Proposed Improvements to the MCAA Method for Quantifying Construction Loss of Productivity

Executive Summary

Project changes are often encountered in construction industry. They can hurt construction craft labor productivity and can cause significant financial loss. Such losses are called loss of productivity (LOP). Calculating a project's LOP is one of the most important and contentious areas in construction disputes and claims.

Several ways to calculate productivity loss exist. One method is the MCAA (Mechanical Contractors Association of America) Factor method. Recognizing the importance and vulnerability of productivity to a wide array of project conditions and the value of having an easy-to-use method for calculating Loss of Productivity (LOP), MCAA developed a table of factors that can impact labor productivity. It has been in use for over forty years and has gained wide acceptance in the construction industry and before various Courts and Boards of contract appeals. But the model has been rejected in several recent claims.

The aim of this thesis is to offer improvements to the existing MCAA model. We document the MCAA model's history, identify typical mistakes made in its application, and compare it with other LOP studies and previous legal case decisions.

Those problems fall into two categories: 1) application problems, which are matters of how users apply the model, and 2) structural problems. The structural problems include 1) lack of guidelines to select factors and prove causation; 2) unclear definitions of what these factors mean and how they can affect labor productivity; and 3) the manual's recommendations of loss percentages are not verified by real project data. After analyzing those problems, we developed and now offer suggested improvements to the model.

Specifically, we found fourteen board and court cases related to LOP that have used the MCAA method. The MCAA method has been used many times during the past twenty years, but the success rate for plaintiffs has generally declined in recent times. Prior to 2000, the model was successfully used in five of five published cases; since 2001 it has been successful in only two of nine cases. One possible explanation for this trend is that Boards and Courts have recently imposed a more stringent standard for proving LOP claims.

In terms of application problems, we found that:

1) Establishing causation is paramount in convincing triers-of-fact that a LOP claims exists.

2) Users of the MCAA model should not blindly rely on the single-point LOP damage percentages contained in the manual. Temper them with professional judgment and a full understanding of the project facts. Include testimony from experience fact witnesses if they are available. Include testimony from expert witnesses who are familiar with LOP claims in general and the MCAA model in particular.

3) Use fewer Factors rather than more. Successful claims used an average of four factors while unsuccessful claims used nine. Season and Weather Change, Stacking of Trades, Site Access, and Overtime were the Factors most likely to be persuasive. Least likely to be persuasive were Errors and Omissions, Joint Occupancy, Ripple, and Logistics.

From the perspective of the model's structural problems, we recommend that:

1) Cause-Effect maps be used as a supplement to the MCAA model analysis to graphically depict causation and liability.

2) The MCAA Factors be more clearly defined. Some MCAA Factor definitions are vague, duplicative, and do not clearly explain how they affect labor productivity. We offer new language for all sixteen Factors that will address this deficiency.

3) The minor-average-severe single-point LOP percentages specified for the MCAA table need to be refined for some of the Factors, as detailed in Table 1 below. For instance:

    a. We analyzed weather data from previous research studies and developed a better formula for predicting LOP across a range of temperature and humidity values.
    b. We determined learning curve models should be used with caution, only for repetitive work, and for unit or moving average data. Avoid use of cumulative average productivity data.
    c. For overtime, the multiplier values presented in curvilinear fashion by The Business Roundtable, Bromberg, O'Connor, and other researchers are more realistic than the 10%, 20%, and 30% values contained in the current MCAA model.

In conclusion, the MCAA model is a valuable tool for parties trying to assess construction craft LOP. However, it has not fundamentally changed since its introduction forty years ago, and subsequent research and industry practice have advanced our understanding of loss of productivity. The work presented in this document helps to advance the model and make

it more useful to contractors, owners, and consultants.

