Cumulative Impact Claims

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LONG INTERNATIONAL

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1. INTRODUCTION

By any measure, it is difficult for a contractor to recover costs due to the cumulative impact of changes, either during the project, through a request for equitable adjustment and claim negotiations, or through arbitration/litigation. The construction industry, courts, and arbitration panels generally agree that the theory of cumulative impact is reasonable, and that multiple change orders and other types of delays and disruption can negatively impact the performance of unchanged work such that a contractor expends additional time, man-hours and costs in completing its "unchanged," base scope work. Yet, as will be discussed, the standard of proof set by the courts in proving these claims is burdensome, and their decisions are somewhat subjective. Further, the construction industry has no definitive standard to calculate such loss of productivity claims.

The purpose of this paper is to provide a blueprint for the contractor[1] seeking to recover costs that result from the cumulative impact of changes. Discussion of construction industry studies and case law, coupled with examples of cumulative impact calculations, is provided to aid the contractor in its claim preparation. Conversely, this paper can be used by the owner[2] to identify weaknesses in the contractor's claim submittal to better defend against such a claim.

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[1] The term "contractor" is used throughout this paper to indicate the party claiming damages for the cumulative impact. Subcontractors or construction managers could also be claimants.

[2] The term "owner" is used throughout this paper to indicate the party defending against a claim for the cumulative impact. Prime contractors or construction managers could also be defendants.

2. CUMULATIVE IMPACT DEFINED

As one commentator noted, "causation and quantum of loss pose a problem because cumulative impacts remain largely an ill-defined concept."[3] A true understanding of cumulative impacts as defined by the construction industry and courts and boards will aid the contractor in preparing its damages and proving causation.

The Construction Industry Institute (CII) has explained the concept of cumulative impact as follows:

> When there are multiple changes on a project and they act in sequence or concurrently, there is a compounding effect - this is the most damaging consequence for a project and the most difficult to understand and manage. The net effect of the individual changes is much greater than a sum of the individual parts.[4]

One of the most helpful definitions of cumulative impact comes by way of comparison with "direct" or "local" impacts. As the Veteran Affairs Board of Contract Appeals (VABCA) defined:

> "Local [or direct] disruption" refers to the direct impact that changed work has on other unchanged work going on around it. Conceptually, for purposes of this appeal "cumulative disruption" is the disruption which occurs between two or more change orders and basic work and is exclusive of that local disruption that can be ascribed to a specific change. It is the synergistic effect... of changes on the unchanged work and on other changes.[5]

Direct disruption has been further defined to be foreseeable, the impacts of which should be included in the contractor's foreword pricing of a change order.[6] Cumulative disruption is typically described as being unforeseeable, as in the following definition from the VABCA:

> Cumulative impact is the unforeseeable disruption of productivity resulting from the "synergistic" effect of an undifferentiated group of changes. Cumulative impact is referred to as the "ripple effect" of changes on unchanged work that causes a decrease in productivity and is not always analyzed in terms of spatial

3 Reginald M. Jones, "Lost Productivity: Claims for the Cumulative Impact of Multiple Change Orders," 31 Pub. Cont. L.J 1 (2001).

4 T. Hester, John A. Kuprenas, & T. C. Chang, "Construction Changes and Change Orders: Their Magnitude and Impact," CII Source Document 66, at 35 (October 1991).

5 *Centex Bateson Constr. Co.*, VABCA Nos. 4613, 5162, 5165, 99-1 BCA ¶ 30,153 (citing *Triple "A" South*, ASBCA No. 46866, 94-3 BCA ¶ 27,194).

6 *Haas & Haynie Corp*., GSBCA Nos. 5530, 6224, 6638, 6919-20, 84-2 BCA ¶ 17,446, 86,897.

> and temporal relationships. This phenomenon arises at the point the ripples caused by an indivisible body on two or more changes on the pond of a construction project sufficiently overlap and disturb the surface such that the entitlement to recover additional costs resulting from the turbulence spontaneously erupts.[7]

This definition, while somewhat theoretical in nature, provides two important points: 1) cumulative impact is unforeseeable and, therefore, the impacts cannot be priced during the project, and 2) cumulative impact cannot necessarily be analyzed by "spatial," *i.e.*, proximity to changes, or "temporal" (*i.e.*, chronological or sequential) relationships. The later point seems to be echoed by one commentator who wrote:

> The cumulative impact effect occurs when the project conditions have deteriorated to the point where work on an activity is adversely affected by another activity or by the mere nature of the site environment.[8] (Underlining added)

Given these definitions, it is apparent that the "ripple" from an activity disrupted by several changes does not only impact nearby or follow-on work, but can potentially impact any and all project work being performed concurrently or subsequent to that activity. In fact, one could argue that the impact to nearby or follow-on work is akin to "local" disruption, which the contractor should recognize and price in the change order. It is the effect, the unforeseeable impact, on other base scope work that seems to be at issue with cumulative impact claims.

Regarding this unforeseeable impact, research conducted by the CII noted the following:[9]

> ...few contractors maintain adequate job-site records to allow evaluation of impact costs for individual change orders. In addition, some contractors do not realize that they have incurred impact costs until final profit and loss statements indicate a sizable loss.

The CII also reported on what it identified as the "hidden costs" of changes on a project:[10]

> Hidden costs are defined as costs not readily apparent or missed when evaluating project change implementation. A major problem with the execution of project change is failure to consider all the costs associated with implementation. Direct costs such as material, equipment and labor or established indirect costs in the

7 *Centex Bateson Constr. Co., Inc.*, VABCA No. 4613, 5162, 5165, 99-1 BCA ¶ 30,153.
8 Robert F. Cushman, Stephen D. Butler, & James F. Nagle, "Construction Change Order Claims," Wiley Law Publications, § 4.11 (1998 Supplement).
9 C.W. Ibbs & Walter E. Allen, "Quantitative Impacts of Project Change," CII Source Document 108, at 10 (May 1995).
10 *Id*. at 32.

> form of overhead are fairly easy to identify and account for in project change estimates. The more difficult task is estimating or predicting the hidden cost associated with change implementation; i.e., delays, lowered productivity, poor communications or rework
>
> The first research objective was to identify and quantify the hidden cost of change. We quickly discovered that it was impossible to accurately estimate all hidden costs associated with implementing change prior to change implementation. Even after project change is implemented, it is difficult to capture and account for the "ripple effect"...

It should also be noted that certain definitions of cumulative impact refer to the impact of "change orders," as in changes of scope approved by the owner. Others refer to the impact of "changes," a broader and more far reaching term which doesn't imply owner approval. As added confusion to this problem, industry studies typically use approved change order man-hours to measure loss of productivity.[11] One could ask whether it is only approved change orders that make up a cumulative impact claim.

Panels, courts and boards seem to at least consider the effects of RFIs and other impacts and not dismiss them for not being approved change orders.[12] One commentator has written that "cumulative impacts derive from multiple change orders, RFIs, differing site conditions, suspensions of work, or other work interruptions that are widely recognized as compensable events."[13] Therefore, not only can owner-approved changes be used as part of a cumulative impact claim, but also unapproved change orders and all other potentially disruptive events. However, the contractor should still recognize any direct disruption caused by these events during the project and submit the required change order documentation and costs.

[11] *See* Section 3 of this paper.

[12] *See, e.g.*, *Centex Bateson Constr. Co.*, 99-1 BCA and *Amelco Elec. v. City of Thousand Oaks*, 98 Cal. Rptr. 2d 159 (Cal Ct. App. 2000).

[13] Geoffrey T. Keating & Thomas F. Burke, "Cumulative Impact Claims: Can They Still Succeed?," 20-APR Construction Law. 30 (2000).

3. INDUSTRY STUDIES

Many industry studies have researched the impact of changes on labor productivity and several have further attempted to provide a model to calculate such productivity losses. These studies consistently aver that a multitude of changes has an adverse impact on a project's labor productivity.

3.1 THE LEONARD STUDY

The often cited industry study is "The Effects of Change Orders on Productivity," sometimes referred to as the Leonard Study, a master's thesis prepared in 1988 by Charles A. Leonard at Concordia University. Leonard analyzed 90 cases drawn from 57 different construction projects to identify and quantify the effects of change orders on productivity.[14] A paper co-written by Leonard in 1990 expanded upon the conclusions drawn from his thesis.[15]

Leonard attempted to correlate three separate relationships between change orders and loss of productivity: 1) frequency of change orders; 2) average change order value; and 3) the percentage of change order man-hours compared with base scope man-hours.[16] Only the third relationship could be proven statistically relevant:

> The results indicate a significant direct correlation between the labor component of change orders and the loss of productivity, for both civil/architectural and electrical/mechanical works. These losses are exacerbated by the added presence of other major causes of productivity losses such as acceleration and inadequate scheduling and coordination.[17]

Using data from the 90 cases, Leonard prepared three models to predict the loss of productivity on other projects, one model for civil/architectural work, one for mechanical/electrical work, and one for a combination of the two. The models show that a direct (straight-line) relationship exists between change order man-hours and loss of productivity. The study notes: "In appropriate cases experiencing greater than 10% to 15% in change orders, these models can be used to estimate productivity losses of labour at the micro level."[18] Leonard's model for electrical and mechanical work is shown in Figure 1.[19]

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[14] Charles A. Leonard, "The Effects of Change Orders on Productivity," Thesis at Concordia University, at iii (1988).

[15] Moselki, Leonard & Fazio, "Impact of Change Orders on Construction Productivity," (1990).

[16] Leonard, supra note 14, at 89.

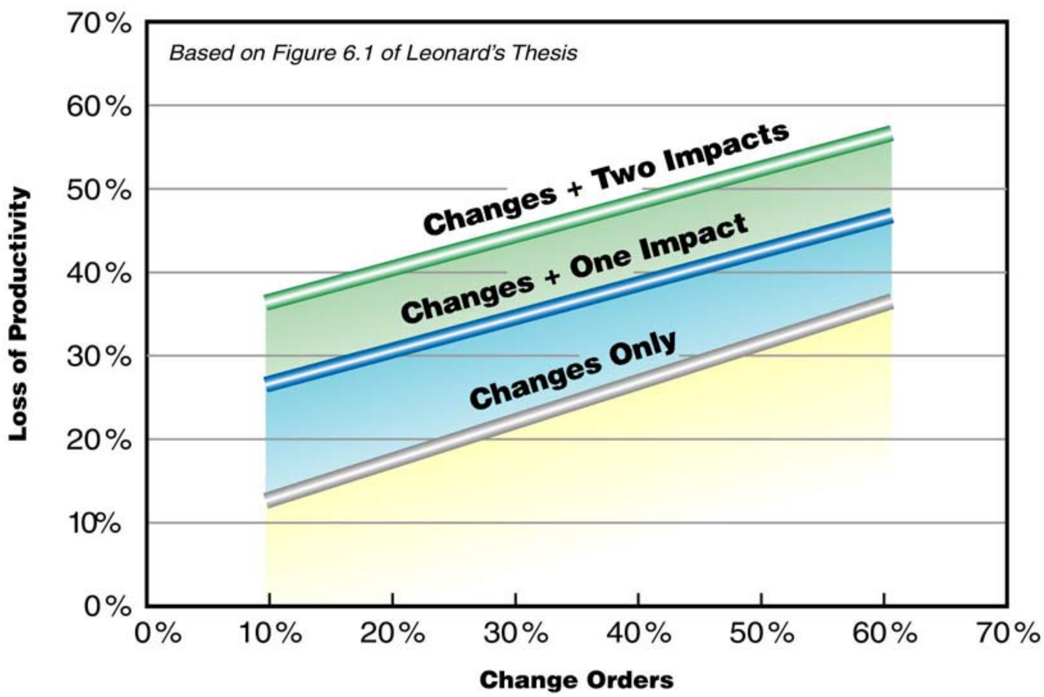
[17] Moselki, supra note 15, at 1.

[18] Leonard, supra note 14, at iv.

[19] *Id*. at 133.

Figure 1

Leonard Study – Effects of Change Orders on Productivity, Electrical/Mechanical Work



Notably, Leonard's findings show that mechanical and electrical work are more negatively impacted than civil and architectural work as change order man-hours increase. Leonard notes that this difference is attributable to "the level of skill required to perform the work, complexity of the work, and the interdependency of the work activities."[20]

3.2 CII STUDIES

In 1995, the Construction Industry Institute (CII) performed a statistical analysis of 104 industrial projects valued from US$3.2 million to US$1.2 billion in an attempt to quantify the impact of project change.[21] The projects used in this study were on average much larger than those project used by Leonard. Further, this study analyzed the impacts of engineering and construction change orders separately.

