Practical Ways to Identify Measured Miles

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Abstract: Change is any addition, deletion, or revision to the general scope of a contract and may require an adjustment to the contract price or contract duration of a design or construction project. Many disputes arise out of changes, and successful resolution of those disputes requires that three elements be evaluated: liability, causation, and resultant injury (damages). A particular type of damage frequently alleged on changed projects is loss of labor productivity. One way to evaluate and quantify loss of labor productivity damages is through use of the measured mile technique. Problems exist with the measured mile approach, however, because there are no generally accepted guidelines for developing and applying the technique. Based on review and synthesis of project management literature and court and appeal board decisions, this paper presents practical considerations in the identification and application of measured miles. The intent is to help contractors, owners, consultants, and other parties step through a logical process for preparing and presenting a credible measured mile analysis. **DOI: 10.1061/(ASCE)LA.1943-4170.0000199.** *© 2016 American Society of Civil Engineers.*

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Introduction

Productivity is a measurement of output per unit of time and is important because it, along with the hourly rate and the work quantity, is one of the three components of labor cost (AACE 2004). If productivity is impaired, project labor costs will increase. Because labor costs are usually a large proportion of total project costs, the overall total project costs will probably increase. Such an increase will jeopardize the project's business value to its investors and the contractor's profit.

One of the ways labor productivity may be impaired is through change, which is any addition, deletion, or revision to the general scope of a contract (Ibbs 1997). Because change may result in idled resources (e.g., waiting for new instructions), reassigned resources (with extra, unplanned transit time or learning curve losses), or other problems, a contractor may suffer a loss of labor productivity (LOP).

To successfully claim LOP damages a contractor must demonstrate what caused the change, why the owner is liable for the change, and that any claimed damages are reasonable.[1] There are different methods for estimating such LOP losses including actual cost, total and modified total cost, project comparison studies, specialty industry studies, general industry studies, and the measured mile approach (AACE 2004).

This last method, the measured mile technique, compares a contractor's labor productivity during two sections of project time: a normal (also sometimes called the reference or nonimpacted) period against an impacted period.[2] It has been accepted by a number of professional organizations such as the American Association of Cost Engineers (AACE 2004) and the Society of Construction Law (2002), and a number of legal decisions.[3]

Though seemingly simple in concept, there are actually a number of issues and nuances associated with measured mile analysis, and it is frequently misapplied because of those issues and nuances. One of the most common mistakes is using a reference period that is not similar to the alleged impacted period. "Similarity," however, is neither well defined nor understood, and clear, practical guidelines are needed as discussed by various experts (AACE 2004; Ibbs 2012; Serag et al. 2010; Barnard 2013; Zhao and Dungan 2013), and by a number of court and board cases.[4]

These writings and decisions indicate that practical guidelines better detailing "similarity" are needed. This paper addresses some of these key factors from a practical applications point of view. A previous paper by the senior writer of this paper reviewed board and court cases to identify and organize a set of measured mile principles (Ibbs 2012). That paper, however, provided only a general framework for properly constructing and applying the measured mile method and did not delve into the details of factors that can be used to determine the similarity or dissimilarity of two project time periods. This paper does such. The intent of this paper is to help contractors, owners, consultants, and other parties step through a logical process for preparing and presenting a credible measured mile analysis.

Measured Mile Background and Literature Review

Zink's paper is the earliest description of the concept of a measured mile (Zink 1986). That technique compares a contractor's labor productivity during two sections of project time: a normal (also sometimes called the reference or nonimpacted) period against an impacted period. He also recommended that the first and last 10% of the project's work-hours be excluded from the measured mile computations because they are "build-up" and "tail-out" periods, and are not representative of the project's productivity. In order for a claim to be successfully pursued, the impacts causing LOP must be the responsibility of the defendant (usually an owner), not the claimant (usually a contractor).

Labor productivity is determined by dividing the actual number of labor-hours expended on a task by the actual quantities of work

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installed.[5] The lost productivity is computed using the difference in the productivity between the impacted and nonimpacted periods and is normally expressed in terms of labor-hours. Those lost labor-hours are then multiplied by an hourly cost to convert the lost labor-hours into a monetary measure of the lost productivity.

