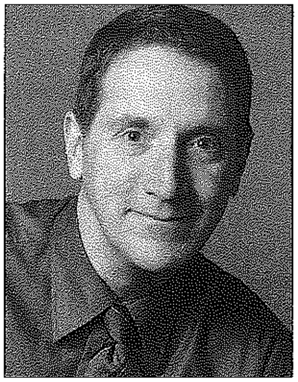
Using the Classical Measured Mile Approach and Variants to Quantify Cumulative Impact Claims

William Ibbs and Long D. Nguyen



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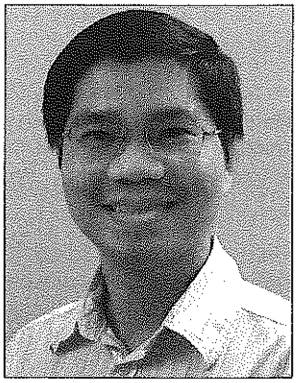

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It is no easy task to quantify the cumulative impacts of multiple changes on a construction project. One reason is that the prerequisites for proving a cumulative impact claim—liability, causation, and resultant injury—are rigorous. Liability is established under a legal right to recover pursuant to the contract or due to breach of contract by the owner together with evidence of owner-caused disruptions (i.e., a multitude of changes).[1] Demonstrating causation requires the contractor to prove that the inefficiency was proximately caused by the owner's changes. Finally, the contractor needs to present a reasonable estimate of the loss of productivity caused by changes to fulfill the last component.

Although liability can be straightforward, causation and resultant injury are usually more difficult to prove. By their nature, cumulative impact claims do not allow precise, contemporaneous measurement of loss of productivity. As one commentator put it, "One of the ironic things about loss of productivity claims is that often the very factors that produce the loss of productivity can also serve to preclude the accurate and precise record-keeping that would constitute evidentiary certitude."[2]

Many methods for estimating lost labor productivity are available, including total cost, modified total cost, Leonard and Ibbs curves, overtime studies, and so forth. The "measured mile" method and its variants are frequently used, when available, and regularly accepted by courts and boards. A review of the court and board decisions presented in this article reveals that there are different versions of the measured mile technique and diverse results in the cases that address the technique.

This article explains those different versions of the measured mile technique and what contractors, owners, and attorneys should know when working with it. A case study example is presented to show that, in terms of reliability, the preferred order of these approaches is classical measured mile analysis, the *Bell BCI* variation, the *Appeal of P.J. Dick* variation, the *James Corp.* variation, and earned value analysis.

Productivity Analysis in Cumulative Impact Claims

The classical measured mile technique determines the amount of lost productivity caused by a change in the project by comparing the unit productivity rates in an undisrupted time period or physical area to those in the disrupted time period or physical areas.[3] An advantage of this method in quantifying lost productivity is that it uses the contractor's actual performance rate rather than the rate that was anticipated at bid time as a standard of comparison.

"Earned value analysis" is also employed for estimating inefficiency, and is especially effective when productivity data are not available for a measured mile analysis. This occurs because information, such as a lack of physical units of work installed, is not available or was not collected.[4] This technique is based on a realistic budget for the contract and relies on a method for measuring percent complete acceptable to the disputing parties.

Courts and boards have proposed, applied, and recognized combinations of earned value and measured mile analyses that reduce the individual shortcomings of the two individual methods. The measured mile analysis technique requires identical or substantially similar work for productivity comparisons. If the affected work is unique, or if the contractor did not keep good contemporaneous records, no measured mile may exist.[5] In contrast, an unreasonable estimate diminishes the reliability of the earned value analysis technique. Therefore, several variants to measured mile analysis have successfully been used in cumulative impact claims.

Case Study

Courts and boards allow various approaches for analyzing causation and quantum of cumulative impact claims. Those approaches are studied in the following case study:

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A contractor alleged loss of productivity caused by the cumulative impact of multiple owner-directed changes. Construction work was originally scheduled for 11 months and was to erect 36,500 units (weight) of structural steel between February and December 2008. With a labor rate of $61 per hour, total labor-hours and labor costs were estimated 30,679 and $1,871,390, respectively. During the period of July to October 2008, the owner directed many changes totaling to 9,300 units or $567,300 of labor costs, representing approximately 30 percent of the original contract work. The approved time extension was one month. Despite these approved changes, the contract was completed on time (January 2009). Actual labor costs were $2,744,398. The contractor's labor budget thus overran by $305,708 ($2,744,398 – $1,871,390 – $567,300). Table 1 summarizes the contract data. Presuming the contractor is entitled for cumulative impacts, the question becomes what is a reliable estimate of the loss of productivity costs.