MCAA Original Definitions	Proposed Improvements on the Definition			MCAA Original Quantification Value			Proposed Quantification
	Definition	Effect on Productivity	Other Remarks	Minor	Average	Severe	
F1 STACKING OF TRADES: Operations take place within physically limited space with other contractors. Results in congestion of personnel, inability to locate tools conveniently, increased loss of tools, additional safety hazards, and increased visitors. Optimum crew size cannot be utilized.	STACKING OF TRADES: Stacking of several trades (the contractor's own work force or with those of other contractors) in the same working area, or work to be performed while facility occupied by other trades; Not anticipated in original bid.	1) Extra work or procedures needed when working with or right after other trades; 2) Site access and logistics problem: limited site access due to storage of materials /equipment; inability to locate tools conveniently; or another trade leaves the work incomplete, preventing the contractor from doing his own work; and 3) Congestion of personnel: more people working in the same area causing extra movement of people, physical conflict, constraints	Related to Beneficial Occupancy, Crew Size Inefficiency, Site Access, and Logistics.	10%	20%	30%	See Figure 7.6 of Ibbs and Sun Technical Report.

		and extra standby time.					
MORALE AND ATTITUDE: Excessive hazard, competition for overtime, over-inspection, multiple contract changes and rework, disruption of labor rhythm and scheduling, poor site conditions, etc.	MORALE AND ATTITUDE: Lower level of labor motivation and enthusiasm for achieving project objectives.	Lower work speed and extra errors and corrections.	Use is not recommended. Boards and courts have generally not accepted. Lower morale can be caused by other MCAA Factors and is closely related to the contractor's management. Hard to establish liability and causation.	5%	15%	30%	Granted amounts in previous cases are small (typically 5%).
REASSIGNMENT OF MANPOWER: Loss occurs with move-on, move-off men because of unexpected changes, excessive changes, or demand to expedite or reschedule completion of certain work phases. Preparation not possible for orderly	REASSIGNMENT OF MANPOWER: Transferring workers from one task to another due to blockages to current work. Workers need to jump frequently to other works and work on a	Time spent on extra movement.	Related to out-of-sequence work and Learning Curve.	5%	10%	15%	Related to Learning Curve. Productivity level can be calculated based on number of units using Learning Curve model in Section 7.2 of Ibbs and Sun Technical Report.

change.	stop-and-start basis.						
CREW SIZE INEFFICIENCY: Additional workers to existing crews "breaks up" original team effort, affects labor rhythm. Also applies to basic contract hours.	CREW SIZE INEFFICIENCY: Adding more manpower to existing construction work.	1) Congestion of personnel: physical conflict and high density of labor; 2) Dilution of Supervision; and 3) Logistics problems such as material, tool and equipment shortage.	Related to Stacking of Trades, Dilution of Supervision, and Logistics.	10%	20%	30%	LOP can be calculated through overstaffing level; see Figure 7.5. Or crowding level; see Figure 7.6.
CONCURRENT OPERATIONS: Stacking of this contractor's own force. Effect of adding operation to an already planned sequence of operations. Unless gradual and controlled implementation of additional operations is made, Factor will apply to all remaining and proposed contract	Suggest this Factor to be combined with Stacking of Trades.			5%	15%	25%	Suggest this Factor be combined with Stacking of Trades.

hours.							
DILUTION OF SUPERVISION: Applies to both basic contract and proposed change. Supervision must be diverted to (a) analyze and plan change, (b) stop and replan affected work, c) take-off, order and expedite material and equipment, (d) incorporate change into schedule, (e) instruct foreman and journeyman, (f) supervise work in progress, and (g) revise punch lists, testing and start-up requirements.	DILUTION OF SUPERVISION: Refers to the situation that the supervisor(s) spending less time overseeing work; or a lower supervisor-labor ratio.	1) Extra Errors and Omissions due to lack of supervision; 2) Lower work speed of workers; and 3) Additional standby time waiting for supervisors to answer questions and solve problems.	Related to out-of-sequence work and Crew Size Inefficiency.	10%	15%	25%	When recognized, awards are typically less than 10%. Reimbursed amount should be smaller than the cost of adding more supervisors.
LEARNING CURVE: Period of orientation in order to become familiar with changed	LEARNING CURVE: Loss of learning due to disruptions, time and cost to	1) Lower work speed during learning period to become familiar with work	Related to Reassignment of Manpower.	5%	15%	30%	Productivity level can be calculated based on number of units. See Eq. 7.4