The advantage of the measured mile approach is that it considers only the actual effect of the alleged impact. It eliminates disputes over the validity of cost estimates, which are a necessary part of some of the other LOP measurement methods such as modified total cost. For this reason it has been referred to as the "gold standard" (Ibbs and Stynchcomb 2013). Of course, even if the claimant has properly selected a measured mile reference period, it must still prove that the defendant caused the LOP and is thus liable for the damages computed by the measured mile analysis.[6]

On highly troubled projects, however, it may be impossible to segregate one period of performance that was not impacted. On such projects courts and boards have allowed minimally impacted periods (the "baseline" method) to be used as the measured mile, though the claiming contractor may be sacrificing some legitimate part of its claim (Thomas and Sanvido 2000; Ibbs and Liu 2005). Courts have even allowed "similar projects" to be used as the measured mile reference.[7] Acceptance of "similar" projects is allowed because courts do not expect mathematical precision in the measurement of loss of productivity damages.[8]

As straightforward as the concept may seem, years of application have revealed a number of nuances and intricacies that sometimes lead to misapplication and denial of a claim. Wilson (1993), for example, was one of the first to illustrate how two different computational approaches applied to the same project—one being the productivity per cubic yard of excavated soil and the other being productivity per lineal foot of excavated soil—can yield substantially different results. The reason is because the cross-sectional area of the measured mile section differs substantially from the allegedly impacted section.

A few years later Finke (1998) reported that the impacted and unimpacted time periods could be concurrent if the underlying works are separate and distinct. He also noted that productivity can be defined as labor-hours per percentage point of completion or progress, labor-hours per dollar of earned value, or labor-hours per quantity installed. Finke also made the important observation that measured mile analyses generally compare an average productivity rate for an unimpacted time period with an average productivity rate for an impacted time period. He noted that averages hide the fact that a contractor does not achieve a single, uniform rate of productivity throughout a time period. Thus, "once it is realized that you are dealing with a collection of productivity rates rather than a single average productivity rate, you open the door for a statistical analysis to determine whether there are meaningful differences" (Finke 1998).

Thomas and Oloufa (1995) compared the productivity of various construction projects that had been disrupted by change. To standardize the data they, like Calvey and Zollinger (2003), used an earned value approach to create conversion factors that, in turn, allowed them to obtain equivalent work types across the projects.

Thomas and Sanvido (2000) note that some projects are disrupted throughout their entire duration, meaning no pure, unimpacted measured mile period exists. For such conditions they propose using a "baseline productivity" method. To define the baseline, they recommended dividing the project into ten equal time periods. The period with the best productivity would then be used as the reference productivity, even if there are owner and contractor-caused impacts. Advantages of this method are that it does not require a continuous, unimpacted time frame, and owner- and contractor-caused inefficiencies may be present throughout. A disadvantage of this method is that the contractor's best productivity may not be truly reflective of its normal productivity, which could result in an understatement of the LOP.

Gulezian and Samelian (2003) note that plotting the to-date productivity in a cumulative fashion may smooth the data and more clearly reveal systematic abnormalities. Eden et al. (2005) note that the measured mile approach does not easily allow disaggregation between different categories of disruption and delay, and triers-of-fact often want to assess disruptions and delays individually because of liability provisions in the project contract. Shea (1989) notes that cases with measured mile analysis are often too complicated to parse in detail.[9]

Braimah (2010) notes that one key to developing a credible measured mile analysis is good, underlying project documentation. To conduct such measured mile analyses requires the contractor to have a good work breakdown structure and cost control system to capture the labor-hours and quantities-installed information needed to compute productivity. That system must be coordinated with detailed information documenting the disruptive or delaying event causing the LOP and why the defendant is liable. Even though a contractor may be able to create hundreds of specific line items in a cost coded accounting system, base contract work and the inefficiency component are often so intertwined that it prevents a clear delineation of the costs attributable to each.

Presnell (2003) and Serag et al. (2010) describe the measured mile process in very general terms as (1) defining the work activity or cost, (2) accounting for the work performed, (3) logging accurate labor-hours used to perform the work, (4) recording accurate quantities of work completed for the period, and (5) defining any condition or event that prevented optimum production. Their guidelines mistakenly refer to production (output) rather than productivity (output per unit of time). Loulakis and Santiago (1999) suggest choosing a measured mile according to two criteria: (1) the work performed during the unimpacted period should be substantially similar in type, nature, and complexity to the affected work, and (2) the skill and composition of the workers should be comparable. They do not elaborate on what constitutes similarity.

Ibbs and Liu (2005, 2011) developed and tested a statistical K-clustering method for separating productivity data into impacted versus nonimpacted categories. Applying this method to an actual claim, Williams (2011) found that it yielded results that were closer to the actual project losses than other methods. The method also demonstrated that a hard-and-fast 10% rule, as proposed by Zink (1986), is arbitrary.