Table 1. Summary of contractor's records

		Planned			Actual					Earned	
Month (1)	Quantity (2)	Productivity[1] (3)	Labor-hours (4)	Labor Costs (5)	Quantity Total (6)	Quantity COs (7)	Productivity (8)	Labor-hours (9)	Labor Costs (10)	Labor-hours (11)	Labor Costs (12)
2/08	1,000	1.1	909	$55,455	1,000		0.9	1,111	$67,778	909	$55,455
3/08	2,000	1.15	1,739	$106,087	2,000		1.1	1,818	$110,909	1,739	$106,087
4/08	4,000	1.2	3,333	$203,333	3,800		1.25	3,040	$185,440	3,167	$193,167
5/08	5,000	1.2	4,167	$254,167	5,500		1.3	4,231	$258,077	4,583	$279,583
6/08	5,000	1.2	4,167	$254,167	5,000		1.2	4,167	$254,167	4,167	$254,167
7/08	5,000	1.2	4,167	$254,167	7,000	3,500	1.1	6,364	$388,182	5,833	$355,833
8/08	5,000	1.2	4,167	$254,167	8,000	3,500	0.8	10,000	$610,000	6,667	$406,667
9/08	5,000	1.2	4,167	$254,167	7,000	1,500	0.95	7,368	$449,474	5,833	$355,833
10/08	3,000	1.2	2,500	$152,500	4,000	800	0.95	4,211	$273,684	3,333	$203,333
11/08	1,000	1.1	909	$55,455	1,000		1.05	952	$61,905	833	$50,833
12/08	500	1.1	455	$27,727	1,000		1.15	870	$56,522	909	$55,455
1/09					500		1.15	435	$28,261	455	$27,727
Total	36,500		30,679	$1,871,390	45,800	9,300		44,566	$2,744,398	38,429	$2,344,140

Note: Labor rate was $61 ($65) per hour for period of February to October 2008 (November 2008 to January 2009).

Alternative Analyses of Cumulative Impacts

Earned value, measured mile, and measured mile variants are examined in the following sections to estimate that loss of productivity.

Earned Value Analysis

Figure 1 presents planned, actual, and earned labor-hours (LHs) from columns 4, 9, and 11 (Table 1), respectively. Earned value analysis is used for quantifying the loss of productivity. The difference between the actual hours expended and the earned hours for the period of the impact are used to calculate the inefficiency experienced.[6] This loss of efficiency is calculated by:

$$\text{Loss of efficiency} = \sum_{k=1}^{n} (\text{Actual LHs}_k - \text{Earned LHs}_k) \text{ (in LHs), or}$$

$$\text{Loss of efficiency} = \sum_{k=1}^{n} (\text{Actual Cost}_k - \text{Earned Value}_k) \text{ (in \$)}$$

where k is the kth month (day, week) of the impacted period and n is the number of months (day, week) of the impacted period.

The actual labor-hours are much greater than the earned hours during the four-month period of July to October 2008, while they are roughly comparable in the other periods (Figure 1). That four-month period coincides with the time period when the multiple change orders occurred and those change orders presumably caused the lost productivity. The actual and earned hours for this impacted period are 27,943 and 21,666 labor-hours, respectively. The loss of efficiency caused by cumulative impacts of change orders is the difference, 6,277 labor-hours.