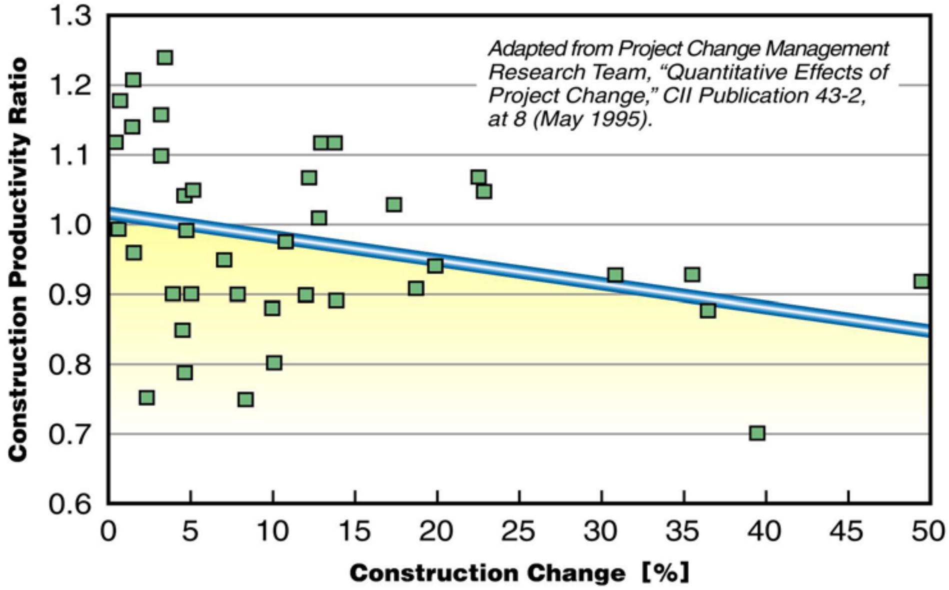
The authors concluded: "This research confirms that project change has a sizable impact on project productivity, schedule and costs." The analysis includes several models, similar to those

[20] Moselki, supra note 15, at 6.
[21] C.W. Ibbs & Walter E. Allen, "Quantitative Impacts of Project Change," CII Source Document 108 (May 1995).

shown by Leonard, which show a direct relationship between change order man-hours and loss of productivity.[22] One such model, shown as Figure 2, comparing construction change man-hours with construction productivity, shows that productivity is impacted when change order man-hours reach approximately six percent of base scope man-hours.[23] In a supplemental paper, CII stated that "the findings of the study are helpful in benchmarking the amount of change and the expected productivity on a given project against the studied projects."[24]

Figure 2

CII Study – Construction Change and Construction Productivity



This study also discussed the impact of late changes on schedule and budget recovery:

> Although the industry acknowledges that the later a change occurs on a project the less efficiently it is implemented, many projects execute significant amounts of changes late in project life cycles. This is especially counter-productive since it can be demonstrated that projects have a significantly reduced ability to recover schedule losses or budget pressures as they approach completion. [25]

It is therefore logical that the timing of changes may also have a significant bearing on a cumulative impact of changes claim. Changes approved very early in the contract before field

[22] *Id*. at Appendix C.
[23] Project Change Management Research Team, "Quantitative Effects of Project Change," CII Publication 43-2, at 8 (May 1995).
[24] *Id*. at 3.
[25] *Id*. at 20 - 21, 25.

management, labor supervision, and direct and subcontract labor have been mobilized to the site have less impact or no impact at all compared to the same changes occurring in the middle or late in the project. The later into engineering and construction completion that changes are made, the more impact those changes have on project execution time and cost. Not only is the impact that each individual change exerts on project cost and schedule greater the more complete the engineering and construction are; so too is the impact greater when there is a large number of cumulative changes.

Another CII study submitted in 2001 attempted to "quantify the cumulative impact that change orders have on the overall project productivity, including the effect on the base contract, for mechanical and electrical construction."[26] This study examined data from 116 projects[27] and provided an equation "to predict the impact of change orders on labor productivity."[28] The equation includes six factors which affect the loss of productivity calculation, specifically: 1) percentage of change order man-hours to budgeted man-hours; 2) percentage of time spent on the project by the Project Manager; 3) percent of change orders initiated by the owner; 4) whether or not productivity was tracked during the project; 5) whether or not the project was overmanned; and 6) the average processing time of the change orders.[29]

A CII study from 1990 took a different approach to investigating loss of productivity. Instead of compiling and comparing data from dozens of different projects, the study focused on measuring the impact of interruption on a pipe insulation crew completing a very discrete scope of work. The study concluded that "productivity drops rapidly with increased frequency of interruptions." For the detailed tasks analyzed, the study found that one interruption reduced productivity by about 9 percent, two interruptions by around 39 percent, and three interruptions by 69 percent, not including the actual interruption time.[30]

The study went further to examine the "ripple effect" of change orders, both on concurrent work and follow-on work. While the study was unable to quantify this "ripple," the observations are noteworthy. Regarding the impact to sequential succeeding activities, it noted:

> Research conducted as part of Study 2…involved the sequential accounts of concrete, structural steel, and above-ground piping. In analyzing the data from these observations, it was noted that a loss of productivity in an account due to a

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[26] Awad S. Hanna, "Quantifying the Cumulative Impact of Change Orders for Electrical and Mechanical Contractors," CII Research Report 158-11 (February 2001).
[27] *Id*. at 133.
[28] *Id*. at 108.
[29] *Id*.
[30] Construction Industry Institute, "The Impact of Changes on Construction Cost And Schedule," Publication 6-10, at 9 (April 1990).

> change was followed almost immediately by a loss of productivity in a succeeding account.[31]

Regarding the impact on adjacent concurrent work, the study explained:

> Lowered productivity seems to be contagious. Just as an accident stops all work in an area, any type of interruption in one activity can affect surrounding activities. Crews affected by changes will not keep their dissatisfaction to themselves and may interrupt adjacent crews. Interferences with adjoining crews also may be created by the change.[32]

While this study is unlikely to help the contractor quantify its cumulative impact claim, the conclusions drawn can be used to enhance the cause-effect proof needed to support such a claim.[33] Interruptions in one form or another, and their impact on other work, are at the very heart of the cumulative impact claim.

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[31] *Id*. at 15.
[32] *Id*.
[33] *See* Section 9 of this paper.

4. LEGAL CONSIDERATIONS

A full discussion of the case law related to cumulative impact claims is not within the scope of this paper. Rather, we have identified relevant excerpts from court and board decisions, as well as attorney commentary, which should be known to the contractor or expert trying to prepare a supportable cumulative impact claim.

In reviewing decisions by courts and boards, two points become clear: 1) they generally acknowledge the theory of the cumulative impacts of changes, and 2) they generally deny recovery to contractors seeking such claims, for a variety of reasons. Both points are further addressed in this section.

4.1 ACKNOWLEDGEMENT OF CUMULATIVE IMPACT

Courts and boards have recognized the theory of the cumulative impacts of changes and have granted recovery to several claimants under this theory.[34] For example, one appeals board defended the theory of cumulative impact, writing:

> In effect the…argument is that the effect from all the changes cannot be greater than the sum of all the parts thereof. We do not agree. The entire basis for recovery of an impact or ripple claim is that the effect of changes can and does create costs beyond those attributable to the changes themselves.[35]

There is general agreement in legal circles that the cumulative impact of changes is a legitimate cause of action, but the contractor must clear several difficult hurdles to prove and support such a claim.

4.2 WHY CUMULATIVE IMPACT CLAIMS FAIL

Cumulative impact claims are extremely difficult to prove. Court and board decisions are rife with examples of why these claims are denied. To make matters worse, "courts and boards are not always consistent in their treatment of cumulative impact claims."[36] Still, an understanding of why claims are rejected should help the contractor in avoiding similar mistakes.

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[34] *See, e.g., David H. Tierney Jr.*, GSBCA Nos. 7107, 6198, 88-2 BCA ¶ 20,806; *Bechtel Nat'l*, NASA BCA No. 1186-7, 90-1 BCA ¶

[35] *Ingalls Shipbuilding Division, Litton Systems, Inc.*, ASBCA 17579, 78-1 BCA ¶ 13,038.45 at 63,663.

[36] Reginald M. Jones, "Lost Productivity: Claims for the Cumulative Impact of Multiple Change Orders," 31 Pub. Cont. L.J 1, at 45 (2001).

4.2.1 Failure To Reserve Rights To Claim

A typical owner's defense to a cumulative impact claim is to demonstrate that in executing the various change orders, the contractor agreed to the price of the changes and thereby waived its rights to seek any further compensation. For example, the change order form may contain the following language:

> This change includes all costs associated with the scope of work associated with this change, including all direct, indirect, and impact costs on the unchanged work such as loss of productivity, ripple effect, and acceleration.

In addition, the change order form may contain fill in blanks for the number of days of delay in addition to the agreed cost of the change. If the contractor continues to fill in the blanks of the change order forms with "zero" days of delay for all changes though the end of the project with no reservation of rights that put the owner on notice that the "accord and satisfaction" language included on the change order form is not longer applicable, and then attempts to submit a cumulative impact claim, the argument to support such a claim is much more difficult.

While this argument is dependent upon the change order language and the intent and knowledge of the parties at the time of change order signing, courts and boards have denied many claims on this basis.

In the appeal of *Dyson & Co.*, the board acknowledged that the contractor likely suffered cumulative impacts from change orders, but denied recovery, ruling that the modifications "represent full settlements for the cost consequences flowing from each of the directed changes, and there is no evidence that appellant, which agreed to these modifications without manifesting any reservations, considered them otherwise." The board further relied on the fact that the modifications were executed after the changed work was almost completed, and therefore the contractor had knowledge of the impacts.[37]

In *Pittman*, the appeals board did not definitively state that the contractor's cumulative impact claim was barred by executed change orders, but that the board was "relatively strict in holding that priced out change orders bar recovery of further costs associated with those changes."[38] The board also examined project correspondence to determine if Pittman had reserved its rights to assert the cumulative impact claim, and commented:

> Now Pittman comes back, after the entire matter has been concluded, and says it does not like the result. But it managed to go through 206 change orders and

[37] *Dyson & Co.*, ASBCA No. 21673, 78-2 BCA ¶ 13,482.
[38] *Pittman Construction Co.*, GSBCA Nos. 4897, 4923, 81-1 BCA ¶ 14,847.

> thirteen extensions of time without raising a single objection that sufficed to reserve a claim for further equitable adjustment.[39]

The board denied Pittman's appeal due to lack of causation.

To avoid this legal challenge, the prudent contractor must reserve its rights to claim for cumulative impacts as soon as the problem becomes apparent.

4.2.2 Flawed Damages Methodology

Courts and boards reject contractor's quantum calculations for either using the wrong methodology or using the correct methodology improperly. For instance, we know of no case where use of the Leonard Study has been successful in proving damages. In one case, the board appointed a Special Master who dismissed the study as "wholly unreliable because it is based on unfounded assumptions, biased and incomplete data, and speculative conclusions."[40] In *J.A. Jones Construction*, the contractor's initial claim for the cumulative impact of changes was calculated based upon the Leonard Study. The board commented that the Leonard Study was "based upon much smaller projects, of different scope, and trades than the project in question," and that "no court has adopted the Leonard Study approach in measuring productivity loss/inefficiency."[41]

Yet the contractor's expert in *J.A. Jones* had dropped the use of the Leonard Study in favor of a measured mile method. The board also rejected this analysis because it found his methodology to be flawed. The government's expert criticized the analysis as "one of a kind" and demonstrated that the criteria for selecting unimpacted and impacted work was illogical.[42] While the measured mile method is generally considered appropriate for calculating loss of productivity,[43] in this case it was implemented improperly.

As one further example, in *Pittman*, the board rejected the contractor's use of the total cost method to calculate its damages. Pittman made a claim on behalf of two subcontractors, F&M and Babst. Both subcontractors calculated its total losses, and applied a reduction factor against these losses in its claim. F&M claimed 75 percent of its total losses; Babst claimed 70 percent of its losses. The board still considered the calculation a total cost claim, and dismissed the

[39] *Id*.
[40] Sgarlata, Barnes & Brasco, "Successful Project Management Through an Understanding of the Risks and Benefits of Early Claims Resolution," (CMAA 2004 National Conference) (citing *Aetna Cas. & Sur. Co. v. George Hyman Const. Co*., LEXIS 22627 (E. D. Pa. 1998)).
[41] *J. A. Jones Construction Co.*, ENGBCA No. 6348, 2000 WL 1014011.
[42] *Id*.
[43] *See* Section 6 of this paper for a full discussion of the measured mile method.

adjustments as a "discount" to the government and the calculations as "flimsy." It further explained how the total cost method was held with "great disfavor" by courts and boards.[44]

These mistakes can seemingly be rectified by using a qualified expert who employs the correct methodology to calculate the contractor's damages. Section 5 of this paper discusses these productivity loss calculation methodologies in detail.

