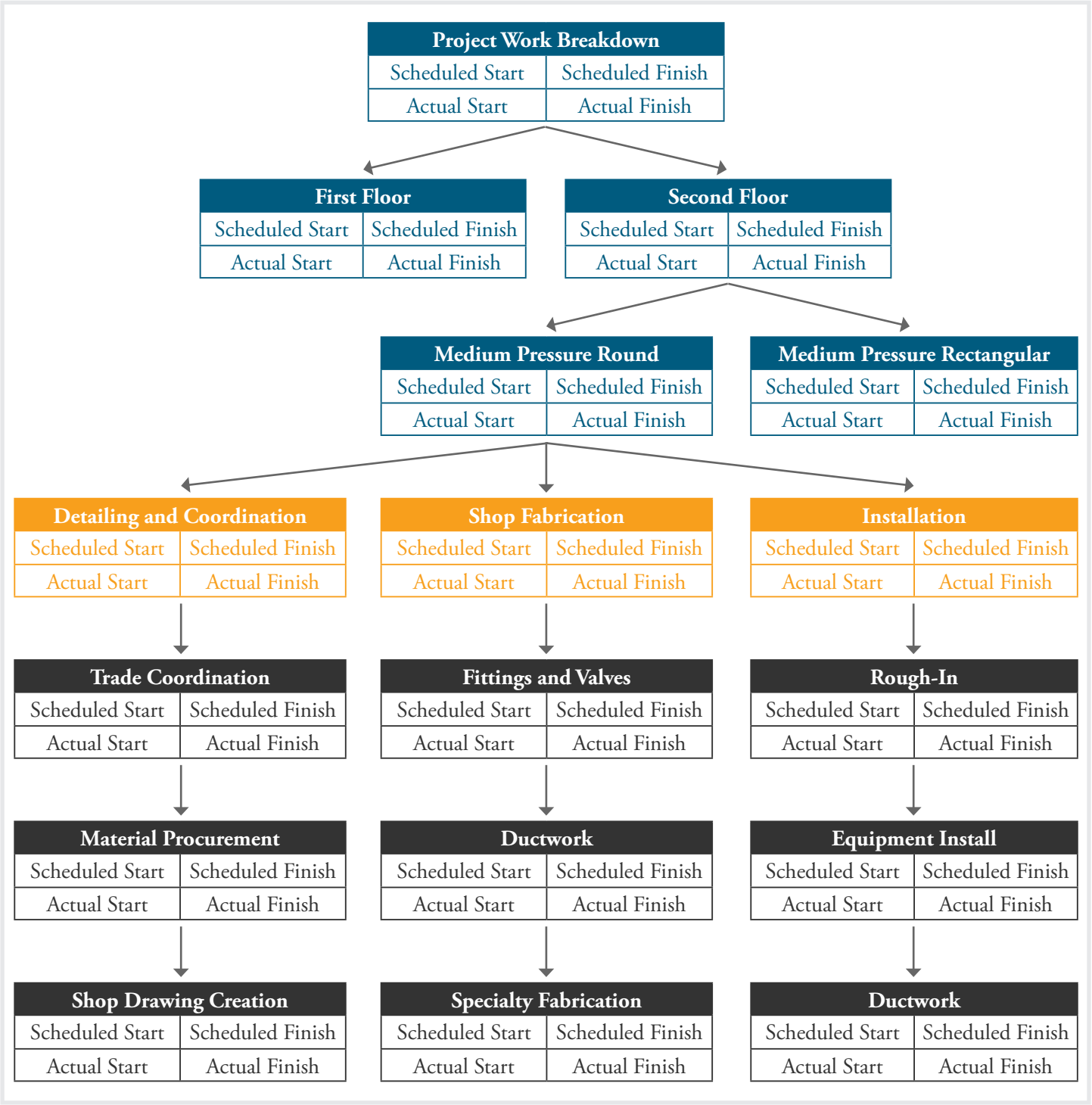
## State of the Industry – Project Budgeting

While there is no single "right" approach to estimating and creating budgets, there are several methods used by sheet metal contractors.

- **Conceptual:** A level of effort approach that is based on providing the number of required personnel and the needed material in an agreed upon time span to generate the total budget.
- **Benchmarking:** Comparing the project being budgeted to a previous project of similar size for which costs are known.
- **Parametric:** Budgeting the work effort based on another characteristic such as sheet metal weight, floor space, etc.
- **Activity-Based:** Developing the budget based on a detailed chronological task breakdown (Work Breakdown Structure or WBS) of activities, with a clear understanding of the tasks that make up the project and an ability to budget each activity with resources, drawings, and materials.

An Activity- or WBS-based budget is very useful in measuring earned value and productivity. The WBS defines the entire scope of activities to be performed, along with the necessary milestones to achieve project completion. A simplified example of a WBS structure for a sheet metal contractor is depicted here:

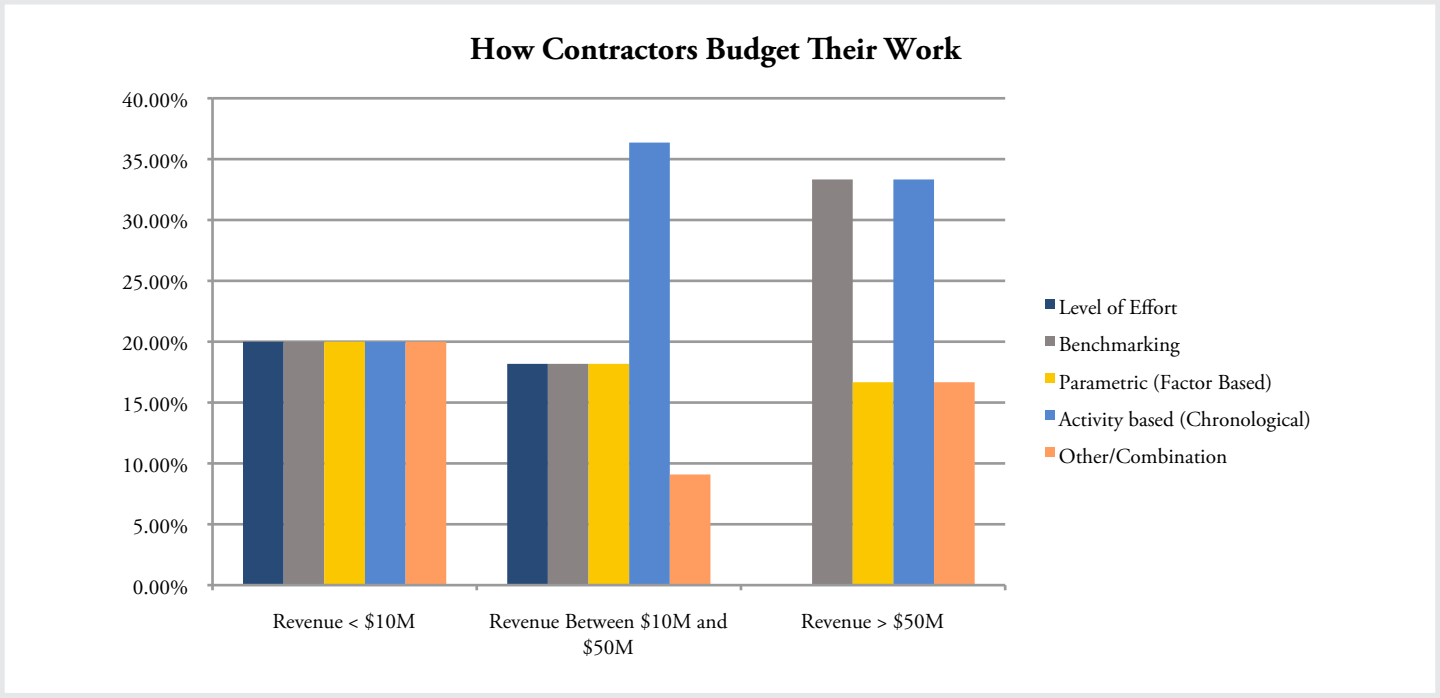
**Figure 13: Work Breakdown Structure Simplified Example**



The example WBS structure is broken down by area (first floor and second floor), then by system (medium pressure round and medium pressure rectangular), then by activity header (detailing, fabrication, installation), and then by activity (coordination, procurement, fabrication, etc.).