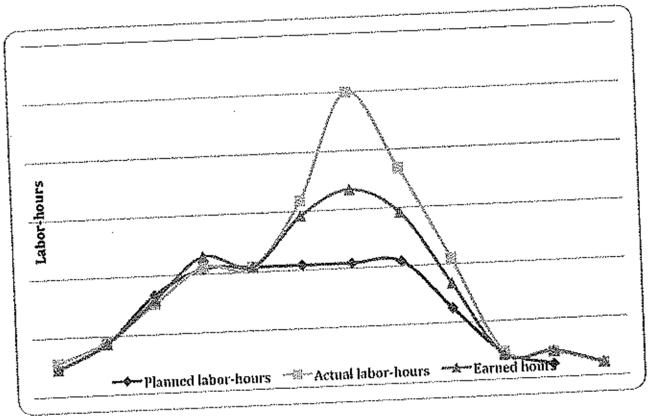

Figure 1. Planned, actual, and earned hours

Measured Mile Analysis

A classical measured mile analysis compares the productivity in the impacted period and productivity in the unimpacted period (Figure 2). The unimpacted period is March to June 2008. As a "build-up" time, February 2008 is not included because it is not representative of expected productivity.[7] *Clark Concrete Contractors, Inc.*[8] involved the construction of a new building for the FBI. The project was a cast-in-place concrete office building with four basement levels below ground (primarily for parking), eight stories above ground, and a penthouse containing a mechanical system. Original contract value was $49,461,000. Clark was the concrete subcontractor whose work was affected when the building's design was changed to include blast walls. This change, in response to the Oklahoma City Federal Building tragedy, affected Clark's forming and stripping of concrete slabs and columns. Here the contractor successfully employed this method to prove the productivity loss of construction work caused by design changes, using the approach represented in Figure 2.

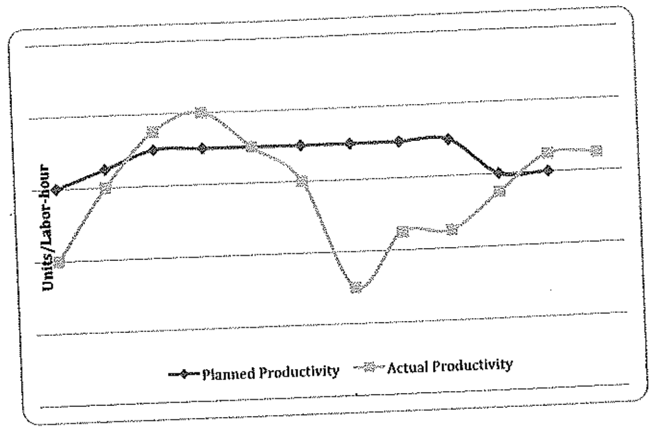

Figure 2. Planned vs. actual productivity

Figure 2 demonstrates the planned and actual productivities over time. The actual productivities in the unimpacted periods were generally higher than those in the impacted period. Table 2 shows the productivity analysis for the impacted period. The expected productivity (1.23 units/labor-hour) is the weighted average of productivities achieved in March to June 2008. The labor inefficiency totals 6,858 labor-hours. The formulas for the expected productivity and lost productivity in the impacted period are

$$\text{Expected productivity} = \frac{\sum_{k=1}^{n} \mathrm{Q}_k * \text{Actual Productivity}_k}{\sum_{k=1}^{n} \mathrm{Q}_k} = \frac{\sum_{k=1}^{n} \mathrm{Q}_k}{\sum_{k=1}^{n} \text{ActualLH}_{sk}} \text{ (in units/LH)}$$

$$\text{Lost productivity}_i = \text{Expected productivity}_i - \text{Actual productivity}_i \text{ (in units/LH)}$$

$$\text{Loss of efficiency}_i = Q_i * \left(\frac{1}{\text{Actual Productivity}_i} - \frac{1}{\text{Expected Productivity}_i}\right) \text{ (in LHs)}$$

where k is the kth month (day, week) of the measured mile (unimpacted) period; n is the number of months (day, week) of the measured mile period; i is the ith month of the impacted period; and Q_i is the actual quantity installed at month i.

Table 2. Productivity loss with measured mile

Impacted period	Jul-08	Aug-08	Sep-08	Oct-08	Total
Actual productivity	1.10	0.80	0.95	0.95	
Expected productivity	1.23	1.23	1.23	1.23	
Lost productivity	0.13	0.43	0.28	0.28	
Quantity installed	7,000	8,000	7,000	4,000	26,000
Inefficient labor-hours	687	3,512	1,692	967	6,858

Variants of Measured Mile Analysis

Courts and boards of contract appeals have accepted analyses that combine earned value and measured mile. Although this hybrid approach is typically called "measured mile," the approach is actually a variant of the classical measured mile approach. The following examples compute inefficient labor-hours for the case study using methods accepted in recent court rulings.

From *James Corp. d/b/a James Construction* (2007).[9] The *James Corp.* variant compares the percentage of work performed to the number of labor-hours used. James renovated five elementary school buildings for the North Allegheny, Pennsylvania, school district. Despite a series of delays involving underground differing site conditions and discovery of asbestos, the school district refused to grant a time extension, forcing the contractor to accelerate. The school district challenged an analysis by the contractor's expert as being "nothing more than the disfavored total cost approach." The court rejected this argument, though, because the expert verified the contractor's original estimate, and, importantly, divided the project into different time periods and analyzed each period on its own merits. That analysis included applying a conservative factor to account for the contractor's own problems.