Dieterle and Gaines (2011) offer some practical points about measured mile use, one recommendation being that any measured mile analysis include a sensitivity analysis. Such a sensitivity analysis might involve shifting the measured mile period forward or backward in time or using different lengths of time periods to see if either substantially impacts the claimed LOP amount.[10] Dieterle and Gaines's article also encourages step-by-step explanations of the LOP analysis with "transparent" use of data.

Ibbs (2012) reviewed board and court cases to identify and organize a set of measured mile principles. That paper provided a general framework for properly constructing and applying the measured mile method. It did not delve into the details of factors that can be used to determine the similarity or dissimilarity of two project time periods. This paper does such.

This issue of the measured mile and its applications is important because it is the most widely accepted approach for calculating loss of labor productivity. Despite the fact that this technique is so widely used in the industry, there is still a high rate of misuse and poor application of the measured mile method. The majority of this misuse stems from the fact that "there is no single application or format for the Measured Mile" (Kelly 2013). Because there is no "mold" to follow when it comes to applying the measured mile, the methodology serves as more of a guide than a rigidly formatted technique. The need for this present paper is substantiated by the fact that "a contractor can learn from the mistakes of predecessors when preparing a claim" (Davis et al. 2007).

Though numerous authors have written about the measured mile concept for the past 20-plus years, a recurring point made by these cases and project management reviews is that there is a need for better guidelines that will help define conditions that are sufficiently similar to apply the measured mile technique. The next section discusses a list of such factors.

Key Similarity Characteristics

Measured mile analysis would be easy if projects had periods of time that were identical. However, that is not and does not have to be the case as the court in *Clark Concrete Contractors, Inc. v. General Services Administration* wrote:

> [The Government] is correct in asserting that the work performed during the periods compared by [the Contractor] was not identical in each period. We would be surprised to learn that work performed in periods being compared is ever identical on a construction project, however. And it need not be; the ascertainment of damages for labor inefficiency is not susceptible to absolute exactness. We will accept a comparison if it is between kinds of work which are reasonably alike, such that the approximations it involves will be meaningful.

A key issue in measured mile analysis thus becomes a question of what constitutes similarity. One legal source defines it using terms such as "analogous, approximate, close, congruent, kindred, like, synonymous" (Free Dictionary 2015). Another reference writes that similar circumstances will bear "a partial resemblance only; but it is also often used to denote sameness in all essential particulars" (Free Dictionary 2015). To understand and provide guidance on the subject of similarity, it is therefore necessary to investigate the "essential particulars" or factors of a project. The following subsections discuss such considerations. These nine factors are not the only factors. There are undoubtedly more factors, but in our experience they represent the typical circumstances.

Type of Work

One of the most obvious points of comparison between two time periods in a project is the *type of work* that is being done. According to Loulakis and Santiago (1999), "the work performed during the mile should be substantially similar in type, nature, and complexity to the work that was affected." Work type and nature relate to the physical characteristics of the installed work (e.g., reinforcing steel in a column versus reinforcing steel in a slab or PVC versus EMT conduit). As mentioned previously, identical periods of time and work will be impossible to find on a project; the courts, therefore, have allowed a certain amount of latitude by holding a claimant to a standard of similarity only.

The court in *Appeal of P.J. Dick* provided insight into this issue of similarity when it considered *work type* factors in a project with electrical circuit work that was disrupted by more than 2,000 changes. Dick, the contractor, argued that all the branch circuits had been disrupted by the government and thus did not have any branch circuit work available as a measured mile. Instead, it used feeder circuits as its reference mile. The court, after considerable in-depth review, accepted the contractor's analysis even though (1) the feeder and branch wire and conduit sizes were different, (2) the feeders were installed in longer continuous runs and in interstitial spaces, and (3) the feeders did not involve device installations. Evidence showed that the work was performed in the same general part of the building. A reading of the court's decision suggests that the large number of owner-caused changes led the court to exercise some leniency in accepting this measured mile comparison.[11]

A counterexample in which a contractor's measured mile was not acceptable to the court is *P.W. Construction, Inc. v. United States*. In this case the court found that the differences in the materials and the means and methods were too great to accept as a measured mile comparison:

> The record shows that welding in the impaired period was butt-welding on polyethylene pipes, which takes only 15 seconds to 2 minutes per weld, whereas the welding done in the pre-disruption period was steel welding, which may take up to 2.69 hours per weld . . . this evidence suggests that a comparison of the pre- and post-disruption periods must take into account the difference in welding . . . Because the impaired rate accurately reflects productivity during the impaired period, but does not accurately reflect productivity during the ideal period, the court vacates the damage award on lost productivity. The rates must account for the differences in welding and trenching costs for the different pipes [emphasis added].[12]

E.C. Ernst, Inc. v. Koppers Company, Inc. is another example of a failed attempt to use measured mile. In this situation, the contractor's expert computed LOP by assigning craft labor-hours to drawing revision production. The approach was unsuccessful because the analysis (1) included nonelectrical drawings and (2) assigned an equal number of labor-hours of lost productivity to each revision even though some drawings had minor revisions. Also, impacts were claimed at times when drawings were produced but no craft work was performed. On remand, Ernst used a different method that was accepted. A final example of a failed analysis is *J.A. Jones Construction Company v. Corps of Engineers*. In this dispute the impacted work was deemed by the court to be too dissimilar and too far away from the reference area to warrant use as a measured mile.[13]

Means and Methods

A second factor to consider in evaluating possible measured miles is contractor *means and methods*. Contractors are usually responsible for and have control over construction means, methods, techniques, sequences, and procedures unless the contract documents give other specific instructions concerning these matters (AIA 2007). Means and methods, in this context, are the installation and erection procedures used to construct a project. Examples include the choice of a tunneling method, the size of a backhoe, or precasting versus casting-in-place concrete work.

This category includes the tools and equipment that are used. As AACE (2004) notes, "It is probable that productivity will decline because the right tools, materials and equipment may not be in the right place at the right time." The *P.W. Construction, Inc. v. United States* court, as cited previously, emphasized that the means and methods between the impacted and unimpacted periods must be reasonably similar.

Labor Force and Worker Characteristics

Labor force and worker characteristics is another factor that should be reviewed as part of preparing a measured mile analysis.[14]

This applies to not only the workforce of the self-performing general contractor, but also to specialty subcontractors (Zink 1986; Crowley and Livengood 2002). Considerations at the project level include union versus nonunion workforces, labor trade, crew sizes, foreman-to-journeyman ratios, training, morale, fatigue, overmanning, and absenteeism and turnover ratios (Business Roundtable 1982; Singh 2003; Hanna et al. 2007; MCAA 2011).

These criteria must also be considered in light of the prevailing economic conditions. In economic slowdowns, the unemployment rate may be high and highly productive workers may be readily available. During economically robust periods, the converse may be true.

Crew mix is also an important part of this general category as realized in the *Appeal of Bay Construction* case, where the board denied a claim because the contractor failed to analyze the labor trades separately. The *Appeal of P.J. Dick* court also highlighted the importance of comparing similar crews when it put emphasis on the fact that the electricians used throughout the project consistently came from the union hall.

Supervision and Management

Another critical factor that must always be considered is *supervision and management*. Without proper leadership, a project will fail to optimize productivity. Hiring and using the correct people in a proper manner and ensuring that the correct equipment, materials, subcontractors, and other resources are available to the craftworker are keys to project success (Oglesby et al. 1989). The importance of supervision and management was highlighted by the Mechanical Contractors Association of America (MCAA) when it was made one of the 16 factors in the MCAA model that can be used to assess LOP.[15]

Another important element of project management is the proper collection of productivity data.[16] A portion of a project may serve as a useful and valid measured mile, but the analysis will be flawed unless the labor-hour and quantity data are collected correctly (Teicholz 1974).

Project Location, Layout, and Logistics

Project location, layout, and logistics can influence measured mile analyses and thus are essential factors to consider in the design and use of a measured mile. Location can be viewed on a micro scale as indoor or outdoor work, or on a more macro scale comparing different geographical locations (Wilson 1993). Four of the sixteen factors in the MCAA model relate to location, layout, and logistics issues: beneficial occupancy, joint occupancy, site access, and logistics.

Location and logistics may also bring into question the accessibility of the work site to workers. Holloway (2007) provides an example in which a welder is working at one point in a prefabrication shop one week and the following week must work outside in subfreezing temperatures. "The contractor might argue that the entire cost overrun was caused solely by the decision to move the work to an outdoor [environment]."

