Summary Report

Development of a Change Order Management Process for Use on Construction Projects at Michigan State University

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Introduction and Project Overview

This summary report outlines a recent research project undertaken by Construction Management Program faculty and students which examined construction change orders and change order management practices at Michigan State University (MSU). Funding for the research was provided by MSU's Office of the Vice President for Finance and Operations, the Physical Plant, Engineering and Architectural Services (EAS), Campus Park and Planning(CPP), and Housing and Food Services Construction, Maintenance & Interior Design(CMID).

The overall research goal was to develop strategies for reducing the impact and cost of construction change orders at MSU and other large universities, through prevention of change orders and effective change order management.

The research led to the development of a statistical database for use in benchmarking and analysis, recommendations for MSU, a preconstruction plan review checklist, process maps outlining change order processes for procuring departments, a suggested alternative process map and three Masters level theses which included:

- Statistical Analysis of MSU Change Orders (Gottschalk 2004)
- Development of Pre-construction Strategies for Reducing Design Errors and Omissions Leading to Change Orders (Yelakanti 2004)
- Development of a Framework for Reducing Change Order Processing Time in University Construction Projects. (Mechanda 2004)

Project Activities

The primary project activities consisted of review of relevant literature, development and analysis of a change order database for 16 recent MSU construction projects and development and administration of an interview process of industry firms and other universities.

In developing the database, data was collected on over 1675 change order items listed on a total of 159 change orders. Change order information was analyzed on a project, change order and item basis. Statistical analysis was conducted on the data base which included general statistical reporting, analysis of change orders by Construction Specification Institute Divisions, and analysis by reason codes assigned by CGA. Keyword analysis was conducted on narrative descriptions included in the database in order to review causes of change orders within CSI Divisions and for comparisons of checklists prepared by Civettelo (2002) and the University of Notre Dame.

The interview process consisted of interviews designed to gather information about change order perspectives and management practices of other organizations. The researchers conducted open-ended interviews of MSU personnel, outside architects, contractors, subcontractors and construction administrators from four Division One Universities. The University of Minnesota, University of Wisconsin, Purdue University and the University of Notre Dame were included in the study. More than 40 experienced construction professionals from these organizations were interviewed. Data from the interviews was paraphrased and tabulated in order to assess general themes expressed by the interviewees.

In order to study change order management practices and seek opportunities for reducing change order processing times, current processes EAS, CPP and CMID were mapped. MSU construction administrators and staff were interviewed to learn about current practices. The interview data was

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integrated with published MSU information on change order practices including the MSU Construction Standards, supplementary Conditions and Division 1 General Requirements.

The researchers applied Graham Flow Chart analysis techniques to the current change order process map for the EAS Formal Process in order to break down current processes and uncover opportunities for improvement. The data and analysis led to the development of a proposed process model and specific recommendations for managing change orders.

Upon completion the proposed process map and pre-construction plan review checklists, were presented to MSU construction administrators for review and feedback. This feedback was used to make appropriate adjustments to the process map and checklists.

Project Oversight Committee

An Oversight Committee comprised of MSU administrators from the Physical Plant, EAS, CPP, CMID, and CGA was created at the inception of the research project. The Oversight Committee met to define the scope of the project and to make recommendations regarding MSU projects to be included in the database. Additionally, the Oversight Committee suggested appropriate industry firms which provide services for MSU including architects, contractors, and subcontractors and other universities which could be included in the interview process.

Research Team and Student Involvement

The research was conducted by Construction Management Program faculty and students at Michigan State University. Five graduate and three undergraduate students were involved in the project. Students were involved in developing the research methodology, data collection instruments, project database, interview process, pre-construction plan review checklists, process maps and final recommendations. Important objectives of involving students were: to foster a research mind set in students, to develop and enhance research skills and to increase student understanding of change orders and construction management processes.

Research Benefit

Through this project the researchers have analyzed over 1675 change order items, classified them by Construction Specification Institute (CSI) specification divisions, determined their cause and proportional impact on projects, as well as provided specific strategies for preventing a variety of recurring types of change orders. This detailed look and reporting by technical category is a unique aspect of this research. The research establishes the foundation for specific processes which are applicable to MSU and other universities.