Using *James*, the case study project can be divided into three periods: before the impact (February to June 2008), during the impact (July to October 2008), and after the impact (November 2008 to January 2009). The contractor expended 14,367 labor-hours to complete 37.77 percent of the project by June 2008 (Table 3). The percent complete for a particular period equals the quantity installed in that period divided by the total quantity installed. Similarly, the contractor spent 27,943 labor-hours to complete 56.77 percent of the project during the impacted period. Had the disruption not occurred, the contractor would have spent only 21,592 labor-hours (14,367 × 56.77% / 37.77%) to complete this portion of the work. The inefficiency caused by the multiple changes totals 6,351 labor-hours (27,943 – 21,592). The mechanics for calculating the loss of productivity is below:

$$\text{Expected LHs in impacted period} = \text{Actual LHs in unimpacted period} * \left(\frac{b\%}{a\%}\right) \text{ (in LHs)}$$

$$\text{Loss of efficiency} = (\text{Actual LHs} - \text{Expected LHs}) \text{ in impacted period (in LHs)}$$

where *a* and *b* are the percent complete of the unimpacted and impacted periods, respectively.

Table 3. Inefficient labor-hours with method used in James Corp. (2007)[18]

Description	Quantity
% complete before the impact (Feb to Jun 08)	37.77%
Actual labor-hours before the impact	14,367
% complete during the impact (Jul to Oct 08)	56.77%
Expected labor-hours during the impact	21,592
Actual labor-hours during the impact	27,943
Inefficient labor-hours due to the impact	6,351

Had the disruption not occurred, the contractor would have spent an additional 23,668 labor-hours (14,367 × (100% – 37.77%) / 37.77%) to complete the project. The actual labor-hours for the remaining work were 30,199. A similar analysis yields a loss of productivity of 6,532 labor-hours.

From *Bell BCI Co.* (2008).[10] This case arises from the construction of a National Institutes of Health laboratory building. Originally the building was to have five story building. Originally the building was to have five stories and a full basement area, consisting of approximately 23,040 square meters of finished office and laboratory space, including 2,788 gross square meters of laboratory animal holding areas. Nine months into construction NIH discovered it had surplus funds and decided to add a new floor. Eventually, the building had six stories and a full basement, totaling approximately 27,363 square meters of finished office and laboratory space. Even after Modification 093 and assuring the contractor that future changes would be held to a minimum, NIH continued to issue changes. All told, NIH issued 206 contract modifications that delayed the completion of the project by 19½ months, and increased the contract price by $21.4 million, or 34 percent.

The *Bell BCI* variant starts with identifying a "reasonable labor-hour level" as the ratio of the actual and planned labor-hours for the planned quantity installed in the unimpacted period (February to June 2008). It then identifies reasonable labor-hours for the impacted period and compares them with the actual labor-hours. The court in *Bell BCI v. United States*[11] referred to "reasonable productivity level" and "reasonable labor-hour level" in an attempt to avoid confusion. That is, "reasonable productivity level" was determined at "104 percent of the originally planned productivity" in the unimpacted period. One may think that the actual productivity was higher than the planned, but in fact the actual productivity was less than the planned productivity in the unimpacted period. The following is the process for quantifying the productivity loss:

$$\text{Reasonable LH level} = \left(\frac{\text{Actual LHs in unimpacted period}}{\text{Budgeted LHs in unimpacted period}}\right) * 100\% \text{ (in \%)}$$

$$\text{Reasonable LHs in impacted period} = \text{(Earned LHs in impacted period)} * \text{(Reasonable LH level)}$$

$$\text{Loss of efficiency} = \text{(Actual LHs – Reasonable LHs) in impacted period (in LHs)}$$

Table 4 summarizes the analysis. The "reasonable labor-hour level" is 76.4 percent (14,117 / 18,482). In other words, the actual productivity was more than the planned productivity in February to June of 2008. Reasonable labor-hours for base contract and change orders in the impacted period (July to October 2008) are the multiplicative product of the earned hours in the same period and the "reasonable labor-hour level." Inefficiency due to the cumulative impact of change orders is 11,393 labor-hours.