AACE (2004) notes that "poor site layout can contribute to loss of productivity ... if crews have to walk a long way to lunch rooms, tool cribs, laydown areas, washrooms, entrances and exits, etc., then productivity may suffer as a result." One recent construction project this senior writer visited required more than 800 craftworkers to check-in at a gate that, at one point, was located 2,000 feet from the actual work site. The gate was eventually moved closer to the actual work space. Because the workers were paid to walk the extra distance at the start and conclusion of each workday (sometimes in snowy conditions), their labor productivity increased after the gate was relocated.

Schedule

A sixth important factor to consider in defining a suitable measured mile period is project *schedule*, in terms of details such as activity sequence, work flow, activity density, and overall duration.[17] *Appeal of P.J. Dick* is an example in this regard. Government-driven acceleration of work resulted in the contractor directing a subcontractor to work on multiple floors concurrently in an attempt to make up for government-caused delays. As a result the subcontractor was forced to assign multiple crews on each floor that were required to perform all aspects of branch circuit installation. This caused labor inefficiencies because it made the subcontractor's crew training efforts more difficult and prevented it from realizing the learning curve benefits of sequential circuit installation by task-dedicated crews. Having its crews working on all floors concurrently affected the subcontractor's ability to properly supervise the work, a factor that also contributed to labor inefficiency.

Work flow, which influences the pace of a schedule, was instrumental to the court in *P.W. Construction, Inc. v. United States* when it studied the concurrency of the feeder and branch work and the movement of crews between building floors. Conversely, failure to account for a contractor's mis-scheduling in the *Gulf Coast* case resulted in the court disqualifying its measured mile presentation.[18]

Schedule should also be reviewed in terms of work times when conducting measured mile reviews. Night work is less productive (and less safe) than daytime work, just as work during months with favorable weather has higher productivity levels (Hancher and Taylor 2001). Oglesby et al. (1989) cited research where the *time of week and day* is influential on the productivity levels. Monday mornings and Friday afternoons are less productive times than, for instance, Tuesday afternoons.

In long-term projects, *project duration* may become a factor as well. Frequently referred to as a "build-up" or "tail-out" period, both ends of projects tend to reflect inefficient man-hours due, in part, to the longevity and duration of the project. This is one of the points that Zink (1986) stressed in his article: he proposed eliminating the first and last 10% of a project's schedule from measured mile analyses because of inherent start-up, punch list, and fatigue inefficiencies. The *Appeal of Bay West* court also stressed this point when it adjusted a contractor's claim for learning curve effects.[19]

Weather/Seasonality/Time of Year

Weather can factor greatly into the productivity of workers and has been researched extensively (Hancher and Abd-Elkhalek 1998; Koehn and Meilhede 1981; Koehn and Brown 1985; Loulakis and Santiago 1999; NECA 2004; Thomas and Yiakoumis 1987). Specific weather factors that have been studied include temperature and humidity, precipitation, and wind speeds. MCAA (2011) also listed season and weather change as one of its factors. *Appeal of P.J. Dick* and *P.W. Construction, Inc. v. United States* are cases that involved weather conditions.

Seasonality and *time of year* can be influential to the productivity levels that are achieved by workers, and both should be considered in measured mile analysis. Aside from the obvious changes in weather that arise over the course of a year, seasonality also impacts the amount of daylight available during working hours. Less daylight means dimmer working conditions and increased need for temporary lighting facilities (adding to site congestion), both of which can impair labor productivity. Also, holidays and vacations are somewhat seasonal, which can increase labor force absenteeism and turnover, and impair productivity. Multiyear projects may span multiple seasons, and measured miles must be chosen carefully in such situations (Crowley and Livengood 2002).

Overtime and Shiftwork

Another factor that influences labor productivity is *overtime and shift work*. Numerous studies have shown that overtime and shiftwork impact labor productivity (Kossoris 1944; Blough 1973; CII 1988; Hanna et al. 2005; Singh 2003; Thomas 1992). Such measures are often used to accelerate a project, and their impact on productivity has been ratified by the AACE (2004) and the MCAA (2011).

The *Natkin & Co. v. George A. Fuller Co.* case exemplifies the consequences of substantial amounts of overtime and shiftwork. Natkin, a mechanical contractor installing industrial process machinery, had maintained detailed records documenting the quantities of work installed and labor-hours expended as well as correspondence protesting a constructive acceleration condition. As a consequence, its LOP claim was successful. Conversely, even though it noted "working of overtime hours does adversely affect labor efficiency," the *Havens Steel v. Randolph Engineering Co.* court rejected the contractor's claim because

> [t]here was no testimony, expert or otherwise, as to the causal relationship, if any, between the deviations mentioned previously and the ultimate failure of the cladding and insulation system which followed the storms of September 20 . . . I believe one can find, even without expert testimony, that those inverted laps do represent a "defect" in "workmanship." That finding, however, is of no real significance here because I have no way of determining — even if I knew how many inverted laps there were — that they had any possible causal relationship to the cladding failure.

