Change Orders In Illinois
Lost Productivity And Efficiency

Measurement Approaches

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Cumulative Impact - Definition

"The costs associated with impact on distant work, which are not as readily foreseeable or, if foreseeable, not as readily computable as direct impact costs. The source of such costs is the sheer number of and scope of changes to the contract. The result is an unanticipated loss of efficiency and productivity which increases the contractor's performance costs and usually extends his stay on the job."

What is Productivity

Productivity is a measurement of rate of output per unit of time or effort.

For example:

Productivity = Output / Input

Or

Productivity = Units / work-hours

Lost Productivity

Lost Productivity occurs when a contractor does not accomplish its anticipated rate of production. I.E. The contractor produces less than planned output per work hour of input.

Stated another way, the contractor expends more effort per unit of production than originally planned.

Production v *Productivity*

- Terms are not interchangeable
- *Production* is the measure of output.
- *Productivity* is the measure of production.
- A contractor can achieve its planned production without achieving its planned productivity.
- For example, a contractor could meet its planned production of pouring 1,000 cf of concrete per day, but expend twice the amount of planned labor to do so.

Why Measurement is Difficult

- Lost productivity is not easily detected at the onset.
- Productivity is often not tracked contemporaneously.
- Lost productivity is usually calculated at the end of a project.
- Baseline is often poorly documented.

Measurement Approaches

- Total Cost
- Modified Total Cost
- Industry Studies
- Project Comparison Studies
- “Measured Mile”
- “Earned Value”
- Specific Allocation

Total Cost Method

Total Hours Incurred	4,688
Less Hours Estimated	(3,600)
Excess Hours	1,088
Average Labor Rate	$ 50
Total Claimed	$ 54,400

Modified Total Cost

Total Hour Incurred		4,688
Less Hours Estimated		(3,600)
Excess Hours		1,088
Less:	Change Orders	(100)
	Hours Under Bid	(150)
	Less XYZ's Errors	(75)
Net Excess Hours		763
Average Labor Rate		$ 50
Total Claimed		$ 38,150

Industry Studies

Month	Hours	Inefficiency % [1]	Excess Hours
Jan '02	200	5%	10.0
Feb '02	250	5%	12.5
Mar '02	400	10%	40.0
Apr '02	480	20%	96.0
May '02	460	20%	92.0
June '02	500	25%	125.0
Total Excess Hours			375.5
Average Rate			$ 60.00
Total Claimed			$ 22,530.00

[1] Per XYZ Association Study, Stacking of Trades typically results in inefficiencies in the range of 5% to 25%

Measured Mile

Unimpacted Period		
Jan thru March '02		
	Total Hours Incurred	2,400.00
	Feet of Pipe Run	10,000.00
	Hours per Foot	0.24
Impacted Period		
April through December		
	Total Hours Incurred	12,000.00
	Feet of Pipe Run	30,000.00
	Hours Per Foot	0.40
Excess Hours Per Foot During Impacted Period		0.16
# of Impacted Feet Run		30,000.00
Excess Labor Hours		4,800.00
Average Labor Rate		$ 55.00
		$ 264,000.00

Earned Value Method

- Earned Value analysis is a method for measuring project performance. It indicates how much of the budget should have been spent in view of the amount of work done so far and the baseline costs for the tasks, assignments, or resources.

Most Common Measurements:

- *Schedule Variance* is a subjective indicator that does not reveal the critical path. A positive schedule variance is an indication that work in process is ahead of schedule.

- *Cost Variance* is an objective indicator stating the value of what was accomplished for the resources expended. A positive cost variance indicates that work was accomplished with less resources than planned

Most Common Measurements:

- Cost Variance:
  CV = Budget Cost of Work Performed (BCWP)
  - Actual Cost of Work Performed (ACWP)