Table 4. Inefficient labor-hours with method used in Bell BCI Co. (2008)[19]

Description	Quantity
Planned quantity performed in unimpacted period	17,000
Planned labor-hours for the first 17,000 units	18,482
Actual labor-hours for the first 17,000 units	14,117
"Reasonable labor-hour level"	76.4%
Reasonable labor-hours for base contract and change orders in impacted period	16,550
Actual labor-hours in impacted period	27,943
Inefficient labor-hours	11,393

From *Appeal of P.J. Dick, Inc.* (2001)[12] The *P.J. Dick* variant is used when the period without owner-caused disruptions is not available for the same work. Similar work with an undisrupted period needs to be identified in the same project or from a similar project. However, productivities are not compared directly to find the loss of efficiency as in the measured mile analysis with a similar work. Instead, an "efficient factor" is determined as the ratio of actual labor-hours and budgeted labor-hours for the similar work in the undisrupted period. Realistic budgeted labor-hours for the disrupted work are calculated by multiplying the budgeted labor-hours with the "efficient factor." This analysis is similar to the one used in *Bell BCI*,[13] except for reliance on "similar work." Therefore, similar formulas are as follows:

$$\text{Efficient factor} = \frac{\text{Actual LHs in unimpacted period for similar work}}{\text{Budgeted LHs in unimpacted period for similar work}}$$

$$\text{Realistic budgeted LHs} = (\text{Budgeted LHs in impacted period}) * (\text{Efficient factor})$$

$$\text{Loss of efficiency} = (\text{Actual LHs} - \text{Realistic budgeted LHs}) \text{ in impacted period (in LHs)}$$

In this approach consider that the work during the disrupted period (July to October 2008) is compared to "similar work" performed in February and March 2008. Table 5 illustrates the analysis.

The "efficient factor" for the similar work is 1.106. Budgeted labor-hours in the impacted period are the earned hours in the same period (Table 1). A loss of 3,976 labor-hours results.

Table 5. Inefficient labor-hours with method used in Appeal of P.J. Dick, Inc. (2001)[20]

Description	Quantity
Budgeted labor-hours for similar work (Feb to Mar 08)	2,648
Actual labor-hours for similar work (Feb to Mar 08)	2,929
"Efficient factor"	1.106
Budgeted labor-hours in the impacted period	21,667
Realistic budgeted labor-hours in the impacted period	23,966
Actual labor-hours in the impacted period	27,943
Inefficient labor-hours	3,976

General Discussion

The above case study illustrates that lost productivity and cumulative impact can be proved and quantified by different methods. Although different methods are acceptable to courts and boards, the results can be significantly different.

Table 6 summarizes lost productivity estimated by the foregoing methods for the case study. For the case study described above, the loss of productivity ranges between 3,976 and 11,393 labor-hours. A total cost approach is included in this figure, where the total cost method is the difference between the actual labor-hours and the sum of planned and change order labor-hours.

Table 6. Lost productivity for the case study

Method	Lost productivity (labor-hours)
Earned value analysis	6,277
Measured mile analysis	6,858
Variant in James Corp. (2007)	6,531
Variant in Bell BCI Co. (2008)	11,393
Variant in the Appeal of P. J. Dick, Inc. (2001)	3,976
Total cost method	6,138

Variants to measured mile may be more effective and acceptable in legal proceedings in such circumstances. In *Bell BCI*,[14] the contractor did not achieve the originally planned productivity when extensive changes did not occur. That is, during the undisrupted time, the contractor spent 1.08 hours to earn one hour in the budget. Thus, the calculation of inefficiency would be rejected if the earned value analysis was employed.

In *Appeal of P.J. Dick, Inc.* (2001),[15] a traditional measured mile study could not be used because the measured mile period simply did not exist. Additionally, the similar work (feeder circuit) was not too similar to the impacted work (branch circuit) to directly compare their productivity. Therefore, the lost productivity was indirectly determined through the "efficient factor" of the similar work. The combinations of the two techniques proved to work well in those situations.

A claimant may apply different approaches for comparison to obtain a more reliable result. Contractors, owners, experts, and attorneys usually employ more than one method when assessing claims.[16] This practice is also applicable in lawsuits. In *Appeal of P.J. Dick, Inc.*,[17] the contractor's expert used the industry study (MCAA) as an alternate method to demonstrate the inefficiency of the electrical work in addition to a measured mile analysis.