A National Change Order Perspective

There is an extensive body of literature which addresses change orders during construction projects. A common theme expressed in virtually all of this literature is that during complex construction projects, change orders are inevitable. Project complexity, project uniqueness, site conditions, varying expertise of designers and competitive market forces which require contractors to bid "lean" all contribute to the generation of change orders. In 1995, the Construction Industry Dispute Avoidance Task Force (DART) reported that more than $60 billion annually was spent on change orders in the United States (Ibbs 1997).

While the magnitude of change orders on any given project varies with many factors, several authors have offered opinions about average change order rates. James Obrien, in his text “Construction Change Orders”, suggests that experienced owners expect to pay more than the initial contract price and acceptable cost increases range around 5% (Obrien 1998). In a study of 35 organizations and 104 private sector projects, Ibbs found that cost increases due to design and construction changes averaged 5 percent.

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Numerous authors have also identified and categorized potential causes of change orders. Diekman and Nelson (1985), Jacobs and Richter (1978) and Clark (1990) classified change orders into three main categories: design errors and omissions, scope changes and unforseen conditions. They also suggest that design errors and omissions account for 65% of changes, design changes (scope changes) account for 30% and unforseen conditions account for 5% (Ibbs 1997). Civetello, in his book “Contractor's Guide to Change Orders”, identifies many detailed causes of change orders and dedicates an entire chapter to "prospecting" for change orders (Civetello 2002).

Change orders naturally are noncompetitive and have inherent increased general conditions and overhead costs. Impacts of changes on project schedule, working relationships of parties and overall project flow can also be significant. This research was targeted at minimizing the impact of construction project change orders in all of the above areas.

The MSU Perspective and Analysis

MSU construction projects typically total between $60-$100 million annually. Overall, the projects in the database totaled $133.35 million at contract start and had ending costs of $144.19 million for a total increase by change order of $10.84 million or 8.1% from starting contract price. Projects selected for the database ranged from the approximate $90 million new Bio-physical Sciences Building to a $313,000 contract for renovations at Wilson Hall. Projects which were predominately new buildings or substantial additions were classified as new buildings. Projects which consisted mostly of renovation work were classified as renovations. The database consists of eleven contracts classified as new buildings and eight contracts classified as renovations. Projects were generally completed during the last three years.

Overall, the database average change order rate of 8% was found to be in the reasonable range reported by the other universities and organizations interviewed. Outside architects, contractors and subcontractors for this study self-reported average rates from 5-10% of original contract price. The interviews of Division One universities indicated self-report rates as follows: Purdue, 3% self-estimate (new buildings); Notre Dame 3% self-estimate (new buildings), Wisconsin 7-10% self-estimate, Minnesota 5-10% self-estimate. The State of Michigan Department of Management and Budget (DMB) reported a 5-10% estimated change order rate on projects at a meeting of the Construction Owners of America (COA) in East Lansing, Michigan on April 2004.

Table 1.1 below shows project name, initial cost, ending cost and percent change for the projects included in the database.