- Cost Performance Index:
  CPI = BCWP/ACWP

- Cost Variance Percentage:
  CV% = (BCWP – ACWP) / BCWP

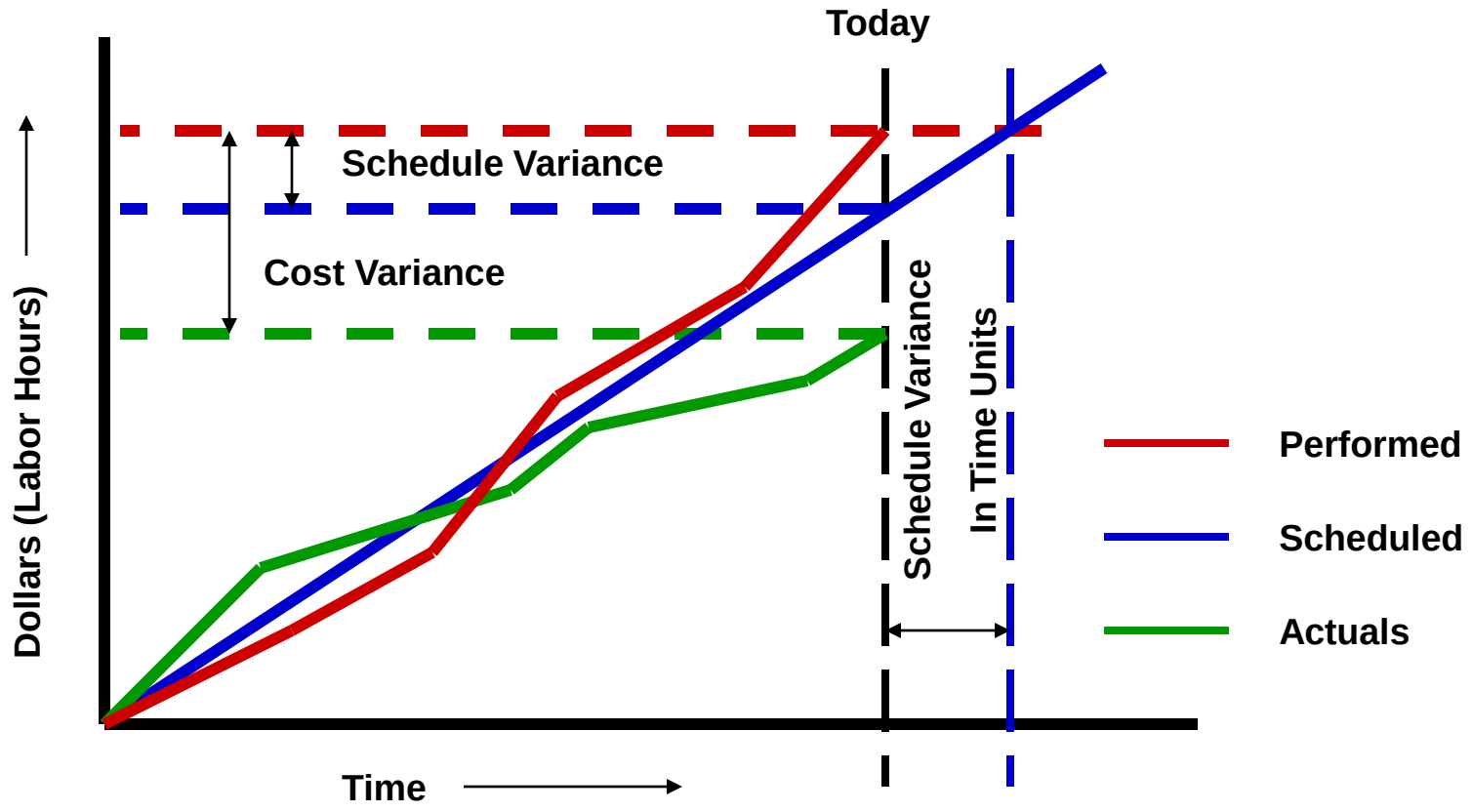
Most Common Measurements:

- Schedule Variance:
  SV = Budget Cost of Work Performed (BCWP)
  - Budget Cost of Work Scheduled (BCWS)

- Schedule Performance Index:
  SPI = BCWP/BCWS

- Schedule Variance Percentage:
  SV% = (BCWP – BCWS) / BCWS

Schedule and Cost Variances



Earned Value Measurement of Lost Labor Productivity:

- Unimpacted Period Sample Data:
  Budgeted Cost of Work Scheduled = $80,000
  Budgeted Cost of Work Performed = $92,000
  Actual Cost of Work Performed = $90,000

- Schedule Performance Index:
  SPI = $92,000/$80,000 = 1.15 (ahead of schedule)
- Labor Cost Performance Index:
  CPI = $92,000/$90,000 = 1.02

Earned Value Measurement of Lost Labor Productivity:

- Impacted Period Sample Data:
  Budgeted Cost of Work Scheduled= $160,000
  Budgeted Cost of Work Performed = $150,000
  Actual Cost of Work Performed = $180,000

- Schedule Performance Index:
  SPI = $150,000/$160,000 = 0.94 (behind schedule)
- Labor Cost Performance Index:
  CPI = $150,000/$180,000 = 0.83