4.2.3 Lack Of Causation

Most cumulative impact claims are denied, at least in part, because the contractor fails to show the causal link between the multitude of owner-caused changes and the contractor's loss of productivity. The contractor must first establish that the changes were excessive. Legal analysts agree that the quantity of changes alone does not establish a claim's validity, but that a combination of the quantity and the total cost of the change orders compared to the base contract may be more indicative that a cumulative impact has occurred.[45, 46] As one court stated:

> Each case must be analyzed on its own facts and in light of its own circumstances, giving just consideration to the magnitude and quality of the changes ordered and their cumulative effect upon the project as a whole.[47]

In *Pittman*, the GSBCA denied the contractor's cumulative impact claim where 206 changes were issued amounting to approximately $3 million, on a base contract of $25 million. After a review of the change orders in question, the board found that the contractor had essentially built the same facility required under the contract as awarded.[48]

Reviewing court decisions which have granted or denied claims, and tracking the quantity and relative value of the change order work in each case, may be a meaningless exercise. Courts and boards have no set bar on cumulative impact, where change order values under the bar are denied, and those over are granted. In *Pittman*, the board did not deny the claim because the

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44 *Pittman Construction Co.*, GSBCA Nos. 4897, 4923, 81-1 BCA ¶ 14,847.

45 See Reginald M. Jones, "Lost Productivity: Claims for the Cumulative Impact of Multiple Change Orders," 31 Pub. Cont. L.J 1 (2001); Leland E. Backus, "The Cumulative Impact Claim: What Does it Take to Prove?," ABA Forum on the Construction Industry (2001); Sgarlata, Barnes & Brasco, "Successful Project Management Through an Understanding of the Risks and Benefits of Early Claims Resolution," (CMAA 2004 National Conference).

46 As discussed in Section 3 of this paper, construction industry studies estimate the effect of cumulative impact based upon the amount of change order man-hours, not change order costs. A change order revising the type or size of a compressor to be installed may have a substantial cost but no impact on labor productivity.

47 *Wunderlich Contracting v. U.S.*, 351 F.2d 956 (C.C. Cir. 1965) (citing *Saddler v. United States*, 287 F.2d 411, 152 Ct.Cl. 557, 561 (1961)) (discussing cardinal change, but still relevant to cumulative impact claims no matter how the claim is characterized).

48 *Pittman Construction Co.*, GSBCA Nos. 4897, 4923, 81-1 BCA ¶ 14,847.

change order value was only twelve percent of the base contract, but because the contractor failed to prove that those changes severely impacted its productivity.

Claims are denied due to the contractor's failure to demonstrate the link between changes and loss of productivity. Courts and boards acknowledge the difficulty of making this connection. As one board stated, "the conceptual problem is that there is no easy way of drawing a line between those costs that directly result from changes and those that are more remote."[49] In *Centex Bateson*, the GSBCA, in rejecting a contractor's cumulative impact claim, was more specific:

> To find entitlement to cumulative impact damages here, we would have to find that an event involving changing the location of a light switch in a room in the east basement of VAMC Houston impacted the efficiency of all its work on the west side of the sixth floor simply because Dynalectric overran its labor projections for certain work activities for that month. The record simply does not support such a finding.[50]

This excerpt highlights the contractor's burden in proving causation: showing a large number of changes and a corresponding cost overrun is typically not enough. Some meaningful connection must be drawn. Yet explaining how changing the light switch's location in the east basement can impact other work is not an easy task.

The GSBCA, in the same matter, suggested that proof "may take the form of demonstrating that there are no other reasons for a loss of productivity for which the Government is not responsible."[51] This suggestion may not be applicable in every circumstance. The contractor in this case submitted a total cost claim and under this methodology had to prove that its actions did not negatively impact the work anyway.[52]

In *David H. Tierney*, the GSBCA granted recovery on the contractor's cumulative impact claims, stating:

> Although we are not able to pinpoint, day by day, the effect of each change on each item of work, we do find that some of those changes had a cumulative impact on job progress as a whole, for which appellant is entitled to compensation.[53]

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49 *Id.*
50 *Centex Bateson Constr. Co., Inc.*, VABCA No. 4613, 5162, 5165, 99-1 BCA ¶ 30,153.
51 *Id.*
52 *See* Section 5.2 of this paper for a full discussion of the total cost method.
53 *David H. Tierney Jr*., GSBCA Nos. 7107, 6198, 88-2 BCA ¶ 20,806 at 105,121

Yet the GSBCA in *Centex Bateson*, having reviewed the above decision and other decisions granting recovery of cumulative impact damages, opined that the recovery was more the result of "subjective conclusions rather than hard, objective evidence."[54] It went further:

> We find little difference between the proof adduced in the cases where recovery was allowed and those where recovery was not allowed. That is, in some cases, the panel concluded that there was sufficient proof of causation due to the number of changes and labor cost overruns and other panels, on the same subjective basis, came to the opposite conclusion.[55]

The board went on to compare the legal analysis of impact costs with one judge's comments on obscenity, when he stated that he could "never succeed intelligently" in defining obscenity but "I know it when I see it."[56]

Hence, there is no magical formula to determine the quantity or magnitude of changes that constitutes a recoverable cumulative impact claim, nor is there any set standard for proving how two or more change orders synergistically impacted other basic work. Court and boards seem to look at the facts and circumstances of each case independently, and, by their own admission, make a subjective decision as to the merit of the claim.

Section 8 of this paper provides suggestions on proving causation in cumulative impact of changes claims.

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[54] *Centex Bateson Constr. Co., Inc.*, VABCA No. 4613, 5162, 5165, 99-1 BCA ¶ 30,153.
[55] *Id*.
[56] *Id*. (citing *Jacobellis v. Ohio*, 378 U.S. 184, 197 (1964)).

5. CHOOSING A DAMAGES METHODOLOGY

As discussed in Section 4.2.2, many cumulative impact claims fail in court because the calculation of damages is flawed. Yet courts do not require a dollar by dollar account of the contractor's claim:

> 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 computation, even though the result is only approximate.[57]

This section provides a brief overview of the common damages methodologies and the criteria used to determine which one should be used.

5.1 PRELIMINARY ANALYSES

Preparing a cost variance analysis (CVA) and man-hour variance analysis (MVA) is the first step in any quantum calculation. The CVA and MVA are calculations of the contractor's overruns from its contract budget, detailed by cost code (typically the discipline of work performed, *i.e.*, civil, structural, mechanical equipment, piping, instrumentation, electrical, painting, insulation, etc.) and cost type (typically labor, materials, installed equipment, subcontract, field overhead/general conditions, etc.), and are typically only slight modifications from a contractor's cost report. A high level CVA and MVA is shown in Figure 3.

Figure 3

Cost/Man-Hour Variances - Total Project

	Man-Hours	Labor Costs	Total Costs
Base Contract	120,000	$4,800,000	$10,000,000
Approved COs	30,000	$1,300,000	$2,000,000
Revised Contract	150,000	$6,100,000	$12,000,000
Actual MHs/Costs	200,000	$8,500,000	$15,000,000
Variance	50,000	$2,400,000	$3,000,000

The cost and man-hour data shown above, while hypothetical, is typical of highly impacted projects in that the contractor lost most of its money in labor. In this example, the contractor

57 *Wunderlich Contracting v. U.S.*, 351 F.2d 956 (C.C. Cir. 1965).

expended 50,000 more man-hours and $2.4 million more than its approved labor budget, which is likely due to a variety of factors including contractor bid error, contractor performance problems, and owner-caused problems. The contractor may have a basis for a cumulative impact of changes claim because it expended 25 percent of its base scope man-hours on approved change order work.

Given a complex, highly impacted project, it is likely that other factors besides change orders affected the contractor's labor productivity. As one example, the contractor may have been forced to accelerate, subjecting the work to productivity losses as a result of extended overtime periods, overcrowding, inefficient crew sizes, and other factors.

A contractor seeking equitable compensation on its cost overrun has several damages methodologies from which to choose. Several variables factor into the decision, including:

1. The detail and reliability of the contractor's cost and man-hour records. Can costs and man-hours be accurately allocated by day, week, or month? Were actual change order man-hours captured in separate cost accounts? Certain methodologies can be utilized only if this detail exists.

2. The detail captured in contemporaneous project documentation. Were detailed daily reports kept? Do they indicate the effects of owner-caused impacts? Does project correspondence adequately document owner-caused impacts? These records, demonstrating the cause of the problems and the effect on the contractor's productivity, are important to all methodologies. Still, to use detailed quantum calculations, contemporaneous documentation must be detailed as well.

3. The stage of the claim's process. Is the claim for negotiating purposes only or being submitted as part of an expert report to the court? Certain methodologies are useful in negotiations, but are ineffective in court.

4. The size of the contractor's cost overrun. From a business perspective, the costs to prepare the damages analysis must be weighed against the size of the potential recovery.

5. The extent of contractor-caused problems and the ability to separate those costs. It is problematic in most methodologies if contractor-caused problems cannot be identified and accurately priced.

Presented below are some standard methods for calculating damages that include an element of productivity loss claims. In certain methodologies, all loss of productivity costs, including the cumulative impact of changes, are subsumed into the total claimed costs. Costs associated with the basis of each issue, such as the cumulative impacts or acceleration, are not segregated. These methodologies include the total cost method, the modified total cost method, jury verdict and the measured mile method. Other productivity loss calculation methodologies include a direct calculation of the cumulative impact costs. These methodologies employ MCAA factors, the Leonard Study models, the CII study models, or some combination of the three. The "specific damages analysis method," described in Section 5.4, can include either a direct calculation of productivity losses using industry studies, measured mile, or an indirect calculation where the contractor claims a portion of its cost overrun for productivity losses.

Also, a contractor may have been damaged not by the cumulative impact of changes, but on a specific issue causing loss of productivity such as directed acceleration or overtime. A brief overview of the studies used to show such impacts is also provided.

5.2 TOTAL COST METHOD

The total cost method involves a simple claim calculation based upon the assumption that all cost overruns are the result of the owner's actions. The contractor claims the difference between the costs it expended and the costs it was paid, and adds applicable overhead and profit. Referring to the project conditions in Figure 3, the contractor could claim $3 million plus overhead and profit under the total cost method. Alternatively, the contractor could claim only its total labor losses of $2.4 million as a total labor claim. In either case, the claimed costs for cumulative impact of changes, and all other productivity losses, are subsumed into the total claim amount.

This method is looked upon with disfavor from the courts and should be applied only in "extreme cases, where no more satisfactory method is available."[58] Many courts and boards have applied strict standards to its use. The contractor generally needs to show:

1. The impracticality of proving actual losses directly;
2. The reasonableness of its bid;
3. The reasonableness of its actual costs; and
4. Its lack of responsibility for the added costs.[59]

Therefore, the total cost method should only be used when cost and field records are not sufficiently detailed to allow calculation by any other means. Moreover, it must be shown that

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[58] *Wunderlich Contracting v. U.S.*, 351 F.2d 956 (C.C. Cir. 1965) (citing *F.H. McGraw & Co. v. United States*, 130 F. Supp. 394, 131 Ct.Cl. 501, 511 (1955)).

[59] *Centex Bateson Constr.*, VABCA Nos. 4613, 5162, 5265, 99-1 BCA ¶ 30,153; *See* also *Chicago College of Osteopathic Medicine v. George A. Fuller Co.*, 719 F.2d 1335 (7th Cir. 1983); *John F. Harkins Co., Inc. v. School District of Philadelphia*, 460 A.2d 260 (Pa. Super. 1983).

the contractor did not contribute to its losses by its own conduct. Because this is seldom the case, the modified total cost method is the typical alternative.

5.3 MODIFIED TOTAL COST METHOD

The modified total cost method involves calculating the contractor's cost overrun and subtracting out any costs associated with the contractor's bid error or performance problems. It is a deductive analysis, that is, the calculation method assumes that the owner is responsible for all cost overruns, except those costs specifically identified and deducted for being contractor-caused overruns. While the method has had some success in court,[60] the contractor typically must still prove the impracticality of proving actual losses directly, similar to the condition set by the courts in proving damages under the total cost method. That being said, the modified total cost is viewed as more reasonable than the total cost because it acknowledges the contractor's errors.

5.4 SPECIFIC DAMAGES ANALYSIS METHOD

In the modified total cost method, one typically apportions compensable and non-compensable costs on a global basis, using total project costs. In the specific damages analysis method, one apportions such costs on a much more detailed level, typically by the contractor's detailed cost accounts.

The specific damage analysis method appropriates all costs taken from the claimant's cost records into specific damages analysis categories. These categories include the original bid, any bid errors, approved changes, pending changes, compensable problems (claims), and noncompensable (or nonrequested) costs. Because the claimant is in each case associating a particular item of damage for each problem, the cause/effect relationship is established as the numbers are calculated. Accordingly, the claimed amount is both easy to verify and difficult to refute.