This reinforces the point that expert testimony is often important to establish cause-and-effect, especially in highly technical disputes.

Crowding/Congestion/Trade Stacking

Crowding/Congestion/Trade Stacking is a factor that is important to be considered when applying a measured mile comparison. Whether it is too many workers of the same trade or too many workers of different trades in a physical space, labor productivity can be impaired. This crowding effect can extend to not just the physical space used by the bodies of human workers ("hard" impediments); it can also pertain to the tools, equipment, and means and methods they use. For instance, welding generally should not be performed in a confined space if painting is also occurring at the same time in that space (a "soft" impediment). This risk that this factor presents to labor productivity has been recognized by the AACE (2004) and the MCAA (2011).[20]

Summary, Conclusions, and Recommendations

The measured mile technique is a popular and widely accepted method for measuring loss of productivity damages. Fundamentally, the method compares the productivity achieved during an impacted portion of a project against an unimpacted (or minimally impacted) portion of that project that is of a similar nature. In certain instances, productivity from other similar projects may be accepted as a reference. The credibility of the measured mile comparison hinges on the similarity of the two compared periods.

Based on a review of various court and board decisions and project management literature, this paper presents a list and discussion of key factors that should be considered when selecting a reference period. The factors discussed in this review include the type of work; means and methods; worker characteristics; supervision and management; project location, layout, and logistics; schedule; weather/seasonality/time of year; overtime and shiftwork; and crowding/congestion/trade stacking. There are other factors that may arise and should be considered in defining a measured mile—the contract delivery system, the owner, the designer, and the prevailing regulatory conditions are just a few examples that are not analyzed in this paper. The paper presents the more important factors, especially those that have been discussed in some detail in published court decisions and construction management literature.

Finally, the preceding discussions about labor-impairing factors were presented in a separate, stand-alone manner. That is not the way that construction occurs and is not the way that measured mile design and application should be practiced. A period impacted by an owner's insistence on extensive overtime combined with a contractor's poor project management cannot be directly compared to an ideal period where all the work is straight time and the contractor's management is satisfactory. Thus, the *combination of multiple factors caused by both the defendant and plaintiff* can complicate the analysis and make the use of expert services even more important (*J.A. Jones Construction Company v. Corps of Engineers* and *Daewoo Engineering and Construction Ltd v. United States*). No one-size-fits-all formula will apply in such cases, except to say that these authors recommend that the dispute analyst be conservative in his or her measured mile computations.

Although these factors may be difficult to isolate and identify individually within a project, there is often overlap of multiple factors that must be taken into consideration when determining the measured mile comparison time. The courts have repeatedly relied on conservative, expert judgment in analyzing such cases.[21] Employing conservative and expert judgment increases the likelihood of a fair analysis and successful outcome.

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Endnotes

[1]In *Warwick Construction, Inc.*, the court noted: “It has always been the law that in order to prove entitlement to an adjustment under the contract or for its breach, a contractor must establish the fundamental facts of liability, causation and damage.” And in *United States v. Wunderlich*, “A claimant need not prove his damages with absolute certainty or mathematical exactitude … It is sufficient if he furnishes the court with a reasonable basis for his computation, even though the result is only approximate … Yet this leniency as to the actual mechanics of computation does not relieve the contractor of his essential burden of establishing the fundamental facts of liability, causation, and resultant injury.”

[2]See, for example, *United States Industries, Inc. v. Blake Construction Co*. Also, *Leo Harmonay, Inc. v. Binks Mfg. Co.*: “Such comparison of the cost of performing the work in different periods is a well-established method of proving damages.”

[3]See, for instance, *Advanced Engineering & Planning*; *Bell BCI Company v. United States*, in which the HVAC subcontractor “installed the changed duct work on the third floor at a rate of 6.26 pounds per hour, compared to the 11.23 pounds per hour it experienced early in the project”; *Goodwin Contractors*; *Appeals of W.G. Yates & Sons Constr. Co.*; and *Appeal of Batteast* in which the project superintendent testified that he had 20+ years of masonry experience and on this particular project, productivity was 33% lower in a disrupted area than nondisrupted areas. The contractor’s case was also strengthened when the government’s experts testified that they “pulled [numbers] out of the air” and used “strictly a gut feeling.”