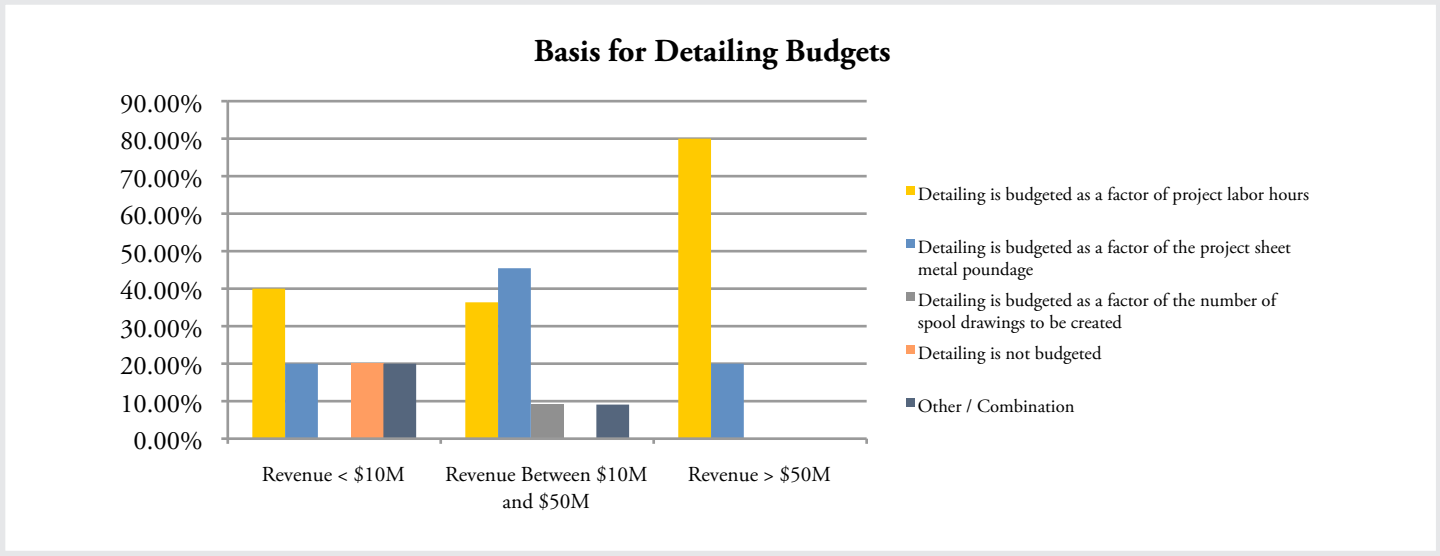
As the figure below shows, when contractors increase in revenue, there is a corresponding increase in the use of parametric and/or activity-based budgeting for their overall project budgets. This is to be expected, given that larger projects will have greater levels of risk, and more resources are necessary to track project performance. Contractors that collect this data and store it in an ERP or estimating system can then use it to accurately estimate future work.

**Figure 14: How Contractors Budget Their Work**



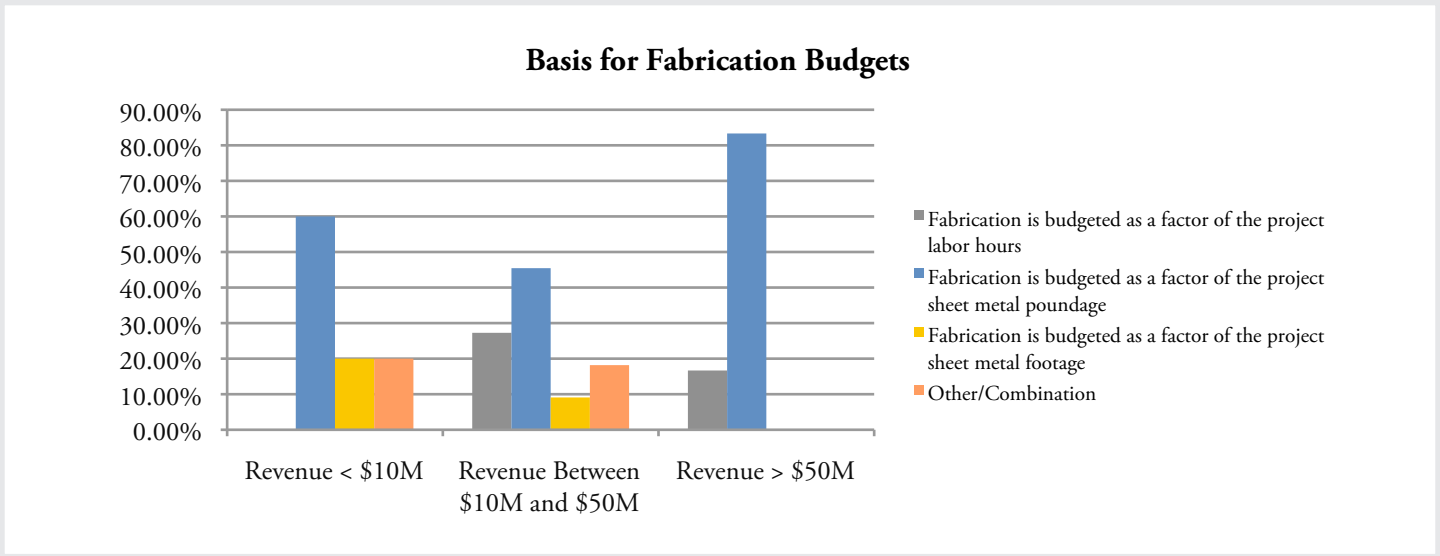

When breaking down the budgeting process specifically for detailing activities, Figure 15 shows that overwhelmingly across all revenue categories, respondents tend to create their detailing budgets parametrically as a factor of the project field labor hours or project sheet metal weight. Said differently, they estimate the amount of installation labor or material and then apply a percentage or factor to the labor estimate and obtain their budget for detailing.
A minimal number of respondents set their detailing budgets up by the number of spool drawings to be created, or do not setup budgets at all.