However, this method may be difficult to apply in a case where there are several interrelated cause-and-effect relationships, such as a project impacted by numerous change orders. Using this method, the damages caused by the cumulative impact of changes might be calculated directly using industry studies,[61] measured mile,[62] or indirectly by claiming some portion of the remaining cost overrun in each cost account. Depending on the method used for calculating

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[60] Reginald M. Jones, supra note 3, at 33 (2001) (citing *Amelco Elec. v. City of Thousand Oaks*, 98 Cal. Rptr. 2d 159, 173 (Cal Ct. App. 2000).

[61] See Sections 5.7 and 7 of this paper.

[62] See Section 6 of this paper.

productivity loss, the claim can be calculated on a cost account basis or based on all remaining labor overruns.

5.5 JURY VERDICT METHOD

If a contractor cannot calculate its damages with any certainty, it leaves the computation to the discretion of the court by way of the jury verdict method. This approach is typically employed when there is clear proof that the contractor was injured, but there is no reliable method for determining damages.[63] While this approach is not recommended, courts may award damages even if costs cannot be documented.[64]

5.6 MEASURED MILE METHOD

The measured mile method utilizes the contractor's actual performance on a portion of the work to determine what the full scope of work should have cost, absent any owner-caused impacts. While the method is still an estimate, its use of actual productivity data lends credibility to the results. Most industry experts, panels, courts and boards would agree that employing the measured mile method is the contractor's best chance of proving and recovering loss of productivity costs.

This method should be used by the contractor if at all possible. However, detailed cost, man-hour, and installed quantity data is required to perform the calculation accurately. A full discussion of the measured mile method is presented in Section 6 of this paper.

5.7 INDUSTRY STUDIES ON CUMULATIVE IMPACTS OF CHANGES

If a contractor's records are sufficiently detailed such that the modified total cost cannot be used, and the measured mile analysis cannot be utilized,[65] the contractor can employ industry studies to directly calculate the cumulative impact of changes. Section 7 of this paper provides example calculations using the various industry studies below.

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[63] *Delco Electronics Corp. v. United States*, 17 Ct.Cl. 302, 320-324 (1989); *WRB Corp. v. United States*, 183 Ct.Cl. 409, 426-427 (1968).
[64] *See, e.g.*, *Clark Construction Group, Inc.*, VABCA No. 5674 (April 5, 2000).
[65] *See* Section 6 of this paper for a discussion of the limitations of the measured mile method.

5.7.1 MCAA Factors

The Mechanical Contractors Association of America (MCAA) issued Bulletin No. 58 in 1976, entitled "Factors Affecting Productivity." This document lists sixteen factors which potentially impact productivity and provides a range of productivity losses for each factor, dependant on the severity of the conditions. The factors include: Stacking of Trades, Morale and Attitude, Reassignment of Manpower, Crew Size Efficiency, Concurrent Operations, Dilution of Supervision, Learning Curve, Errors and Omissions, Beneficial Occupancy; Joint Occupancy, Site Access, Logistics, Fatigue, Ripple, Overtime, and Season and Weather Change.[66] MCAA advises that these factors are intended to "add onto costs of change and in some cases, original contract hours" and warns that the factors are "intended to serve as a reference only."[67]

In 2005, the MCAA issued a new document, "Change Orders, Productivity, Overtime: A Primer for the Construction Industry." In this document, the MCAA includes a table with the same seixteen "Factors Affecting Labor Productivity."[68] These factor titles, descriptions, and the estimated impacts have remained unchanged from MCAA's earlier publications.

The MCAA factors can be used to specifically quantify the cumulative impact of changes separately from other inefficiencies, such as those brought about by acceleration. MCAA provides typical causes for each loss of productivity factor and specifically identifies the impact of "changes" for several factors. For example, the MCAA factor "Moral and Attitude" can be caused by "multiple contract changes and rework"; "Reassignment of Manpower" caused by "unexpected, excessive changes"; and "Dilution of Supervision" caused when supervision is diverted to "analyze and plan change" or "stop and replan affected work."[69]

Even though the productivity factors are "necessarily arbitrary,"[70] courts and boards seem to prefer the use of the MCAA factors over other industry studies.[71] In *Clark Construction Group*, the board, when determining the contractor's damages under the jury verdict method, applied the MCAA factors (even though the contractor did not present these factors), stating, "We will utilize the productivity factors from the MCAA Manual as the best method to arrive at the percentage estimates of…undeniable productivity losses."[72]

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66 Mechanical Contractors Association of America, "Factors Affecting Productivity," Bulletin No. 58 (1976).
67 *Id.*
68 Mechanical Contractors Association of America, "Change Orders, Productivity, Overtime: A Primer for the Construction Industry," p. 63-64.
69 *Id.*
70 Mechanical Contractors Association of America, "Factors Affecting Productivity," Bulletin No. 58 (1976).
71 *See, e.g., Clark Construction Group, Inc.*, VABCA No. 5674 (April 5, 2000); *Clark Concrete*, GSBCA 14340 99-1, BCA @ 630, 829 (1999), *Fire Security Systems, Inc.*, 91-2 BCA ¶23,743; *Stroh Corporation*, GSBCA No. 11029, 96-1 BCA ¶28,265; *Appeal of Centex Bateson Construction Co., Inc.*, VABCA04613 and 5162-5165; *Triple "A" South*, 94-3 BCA P 27, 194, ASBCA No. 46, 866. *See*, by comparison, Sections 5.6.2 and 5.6.3 of this paper.
72 *Clark Construction Group, Inc.*, VABCA No. 5674 (April 5, 2000).

Using the MCAA factors may be an alternative if the measured mile method cannot be utilized. However, if the scope of work is not mechanical in nature, other industry studies may have to be used.

5.7.2 Leonard Study Models

While it remains a commonly cited industry study regarding cumulative impact of changes, the fact remains that the Leonard Study has never been successfully used to recover damages in court.[73] The models can be used by a contractor to negotiate equitable adjustments, or at best, to corroborate the results of other damages methodologies.

5.7.3 CII Study Models

The use of the CII models is similarly unproven by courts and boards. As one commentator noted, as of 2001 the CII model developed for mechanical and electrical contractors has not yet been tested by a board of contract appeals, the U.S. Court of Claims, or any state appellate court.[74]

We recommend that all applicable industry studies be used to calculate separate damages figures, and that a comparison be made to determine the most reasonable compensable claim amount.

5.8 INDUSTRY STUDIES ON SPECIFIC LOSSES OF PRODUCTIVITY

Several studies have focused on quantifying the productivity loss due to other factors, most notable those caused by acceleration. The Business Roundtable, in its report entitled "Schedule Overtime Effect on Construction Projects," presents several charts which a contractor can use to show productivity losses due to overtime.[75] The study concluded:

> Placing field construction operations on a project on a scheduled overtime basis disrupts the economy of the affected area, magnifies any apparent labor shortage, reduces labor productivity, and creates excessive inflation of construction labor costs without material benefit to the completion schedule.[76]

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73 *See* Section 4.2.2 of this paper.
74 Reginald M. Jones, supra note 3, at 11.
75 Business Roundtable, Report C-2, "Schedule Overtime Effect on Construction Projects," November 1980 (Reprinted August 1991).
76 *Id.* at 1.

Cumulative Impact Claims

The "Modification Impact Evaluation Guide," issued by the Army Corp of Engineers in 1979, provides charts to help quantify the loss of productivity for many impacts, including disruption, overcrowding, and acceleration.[77] The study was rescinded in 1996 because the content "has been updated and is incorporated in other publications…."[78] However, the study may still be applicable, especially in negotiating an equitable claim settlement.

Both the Business Roundtable study and the Corp of Engineers study can be used to estimate the costs of acceleration type impacts, either separately or in combination with the studies on the cumulative impact of changes.

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[77] Office of the Chief of Engineers, Department of the Army, "Modification Impact Evaluation Guide" (EP 415-1-3) (Washington, D.C.: July 1979).

[78] Mark G. Jackson, Carl W. LaFraugh and Robert P. Majerus, "Using Industry Studies to Quantify Lost Productivity" (citing Albert J. Geneni, Jr., Department of the Army, U.S. Army Corps of Engineers, Circular No. 25-1-244 (Washington, D.C.: June 14, 1996)).

6. MEASURED MILE METHOD

If the appropriate data is available, the best approach to pricing any loss of labor productivity claim, including claims arising from the cumulative impact of change orders, is the measured mile analysis. The measured mile analysis is a comparison between a contractor's actual labor productivity during a relatively unimpacted period (the "measured mile") and its actual labor productivity during a period impacted by changes or other owner-caused events. The basis of the contractor's argument is that its decreased productivity during the impacted period is a result of owner-caused impacts, and it is therefore entitled to the difference between its actual costs to perform the work and what it should have cost to perform the work, based upon its measured mile productivity.

The following steps should be employed by the analyst in preparing a measured mile analysis:

1. Determine the discipline (e.g., pile driving, concrete work, or piping) and scope of work (e.g., all piping, System 2100 piping, or six-inch carbon steel piping) to be used in the analysis.

2. Determine the measured mile period of performance.

3. Calculate the contractor's labor productivity in the measured mile period.

4. Calculate the contractor's "should have been" cost based upon actual quantities of work and its measured mile productivity, making any adjustments necessary for contractor-caused problems during the impacted period that were not present in the measured mile period.

5. Calculate the contractor's damages using the difference between the contractor's actual costs and its "should have been" costs, as adjusted for contractor-caused impacts.

6. Develop specific cause-effect matrices and narratives explaining how owner-caused impacts lead to decreased labor productivity.

The disciplines chosen for the measured mile analysis must meet two common criteria: 1) they have been impacted by the owner, and 2) the contractor experienced a cost and man-hour overrun in completing the work. Determining the scope of work within that discipline is more complicated and is almost always driven by the detail in the contractor's job cost records and the total losses on the project. Should the contractor prepare one measured mile analysis which encompasses all of piping, or five separate analyses which shows piping by area? As with the preparation of any claim, the more detail provided, the better chance of recovery, but the contractor must weigh the cost and time of preparing such analyses against potential recovery.

Steps 2 – 6 of the methodology described above will be explained by way of a hypothetical example. From the contractor's cost and schedule records, Figure 4 was compiled, showing that the contractor had overrun its labor costs for Above Ground Piping by $500,000:

Figure 4

Above Ground Piping Data

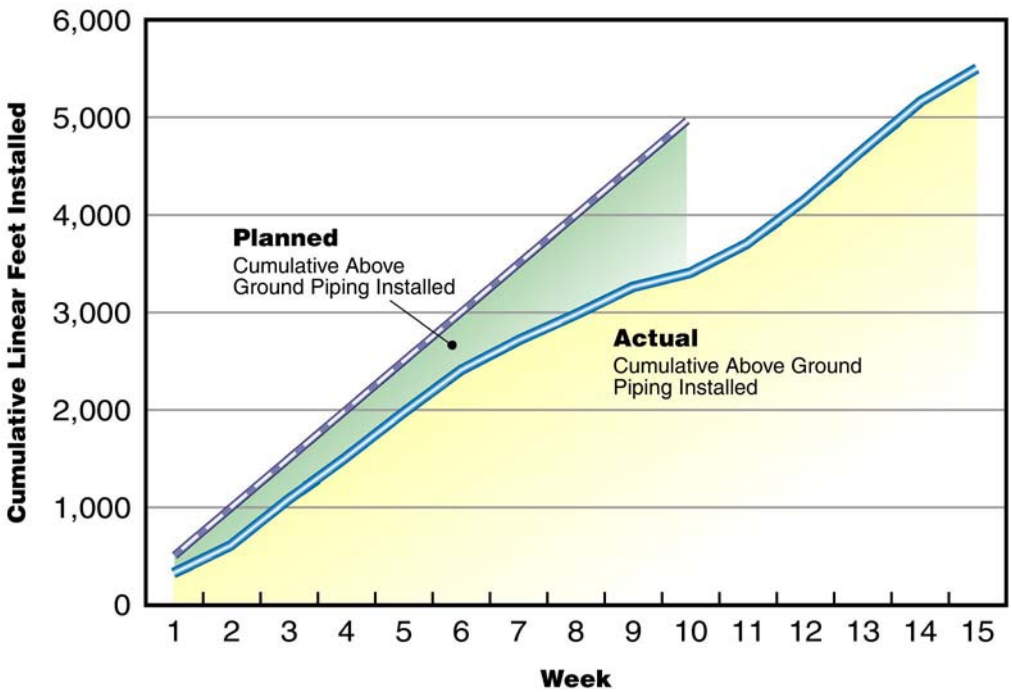
Description	**Planned**	**Actual**	**Variance**
Quantity (LF)	5,000	5,500	500
Man-Hours	10,000	20,000	10,000
Productivity (MH/LF)	2.0	3.64	1.64
Labor Cost ($)	$400,000	$900,000	$500,000
Duration (Weeks)	10	15	5

In determining the measured mile period, tables and graphics are used to detail the contractor's actual performance by time, measured both by installed quantities and actual productivities. For example, Figure 4 demonstrates that the contractor nearly achieved its planned weekly installation quantities in Weeks 3 through 6 and Weeks 12 through 14. Based upon this graphic, both periods are candidates for the measured mile.