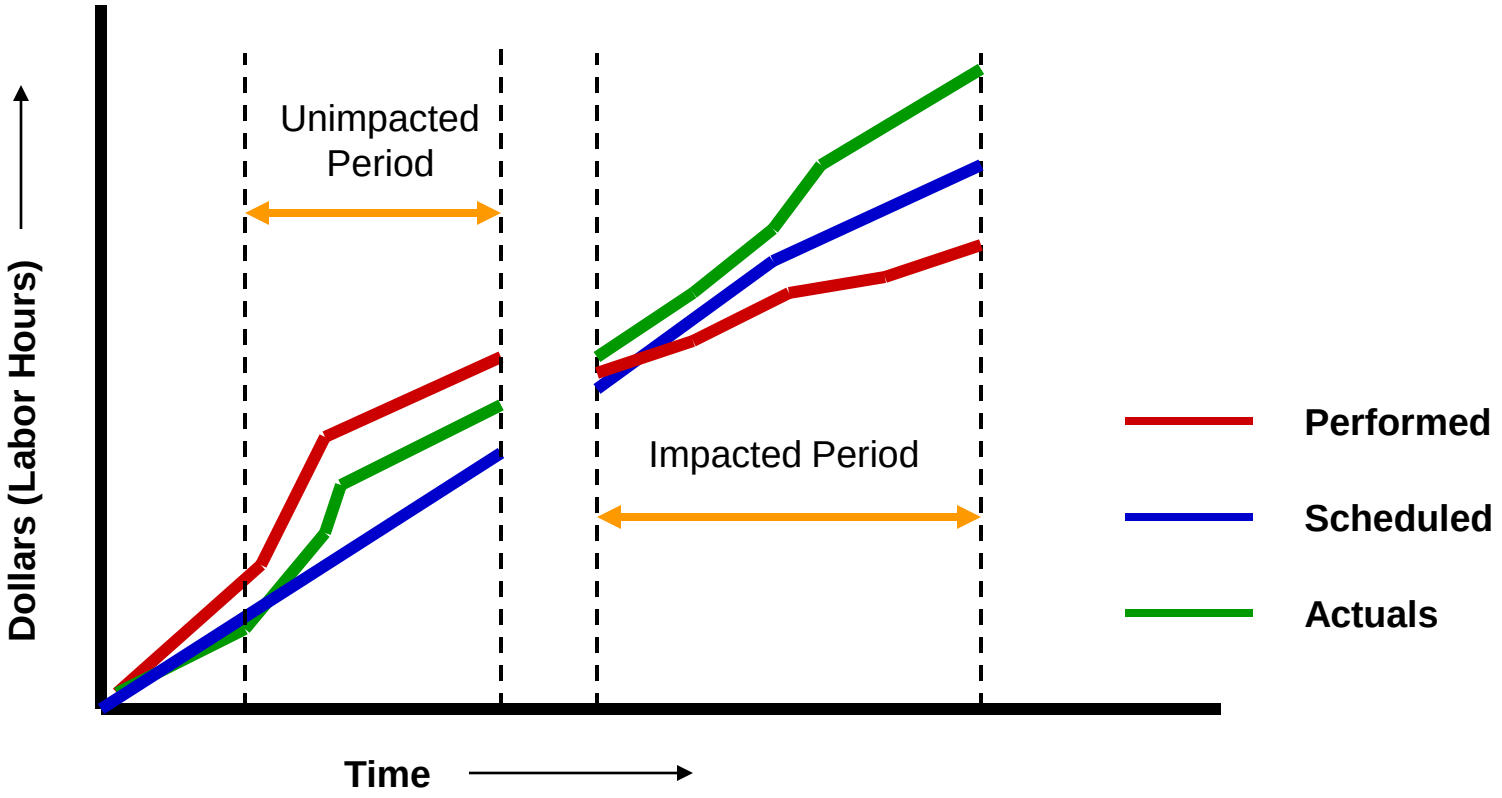
Earned Value Measurement of Lost Labor Productivity:

- Unimpacted versus Impacted Period Comparison:

  Unimpacted Cost Performance Index = 1.02
  Less
  Impacted Cost Performance Index = 0.83
  Lost Productivity 0.19

- Lost Labor Productivity Cost:
  0.19 x $180,000 = $34,200

Labor Productivity Measurement



Specific Allocation

Issues Requiring System Specialist Time Beyond Scope

Expanded Fuel Oil Wiring	30.00	hrs
Incorrectly Installed Return Isolation Dampers	18.00	hrs
Open & Close Floor to Install Sensors	516.00	hrs
Manually Opening Cooling Control Valves	54.00	hrs
Out of Sequence Installation of VAV's & FPB's on Floors 2-6	60.00	hrs
Low Voltage at Panels in areas B & C on Floors 3, 4, & 5	30.00	hrs
Total Excess System Specialist Hours	708.00	hrs
Hourly Rate	$ 81.00	
Total Excess System Specialist Labor	$57,348.00	

Lost Productivity and Efficiency

Ranking of Best Practices

AACE Recommended Practice No. 25R-03

The Association for the Advancement of Cost Engineering's Recommended Practice No. 25R-03 identifies lost productivity estimating methodologies, ranks the methodologies in order of preference, defines and discusses each methodology, and identifies selected studies applicable to each methodology.

Common Causes of Lost Productivity

- Absenteeism and the Missing Man Syndrome
- Acceleration
- Adverse or Unusually Sever Weather
- Availability of Skilled labor
- Changes, Ripple Impact, Cumulative Impact of Multiple Changes and Rework
- Competition for Craft Labor
- Craft Turnover
- Crowding of Labor or Stacking of Trades

Common Causes of Lost Productivity (con't)

- Defective Engineering, Engineering Recycle and/or Rework
- Dilution of Supervision
- Excessive Overtime
- Failure to Coordinate
- Fatigue
- Labor relations and labor management factors
- Learning Curve
- Material, Tools, and Equipment Shortages
- Over manning

Common Causes of Lost Productivity (con't)

- Poor morale of craft labor
- Project management factors
- Out of sequence work
- Rework and errors
- Schedule Compression Impacts on Productivity
- Site or work area access restrictions
- Site Conditions
- Untimely approvals or responses

Preferred Methodologies
Order of Preference

1. Project Specific Studies
2. Project Comparison Studies
3. Specialty Industry Studies
4. General Industry Studies
5. Cost Basis

Project Specific Studies

Damage calculations based directly on data from the project in dispute and supported by contemporaneous documentation are most favorably received by courts and board of appeal.

Project Specific Studies

- Measured Mile Study
- Earned Value Analysis
- Work Sampling Method
- Craftsmen Questionnaire Sampling Method

Work Sampling Method

The work sampling method involves the claims analyst making numerous direct observations of work activities.

Statistically valid sampling techniques are used to determine how much time is spent between direct work, support work and delays/disruptions.

Craftsmen Questionnaire Sampling Method

This method involves preparing a questionnaire and providing it to the craftsmen in the field during the lost productivity period.

The questionnaire allows the craftsmen to estimate the amount of lost productivity on a daily or weekly basis, identifying the causes of the lost time.

Project Comparison Studies

When there is insufficient contemporaneous project documentation available to support a *Project Specific* Study, AACE recommends a *Project Comparison* study as the next best alternative.

Project Comparison Studies

Comparable Work Study

Compares productivity of one work activity to a similar work activity on the *same* project.