## Figure 15: Basis for Detailing Budgets



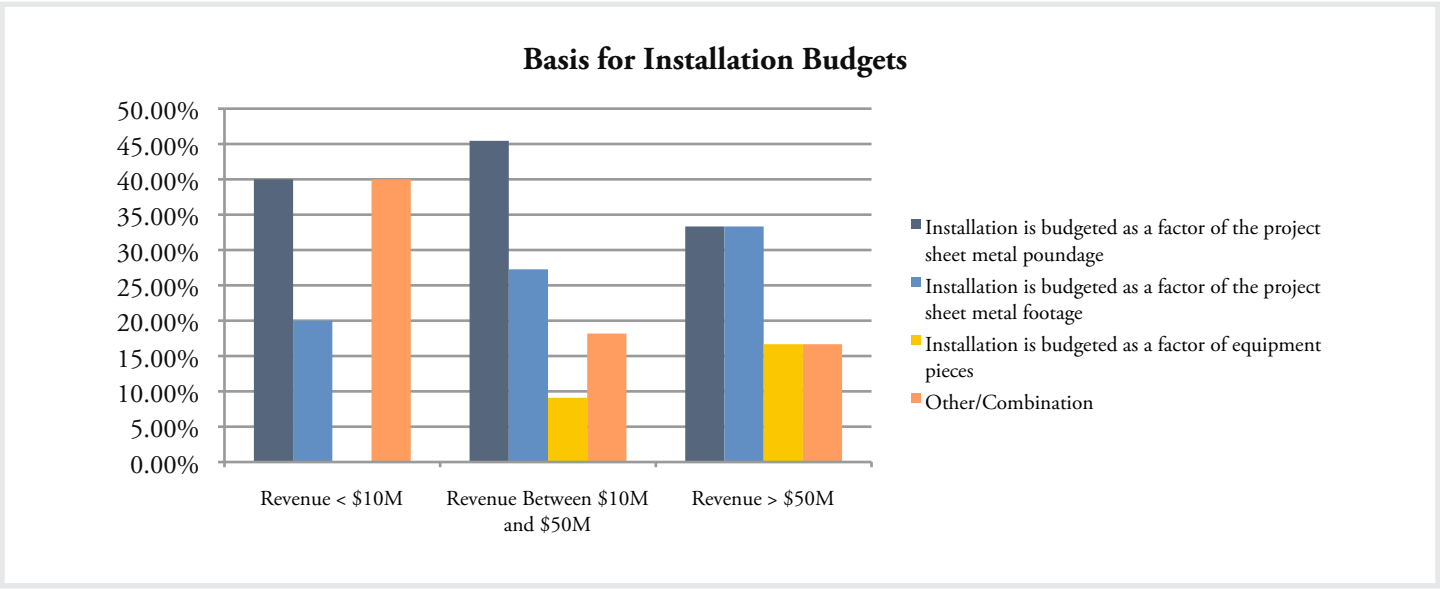

When reviewing the budgeting process specifically for fabrication in *Figure 16*, most contractors create their budgets for fabrication parametrically. However, here most contractors create their budgets as a factor of sheet metal weight, where as in detailing it was as typically a factor of field labor hours. A few contractors look at it as a factor of field labor hours as well. Other factors that affected the budgets were fitting sizes, valves, and types. These are not classified as uniformly by weight as sheet metal types are. Depending on the shop size there may be a specific employee (or set of employees) who make up most of the fittings for the shop and are responsible for stockpiling patterns and tracings on standard fittings used for sheet metal duct systems.

## Figure 16: Basis for Fabrication Budgets



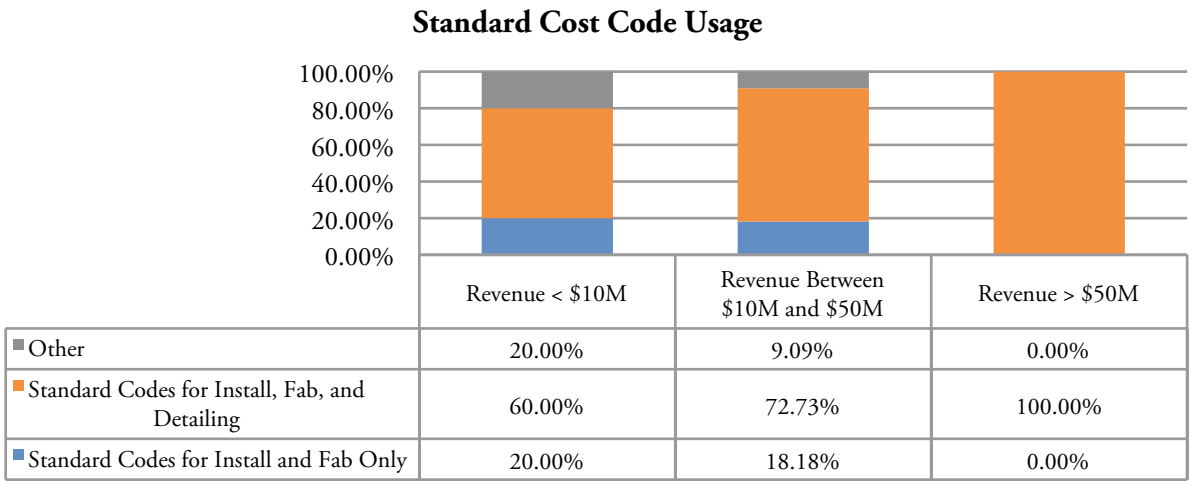
Field labor is usually the largest share of the work for any sheet metal contractor and is consequently the riskiest. Given the risk inherent in field work and the impact it can have on a project, it is no surprise in *Figure 17* that contractors are using a variety of methods for creating project budgets. While contractors across all revenue categories tend to prefer sheet metal weight as their method of budgeting installation work, many contractors also use sheet metal footage and equipment pieces (in combination or standalone) to set their installation budgets.

**Figure 17: Basis for Installation Budgets**




After the project has been budgeted and distributed to the project team, *Figure 18* shows that as a contractor's revenue increases, the use of standard cost codes in all three areas of detailing, fabrication, and installation increases as well. Smaller contractors will use some non-standard cost codes that they customize per project, in the belief that each project is unique. Larger contractors identify standard operations or tasks using cost codes for all work performed, and will divide those up into areas and/or systems throughout the project. Standardizing tasks and codes provides consistency and enables time and quantity collection – leading to accurate productivity tracking and earned value analysis.

## Figure 18: Standard Cost Code Usage

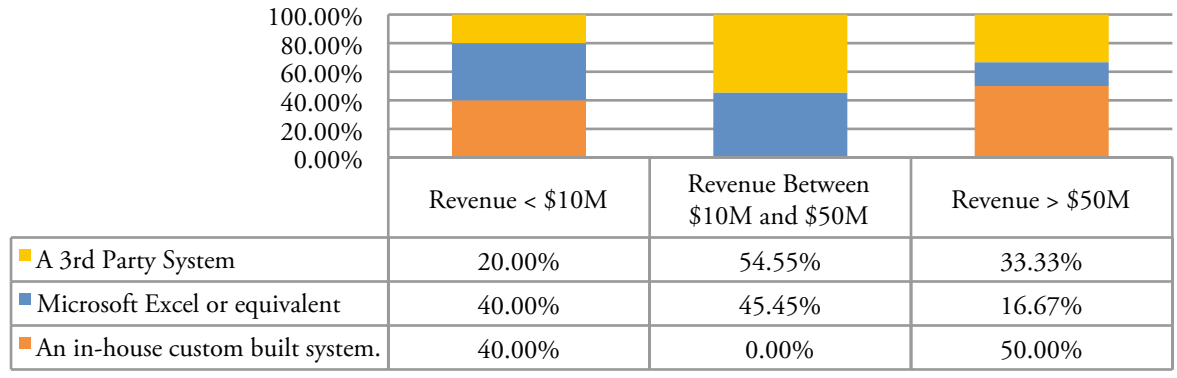



| | Revenue < $10M | Revenue Between $10M and $50M | Revenue > $50M |
|---|---|---|---|
| Other | 20.00% | 9.09% | 0.00% |
| Standard Codes for Install, Fab, and Detailing | 60.00% | 72.73% | 100.00% |
| Standard Codes for Install and Fab Only | 20.00% | 18.18% | 0.00% |

Generally, after contractors create their budgets, the process that most contractors follow is to distribute the budget to the project team via a report of some kind. Most contractors do not have a completely integrated system or set of systems that estimates the work, loads the budget first into their accounting/ERP system, and then to the CAD system and other computer aided manufacturing tools.

Surprisingly, even as contractors increased in revenue, the use of spreadsheets to build their budgets remained surprisingly strong as *Figure 24* illustrates. However, once revenue exceeded the $10 million mark a majority used either a third-party system or a custom system built in-house to perform budgeting activities. Third-party systems in use varied and included products such QuickPen, Autobid, CADMEP, QuoteExpress, Quotesoft, etc.