Cumulative Impact Claims

Figure 5

Cumulative LF Installed Per Week – Above Ground Piping



However, Figure 5 does not include the man-hours expended to install those quantities. In this example, the contractor accelerated during the later period and, therefore, its productivity was greatly reduced. Figure 6, showing the contractor's productivity by week, paints a much clearer picture of both the contractor's productivity loss and the events impacting its productivity.

Figure 6

Planned and Actual Productivity – Above Ground Piping

Week	Planned LF per Week	Planned MHs per Week	Planned Productivity per Week (MH/LF)	Actual LF per Week	Actual MHs per Week	Actual Productivity per Week (MH/LF)	Drawings Revised	RFI's Issued	Instances of Interference
1	500	1,000	2.00	300	900	3.00	–	2	–
2	500	1,000	2.00	300	900	3.00	–	–	–
3	500	1,000	2.00	450	1,000	2.22	5	1	–
4	500	1,000	2.00	425	1,050	2.47	–	3	–
5	500	1,000	2.00	475	1,000	2.11	7	1	–
6	500	1,000	2.00	450	1,100	2.44	–	–	–
7	500	1,000	2.00	300	1,100	3.67	67	10	–
8	500	1,000	2.00	275	1,050	3.82	125	15	7
9	500	1,000	2.00	275	1,100	4.00	80	17	4
10	500	1,000	2.00	150	1,000	6.67	55	11	8
11	–	–	–	300	1,600	5.33	–	8	3
12	–	–	–	450	2,000	4.44	15	6	1
13	–	–	–	500	2,000	4.00	–	4	–
14	–	–	–	500	2,400	4.80	–	–	–
15	–	–	–	350	1,800	5.14	–	–	–

From Figure 6, four distinct periods of work are identified:

Weeks 1-2: Start-up Period. The contractor is unimpeded but slow to start due to mobilization of crews and learning curve. (Productivity[79]: 3.00 man-hours/LF)

Weeks 3-6: Likely Measured Mile Period. The contractor encounters some changed work, but no more than is typical with like projects, and achieves near its as-planned productivity. (2.31 man-hours/LF)

Weeks 7-11: Impacted Period. The contractor encounters a multitude of changes, questions on installation due to poor design, and interference from other subcontractors, causing a great reduction in productivity. (4.50 man-hours/LF)

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79 Productivity is often measured in terms of units installed per man-hour of work, *e.g.*, 0.33 linear feet per man-hour. In this paper, productivity is measured by man-hours per unit installed.

Weeks 12-15: Acceleration Period. Behind schedule, the contractor is forced to employ more men and overtime to catch up. While installed quantities per week are near plan, the costs are much greater than planned. (4.55 man-hours/LF)

Based upon productivities alone, the period from Weeks 3 through 6 is a reasonable measured mile period. However, the analyst must determine if the period is a representative sample of the entire scope of work. The critique from the owner, its attorney, and its expert will likely focus on the following three areas:

1. The measured mile period chosen is not long enough, could be an anomaly, and was "cherry-picked" to show a productivity that could not be sustained.

2. The period reflects simplified work or work that was materially different from work outside the measured mile period.

3. The actual man-hours and costs in the analysis include work that was not impacted by the alleged owner-caused problems, some of which may not show a cost overrun in the contractor's cost report.

If, for example, in Weeks 3 through 6, the contractor installed mostly four-inch diameter piping, and subsequently installed mostly eight-inch diameter piping (which requires more man-hours to install per linear foot), the period should not be used. In this instance, one would have to either choose a more detailed scope of work for the analysis, possibly by pipe size, or abandon the measured mile method to calculate damages.

In practice, these three likely critiques are not easily overcome. Often the unimpacted period occurs early in the project, when the contractor's work is less complex, and therefore no applicable comparison can be drawn between the unimpacted and impacted periods. Thus, choosing the correct scope of work to analyze can be an iterative process. If a supportable measured mile period cannot be determined for a given scope of work, one must analyze the components of that work to determine if a more applicable comparison is possible.

Assuming that the period in this example is reasonable, the measured mile productivity is calculated as 2.31 man-hours per lineal foot (4,150 mhs / 1,800 LF installed). This productivity, as well as the "should have been" lineal footage per week and the "should have been" cost per week are used to extrapolate the final "should have been" cost.

In this example, Weeks 1 through 6 were unimpacted, and therefore the "should have been" costs are equal to the contractor's actual costs. For all remaining weeks, the measured mile productivity of 2.31 mhs/LF, as well as the "should have been" progress per week of 450 LF and the "should have been" man-hours expended per week of 1,038, are used to calculate the final cost. See Figure 7 for the final calculation of "should have been" cost.

Figure 7

"Should Have Been" Costs – Above Ground Piping Labor

Week	Should Have Been LF per Week	Should Have Been Cumulative LF	Should Have Been MHs per Week	Should Have Been Productivity per Week (MH/LF)	Should Have Been Costs per Week	Source
1	300	300	900	3.00	$36,000	Actual Data
2	300	600	900	3.00	$36,000	Actual Data
3	450	1,050	1,000	2.22	$40,000	Actual Data
4	425	1,475	1,050	2.47	$42,000	Actual Data
5	475	1,950	1,000	2.11	$40,000	Actual Data
6	450	2,400	1,100	2.44	$44,000	Actual Data
7	450	2,850	1,038	2.31	$41,500	Measured Mile Data
8	450	3,300	1,038	2.31	$41,500	Measured Mile Data
9	450	3,750	1,038	2.31	$41,500	Measured Mile Data
10	450	4,200	1,038	2.31	$41,500	Measured Mile Data
11	450	4,650	1,038	2.31	$41,500	Measured Mile Data
12	450	5,100	1,038	2.31	$41,500	Measured Mile Data
13	400	5,500	922	2.31	$36,889	Measured Mile Data
Totals	**5,500**	**–**	**13,097**	**2.38**	**$523,889**	

Note that this "should have been " cost of $523,889 assumes that there were no contractor-caused problems or inefficiencies in weeks 7 through 13, apart from those included in the measured mile productivity. If the contractor-caused problems were minor, these incidents could be separately priced and added to the "should have been" cost. However, if these problems were significant, and persisted throughout the period, the "should have been" cost as calculated would be unreasonable, as it would not represent the actual conditions. In this example, assume that no such contractor-caused problems existed.

Therefore, the contractor's compensable damages claim for Above Ground Piping would be $376,111 ($900,000 actual cost less $523,889 "should have been" cost), less any amount paid by the owner for approved change orders affecting the total quantity of pipe installed. The contractor's non-compensable cost would be $123,889, or the difference between its planned costs and its "should have been" costs, and would likely be attributed to bid error or performance problems. This non-compensable cost is justified because, even in the unimpacted period, the contractor did not meet its planned productivity.

The final step is to show that the owner-caused impacts – in this case design changes, interference with other contractors, and acceleration – actually caused the contractor's loss of productivity. This step will be reviewed in Section 8 of this paper.

Cumulative Impact Claims

One advantage of the measured mile is that it encompasses the impacts of all labor inefficiencies. In the above example, if the measured mile could not be used, the analyst might have to separately calculate the labor inefficiencies caused by cumulative impact of change orders, the effects of overtime on productivity, and the impact of interference. These separate analyses would offer a less reliable result than the measured mile.

The measured mile method should be the preferred choice for a contractor submitting a loss of productivity claim. In many instances, however, the measured mile cannot be used, typically for three reasons: 1) there exists no unimpacted period of work to establish a baseline; 2) the contractor's cost, man-hour, and installed quantity data lacks sufficient detail to determine productivities by time and relevant scope of work; and 3) there are contractor-caused performance problems in the impacted period and they cannot be distinguished from the owner-caused impacts.

While other methods, some of which are discussed in this paper, can be utilized to calculate loss of productivity, certain methods also require detail from the contractor's cost records. A contractor seeking to recover these costs must keep adequate cost, man-hour, and installed quantity data, at least to the level shown in the example above.

7. EXAMPLE CALCULATIONS FROM INDUSTRY STUDIES

This section provides example calculations from the industry studies previously discussed, including MCAA factors, Leonard Study models, and two CII studies. The calculations will be based upon Figure 8, showing data in direct construction man-hours. For this example, assume that the work was mechanical in nature and that the contractor accelerated its work to meet its contractual completion date. Further, from detailed cost records, the contractor-caused errors and other non-compensable time are estimated to total approximately 10,000 man-hours.

Figure 8

Man-Hour Data - Mechanical Project

	Man-Hours
Base Contract	120,000
Approved COs	30,000
Revised Contract	150,000
Actual MHs/Costs	200,000
MH Variance	50,000
Contractor Performance Problems	10,000

7.1 LEONARD STUDY MODELS

Leonard provides several simple steps to estimate productivity losses:[80]

1. Determine the actual change order man-hours, or in absence of actual man-hours, use earned man-hours. In this example, the value is 30,000 earned change order man-hours.

2. Calculate the "actual contract hours," which is the total actual man-hours less change order man-hours less man-hours attributable to contractor inefficiencies. The value in this example is 160,000 actual contract hours (200,000 – 30,000 – 10,000).

[80] Charles A. Leonard, "The Effects of Change Orders on Productivity," Thesis at Concordia University, at 125-126 (1988).

3. Calculate the percent change order by dividing change order man-hours by actual contract hours. The result is 0.1875 or 18.75 percent (30,000/160,000).

4. Use the appropriate model to determine percentage loss of productivity based upon percent change orders. In this example, the model for mechanical and electrical work would be used.[81] Further, because the example project was also impacted by acceleration, the line including changes plus one major cause should be used. From the table, a 28 percent productivity loss is calculated.

5. Calculate the unproductive hours on the original contract work by multiplying the percent loss of productivity by the actual contract man-hours. The result is 44,800 unproductive man-hours (28 percent x 160,000).

The 44,800 man-hours calculated are more than would be claimed using a modified total cost approach, where the contractor would claim only 40,000 man-hours. Note, however, that if the acceleration was not determined to be a "major cause," the revised productivity loss would be approximately 17 percent, yielding 27,200 unproductive man-hours. Due to the general nature of the model, the answer is likely somewhere in between.

7.2 CII PUBLICATION 43-2

CII Publication 43-2, entitled "Quantitative Effects of Project Change" provides several models for estimating the cumulative impact of changes.[82] For this example, the most applicable model is that comparing the Construction Change % to the Construction Productivity Ratio.[83] The steps provided by CII are as follows:[84]

1. Calculate the change percentage by dividing the change order man-hours by the total planned man-hours. This value is 20 percent (30,000 / (120,000 + 30,000)).

2. Use the appropriate model to determine the productivity ratio based upon change percentage.[85] The productivity ratio in this example is approximately 95 percent.

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[81] *See* Figure 1 in Section 3.1 of this report.

[82] Project Change Management Research Team, "Quantitative Effects of Project Change," CII Publication 43-2, (May 1995). (Using data from C.W. Ibbs & Walter E. Allen, "Quantitative Impacts of Project Change," CII Source Document 108 (May 1995)).

[83] *Id*. at 8.

[84] *Id*.

[85] *See* Figure 2 in Section 3.2 of this report.

3. Calculate the expected final work hours by dividing the total planned man-hours by the productivity ratio. This results in 157,895 expected final work hours (150,000 / 0.95).

4. Calculate the lost man-hours due to change orders by taking the difference between the expected final work hours and total planned man-hours. In this example, the calculation shows 7,895 man-hours lost (157,895 – 150,000).

Using this study, the contractor would claim 7,895 man-hours for the cumulative impact of changes. The impact of acceleration is not included in the results. Note that because the man-hours actually incurred by the contractor were not used in the calculation, the value is much lower than that shown by Leonard.