Comparable Project Study

Compares productivity on one project to productivity achieved on a *similar* project.

Specialty Industry Studies

When there is insufficient contemporaneous project documentation to allow for use of a Project Specific or Project Comparison study, AACE recommends use of an appropriate Specialty Industry study.

The primary differences between Specialty Industry Studies and General Industry studies are the Specialty studies are subject specific, limited to a specific industry, and based upon a small number of specific projects rather than a generalized survey of the industry.

Specialty Industry Studies

- Acceleration
  - Construction Industry Institute, CII Research Summary RS 41-1, *Schedule Reduction Executive Summary,* Austin, Texas, April 1995
  - NECA, *Electrical Construction Peak Workforce Report,* 2nd Edition, Washington D.C., 1987
- Changes, Cumulative Impact and Rework
  - Leonard, Charles A., *The Effects of Change Orders on Productivity,* Concordia University, Montreal, Quebec, April 14, 1987
  - Mechanical Contractors Association of America, *Change Orders, Overtime and Productivity,* Publication M3, Rockville, MD., 1968
- Learning Curve
  - Cass, Donald J., *Labor Productivity Impact of Varying Crew Levels,* C.2.1, AACEI Transactions, 1992
  - Emir, Zey, Learning Curve in Construction, Revay Reports, Vol. 18, No. 3, October 1999.

Specialty Industry Studies

- Overtime and Shift Work
  - Adrian, James J., *Construction Productivity Improvement,* Elsevier Science Publishing, New York, 1987.
  - Business Roundtable, *Effect of Scheduled Overtime on Construction Projects-coming to Grips with Some Major Problems in the Construction Industry, New York, 1974.*
- Project Characteristics
  - Construction Industry Institute, *Engineering Productivity Measurement*, CII Research Summary RS156-1, Austin, TX, December 2001.
  - Merrow, Edward W., *Understanding the Outcome of Mega Projects: A Quantitative Analysis of Very Large Civil Projects,* March 1988.

Specialty Industry Studies

- Project Management
  - Chitester, David D., *A Model for Analyzing Jobsite Productivity,* C.3.1, AACEI Transactions, 1992.
  - Thomas, H. Randolph, Jr., Victor E. Sanvido and Steve R. Sanders, *Impact of Materials Management on Productivity,* Journal of Construction Engineering and Management, Vol.115, No. 3, Sep 1989.
- Weather
  - U.S. Army Cold region Research and Engineering Laboratory, *Impact of Climatic Conditions on Productivity*, Hanover, N.H., 1987.
  - National Electrical Contractors Association, *The Effect of Temperature on Productivity*, Washington, D.C. 1974

General Industry Studies

In situations where there is insufficient contemporaneous documentation to support either a project specific or project comparison study and the lost productivity stems from numerous or non-specific factors, the AACE recommended practice is to utilize an appropriate General Industry Study.

General Industry Studies

- U.S. Army Corps of Engineers, *Modification Impact Evaluation Guide,* EP 415-1-3, Department of the Army, Office of Chief of Engineers, Washington, D.C., July 1979
- Mechanical Contractor's Association of America (MCAA), *Labor Estimating Manual: Appendix B, Factors Effecting Productivity,* Rockville, MD., August 1988.
- National Electrical Contractor's Association (NECA), *Manual of Labor Units,* Bethesda, MD., 1976 and 2003.

Cost Basis

When there is insufficient documentation to support any of the previously discussed techniques, the AACE recommends employing one of the Cost Basis Methods.

However, contractors should bear in mind that there are significant legal hurdles to overcome for use of a cost basis methodology.

Cost Basis

To use a Cost Basis, the courts generally require that:

1. The nature of the losses make it impractical, if not impossible, to determine damages in a more particular manner.
2. The contractor's estimate was reasonable.
3. The contractor's actual costs were reasonable.
4. The contractor was not responsible for any of the events leading to the loss of productivity.

Cost Basis

- Total Unit Cost Method
- Modified Total Labor Cost Method
- Total Labor Cost Method

Total Unit Cost Method

Unimpacted Period:

Total Costs Incurred	$100,000
Total Units Installed	1,000
Cost Per Unit	$100

Impacted Period:

Total Costs Incurred	$160,000
Total Units Installed	1,300
Cost Per Unit	$123

Lost Productivity Per Unit	$ 23
Total Impact ($23 x 1,300)	$ 29,900

Lost Productivity And Efficiency

Understanding Cumulative Impact

Cumulative Impact - Definition

"The costs associated with impact on distant work, which are not as readily foreseeable or, if foreseeable, not as readily computable as direct impact costs. The source of such costs is the sheer number of and scope of changes to the contract. The result is an unanticipated loss of efficiency and productivity which increases the contractor's performance costs and usually extends his stay on the job."

Cumulative Impact - Components

- The dilution of supervision
- Out-of-sequence work
- Piecemeal work
- Reassignment of manpower
- Loss of learning
- Stacking of trades
- Change order/Request for information processing time
- Material lead time
- Rework
- Morale and attitude
- Clean up

Cumulative Impact – Quantification

- Methodology developed jointly by:
  - Construction Industry Institute
  - Electrical Contracting Foundation
  - Mechanical Contracting Foundation

Cumulative Impact – Quantification

- First Step –

  What is the probability of being affected?