Practically, at least two parties are involved in a dispute, and an approach that works well for one party is not always in the best interest of the other. Although the contractor in this case study may prove its claim with the *Bell BCI* variation (11,393 labor-hour loss), the owner might counter the *Appeal of P.J Dick* variation (3,976 labor-hour loss).

Based on the cases reviewed in this article, the available methods are preferred in the following order (from most to least preferred): the classical measured mile analysis, the *Bell BCI* variation, the *Appeal of P.J. Dick* variation, the *James Corp.* variation, and earned value analysis. The differences can be summarized as follows:

- Measured mile analysis is most credible because it directly compares productivities of the same work between impacted and unimpacted periods.
- The *Bell BCI* variation and the *Appeal of P.J. Dick* variation employ the "reasonable labor-hour level" and "efficient factor," respectively, to adjust budgeted labor hours. However, the *Appeal of P.J. Dick* variation calculates the "efficient factor" based on similar work, whereas the *Bell BCI* variation uses the same type of work.
- The *James Corp.* variation calculates inefficiency by extrapolating actual labor-hours in the unimpacted period to the impacted period for the whole contract work and not for a specific work being disrupted due to multiple changes.
- Earned value analysis is based on the original estimate, which is not always reasonable.

Therefore, unless a contract specifies otherwise, results from analysis of a more reliable approach should be chosen and/or should be a basis for negotiation if available data allow such analysis. That is, the results of measured mile analysis are preferred to those of the *Bell BCI* variation, which in turn are preferred to those of the *Appeal of P.J. Dick* variation, and so on. This may avoid any disagreement for the wide range of results drawn from different approaches.

Choosing the Best Method

Measured mile analysis is commonly accepted in the construction industry as a method to quantify loss of productivity associated with cumulative impact. The classical measured mile approach and its variants are commonly accepted because they can demonstrate causation and resultant injury for cumulative impact claims. There are different versions of the measured mile technique, and those different versions can yield substantially different results. The best method used will depend on the circumstances of the case, including the data that are available and the nature of the underlying changes. Generally speaking, the classical measured mile analysis is favored, but the other methods can be the best choice depending on the situation. It is prudent to use more than one of these methods so that an estimate of the productivity loss is corroborated.

Endnotes

1. Reginald M. Jones, *Update on Proving and Pricing Inefficiency Claims*, CONSTR. LAW., Summer 2003, at 3.
2. Thomas E. Shea, *Proving Productivity Losses in Government Contracts*, 18 PUB. CONTRACT L.J. 414 (1989).
3. D. A. Zink, *The Measured Mile: Proving Construction Inefficiency Costs*, 28:4 J. COST ENG'G 19 (1986).
4. Ass'n for the Advancement of Cost Eng'g (AACE) Int'l, Inc., Estimating Lost Labor Productivity in Construction Claims, *AACE Int'l Recommended Practice No. 25R-03* (2004).
5. M. C. Loulakis & S. J. Santiago, *Getting the Most out of Your "Measured Mile" Approach*, 69:11 CIVIL ENG'G 69 (1999).
6. AACE, *supra* note 4.
7. Zink, *supra* note 3.
8. Clark Concrete Contractors, Inc. v. Gen. Servs. Admin., G.S.B.C.A. No. 14340, 99-1 B.C.A. (CCH) ¶ 30,280 (1999).
9. James Corp. d/b/a James Constr. v. N. Allegheny Sch. Dist., et al., 938 A.2d 474 (Pa. Commw. Ct. 2007).
10. Bell BCI Co. v. United States, 81 Fed. Cl. 617 (2008), *aff'd in part and vacated in part*, 570 F.3d 1337 (Fed. Cir. 2009).
11. *Id.*
12. Appeal of P.J. Dick, Inc., V.A.B.C.A. Nos. 6080-82, 01-2 B.C.A. (CCH) ¶ 31,647 (2001).
13. 81 Fed. Cl. 617.
14. *Id.*
15. 01-2 B.C.A. (CCH) ¶ 31,647.
16. Jones, *supra* note 1, at 18.
17. 01-2 B.C.A. (CCH) ¶ 31,647.
18. James Corp. d/b/a James Constr. v. N. Allegheny Sch. Dist., et al., 938 A.2d 474 (Pa. Commw. Ct. 2007).
19. 81 Fed. Cl. 617.
20. 01-2 B.C.A. (CCH) ¶ 31,647.