7.3 CII RESEARCH REPORT 158-11

CII Research Report 158-11 entitled, "Quantifying the Cumulative Impact of Change Orders for Electrical and Mechanical Contractors" provides the following equation to predict the impact of change orders on productivity:[86]

%Delta = 0.36866 + 0.11957 Percent Change – 0.08065 PM%TimeOnProject – 0.16723 %OwnerInitiatedCO – 0.09147 Productivity – 0.05213 Overmanning + 0.022345 Processing Time

The following values are calculated based upon the project information, some of which were assumed for this example:[87]

- Percent Change: (CO MHs/Base Contracts MHs) = (30,000/120,000) = 0.25
- PM%TimeOnProject: (Assumed 50 percent) = 0.5
- %OwnerInitiatedCO: (Assumed 50 percent) = 0.5
- Productivity: (Contractor did track productivity) = 1.0
- Overmanning: (Overmanning occurred) = 1.0
- Processing Time: (Assumed 14 days for average CO approval) = 2

Inputting these values into the above equation, the final %Delta value is calculated as 0.1757, or 17.57 percent. This value is multiplied by actual hours incurred: (17.57%)(200,000 mhs) = 35,140 mhs. This corresponds to 35,140 man-hours that could be attributed to changes and their

[86] Awad S. Hanna, "Quantifying the Cumulative Impact of Change Orders for Electrical and Mechanical Contractors," CII Research Report 158-11, at 108 (February 2001).
[87] *Id*. at 109 (Table 6.2 – Factors Defined).

effect on the contractor's labor efficiency.[88] However, this value includes all inefficient work hours, including those caused by the contractor. After deducting 10,000 man-hours in contractor-caused losses, the contractor's claim for cumulative impact of changes would be 25,140 man-hours.

7.4 MCAA FACTORS

In determining their models, the Leonard Study and the CII studies collected data on a total project basis, and therefore the analysis of loss of productivity using these models must be calculated on a total project basis. Using MCAA factors, the contractor is not confined to determining the losses on a total project basis; the impacted scope of work can be segregated so that the correct loss of productivity factors can be applied. Such is the case in this hypothetical example.

A qualified expert has reviewed the project and cost records (including Figure 8) and has interviewed several project participants. He has determined that the contractor suffered productivity losses due to the cumulative impact of changes and acceleration. Using the MCAA factors, the expert has determined the following productivity losses:[89]

- <u>Cumulative impact of changes</u>: a 5 percent productivity loss due to minor "Morale and Attitude" impacts; a 5 percent loss for minor "Reassignment of Manpower" impacts; a 10 percent loss for minor "Dilution of Supervision" impacts; and an additional 5 percent productivity loss due to minor "Learning Curve" impacts. The total productivity loss calculated is 25 percent.

- <u>Acceleration</u>: a 20 percent productivity loss due to average "Stacking of Trades" impacts; a 10 percent loss due to minor "Crew Size Inefficiency" impacts; and a 10 percent loss due to minor "Overtime" impacts. The total productivity loss calculated is 40 percent.

However, the contractor did not suffer this loss of productivity from day one. The expert determined that the excessive change orders did not start impacting the project until it was approximately one-third complete. Also, the contractor accelerated during the last quarter of the project only. Using base scope man-hours, the expert calculated the lost man-hours as follows:

Cumulative impact of changes:

(120,000 base scope mhs) (66% of mhs impacted) (25% loss of productivity) = **20,000 lost mhs**

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88 *Id*. at 119-120 (provides example calculation).
89 Mechanical Contractors Association of America, "Factors Affecting Productivity," Bulletin No. 58 (1976).

Acceleration:

(120,000 base scope mhs) (25% of mhs impacted) (40% loss of productivity) = **12,000 lost mhs**

Based upon the use of MCAA factors, the contractor is due to recover the costs of 32,000 man-hours for the loss of productivity caused by the cumulative impact of change orders and acceleration.

7.5 COMPARISON OF RESULTS

The results of the four analyses are shown in Figure 9.

Figure 9

Results From Industry Studies

	Lost Man-Hours		
Industry Study	**Due to Changes**	**Due to Acceleration**	**Total**
Leonard Study	27,200	17,600	44,800
CII 43-2	7,895	N/A	7,895
CII 158-11	25,140	N/A	25,140
MCAA Factors	20,000	12,000	32,000
Average	**20,059**	**14,800**	**27,459**

The calculations of loss of productivity due to the cumulative impact of changes are somewhat inconsistent, showing a low value of 7,895 man-hours and a high value of 27,200 man-hours. This discrepancy is not unexpected. Industry studies are models used to estimate loss of productivity and all of these studies warn generally that results may vary and that productivity losses are project specific.

The results do show that industry studies work well when used together. The average man-hour loss due to cumulative impact of changes is 20,059 man-hours, similar to the results when using MCAA factors alone. The expert might use the 20,000 man-hours for cumulative impact calculated using MCAA factors and show the average of Leonard and the two CII studies as confirmation of his estimate.

Regarding the two values for acceleration, the Leonard value of 17,600 man-hours is suspect because the total of 44,800 man-hours is more than the contractor lost, and technically, the lost man-hours due to change orders and acceleration should not be isolated, but rather, shown together and totaling 44,800 man-hours. The only true calculation of lost productivity due to acceleration is provided by the MCAA factors, and therefore the expert would likely perform additional analyses to support this calculation, using the Corp of Engineers Study or the Business Roundtable.[90]

In this example, an expert might conclude, from analysis of the contractor's 50,000 man-hour overrun, that 20,000 man-hours are compensable due to the cumulative impact of changes, 12,000 man-hours are compensable due to acceleration, 10,000 man-hours are non-compensable due to contractor-caused problems, and the remaining 8,000 man-hours were unable to be allocated to either party.

90 *See* Section 5.8 of this paper.

8. PROVING THE CAUSE-AND-EFFECT LINKAGE

Contractor's claim submittals and expert reports are often deficient in proving the cause-and-effect linkage. These claims generally provide a section outlining the owner-caused impacts and separately provide a section calculating quantum – the two are rarely linked in any meaningful way. The large majority of claims are settled prior to a decision by a panel, court or board and therefore these deficiencies are not made apparent. Yet, a well-prepared claim document which includes a persuasive and accurate cause-and-effect analysis can greatly improve the contractor's chances of a successful recovery, either through negotiations or in arbitration/litigation. This analysis is difficult, and often costly, to prepare and is therefore not performed in many claims.

For the analyst seeking to show the cause-and-effect linkage in a cumulative impact of changes claim, the task is even more difficult. By an earlier definition, cumulative impact is "exclusive of that local disruption that can be ascribed to a specific change,"[91] or stated another way, cumulative impact cannot be ascribed to a specific change. Yet court and board decisions have shown that simply showing that a large number of changes existed and that the contractor suffered a loss of productivity is not sufficient for recovery.[92] This dichotomy is difficult to overcome.

This section is intended to provide suggestions for establishing the cause-and-effect linkage in cumulative impact claims. Included are two subsections: the first discusses the documentation that a contractor should prepare during the project to help prove cumulative impact; the second provides suggestions in preparing the cause-and-effect analysis, and proving causation under the scrutiny of litigation.

8.1 THE PROJECT RECORD

Contractors know when a project is troubled by the impact of many changes. Upon that realization, the contractor should step up its efforts to document the impact to the work and allocate costs of specific change orders to separate cost accounts. Yet when projects are impacted, the opposite typically holds true. Foreman and supervisors spend their time coordinating the changed work and finding the most productive work for their crews in an attempt to stay on budget and on schedule; they have less time to document the impacts to their work and fill out timesheets showing who did what.

Even though it is difficult, or by definition impossible, to quantify cumulative impact in terms of man-hours and costs, the field staff must document the changed conditions which are causing the

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[91] *Centex Bateson Constr. Co.*, VABCA Nos. 4613, 5162, 5165, 99-1 BCA ¶ 30,153 (citing *Triple "A" South*, ASBCA No. 46866, 94-3 BCA ¶ 27,194).

[92] See Section 4.2.3 of this paper.

loss of productivity, such as design interferences, crowded work areas, out of sequence work, or stop-and-go work. A consistent record of problems documented contemporaneously through daily reports, RFIs, change requests and correspondence is of much greater value than any analysis or expert opinion that can be offered after the project is completed. Absent these records, the contractor will find it difficult to recover on any cost overruns, much less those caused by the cumulative impact of changes.

One of the best ways to track owner-caused impacts is through daily reports. A contractor's daily reports typical provide only general information, such as temperature, how many men each subcontract had on site, and what work was being performed. During a highly impacted project, the foreman or superintendent should use the daily reports as a vehicle to track changed conditions, owner directions, design interference problems, or any variance from the contract. An entry such as, "Mike's crew stopped work on pipe spool BG-235 (issued RFI112) – moved to spool BB-002 per CM" is much more effective than, "Pipe crews – 20 people today." An accurate daily record of such impacts is invaluable in proving loss of productivity.

The contractor should also track the costs of change orders in separate cost accounts, apart from the cost codes for base scope work. Change orders are often estimated prior to the performance of the changed work and often the costs to perform that work are greater than estimated. This overrun might not be due to a poor estimate, but caused by the unforeseeable disruption on the changed work, particularly when the work is performed well after the estimate has been prepared and concurrent with numerous other unplanned changes that also have to be integrated into the contractor's work schedule. Tracking the costs of changes separately may allow the contractor to recover extra costs through negotiations, or to alert the owner that productivity is being compromised by the cumulative impact of changes. As one commentator noted, "the use of effective cost-accounting methods and the maintenance of appropriate cost records can minimize many of the proof problems inherently associated with construction claims."[93]

Once the contractor becomes aware that a multitude of changes are impacting its productivity, *i.e.*, the impacts are foreseeable, it is essential that the contract notify the owner of its findings and that the contractor reserves its rights to claim such impacts on any subsequent change orders. As shown in Section 4, courts and boards have denied many cumulative impact claims in part because the contractor has not taken such steps.

[93] Sweeny, et al, Smith, Currie & Hancock's "Common Sense Construction Law," John Wiley & Sons, Inc., at 284 (1997).

8.2 CAUSE-AND-EFFECT ANALYSIS

In *Luria Bros. & Co. v. United States*, the court stated: “It is a rare case where loss of productivity can be proven by books and records; almost always it has to be proven by the opinion of expert witnesses.”[94] Proving causation in a cumulative impact of changes claim likely requires both a qualified expert and detailed and complete contemporaneous project documentation. The following suggestions, while case sensitive and highly dependent on the detail in the project record, provide several ideas on linking excessive changes with a loss of productivity:

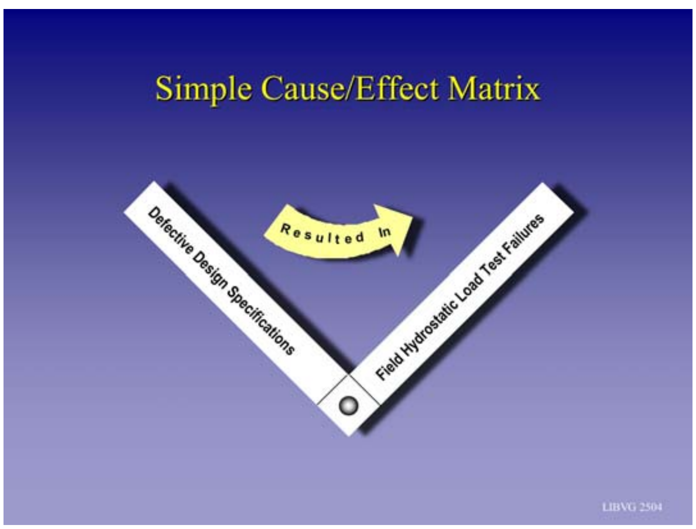
- Prepare a cause-effect matrix for entire project;
- Track the impact on an activity or crew;
- Show how the site environment changed from plan; and
- Tell the factual story with graphics.

8.2.1 The Cause-Effect Matrix

The backbone of the cause-and-effect linkage in any claim is the cause-effect matrix. For any given owner-caused problem, one can graphically trace the effects to the contractor’s work. Figure 10 is a simple cause/effect matrix showing that defective specifications resulted in hydrostatic test failures.

Figure 10

Simple Cause/Effect Matrix



94 *Luria Bros. & Co. v. U.S.*, 369 F.2d 701 (Ct. Cl. 1966).