Evaluation of Probability of Being Affected by Change

	Factor A	Value B	Coefficient C	Product D = BxC
1	**Constant**	1.00	-6.9970	-6.9970
2	**Electrical or Not Electrical** 1 if electrical, 0 if not electrical	1.00	-1.0939	-1.0939
3	Percent Change Percent change as a decimal	0.14	3.8890	0.5445
4	**Estimated/Actual Peak Manpower** Estimated Peak Manpower = 35 Actual Peak Manpower = 50 Estimated / Peak = 0.70	0.70	-1.0371	-0.7260
5	**Change Order Processing Time** Period of time between initiation of the change order and the owner's approval 1 = 1-7 days 2 = 8-14 days 3 = 15-21 days 4 = 22-28 days 5 = Greater than 28 days	3.00	0.6342	1.9026
6	**Overmanning** 1 if overmanning occurred on project, otherwise 0	1.00	2.6433	2.6433
7	**Overtime** 1 if overtime was used to complete change order work on project, otherwise 0	1.00	1.1933	1.1933
8	**Peak Manpower / Average Manpower** Peak Manpower = 50 Average Manpower = 22 Peak / Average = 2.3	2.30	1.2048	2.7710
9	**Percent Change Orders Related to Design Issues**	100.00	0.0172	1.7200
	SUM			1.9578

Cumulative Impact – Quantification

- Inserting the sum from the table, 1.9578 into the equation below yields the probability of project being affected by change:

Probability of being affected =

$$= e^{1.9578}/(1 + e^{1.9578}) = 0.876$$

Cumulative Impact – Quantification

- Second Step –

  Quantify cumulative impact of change

  Lost Efficiency = 0.37 + 0.12 x Percent Change –
  - 0.08 x PM % Time on Project – 0.17 x % Owner
  Initiated CO – 0.09 x Productivity – 0.05 x Overmanning
  + 0.02 x Processing Time

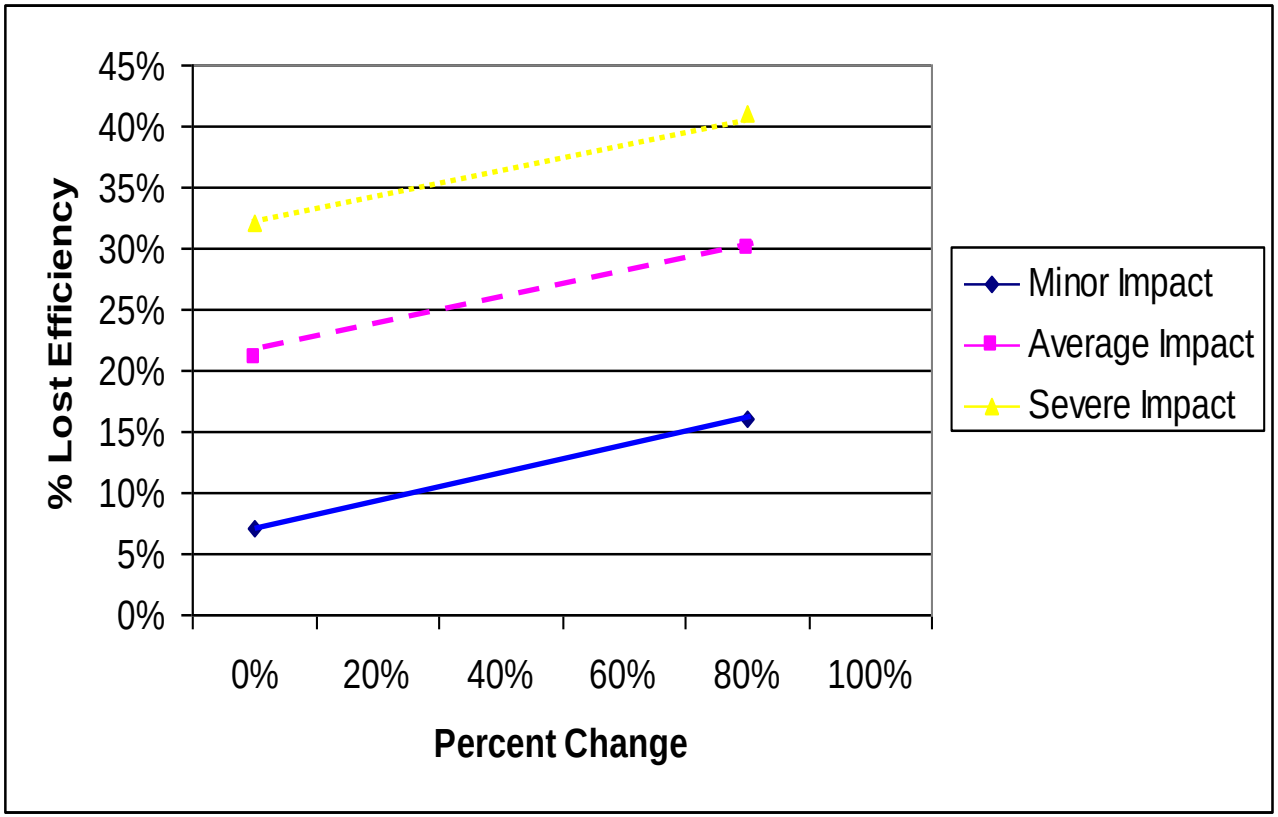
Description of Cumulative Impact Quantification Equation