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Change Order Summary of Project Percent Change					
Project ID	**Project Name**	**Initial Cost**	**Ending Cost**		**% Change**
0365	Hannah Administration	$849,000.00	$925,818.13		9.05
1707	Agriculture Hall Annex Renovation and Window replacement	$6,260,300.00	$6,605,238.00		5.51
3482	Jenison Fieldhouse Locker Room Renovation and Addition	$6,394,000.00	$6,931,214.96		8.40
2474A	MSU Bio-Physical Science Bld.	$1,647,000.00	$2,886,756.00		75.27
2474B	MSU Bio-Physical Science Bld. Cd#2	$4,522,200.00	$4,698,577.00		3.90
2474D	MSU Bio-Physical Science Bld. Cd#4	$71,148,082.00	$74,777,169.40		5.10
2124	Nisbet Building Chiller Installation	$385,000.00	$396,501.34		2.99
3067	Spartan Stadium-East Concorse Restoration	$2,565,000.00	$4,955,991.54		93.22
3119	Breslin Center - Berkowitz Addition	$6,136,953.00	$6,498,546.64		5.89
3147	Chemisty Building Renovations	$931,889.00	$991,284.00		6.37
3158	Wilson Hall Alterations	$313,000.00	$312,208.00		(0.25)
3282	Life Sciences Alterations	$420,531.00	$469,489.92		11.64
3347	Spartan Child Development Center	$2,035,000.00	$2,324,281.03		14.22
3496	Campus Fiber-Optic System Phase VIII	$1,995,000.00	$2,028,923.06		1.70
3981	MSU Cyclotron Building Office Expansion	$3,205,108.00	$3,533,998.09		10.26
02140A	Intercollegiate Athletics New Track and Field Facility Phase I	$242,500.00	$265,776.80		9.60
02140B	Intercollegiate Athletics New Track and Field Facility Phase II	$2,547,000.00	$2,572,226.80		0.99
0584	Food Safety/ Tox Lab	$18,737,710.00	$19,241,573.00		2.69
99072	Parking Lot #89 Expansion	$3,020,000.00	$3,775,743.12		25.02
	Totals	$133,355,273.00	$144,191,316.83	**Average % Change**	15.35
				Total Project % Change	8.13

Table 1.1 Database Projects, Initial Cost, Ending Cost and Average Change Order Rate

Renovations

Project ID	**Project Name**	**Initial Cost**	**Ending Cost**		**% Change**
0365	Hannah Administration	$849,000.00	$925,818.13		9.05
1707	Agriculture Hall Annex Renovation and Window replacement	$6,260,300.00	$6,605,238.00		5.51
3482	Jenison Fieldhouse Locker Room Renovation and Addition	$6,394,000.00	$6,931,214.96		8.40
2124	Nisbet Building Chiller Installation	$385,000.00	$396,501.34		2.99
3067	Spartan Stadium-East Concorse Restoration	$2,565,000.00	$4,955,991.54		93.22
3147	Chemisty Building Renovations	$931,889.00	$991,284.00		6.37
3158	Wilson Hall Alterations	$313,000.00	$312,208.00		(0.25)
3282	Life Sciences Alterations	$420,531.00	$469,489.92		11.64
	Totals	$18,118,720.00	$21,587,745.89	**Average % Change**	17.12
				Total Project % Change	19.15

New

Project ID	**Project Name**	**Initial Cost**	**Ending Cost**		**% Change**
2474A	MSU Bio-Physical Science Bld.	$1,647,000.00	$2,886,756.00		75.27
2474B	MSU Bio-Physical Science Bld. Cd#2	$4,522,200.00	$4,698,577.00		3.90
2474D	MSU Bio-Physical Science Bld. Cd#4	$71,148,082.00	$74,777,169.40		5.10
3119	Breslin Center - Berkowitz Addition	$6,136,953.00	$6,498,546.64		5.89
3347	Spartan Child Development Center	$2,035,000.00	$2,324,281.03		14.22
3496	Campus Fiber-Optic System Phase VIII	$1,995,000.00	$2,028,923.06		1.70
3981	MSU Cyclotron Building Office Expansion	$3,205,108.00	$3,533,998.09		10.26
02140A	Intercollegiate Athletics New Track and Field Facility Phase I	$242,500.00	$265,776.80		9.60
02140B	Intercollegiate Athletics New Track and Field Facility Phase II	$2,547,000.00	$2,572,226.18		0.99
0584	Food Safety/ Tox Lab	$18,737,710.00	$19,241,573.00		2.69
99072	Parking Lot #89 Expansion	$3,020,000.00	$3,775,743.12		25.02
	Totals	$115,236,553.00	$122,603,570.32	**Average % Change**	14.06
				Total Project % Change	6.39

Table 1.2 Intial Cost, Ending Cost and Average Change Order Rate for New Projects vs Renovations

Table 1.2 above shows that new projects increased an average of 6.39% over starting contract price due to change orders. Renovation projects averaged 19.15% increases due to change orders. The renovation data is heavily influenced by the Spartan Stadium Concourse, which had a 93% cost increase, rising from a starting contract price of $2.56 million to an ending price of $4.96 million. This project encountered substantial repair of structural concrete. If this project is removed, then the average rate for the remaining seven renovation projects would be approximately 7%.