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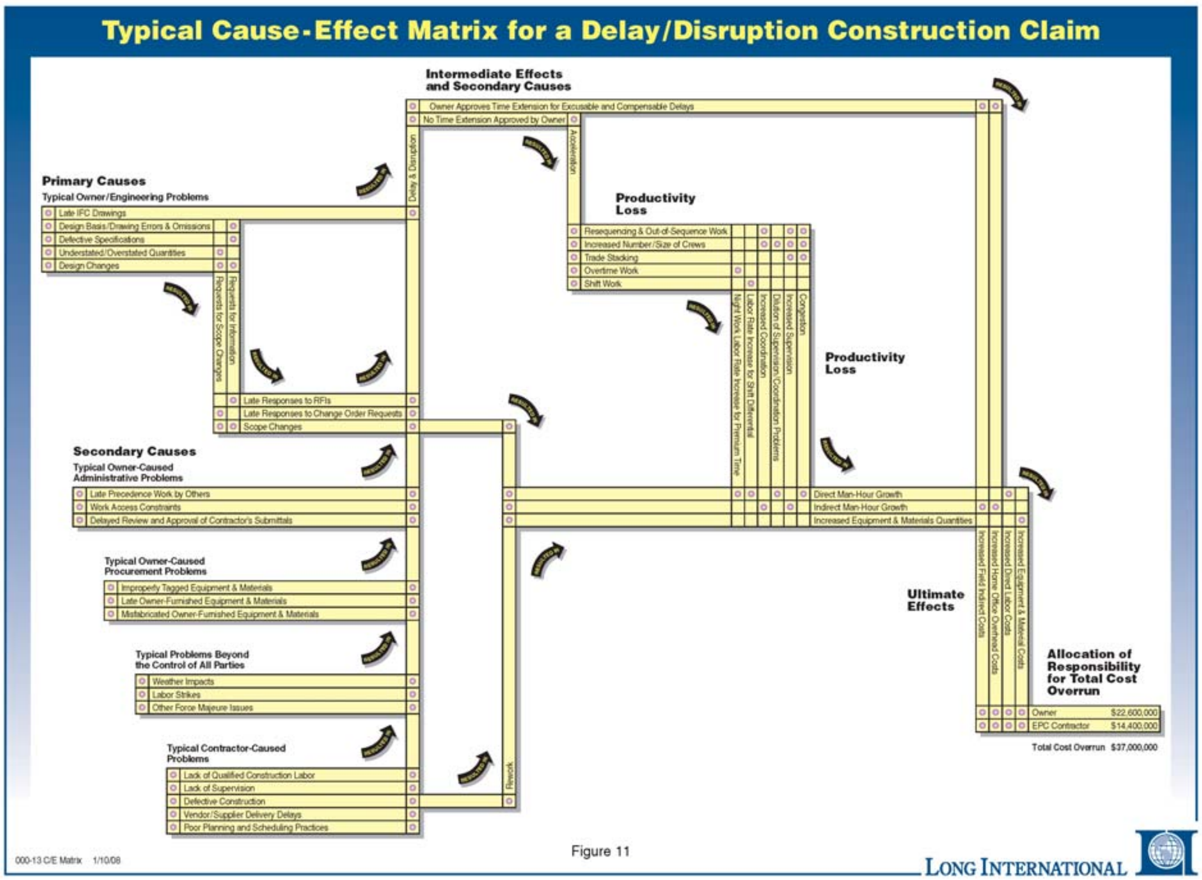
As multiple causes and their resultant effects are added, the matrix ultimately gets much more complicated. Figure 11 shows a typical cause-effect matrix for a highly impacted project. Primary and secondary causes, including contractor-caused problems, are shown to have multiple and duplicative effects, the end result being a cost overrun. Even though it is complex, Figure 11 can still be broken down into simple relationships, as shown in Figure 10.

Figure 11

Typical Cause/Effect Matrix for a Delay/Disruption Construction Claim



Tracing one path through this matrix tells a factual story: design changes resulted in the contractor requesting scope changes; the owner was late in responding to many change order requests which resulted in delay and disruption; the owner did not approve the proper time extensions which resulted in the contractor accelerating its work; the acceleration caused trade stacking and congestion, which lead to direct man-hour growth and increased direct labor costs, a portion of which are being claimed against the owner. Each of the causes has a similar factual story, the ultimate effect being increased costs.

Showing these relationships graphically, in addition to a narrative containing relevant excerpts from contemporaneous documents, provides the contractor, the owner, the attorneys and the arbitration panel or court a better understanding of all of the impacts on the project. A similar but more detailed graphic could be prepared showing the effects of several change orders during a given time period to help support a cumulative impact claim.

8.2.2 Tracking Impacts By Activity Or Crew

One definition of cumulative impacts cited earlier was:

> The cumulative impact effect occurs when the project conditions have deteriorated to the point where work on an activity is adversely affected by another activity or by the mere nature of the site environment.[95]

In a claim submittal, it is extremely effective to explain the impacts caused to one activity or group of activities. After that impact is established, one may be able to show the "ripple," or the impacted activities negative effect on other activities. For example, with detailed project documentation the following description could be provided:

> The work on pipeline 2A01 was planned to take 10 work days, but actually took 30 work days. In that period, five RFIs were issued requesting clarification on design discrepancies. The owner took on average four days to respond. The owner issued Rev 2 isometric drawings on September 3rd, ten days after work had commenced, which lead to rework. Further, owner-supplied valves were late and much of the pipe could not be installed until the valves were set. As shown in the daily reports, there were constant interruptions to the work…

From the project schedules, one could then determine which activities ran concurrently with this activity, and which activities were its logical successors. The changes on pipeline 2A01 may have impacted these successor activities as well. If the above description of the impacts to pipeline 2A01 included, "work delayed by open excavation of underground pipe for 2B18," the theoretical "ripple" becomes real.

Even though the work described is likely a very small percentage of the total scope, providing just a few such examples begins to demonstrate cumulative impact. The next step, per the definition above, is showing how the overall site environment was impacted.

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[95] Robert F. Cushman, Stephen D. Butler, & James F. Nagle, "Construction Change Order Claims," Wiley Law Publications, § 4.11 (1998 Supplement).

8.2.3 Site Environment Changes

Changes to site environment can be any difference in the way work was actually performed, compared to the way it was planned to be performed. Both MCAA and Leonard provide typical causes of lost productivity, which could also be considered site environment changes. Leonard provided the following:

> Cumulatively, change orders result in the following causes of productivity loss: stop-and-go operations; out-of-sequence work; loss in productive rhythm; demotivation of work force; loss in learning curve; unbalanced crews; excessive manpower fluctuations; unbalancing of successive operations; lack of management and engineering support; and acceleration when equitable time extensions are not granted.[96]

The cause-and-effect link is shown by proving that these conditions existed. The contractor's best case could be made if these impacts were noted in the daily reports. Assuming there is no such record, below are a few examples of analyses that might be performed to demonstrate this proof:

Out-of-Sequence Work: A comparison could be made of the contractor's as-planned and as-built schedules showing which activities were performed out-of-sequence from plan. One could review the causes of this sequence change and show a detailed list of activities that were impacted due to changes.

Using the same comparison, one could review concurrent activities in the planned schedule versus those in the as-built schedule. If only four piping activities were planned to run concurrently, but the as-built schedule shows that ten piping activities ran concurrently, this may help prove productivity loss. This analysis would correspond to the MCAA factor "Concurrent Operations."[97]

Demotivation of Work Force: From human resources and cost records, one could calculate the absenteeism and turnover rates on the project and compare them with other similar projects that were not as severely impacted by changes. If the increased absenteeism and turnover occurred during the same period as did the owner-caused impacts, the cause-effect relationship may be justified.

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[96] Charles A. Leonard, "The Effects of Change Orders on Productivity," Thesis at Concordia University, at 121 (1988).

[97] Mechanical Contractors Association of America, "Factors Affecting Productivity," Bulletin No. 58 (1976).

Loss in Learning Curve: One could make a comparison between the planned peak manpower and the actual peak manpower and potentially show that the timing of additional forces corresponded to the timing of change order work. Were the added workers craftsmen or laborers, and what was the impact?

These are the types of analysis that fill the gap between a large number of change orders and a large overrun on labor costs. Providing these or similar analyses to the court may take some of the subjectivity out its decision.

8.2.4 Tell The Factual Story With Graphics

In reading this section, most people likely stopped at the cause-effect matrix graphic, spending more time studying that graphic than reading the rest of this section combined. A similar thing occurs when one reads a claim document or attends settlement meetings or mediations – the focus is on graphics. Dozens of pages of narrative can be effectively summarized in one graphic, or to put it another way, a picture's worth a thousand words.[98]

Including interesting and factual graphics in a claim submittal grabs the reader's attention and focuses that attention on one's argument. Figure 12 is a graphical example of tracking impacts by activity, per Section 8.2.2.

[98] Loosely translated from a Chinese proverb, which stated: "One picture is worth ten thousand words."

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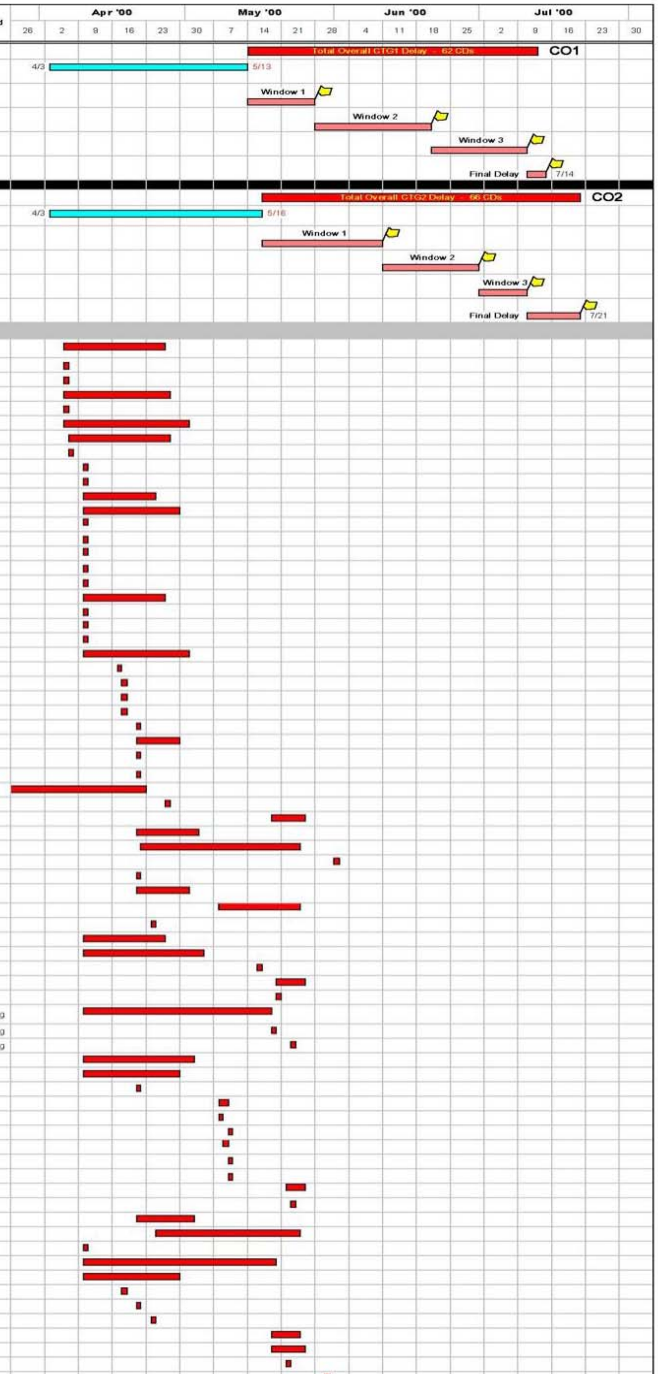
Figure 12