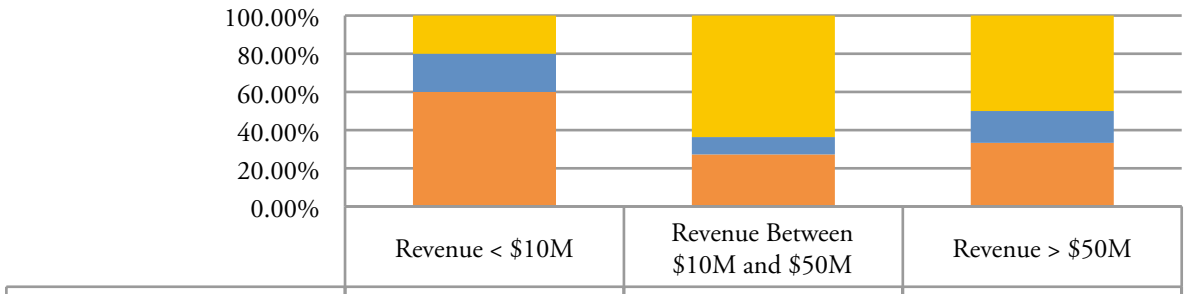
## Figure 19: Systems for Budgeting




| | Revenue < $10M | Revenue Between $10M and $50M | Revenue > $50M |
|---|---|---|---|
| A 3rd Party System | 20.00% | 54.55% | 33.33% |
| Microsoft Excel or equivalent | 40.00% | 45.45% | 16.67% |
| An in-house custom built system. | 40.00% | 0.00% | 50.00% |

For reporting time/hours worked, *Figure 19* shows that few contractors use a spreadsheet system. A majority either used an in-house custom system, or as their revenue increased they trended towards using a third-party system – either the ERP system or a commercially available time tracking program.

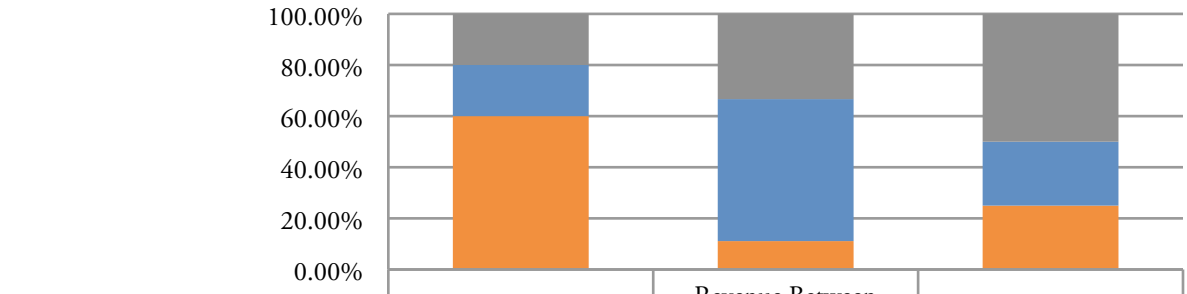
**Figure 20: Systems for Reporting Hours**




| | Revenue < $10M | Revenue Between $10M and $50M | Revenue > $50M |
|---|---|---|---|
| A 3rd party system | 20.00% | 63.64% | 50.00% |
| Microsoft Excel or equivalent | 20.00% | 9.09% | 16.67% |
| An in-house, custom system. | 60.00% | 27.27% | 33.33% |

While the use of third-party systems for measuring progress (work completed or quantities) in *Figure 20* is strong, there is also a significant increase in the use of spreadsheet-based or custom systems. This is indicative of a dearth of solutions that can report both time and quantity in one system, which are the cornerstones of measuring earned value, productivity, and project forecasting.

**Figure 21: Systems for Reporting Progress**




| | Revenue < $10M | Revenue Between $10M and $50M | Revenue > $50M |
|---|---|---|---|
| A 3rd party system | 20.00% | 33.33% | 50.00% |
| Microsoft Excel or equivalent | 20.00% | 55.56% | 25.00% |
| An in-house, custom built system | 60.00% | 11.11% | 25.00% |

This document has thus far detailed the current state of the industry in terms of contractors setting up budgets, and identified the systems they currently use to manage their reported progress and track time. The next section examines how contractors are using the data that is collected.

## State of the Industry – How Contractors Track and Measure Progress

When examining how contractors are using the data gathered, two questions were asked for each phase of detailing, fabrication, and installation:

- Which metric best describes the method of tracking progress of work completed?
- How are contractors currently using data from tracking time and / or quantities?

**Detailing Phase:** Similar to the budgeting process, as contractors increase their revenue, the methods for tracking progress became increasingly sophisticated. During the detailing phase, *Figure 22* below shows most respondents measure their progress in detailing by using hours worked. This was consistent across all revenue categories. The assumption here is that every hour worked or charged to a detailing cost code is a productive hour, which may not always be the case. That can lead to errors in forecasting project costs, or subjective reporting of observed completion during the detailing progress. It is no wonder that most detailing departments in the country are over budget and behind schedule – given the lack of clearly defined deliverables and a consistent earned value process.