[4]As discussed later in this paper the *P.W. Construction, Inc. v. United States* court criticized use of two project sections that had very different joining methods. Another example where missing guidelines undercut a contractor’s claim is *Southern Comfort Builders, Inc. v. United States*. In that situation Southern Comfort Builders, Inc. (SCBI) tried unsuccessfully to apply a measured mile derived from productivity experiences of two entirely separate projects and companies. That court also determined that many of the obstructions and interferences encountered by SCBI could have been identified and mitigated by SCBI before productivity was impacted. It also failed to establish a cause-and-effect nexus between the government’s actions and the contractor’s impacts. A final, fatal flaw was that SCBI’s measured mile computations resulted in a damage claim that was larger than if it had submitted a total cost claim.

[5]Sometimes work does not have a quantity of measurement (e.g., “inspection of work”) or there may be only one unit of work (e.g., “install boiler”). In such cases, an earned value–based approach may be applied (AACE 2004).

[6]One of the many notable examples where the claimant failed to prove causation is *Advanced Engineering & Planning Corp.* “Because AEPCO has failed to establish a causal connection between the disruption factors or variables used in its methodology and the disruptive events that are the subject of its claim, and because AEPCO has failed to allocate its claim disruption costs between itself and the Navy, we hold that AEPCO is not entitled to recover any such costs.”

[7]*Clark Concrete Contractors, Inc. v. General Services Administration*: “[The GSBCA] will accept a [measured mile] comparison if it is between kinds of work which are reasonably alike, such that the approximations it involves will be meaningful … We find no basis to conclude that either the productivity of *the same crew or that exactly the same work* is a prerequisite for a valid measured mile analysis to establish the amount loss of productivity [emphasis added].” See also *Maryland Sanitary Mfg. Corp. v. United States.*

[8]For instance, in *Atlas Casualty Surety Co. v. The George Hyman Constr. Co.* the court wrote: “The absence of more exact proof of damages is justified when factors such as the size of appellant’s firm, cost of maintaining more accurate records and the nature and complexity of the project are considered. L.L. Hall Construction Co. v. United States, 177 Ct. Cl. 870, 885, 379 F.2d 559, 567 (1966).” And in *Clark Concrete Contractors, Inc. v. General Services Administration*, “[The Government] is correct in asserting that the work performed during the periods compared by [the Contractor] was not identical in each period. We would be surprised to learn that work performed in periods being compared is ever identical on a construction project, however. And it need not be; the ascertainment of damages for labor inefficiencies is not susceptible to absolute exactness. We will accept a comparison if it is between kinds of work which are reasonably alike, such that the approximations it involves will be meaningful.” And as Jackson et al. (2001) says about *Clark Concrete*: “However, reliance on the measured mile approach is not always feasible. For example, if the project never really experienced an unimpacted period, or if the project records are insufficient, then a contractor may choose to rely on an industry study to quantify its lost productivity claim.” “[The GSBCA] will accept a [measured mile] comparison if it is between kinds of work which are reasonably alike, such that the approximations it involves will be meaningful.” And in *Safeco Insurance Co. of America v. County of San Bernardino* the federal appeals court ruled that the expert’s measured mile was acceptable even though it may have inaccurately treated some low-productivity days: “Because damages need not be proved with mathematical precision, nitpicking regarding the calculation is seldom successful grounds for appeal.”

[9]“Commenting on the practicality of proving damages the board [in *Robert McMullan & Sons, Inc.*] stated that to attempt to deal with each individual issue and to segregate delays and loss of efficiency would be a wasteful exercise. It was impractical if not impossible to distinguish with any degree of accuracy the contract work from extra work.”

[10]In *Daewoo Engineering and Construction Ltd v. United States* the contractor’s expert apportioned adverse weather days on a weekly basis, and the government’s expert used a monthly basis. The weekly basis yielded a higher LOP because the monthly analysis smoothed the data. For contractual reasons, the court found on behalf of the government.