Example of Tracking Impacts by Activity

Code	No.	Description	Date	Date	Schedule Activity Affected
CTG1	CTG1	Total Overall CTG1 Delay - 62 CDs	5/14/00	7/13/00	
CTG1	CTG1	As-Planned Performance as of April 3, 2000 Schedule Update (4/3/00 Schedule Status)	4/3/00	5/13/00	
CTG1	CTG1	Window No. 1 Delay - 14 Cal Days (Based on 5/8/00 Schedule Status Update)	5/14/00	5/27/00	
CTG1	CTG1	Window No. 2 Delay - 24 Cal Days (Based on 6/5/00 Schedule Status Update)	5/28/00	6/20/00	
CTG1	CTG1	Window No. 3 Delay - 20 Cal Days (Based on 6/19/00 Schedule Status Update)	6/21/00	7/10/00	
CTG1	CTG1	Window No. 4 Final Delay 4 Cal Days	7/11/00	7/14/00	
CTG2	CTG2	Total Overall CTG2 Delay - 66 CDs	5/17/00	7/21/00	
CTG2	CTG2	As-Planned Performance as of April 3, 2000 Schedule Update (4/3/00 Schedule Status)	4/3/00	5/16/00	
CTG2	CTG2	Window No. 1 Delay - 25 Cal Days (Based on 5/8/00 Schedule Status Update)	5/17/00	6/10/00	
CTG2	CTG2	Window No. 2 Delay - 20 Cal Days (Based on 6/5/00 Schedule Status Update)	6/11/00	6/30/00	
CTG2	CTG2	Window No. 3 Delay - 10 Cal Days (Based on 6/19/00 Schedule Status Update)	7/1/00	7/10/00	
CTG2	CTG2	Window No. 4 Final Delay 11 Cal Days	7/11/00	7/21/00	
DCN		**Design Change Notice Impacts**			
DCN	H3181-117	Add Cable 11BFE1234 Between MCC & CJT Cabinets	4/6/00	4/26/00	CTG Electrical
DCN	H3181-118	Revise Cable Terminations	4/6/00	4/6/00	CTG Electrical
DCN	H3181-120	Added Cables 11BUB1232/12BUB1232	4/6/00	4/6/00	CTG Electrical
DCN	H3181-120	Install 125 DC to CJT Cabinets	4/6/00	4/27/00	CTG Electrical
DCN	H3181-127	Revised Cable List	4/6/00	4/6/00	CTG Electrical
DCN	H3181-129	Purchase and Install MBY22 Boxes	4/6/00	5/1/00	CTG Electrical
DCN	H3181-118	Revised Cable Terminations 11CJT01	4/7/00	4/27/00	CTG Electrical
DCN	H3181-129	Add H3181-054-X-1122&H3181-054-X-1222	4/7/00	4/7/00	CTG Electrical
DCN	3181-0004	11CHA11 Cabinet List	4/10/00	4/10/00	CTG Electrical
DCN	3181-0005	11CHA11 Cabinet Wire List	4/10/00	4/10/00	CTG Electrical
DCN	414-DCN	Ignition Transformers	4/10/00	4/24/00	CTG Electrical
DCN	H3181-101	Blowoff Valve Proximity Switches	4/10/00	4/29/00	CTG Electrical
DCN	H3181-115	Proximity Switches	4/10/00	4/10/00	CTG Electrical
DCN	H3181-116	Proximity Switches	4/10/00	4/10/00	CTG Electrical
DCN	H3181-121	Proximity Switches	4/10/00	4/10/00	CTG Electrical
DCN	H3181-121	Rewire 482 Card	4/10/00	4/10/00	CTG Electrical
DCN	H3181-122	Delete Pages to AIC & CFA Cable	4/10/00	4/10/00	CTG Electrical
DCN	H3181-125	CJR01 Power Distribution (Replaces #31)	4/10/00	4/26/00	CTG Electrical
DCN	H3181-125	Delete Pages to AIC & CFA Cable	4/10/00	4/10/00	CTG Electrical
DCN	H3181-125	Power Distribution 11/12CJR01	4/10/00	4/10/00	CTG Electrical
DCN	H3181-126	Delete Pages to AIC & CFA Cable	4/10/00	4/10/00	CTG Electrical
DCN	H3181-127	Drawing and Cable Revisions Unit #11	4/10/00	5/1/00	CTG Electrical
DCN	H3181-127	Revised Cable List	4/17/00	4/17/00	CTG Electrical
DCN	H3181-114	Change Signal Cables from 11CJP01 to 12CJP01	4/18/00	4/18/00	CTG Electrical
DCN	H3181-114	Rev. Connections	4/18/00	4/18/00	CTG Electrical
DCN	H3181-128	Drawing and Cable Revisions Unit #12	4/18/00	4/18/00	CTG Electrical
DCN	H3181-100	Connections to DCS need to be revised	4/21/00	4/21/00	CTG Electrical
DCN	H3181-100	Limit Switches on MBP Changed with Proximity Sw	4/21/00	4/29/00	CTG Electrical
DCN	H3181-102	Connections to the DCS for both Units Needs Revised	4/21/00	4/21/00	CTG Electrical
DCN	H3181-110	Corrections to Terminal Points	4/21/00	4/21/00	CTG Electrical
DCN	H3181-109	Fiber Optics	4/23/00	3/25/00	CTG Electrical
DCN	H3181-103	Diesel Generator DCS Terminations	4/27/00	4/27/00	CTG Electrical
DCN	H3181-149	Heat Trace Controllers & Wiring #11 and #12	5/19/00	5/25/00	CTG Electrical
DCN	H3181-107	Evaporative Coolers Wiring Unit #1	4/21/00	5/3/00	Evaporator
DCN	H3181-108	Evaporative Coolers Wiring Unit #2	4/22/00	5/24/00	Evaporator
DCN	H3181-152	Evap. Cooler OM Screens	6/1/00	6/1/00	Evaporator
DCN	H3181-102	Burner Temperature Protection	4/21/00	4/21/00	FM200-Fire Protection
DCN	H3181-111	Relocate Fire Protection Alarm From 11CJP01 to 12 CJP01	4/21/00	5/1/00	FM200-Fire Protection
DCN	H3181-110	Fire Panel Terminations	5/8/00	5/24/00	FM200-Fire Protection
DCN	H3181-110	Fire Panel Terminations	4/24/00	4/24/00	FM200-Fire Protection
DCN	H3181-123	Fuel Gas Control Valves	4/10/00	4/26/00	Fuel Gas
DCN	H3181-119	Hydrogen Cooled Generator Junction Box Drawings	4/10/00	5/4/00	H/CO
DCN	H3181-144	H2 Discharge Operator Modifications	5/16/00	5/16/00	H/CO
DCN	H3181-150	H2 Skid Transmitters	5/20/00	5/25/00	H/CO
DCN	H3181-151	Hydrogen Purge Pushbutton Circuit	5/20/00	5/20/00	H/CO
DCN	H3181-115	Replace 1A Fuses with 2A Fuses in Unit 1 & 2CCJP41	4/10/00	5/18/00	Startup & Commissioning
DCN	H3181-130	Remote Load Control Capability	5/19/00	5/19/00	Startup & Commissioning
DCN	H3181-130	Remote Load Control	5/23/00	5/23/00	Startup & Commissioning
DCN	H3181-116	Check Out I/O Points in Cabinet CJP01	4/10/00	5/2/00	Teleperm
DCN	H3181-126	Flight Recorder	4/10/00	4/29/00	Teleperm
DCN	H3181-111	BOP I/O Points/Fire Protection Alarm	4/21/00	4/21/00	Teleperm
DCN	H3181-135	Software Changes for Fuel Gas Supply (BOP)	5/8/00	5/9/00	Teleperm
DCN	H3181-136	Software Changes	5/8/00	5/8/00	Teleperm
DCN	H3181-137	Software Changes	5/10/00	5/10/00	Teleperm
DCN	H3181-138	Software Changes	5/9/00	5/9/00	Teleperm
DCN	H3181-139	Software Changes	5/10/00	5/10/00	Teleperm
DCN	H3181-140	Software Changes	5/10/00	5/10/00	Teleperm
DCN	H3181-141	Software Changes	5/22/00	5/25/00	Teleperm
DCN	H3181-146	11/12 MBP31, 32& 33AH001 Software Changes	5/23/00	5/23/00	Teleperm
DCN	H3181-112	Add Vibro-Meter Electronic Rack to 11CJQ Cabinet	4/21/00	5/2/00	Vibrometer
DCN	H3181-113	Add Vibro-Meter Electronic Rack to 12CJQ Cabinet	4/25/00	5/24/00	Vibrometer
DCN	H3181-119	Gen. MK Units 11 & 12	4/10/00	4/10/00	Other
DCN	H3181-121	Compressor Blowoff MBA 10AT001 (11 & 12)	4/10/00	5/19/00	Other
DCN	H3181-122	Delete AIC System	4/10/00	4/29/00	Other
DCN	H3181-128	Rev. of Orginal H3181-128	4/18/00	4/18/00	Other
DCN	H3181-132	Add Additional Inputs to Track TPC (BBE01)	4/21/00	4/21/00	Other
DCN	MO-0086	Turning Gear Vavle	4/24/00	4/24/00	Other
DCN	H3181-145	Fule Gas Supply	5/19/00	5/24/00	Other
DCN	H3181-147	Alarm for Units #11 & #12 4160 Gear	5/19/00	5/25/00	Other
DCN	H3181-143	Active Load System to CEM's	5/22/00	5/22/00	Other
DCN	H3181-153	Replacement DCN for DCN-138	5/30/00	5/30/00	Other



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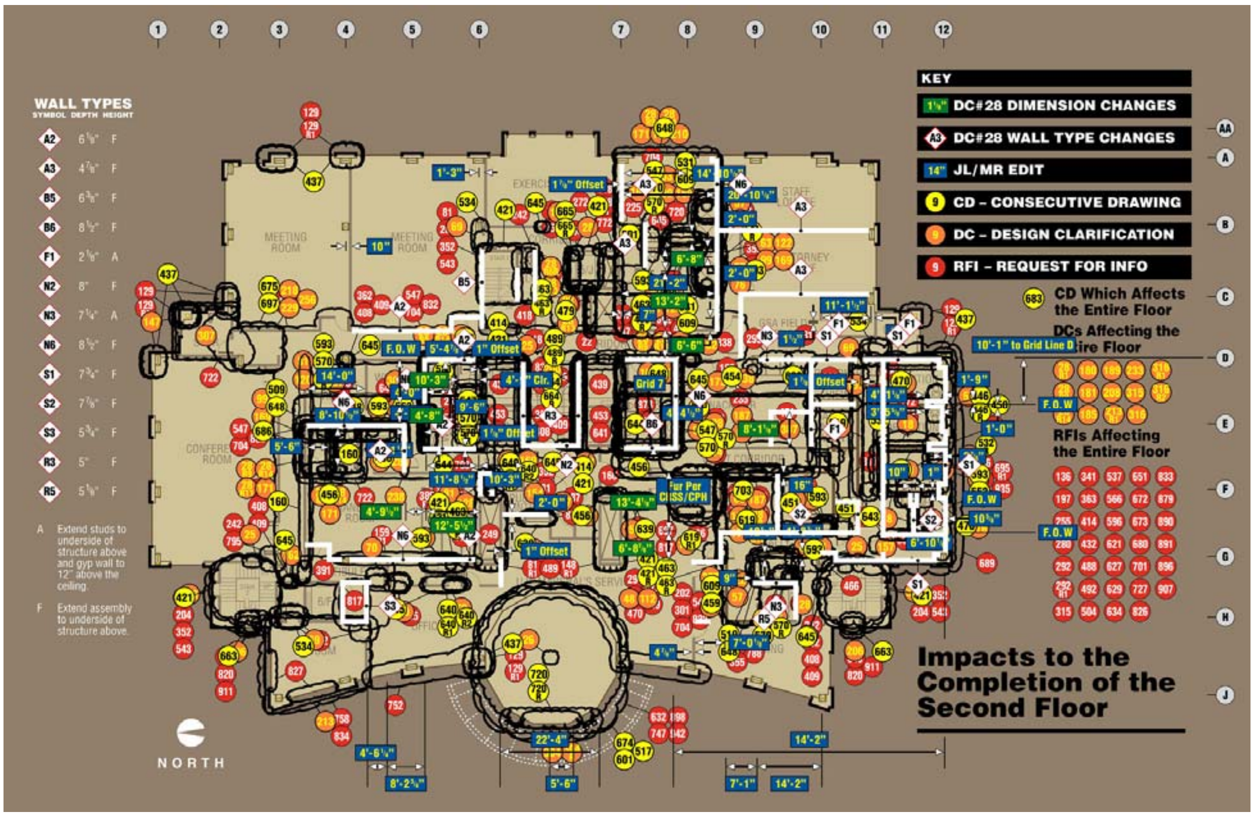
Another demonstrative graphic of impacts is shown by Figure 13, which plots the location of various types of impacts on the plan view of a building. This "Measles Chart" tells the story that the design problems that disrupted the construction contractor's work were significant and logically had to have a ripple effect on its labor productivity.

Figure 13
Multiple Impacts to Project



9. CONCLUSIONS

The construction and legal industries generally agree that a contractor can be damaged as a result of excessive changes on a project. Yet in the final analysis, it is extremely difficult to show proper proof and recover these costs, especially in arbitration or in court. While suggestions have been provided to help the contractor recover these costs, there is substantial effort and expense in preparing such a claim and the court's decision is understandably a subjective one. With this in mind, a contractor must carefully weigh the cost of preparing the analysis with its potential recovery.

If a contractor intends on recovering its loss of productivity costs, much of the proof needs to be documented during the project, through daily reports and detailed cost records. Because the contractor may not always know from the start of a project whether significant changes to its scope and resulting disruptions and productivity loss will occur, keeping such records should be a required procedure for record keeping on all projects. If the project turns out well and, therefore, the contractor was able to meet its planned productivity, that project may also serve as a measured mile on another highly impacted project where the scope of work is similar. The contractor must also provide sufficient notice to the owner and reserve its rights to submit the cumulative impact claim.

The contractor and its expert should employ, if possible, the measured mile method to quantify damages. If not, depending on the detail in the cost record, either the modified total cost method, the specific damages analysis method, or some combination of industry studies should be used. The claim submittal should focus on proving the cause-and-effect link, using graphics and detailed descriptions from the project record of the problems and their effects.

Cumulative Impact Claims

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