condition. If new men are added to project, effects more severe as they learn tool locations, work procedures, etc. Turnover of crew.	familiarize with the work and work site, extra training cost, mobilization, and demobilization cost.	and work environment; 2) Extra training cost; and 3) Extra mobilization and demobilization cost.					and Eq. 7.5 in Section 7.2.
ERRORS AND OMISSIONS: Increases in errors and omissions because changes usually performed on crash basis, out-of-sequence, or cause Dilution of Supervision or any other negative Factors.	ERRORS AND OMISSIONS: Increase in worker's work errors and omissions due to disruptions.	Extra correction work, including rework and cleanup.	Use not recommended. Extra errors can be caused by many other MCAA Factors, and thus may not be primary.	1%	3%	6%	No previous studies on LOP quantification were found. In general amount claimable is extra errors in excess of 1-4%. See Section 7.5.
BENEFICIAL OCCUPANCY: Working over, around, or in close proximity to owner's personnel or production equipment. Also badging, noise	BENEFICIAL OCCUPANCY: Working over, around, or in close proximity to the owner or owner-created	1) Site access problems; 2) Out-of-sequence work; 3) Logistical problems: including storage and	Related to Stacking of Trades, Site Access, and Logistics.	15%	25%	40%	Congestion can be calculated through crowding level. See Figure 7.6.

limitations, dust, and special safety requirements and access restrictions because of owner. Using premises by owner prior to contract completion.	obstacles.	protection of materials; and 4) Badging, noise limitations, dust, and special safety requirements.					
JOINT OCCUPANCY: Change cause work to be performed while facility occupied by other trades and not anticipated under original bid.	Suggest this Factor be combined with Stacking of Trades.			5%	12%	20%	Suggest this Factor be combined with Stacking of Trades.
SITE ACCESS: Interference with convenient access to work areas, poor man-lift management, or large and congested worksite.	SITE ACCESS: Site partially restricted by the material or personnel onsite, or the site is not accessible so that the work is delayed.	1) Extra effort to get site access; 2) Extra movement of labor or equipment; and 3) Extra work such as cleaning up.	Related to Logistics.	5%	12%	30%	No previous studies were found. Highly dependent on project situations.
LOGISTICS: Owner furnished materials and	LOGISTICS: 1) Problems with	1) Extra work for logistics coordination,	Logistics problem can be caused by	10%	25%	50%	Cases and studies found have LOP

problems of dealing with his storehouse people, no control over material flow to work areas. Also contract changes causing problems of procurement and delivery of materials and rehandling of substituted materials and rehandling of substituted materials at site.	owner furnished materials; or 2) Other logistic problems caused by owner's change of materials or work schedule	materials movement and rehandling; 2) Storage cost: storage cost when no storage space; and 3) Standby time to wait for materials.	many other MCAA Factors, it need to be used with caution.				percentage due to Logistics as much as 20%. Highly dependent on project characteristics.
FATIGUE: Unusual physical exertion. If on change order work and men return to base contract work, effects also affect performance on base contract.	FATIGUE: the worker's unusual physical conditions including lack of energy, physical exertion, physical discomfort, lack of motivation and sleepiness.	1) Lower work speed; and 2) Extra errors and omissions.	Use not recommended. Related to Weather and Overtime, hard to establish liability and causation. Low morale can be caused by Fatigue as well.	8%	10%	12%	Questionnaires have been used in other industries to determine Fatigue level. See Table 7.4.
RIPPLE: Changes in	Suggest this Factor not be used in a LOP claim.			10%	15%	20%	Suggest this Factor

other trades' work affecting our work such as alteration of our schedule. A solution is to request, at first job meeting, that all change notices/bulletins be sent to our Contract Manger.							not be used in a LOP claim. Usually the result of some other driving event or Factor, which is where the LOP should be computed.
OVERTIME: Lowers work output and efficiency through physical fatigue and poor mental attitude.	OVERTIME: Work more than forty hours per week, extended workdays, extended workweeks, night and weekend work.	1) Lower work speed and extra errors and omissions; and 2) Logistics problems.	Related to Fatigue, and Morale and Attitude.	10%	15%	20%	See multipliers listed in Table 7.2.
SEASON AND WEATHER CHANGE: Either very hot or very cold weather.	SEASON AND WEATHER CHANGE: Unexpected severe weather, work pushed into inferior work time or unexpected work environment change	1) Impact to physiological conditions, lower work speed and extra errors; 2) Logistical and site access problem; and 3) Extra work such as cleanup.	Related to Fatigue, Logistics, and Site Access.	10%	20%	30%	See Eq. 7.3 and Figure 7.4.

	(such as lack of windows in winter). Possible problems include winter work, rain and snow, hot weather, wind and sun exposure, etc.						