**Figure 22: How Contractors Measure Detailing Progress**

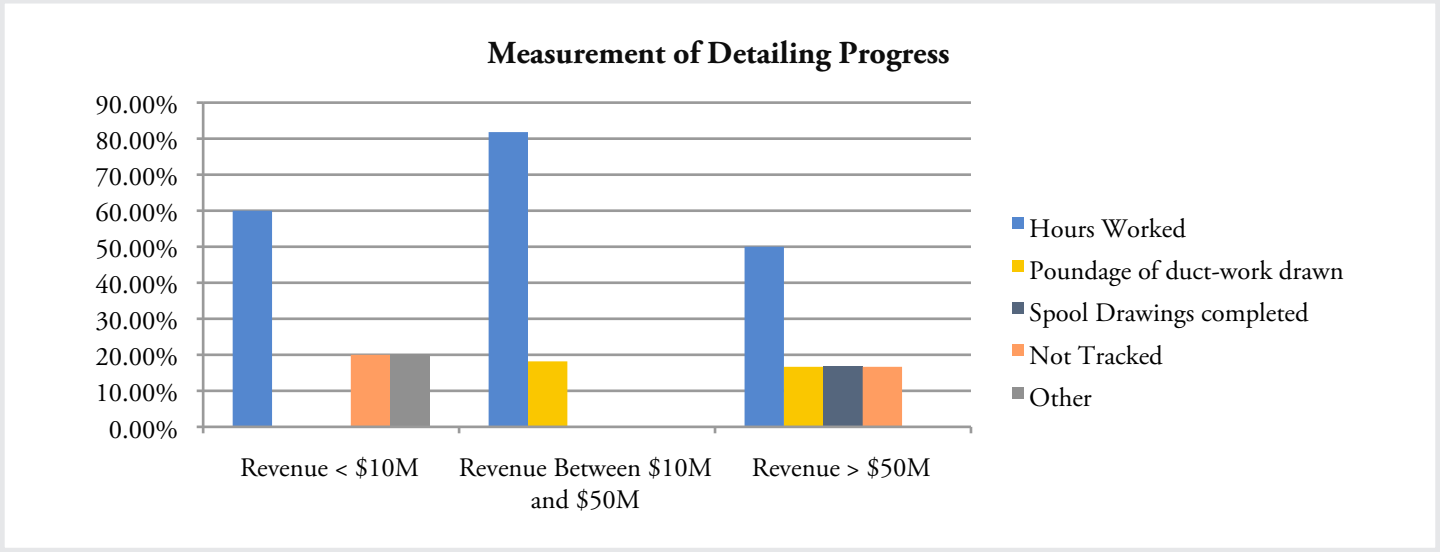
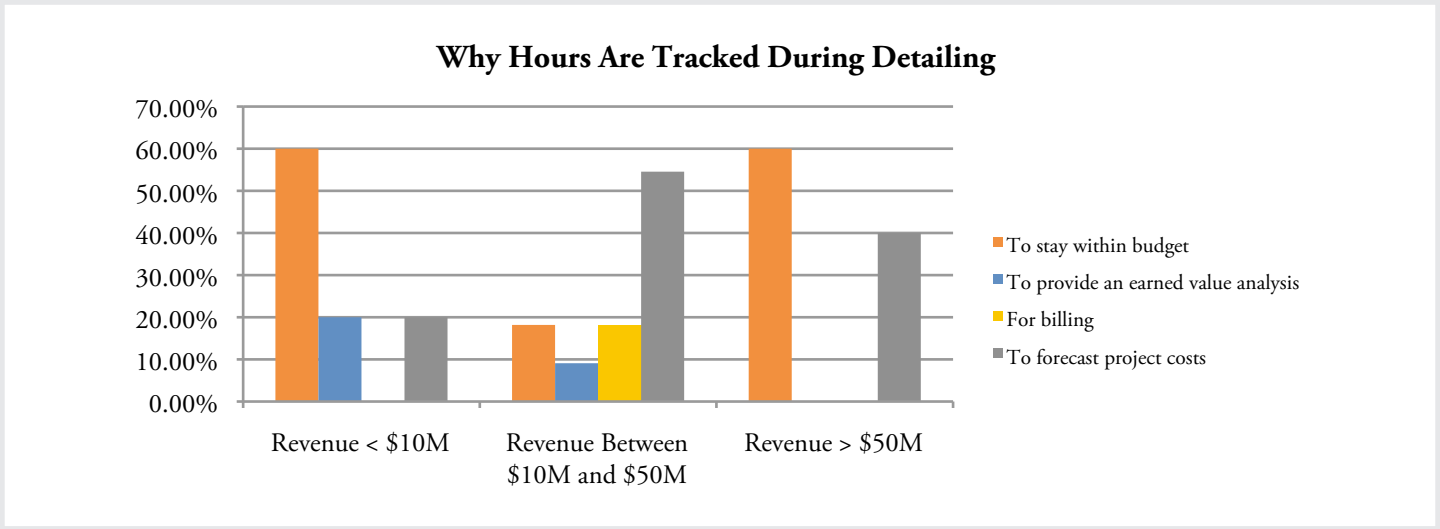


*Figure 23* below shows that once the project detailing budgets are allocated, most contractors only track their detailing hours worked for checking budgets and reporting observed percent complete. This was consistent across all revenue categories. Few perform any kind of earned value analysis to determine if they are productive and effective within the detailing effort itself. This supports the industry view that detailing is considered a "necessary evil".

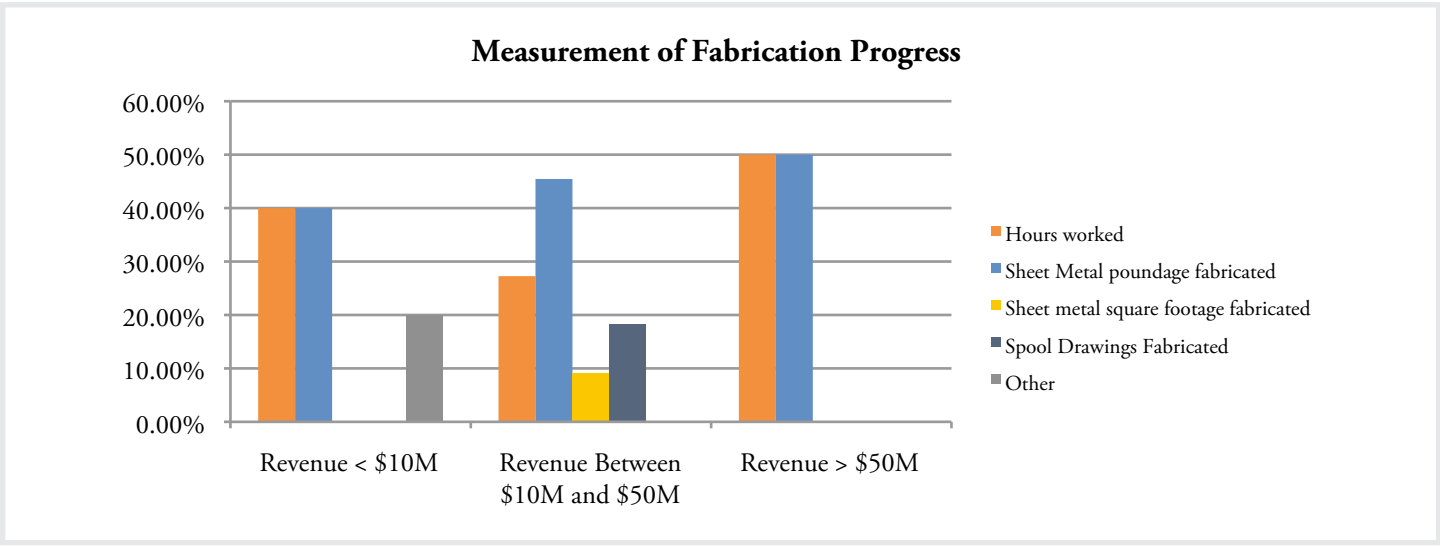
**Figure 23: Use of Detailing Progress Measurement**




Through the interview process, this study determined that a very small minority of contractors perform any kind of earned value analysis on detailing. The minority of contractors who do perform the analysis consider the detailing stage to be a profit center and offer their detailing services to third-party clients such as architects/engineers as a separate offering, in addition to the in-house work necessary to support their own fabrication and installation operations. Further information regarding the appropriate methods to calculate detailing can be found in the SMACNA manual on Establishing Overhead and Burden in a Sheet Metal Business.

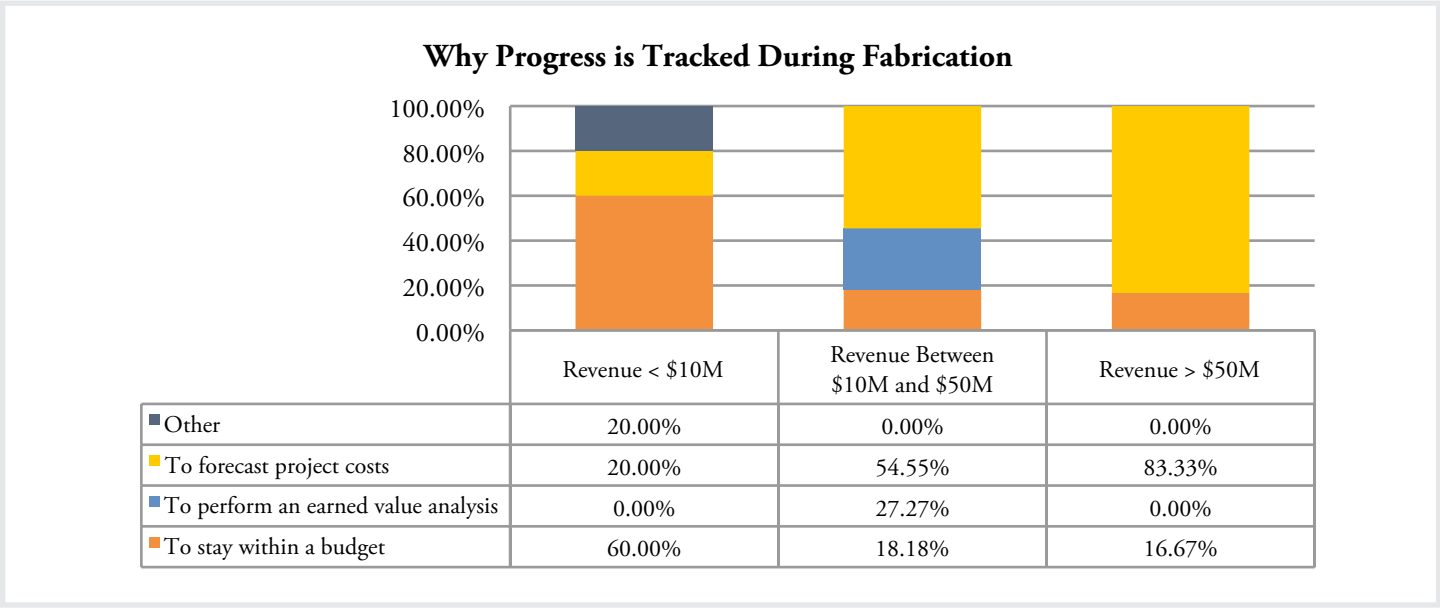
**Fabrication Phase:** Consistent with how contractors estimate and budget their fabrication work (weight and/or hours worked), *Figure 24* shows that contractors generally use the same metrics for measuring progress in fabrication.