Factor	Definition
Percent Change	Percentage of Change experienced on the Project in relation to Original Budgeted Man-Hours (0.025 to 0.90)
PM % Time on Project	Percentage of Time spent on the Project by the Project Manager (0.04 to 1.00)
% Owner-Initiated CO	Percentage of the Change Orders Initiated by the Owner (0.00 to 1.00)
Productivity	Did you track productivity [input (manhours) / output (units installed)] ? (0 = No, 1 = Yes)
Overmanning	Did Overmaning occur on the Project? (0 = No, 1 = Yes)
Processing Time	Period of time between initiation of the change order and the owner's approval 1 = 1 -7 days 2 = 8 -14 days 3 = 15 - 21 days 4 = 22 - 28 days 5 = Greater than 28 days

Description of Cumulative Impact Quantification Equation

	Range	Severe	Average	Minor
Percent Change	2.5% to 90%			
PM % Time on Project	4% to 100%	30%	60%	90%
% Owner-Initiated CO	0% to 100%	50%	75%	95%
Productivity Tracked	0 = No, 1 = Yes	0	0	1
Overmanning	0 = No, 1 = Yes	1	1	0
Processing Time	1, 2, 3, 4, or 5	5	3	1

Cumulative Impact of Change Orders - Approximation



Cumulative Impact - Conclusion

If the primary reason for inefficiency on a project is believed to be the exorbitant number and magnitude of change orders, the cumulative impact approach is best in determining all of the losses resulting from productivity inefficiencies. Conversely, if the primary reason for inefficiency on a project is believed to be the use of overtime, overmanning, and shift work, among other things, the individual factors approach should be employed to calculate the productivity inefficiencies.

Lost Productivity And Efficiency

Recovery of Home Office Overhead

Home Office Overhead Defined

A *Home Office* exists to run a business and to support all the projects in progress. Its costs are real, but are not directly associated with a particular project

Home Office Overhead - Examples

- Executive and Administrative Salaries
- Rent
- Utilities
- Furnishings
- Office Equipment
- Marketing/Advertising
- Interest on Company’s Borrowings
- Real Estate Taxes
- Legal and Accounting Expenses

Profitability Formula

Project Revenue

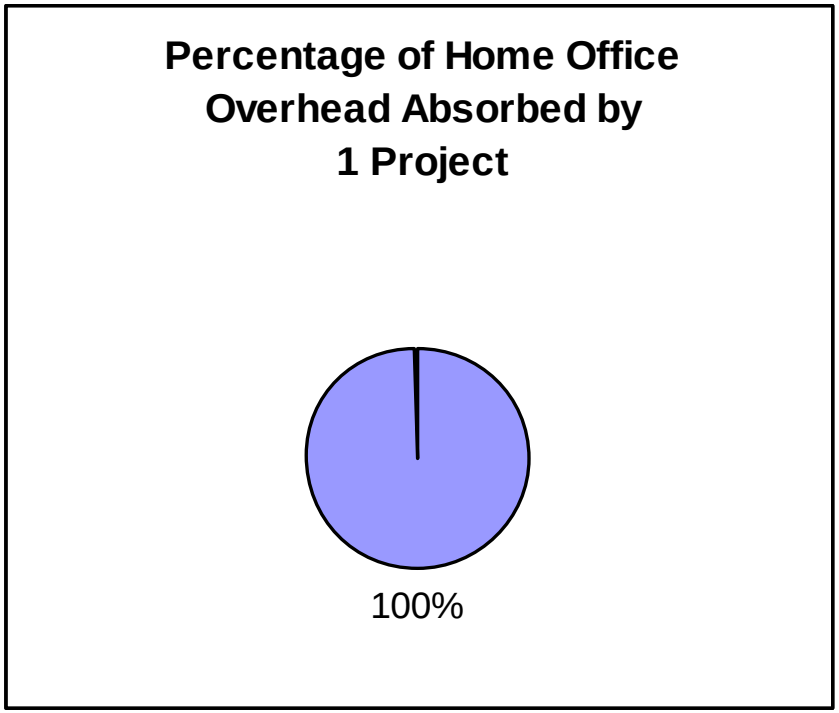
Less:

- Direct Cost
- Field Overhead
- Home Office Overhead

Equals: Profit

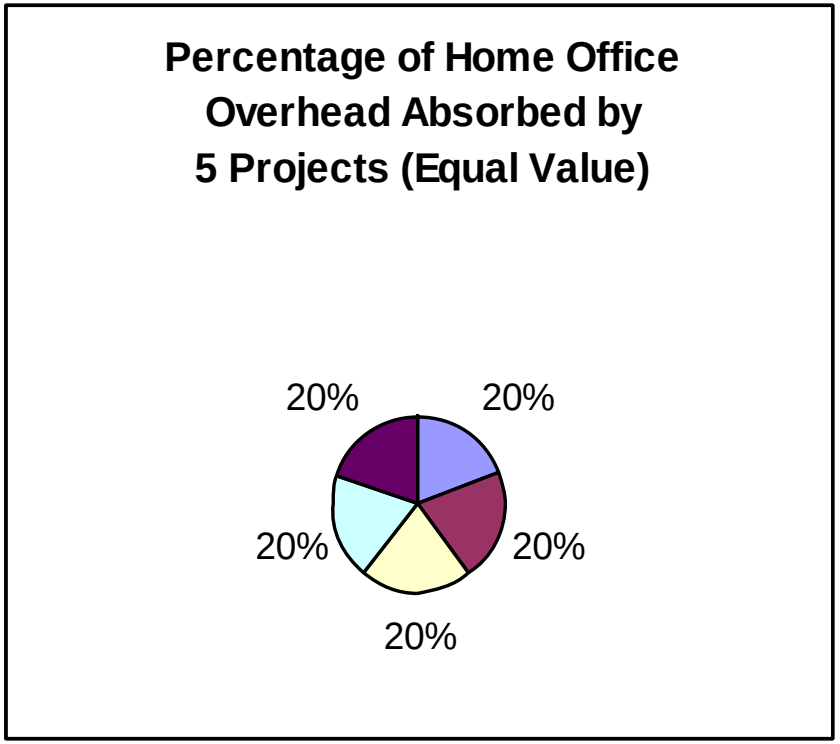
Home Office Overhead Absorption

- 1 Project Example
  - When a contractor performs one project at a time, that project needs to pay for (absorb) 100% of Home Office Cost