[11]“Both branch and feeder circuit installations were performed by union electricians from the Ann Arbor local and used the same basic materials of conduit and wire. However, feeder circuit installation involves larger sizes of conduit and was installed in longer continuous runs. In addition, feeder work was confined to the interstitial spaces, penetrating floors

only to run up the building and did not involve device installations. Installation of feeder circuits generally preceded the branch circuit installation by a month or two. Both feeder and branch work were performed largely at the same time during most of the job and were, therefore, subject to the same weather conditions. They were installed in the same or similar areas of the building. "The feeder circuit work was, for the most part, installed in a manner more consistent with KES' plans than was the branch conduit. The feeder circuits were primarily installed by one crew moving from floor to floor to perform that work permitting this crew to achieve the type of efficiency gained from performing these tasks on a repetitive basis. "On balance, we find that [P.J. Dick's] approach to quantification of the VA-caused productivity loss is reasonable and valid. We recognize that feeder circuit work generally involves installation of larger sized electrical conduit and wire in longer, straighter conduit runs. However, KES' [electrical subcontractor] labor for feeder circuit installation was drawn from the same labor pool as that used for branch circuit work, the skills, knowledge and effort involved in feeder circuit work are reasonably similar enough to branch circuit work to permit a valid comparison and the work was performed in the working conditions planned and budgeted by KES. Consequently, we find PJD's measured mile analysis to be a reasonable approximation of the effect of the VA-caused inefficiencies."

[12]The senior writer of this paper encountered a similar experience recently when the contractor tried to compare productivity rates of butt-welding carbon steel pipe and welding PVC pipe.

[13]The government's expert was highly critical of the measured mile methodology used by the contractor's expert, finding it to be "one of a kind." The government's expert also opined that the plaintiff's expert failed to provide a credible cause-and-effect analysis, failed to demonstrate an understanding of the methodologies that should be applied to the calculation of loss of efficiency claims, and displayed a shallow understanding of the factors affecting crew performance. He averred that Jones's impacted periods included large numbers of hours and quantities that should not be part of the impacted period. For instance, Jones's methodology allowed a single impacted day to put entire blocks of labor-hours and quantities into the impacted periods, even though the crews themselves did not experience an impacted day. As one example of a flaw in Jones's measured mile analysis, a flagger was legitimately included in change order work. But that flagger, who was attached to an eight-person crew for payroll purposes, led Jones to include those eight people into the LOP analysis for an entire month even though they were typically 1/4 mile away from the flagger and clearly not affected by the change work.

[14]Loulakis and Santiago (1999) stressed that "the *composition and level of skill* of the crews [between the "normal" period and the period in question] should be comparable" [Emphasis added].

[15]Productivity may be impaired if "supervision must be diverted to (a) analyze and plan change, (b) stop and re-plan affected work, (c) take-off, order, and expedite material and equipment, (d) incorporate change into schedule, (e) instruct foreman and journeyman, (f) supervise work in progress, and (g) revise punch lists, testing, and start-up requirements" (MCAA 2011).

[16]"A common challenge in field labor productivity performance arises when the contractor has failed to prepare daily timesheets that accurately record the activities of each craftsman" (Holloway 2007).

[17]To some extent the factor of schedule overlaps with weather and seasonality, and with overtime, trade stacking, and congestion, which are discussed later in this paper. However, we consider these to be such important factors that we address them separately.

[18]"We found Hughes undermanned the project, performed its work as it saw fit 'without regard to schedule requirements' and 'with no concern to the interest of all.' ... we rejected Gulf's expert analysis as unreliable because it 'systematically excluded all delays and disruptions except those allegedly caused by the Government.' Such an approach, we concluded, was inherently biased, and could lead to but one predictable outcome ... Conspicuously absent had been an accounting of precisely for what delays and disruptions Gulf had chosen to take responsibility."

[19]Bay West entered into a contract with the government to dredge and transport approximately 170,000 cubic yards of creek material. It encountered differing site conditions and developed three measured mile analyses representing three time periods when it used different means and methods. Learning effects were incorporated in each, with which the court concurred.

[20]"If the project management team fails to get subcontractors, material or equipment to the right place at the right time, then productivity may decline as ... various trades interfere with others" (AACE 2004); and by the MCAA concepts of trade stacking, reassignment of labor, and concurrent operations.

[21]See *Appeal of P.J. Dick*. Use of a "measured mile" analysis developed by a qualified expert is preferred in contrast to one developed by the claimant's own personnel. See also *Daewoo Engineering and Construction Ltd v. United States*: "We assume that a finder of fact faced with the measured mile method of estimating damages would want to have confidence in the expert's ability and objectivity. A court would be particularly concerned to know how the experts picked periods of productive and nonproductive construction for comparison. We did not have such a level of confidence in the plaintiff's witnesses. Cross-examination showed their choices of productive and nonproductive periods to be arbitrary at best. More likely they were chosen to achieve a pre-determined result."

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