## Figure 24: How Contractors Measure Fabrication Progress




As revenue increases, contractors do use the data from measuring fabrication progress to start performing more sophisticated activities such as forecasting project costs. Smaller contractors tend to merely look at their fabrication budget to make sure it is not exceeded (*Figure 25*).

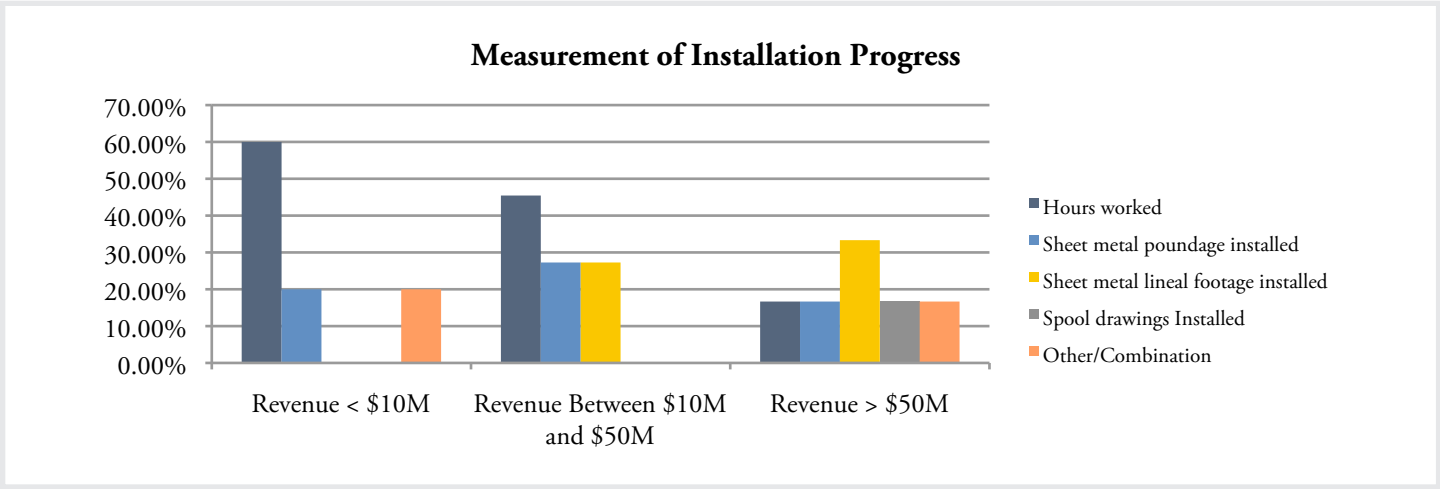
## Figure 25: Use of Fabrication Progress Measurement




| | Revenue < $10M | Revenue Between $10M and $50M | Revenue > $50M |
|---|---|---|---|
| Other | 20.00% | 0.00% | 0.00% |
| To forecast project costs | 20.00% | 54.55% | 83.33% |
| To perform an earned value analysis | 0.00% | 27.27% | 0.00% |
| To stay within a budget | 60.00% | 18.18% | 16.67% |

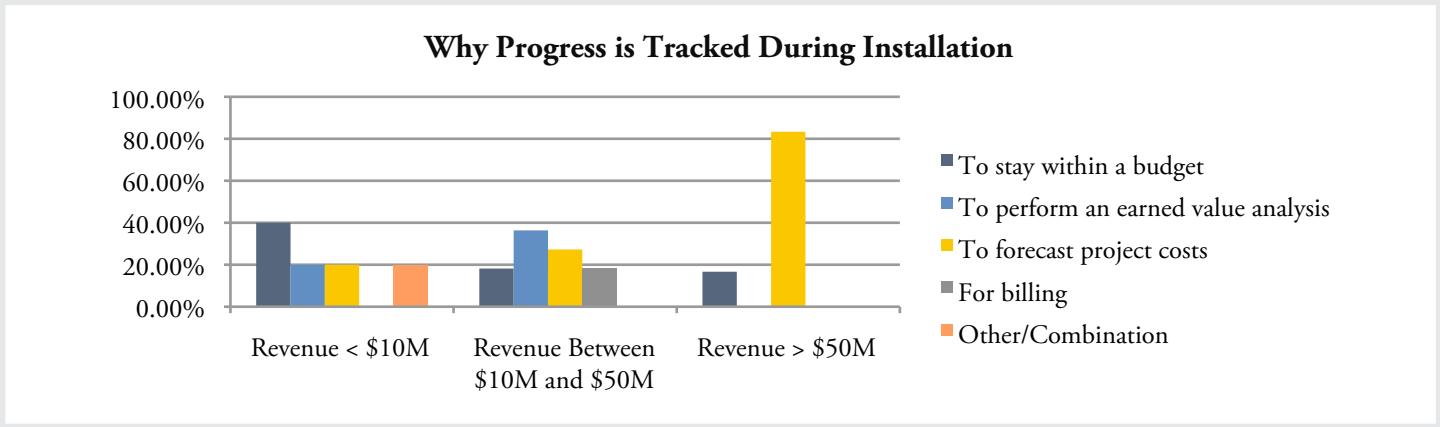
**Installation Phase:** The data for measuring installation progress shows there is a clear distinction between smaller contractors and larger contractors. *Figure 26* shows that smaller contractors overwhelmingly use hours worked (similar to how contractors use hours worked in the detailing phase to measure completion) as a measure for how much work is completed. The flaw with using hours worked as a measure of progress is that it also assumes that every hour worked or charged to a cost code is a productive hour. Rework for example would be captured as a productive hour if charged to that same code, unless there is a method of identifying it separately. As revenue increases, contractors increasingly look to other metrics besides hours worked or weight of the system. The use of linear footage installed (or some variant of volume) or spool drawings are two metrics that increase with sophistication.

**Figure 26: How Contractors Measure Installation Progress**




Overwhelmingly, as contractors increased in revenue the reason for tracking their measured work was to accurately forecast project costs. This is shown in *Figure 27*. Being able to forecast costs is a clear outcome of being able to measure the work and perform an earned value analysis.