Home Office Overhead Absorption

- 5 Projects Example
  - When there are five projects of equal value and duration, each would need to pay for (absorb) 20% of Home Office Cost



When a Project is Delayed

- One Project Example
  - Home Office Overhead: $60,000/year($5,000/month)
  - Contract Value: $1,166,000 (1 year duration)
  - Direct Cost: $1,000,000
  - OH Rate: 6% ($60,000/$1,000,000)

- 1 month delay causes an additional $5,000 Home Office Overhead Expense for a total of $65,000. If the contract amount stays unchanged at $1,000,000, the contractor experiences $5,000 of unabsorbed Home Office Overhead Cost for which it is not being compensated.

When a Project is Delayed

- Five Projects Example
  - Home Office Overhead: $600,000/year($50,000/month)
  - Contract Value: $2,332,000 (1 year duration)
  - Direct Cost: $2,000,000 (each)
  - OH Rate: 6% ($600,000/$10,000,000)
  - Each Project Absorbs: $120,000/year ($10,000/month)

- 1 month delay on one project results in an additional $10,000 of Home Office Overhead Expense allocable to that project. If the contract amount stays unchanged at $2,000,000, the contractor experiences $10,000 of unabsorbed Home Office Overhead for which it is not being compensated.

Home Office Overhead Absorption

- Reality Check
  - Multiple Projects
  - Varying Direct Costs
  - Range of Durations
  - Varying level of Home Office Support
- Overhead Rates computed using historical data are applied to future projects

Overhead Allocation Challenge

- Actual OH Cost Allocation
  - Burdensome
  - Home Office Costs cannot be linked to any specific project:
    - Marketing/advertising
    - Executive salaries
    - Rent and utilities
- Need to use Estimating Formulas

Eichleay Formula

- Most widely accepted
  - Federal Courts
  - Numerous state courts
  - Private arbitration
- Originated in 1960 from an Armed Services Board of Contract Appeals Decision.

Eichleay Formula

Three Steps:

1. Allocable Overhead =
   (Total Contract Billings/Total Company Billings) x
   Total Home Office Overhead

2. Daily Allocable Overhead Rate =
   Allocable Overhead/No. of Days of Contract Performance

3. Extended Home Office Overhead =
   Daily Allocable OH Rate x No. of Days of Compensable Delay

Eichleay Formula – Variation 1

Three Steps:

1. Allocable Overhead =
   (Contract Billings/
   Company Billings during Original Contract Period) x
   Total Home Office Overhead during Original Contract Period

2. Daily Allocable Overhead Rate =
   Allocable Overhead/
   No. of Original Days of Contract Performance

3. Extended Home Office Overhead =
   Daily Allocable OH Rate x No. of Days of Compensable Delay

Eichleay Formula – Variation 2

Three Steps:

1. Allocable Overhead =

   (Contract Billings/

   Total Company Billings for Original Period + Contract Billings during Extended Period) x