**Figure 27: Use of Installation Progress Measurement**



In this section the survey participants summarized the existing state of the industry for tracking productivity during detailing, fabrication, and installation. While clear themes for using sheet metal weight as a major factor in budgeting work emerged from the study across all revenue categories, there were clear differences in how contractors look at progress measured, productivity, and the application of the data collected. Larger contractors tend to do a more detailed analysis when budgeting work, providing a WBS structure that progress can be measured against and using rules or systems for measuring that work. Smaller contractors tend to view projects as unique and budget the work initially as a factor of a project variable like sheet metal weight, and then use observed percent complete as the basis for any earned value analysis – without performing a deeper analysis of productivity, performance, and forecasting project costs.

# APPENDIX D – IMPROVING PRODUCTIVITY FOR A SHEET METAL CONTRACTOR

Through the course of the interview and survey process, consistent themes emerged from contractors who operate with a focus on managing the productivity of their operations in all three areas. Those best practices have been condensed and identified here.

## Best Practices

**Detailing Standardization:** Standardization in the detailing process is often limited as each contractor is attempting to optimize its project costs. However, there are downstream impacts from having non-standard details: unique detailing requirements, special material ordering, varied manufacturing methods, different shipping and handling, and varied installation methods.

Detailing teams need to be tasked with establishing product and application standards. For example, a standard for schools, a standard for hospitals, and a standard for commercial buildings. This might be broken down further into small, medium and large as defined by the load requirements. The impact of detailing standards on downstream work flows is tremendous.

The ultimate output of what detailing produces should be an installation drawing with a bill of materials for the products contained in a specific kit. These outputs should be consistent for every job, every time. Additional information on this topic can be found in the SMACNA manual on Transforming your Organization for the Future.

The detailing process should also be closely managed and should include a standard process that captures:

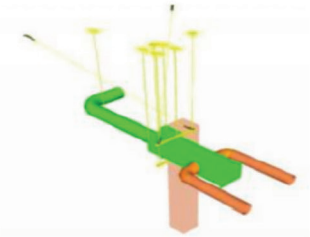
1. Project Setup
    a. Contacts
    b. Software in Use
2. Model Development
    a. Designer Provided Files
    b. Order of Modeling
    c. Deliverables

   d. Level of Development
   e. File Naming Convention
   f. Origin Location
   g. Color Designation
   h. Levels of Detailing
3. File Transfer
   a. BIM 360 Glue
   b. Upload Schedule
4. Coordination
   a. Meeting Location and Frequency
   b. Meeting Details
   c. Clash Detection
5. Schedule
   a. Coordination Milestones
   b. Coordination Schedule
6. Documentation
   a. 2 D Coordination Drawings
   b. Signoff
   c. As-Built Models and Drawings

The detailing process should establish the appropriate amount of information for each detailing level, for each type of system, and for each sub trade as illustrated in *Figure 28*.

**Figure 28: Detailing Standards Example**

HVAC Duct:

| | | |
|---|---|---|
| 300 | Modeled as actual size, shape, spacing, and location/connections of duct, dampers, fittings, and insulation for risers, mains, and branches;<br>actual size, shape, spacing, and clearances required for all hangers, supports, vibration and seismic control that are utilized in the layout of all risers, mains, and branches;<br>actual floor and wall penetrations modeled. |  <br>159D3060.10-LOD-350 Supply Air |

**Simplified Workflow:** Workflow is the number of steps it takes to go through detailing, procurement, fabrication, shipping, and installation. Simplifying (reducing the number of steps) and automating the workflow to the greatest extent possible is key to improving productivity. Selection of a software package that can provide the budget to the detailing software system, and attach the budget from detailing to the shop and then to the field, prevents downtime and communication errors. Another workflow simplification is to integrate the CAD and CAM solutions to provide seamless data transfer between them.

**Quality Built into the Process:** Many computer numerical control (CNC) machines contain probes for part setup. The probes can quickly identify the origin and reduce downtime from human intervention. The probes can also perform in-process inspections during machining to verify conformance to specification rather than waiting to the end of the machining process.

**Standardized Work:** Given that contractors can standardize their cost code structure and corresponding activities, it is only a short step to developing field installation standards and work plans for each code or operation. For example, registers and diffusers should be installed left to right in every room. This becomes a company standard and all field staff know that it is the way the company details, manufactures, and packages the materials for that specific work task. The installation standards should be developed by the field staff and should consider installation constraints. The same principle can be applied to fabrication (*See Figure 29*). There should also be a feedback loop to the estimating, detailing, and fabrication groups so enterprise level standards can be agreed upon.

## Figure 29: Standardized Fabrication Work Instruction Example

**Standardize Work Instruction Sheet**

**Area: Detailing, Fab, Install**

Process Name: **Station 2**

| Created By: | Creation Date: | Revision Date: |
|---|---|---|
| Corey | 15-Aug-18 | |

| STEP | ELEMENT STEPS | Cost Code | Opt. | Time |
|---|---|---|---|---|
| 1 | **Detailing** | | | |
| 2 | Populate Construction Element intent in 3D | 30.1110 | | 2.0 |
| 3 | Coordination with other trades | 30.0000 | | 2.0 |
| 4 | Establish Hanger Locations | 30.1110 | | 0.5 |
| 5 | Download Material to fabrication | 30.1110 | | 0.3 |
| 6 | Create for Construction Drawings | 30.1110 | | 0.5 |
| 7 | | | | |
| 8 | **Fabrication** | | | |
| 9 | Edit material download | 01.1110 | | 0.25 |
| 10 | Form Material panels | 01.1110 | | 4 |
| 11 | Assemble Fittings | 01.1110 | | 5 |
| 12 | Pre assemble duct sections | 01.1110 | | 0.5 |
| 13 | Load carts and Delivery vehicle | 01.1110 | | 0.25 |
| 14 | | | | |
| 15 | **Field Installation** | | | |
| 16 | Highlight Pre-assemblies on Construction Dw | 17.0100 | | 0.25 |
| 17 | Layout and install of hangers/supports | 06.1110 | | 1 |
| 18 | Receive ductwork | 07.1110 | | 0.25 |
| 19 | Installation - erection, connection, sealant | 07.1110 | | 7.5 |
| 20 | duct testing Y/N | 07.1110 | | N/A |
| 21 | | | | |

200' of 140x54 6in. Wg. Supply and return air duct

= Build Assist associated with step

Total Element Cycle Time = **46.0**

| Sign-off / Initials | 1st | 2nd | 3rd |
|---|---|---|---|
| Operators | | | |
| | | | |
| | | | |
| Sub-Supervisor | | | |
| | | | |
| Supervisor | | | |

| SAFETY EQUIPMENT | SAFETY LOCKS | SAFETY GLASSES | SAFTEY SHOES | RESPIRATOR | LOVI | HARD HAT |
|---|---|---|---|---|---|---|
| Check Box if Protective Equipment is Needed | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

## Technology, Tools and Systems to Improve Productivity

When implementing technology for productivity tracking there are many solutions in the marketplace. Many contractors also rely on custom-built applications that were built in house to meet their needs. Regardless if the technology selected is to be custom built or purchased, there are several important practices or features to implement when introducing systems for tracking and improving productivity.

**Automate CAD Programming:** Building tool libraries, creating templates, defining cut and paste parameters, and implementing automated re-machining are all practices that can significantly improve detailing productivity. Using repeatable design elements that are already value engineered can improve both detailing and fabrication productivity. Automated CAD software can also analyze a model and sequence it in a method for maximizing machine efficiency in the shop. There are many solutions that exist in the industry, and this study showed that programs from Autodesk and Trimble are ones that have widespread usage in the industry. Revit, Duct Designer, CADmep, and PractiCAD all provide automated tools and buildable libraries that streamline the detailing process.

**Eliminate Manual Programming:** Using computer aided manufacturing (CAM) is known to improve productivity in a shop environment, as it utilizes software to automate the programming process at the machine controller. In manual programming, there is usually a dry-run to prove the program, and then material is machined. This results in downtime where the machine is not utilized. CAM eliminates the potential for manual errors, reduces machine downtime, reduces the amount of operator time, and allows for quicker changes to the system. All of this improves the productivity and profitability of the fabrication process.

**Increase Machine Utilization:** One of the best ways to increase machine utilization is by fixturing (fitting multiple parts in the machine at the same time). Using multiple vises to hold down multiple parts while machining, installing a tombstone (a multi-sided fixture that rotates), multi-orientation fixtures, and self-centering fixtures are all ways to increase machine utilization. While this may be an expensive proposition, contractors should carefully consider how the improved productivity can result in labor savings when procuring a machine that can perform multiple tasks.

**Integration Between Systems:** Every contractor has solutions for back-office accounting, estimating, material resource planning, and job tracking. Some of those solutions are integrated and some are based on spreadsheet software that the contractor maintains. When implementing systems, contractors should look for ways to seamlessly transmit data between the different solutions. Reducing manual data entry between systems eliminates errors and improves reporting throughput.

**Time and Quantity Entry:** Many shops fill out paper time cards or spreadsheet-based time cards and then send them in for data entry which causes a bottleneck and increases the chance for error. Contractors can gain greater process visibility and more up-to-date reporting by adding shop floor kiosks (like those in *Figure 30*) or mobile entry, and other remote methods that can integrate into their back-office and job tracking solutions.

**Figure 30: Time Entry Kiosk**


**Job Tracking:** Systems should be able to provide production tracking based on real-time or near real-time time entry. They should provide visibility on the project as the workflow for a project proceeds from the detailing stage through to the shop fabrication and then to the field for installation. Detailed reports and summary reporting are necessary features.

# APPENDIX E – A PRIMER ON PRODUCTIVITY AND EARNED VALUE

It is important to understand exactly what productivity is and how it relates to earned value measurement. Improving project performance and increasing organizational profitability requires an understanding and use of earned value analysis and productivity tracking. The most significant issue most contractors face is establishing quantities with a standard unit of measure and then recognizing progress against the quantities.

## Earned Value Analysis

Earned value is important because it:

- Provides a history of production which can be used in pursuit of future work
- Objectively determines percentage of project completion

- Assists with early identification of problems
- Helps identify productive and non-productive operations
- Helps forecast project costs

An earned value process establishes consistent methods for budgeting and recognizing completed work. Consistency helps prevent errors and creates more predictable outcomes. The goal is to ensure that if three employees walk a job, they will all report the same progress or percent complete on the project.

Formulaically, earned value is the estimated or budgeted hours for an activity or project multiplied by the percent complete. There are two possible approaches to calculate an earned value:

$$Earned\ Hours = \frac{Actual\ Quantity}{Budget\ Quantity} * (Budget\ Hours)$$

Or

$$Earned\ Hours = Quantity\ Completed * Budget\ Unit\ Rate$$

Earned value is tied to the budget and the actual work completed, regardless of how accurate the budget is. When the task is completed, the hours earned will be equal to the total budgeted hours for the task but can never exceed the budget.

## Rules of Credit

Rules of credit are used to specify how quantities will be recognized. The rules of credit are typically embedded into a particular phase code and are used to report progress – for example, percent complete, which is then converted into quantities. For example, if a contractor put the man-hours associated with hangers and supports in the same line item as the ductwork itself, they might define the rules of credit such that 25% of the manhours are recognized when the hangers are up, 50% of the manhours are recognized when the duct main is in the air, and 100% of the manhours are recognized when all the supply lines are attached and turned to the proper orientation. With this process, three people should recognize the same amount of progress at any point in the project, creating more consistency.

The use of rules of credit are critical in an earned value analysis. These rules are established prior to the project beginning and aim to remove the subjectivity from evaluating project progress. They also do not change during the project, can help provide a comparison between projects, and ensure that no more than 100% of the project value can be earned (preventing reversals down the road from inaccurate quantity reporting). While there are different methods of putting in place rules of credit, the simplest method is the weighted step approach.

The weighted step approach is used for steps or interim milestones identified as “check in” points with specific criteria and weight defined to evaluate progress. Each step or milestone represents a portion of the effort to perform the task. In this example, creating a detail drawing is broken down into specific work steps. As each step is completed, the corresponding percentage is claimed. For example, once the draft spool detail is completed, 25% of the hours would be claimed. These hours can then be compared to the actual hours used, to determine if the work is ahead or behind budget.

**Figure 31: Detailing Rules of Credit Example**

| Interim Milestone/Step | Weighted Percentage | Hours Earned |
|---|---|---|
| Create draft spool detail | 25% | 10 Hours |
| Initial QC Check and Comment | 15% | 6 Hours |
| Revise based on Comment | 25% | 10 Hours |
| Finalize Bill of Material | 15% | 6 Hours |
| Approve/Release for Fabrication | 20% | 8 Hours |

At each stage of the detailing, regardless of actual hours worked, only the portion of completed work could be earned. This provides a comparison of actual work to earned work, giving a clear picture of project performance.

## *Productivity*

Once earned value is understood, the next step in tracking productivity is understanding the formula for productivity.

$$Productivity = \frac{Units\ of\ Output}{Units\ of\ Inputs}$$

Simply put, that is dividing the work that is earned or completed on a task, by the actual work that is performed. I**n the contracting industry though, the more common approach is to reverse the formula such that it is calculated as actual hours divided by earned hours which can make the results more intuitive such that any number greater than 1.0 is an overrun-on labor and any number under 1.0 is an underrun on labor**.

Consider a task that performed 90 hours of labor, and earned 80 hours of work. Intuitively, that is a labor productivity of:

$$\frac{Actual\ Hours}{Earned\ Hours} = \frac{90\ Hours}{80\ Hours} = 1.125$$

*Figure 32* demonstrates the use of earned value to determine productivity tracking using the intuitive approach, where greater than 1.0 is an overrun on labor and under 1.0 is an underrun on labor.

## Figure 32: Earned Value Reporting and Productivity Tracking

| | | From Estimate | | | From Field | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cost Code | Description | Est. Hours | Est. Quantity | Unit | Actual Hours | Actual Quantity | Earned Hours = ***(Act Qty / Est Qty) x Est Hours*** | Cost at Completion = ***(Act Hours / Act Qty) x Est Qty*** | Task Labor Productivity = ***(Act Hrs / Earned Hrs)*** | Status |
| 1001 | Install Hangers | 800 | 4,000 | EA | 400 | 2,000 | 400 | 800 | 1.0 | On Budget |
| 2002 | Rough-In | 5,000 | 5,000 | LF | 1200 | 1000 | 1000 | 6000 | 1.2 | Over Budget |
| 3005 | Trim-Out | 2,000 | 500 | CY | 1,100 | 300 | 1200 | 1833 | 0.9 | Under Budget |
| | ***Total*** | ***7800*** | | | ***2700*** | | ***2600*** | ***8633*** | | Over Budget |

Labor % Complete = Total Earned Hours / Total Estimated Hours
= 2600 hrs / 7800 hrs
33%

Cost at Complete Labor = 8633 hours x $50/hour composite labor rate
$431,667

Labor Variance = Estimated Labor Cost - Cost at Complete Labor
= (7800 hours x $50/hr) - $431,667

Labor Productivity = Actual Hours / Earned Hours
= 2700 hours / 2600 hours
1.04

*>1 Losing to the Estimate*
*<1 Beating the Estimate*

*Figure 32* shows that two tasks (hanger installation and trim-out) are perfectly productive or better, at 1.0 and 0.9 respectively, and that the other task (rough-in) is overrunning on labor at 1.2. Note that in this scenario, actual quantities of hours were used instead of a percent complete. It is recommended to use quantities in conjunction with rules of credit to calculate an earned value, to easily derive a production rate.