   Total Home Office Overhead during Original Contract Period

2. Daily Allocable Overhead Rate =

   Allocable Overhead/

   No. of Original Days of Contract Performance

3. Extended Home Office Overhead Damages =

   Daily Allocable OH Rate x No. of Days of Compensable Delay

Other Estimating Formulas…

- Manshul (*Direct Contract Cost Allocation)*

  (Cost of Work during Delay) x (Contract Cost %/(Cost + Markup%)) =

  = Direct Cost

  (Direct Cost) x Home Office OH% = Home Office OH owed

- Hudson (*Canadian Method)*

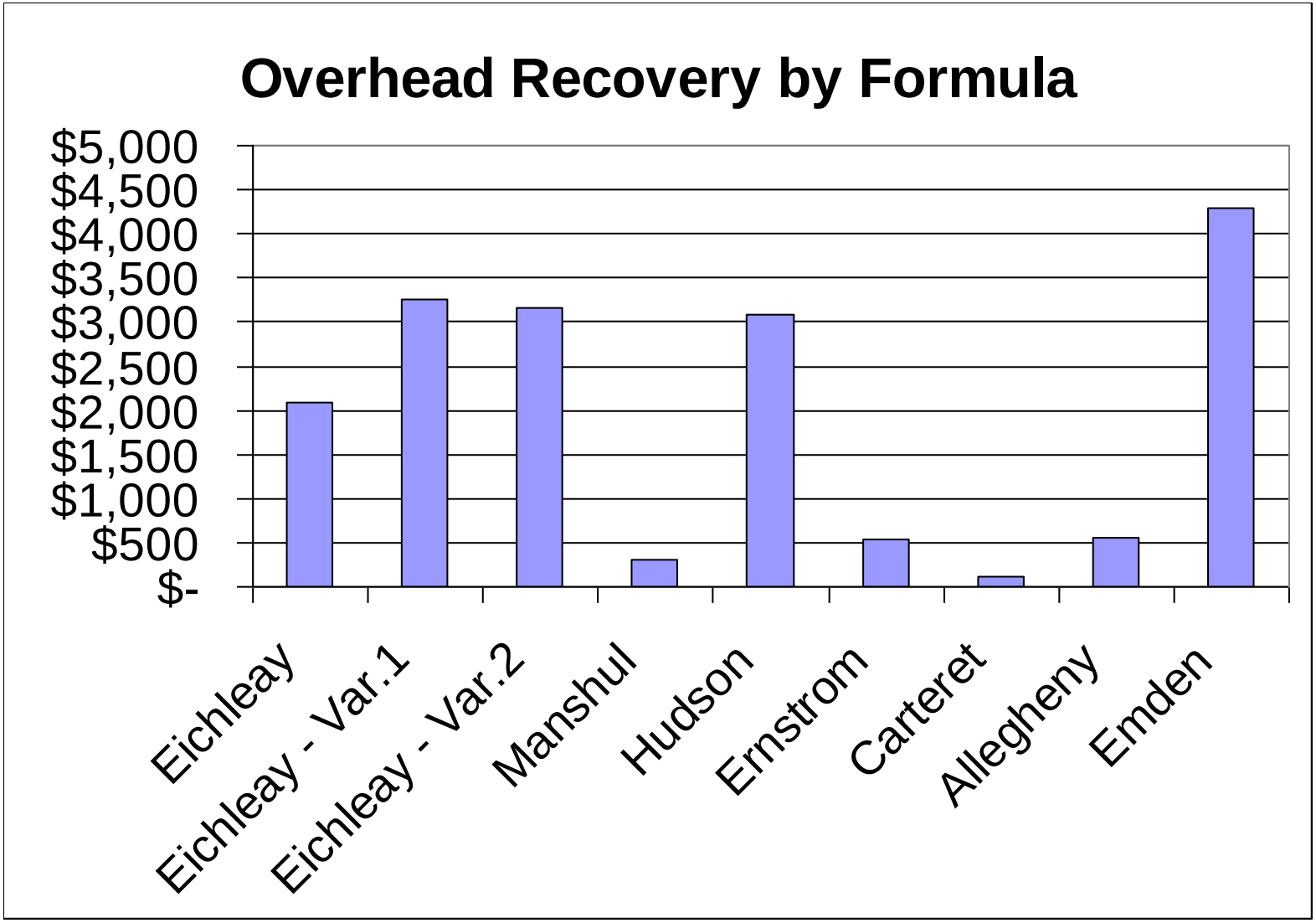
  (Planned Home Office OH & P%) x (Original Contract/Original Duration) =

  = Allocable OH per day

  (Allocable OH per day) x Period of Delay = Home Office OH owed

- Ernstrom
- Carteret (*adopted from manufacturing)*
- Allegheny
- Emden

… and Range of Results they Produce*



Based on the Following Sample Project Data:*

- Firm Financials:
  - Total Revenue: $628M (performance period)
  - Total Overhead:$ 45M (performance period)
- Contract:
  - Original Contract: $68M
  - Planned Duration: 365 cd
  - Owner caused Delay: 235 cd

* *Sample project data and OH damages computation results adopted from the presentation "Calculation and Recovery of Home/Head Office Overhead" by James G. Zack, Jr.*

Entitlement – Raising the Bar

- Three-Part Test as a Prerequisite to apply Eichleay Formula *(required by Courts until recently):*
  - The existence of “compensable delay”
  - The contractor must be on “standby”
  - The contractor must be unable to take other work

Entitlement – Raising the Bar

P.J.Dick Inc. v. Dept of Veteran Affairs

Six questions to ask contractor:

1. Was there a government caused delay that was not concurrent with delay caused by others?

2. Did contractor demonstrate that it incurred additional overhead costs?

3. Did the government CO issue a suspension or other order expressly putting the contractor on standby?

Entitlement – Raising the Bar

P.J.Dick Inc. v. Dept of Veteran Affairs

Six questions to ask contractor continued:

4. If not, can the contractor prove there was a substantial delay of indefinite duration during which it could not bill substantial amounts of work on the contract and at the end of which it was required to be able to return to work full time and immediately?

5. Can the government show that it was not impractical for the contractor to take on replacement work (i.e. new contract) and thereby mitigate its damages?

6. If the government meets its burden of production set in Question # 5, can the contractor show that it was impractical for it to obtain replacement work?

Entitlement – Raising the Bar

P.J.Dick Inc. v. Dept of Veteran Affairs

Further clarification of “standby” from Question 4:

> Unless there is an express order from the CO putting the contractor on standby, the contractor must prove:
>
> – The government delay was not only substantial but was of indefinite duration
> – The contractor was required to be ready to resume full work immediately
> – The effective suspension on much, if not all, of the work on the contract.

Entitlement – Controversial Points

- The difference between “suspension” period versus “delay” period.
  - “suspension” does not automatically lead to extension of time.
- The power of the “no damage for delay” clause; can it prevent recovery under Eichleay?

Entitlement – Controversial Points

- “Credits” are due when:
  - The contractor performs change order work that provides for some extension of time
  - The contractor re-assigns some of its work force to perform replacement work

Practical Suggestions

- Document planned schedules
- Document the cause of the delay, including factors adding to its uncertainty
- Document efforts to obtain replacement work
  - If successful, maintain separate accounting of this work to compute the amount of “absorbed” overhead
- Build in a compensation for Extended Home Office OH into the contract language