Causes of Change Orders at MSU

The database was analyzed to determine causes of change orders using reason codes established by CGA. These standard definitions were used to classify change orders. Approximately 1,000

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items in the database were assigned reason codes. In some instances, researchers were unable to assign reason codes. In the reporting below, items without reason codes, or reason codes indicated as miscellaneous are not considered in the reason code analysis. Database analysis showed that overall, 42% of change order items are generated by document errors, about 31% by field changes and 27% by scope changes. This is a slightly different distribution than studies conducted by Diekman (1998) which showed 65% of change orders caused by document errors, 30% by field errors and 5% by scope changes (although there are some differences in the definitions used). A general conclusion is that MSU is experiencing document-error-related errors at about the same or at a somewhat better rate than what might be expected by Diekman's study. Figure 1.1 below shows the distribution of change order items by cause in the project database.

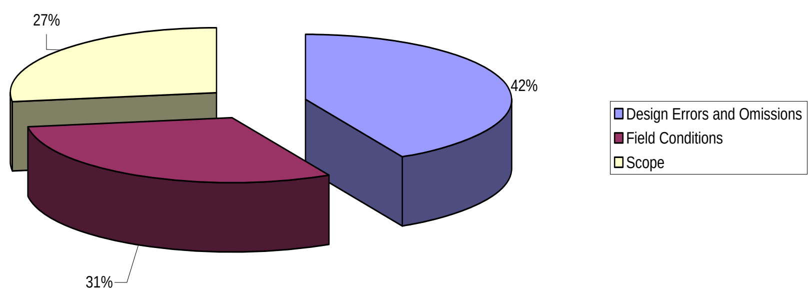

Figure 1.1 Relative Causes of Change Orders in Projects Database

When considering costs, 394 document-related change order items accounted for $1.79 million (25%) of the total costs of items which had reason codes. The 286 field-related change orders accounted for $2.20 million, (31%). The 256 scope-related change orders accounted for $2.2 million (29%), and those classified as reason-not-specified or miscellaneous accounted for $1.02 million (14%). When the items classified as reason-not-specified and miscellaneous are removed, document-related changes account for 30%, field changes 37% and scope changes 33% of the costs.

Reasons for document-related change orders include failure to follow MSU construction standards, corrections for code deficiencies, errors and omissions. Changes generated as a result of document-related reasons are generally seen by the researchers as preventable through improvement in the contract documents by designers. Change orders generated by field-related causes include those involving discovery of hazardous materials, poor soils, hidden conditions, changes to codes during construction period, and allowance adjustments. Strategies for reducing these change orders may include increased testing and investigation during the design and contract document development stages of a project. Scope-related changes orders include changes requested by the end-user department, changes requested by the Physical Plant, changes requested by CPP and value engineering.

Scope changes may arise from allocations of unused contingency to improve portions of the project, but may also stem from misunderstandings of design programs, either by the designer or by the end-user department. Those that flow from lack of communication during the programming and design stage may be preventable by improvements in program documentation and increased interaction between the design team and the end-user department.

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The CSI Divisional Analysis shows that technical divisions 2, 15, and 16 have the most significant impact on the database both in cost and number. These divisions are complicated and encompass a variety of materials and processes which are usually designed by consultants. Of the architecture-based divisions 3, 4, 5 and 9 have some influence on the database, but are not nearly as significant as divisions 2, 15 and 16. Architecture-based divisions 6,7,8,10,11,12,13 and 14 have little impact individually, and collectively only account for 13% of change orders items in the database. Figure 1.2 below shows distribution of change order items by CSI division.

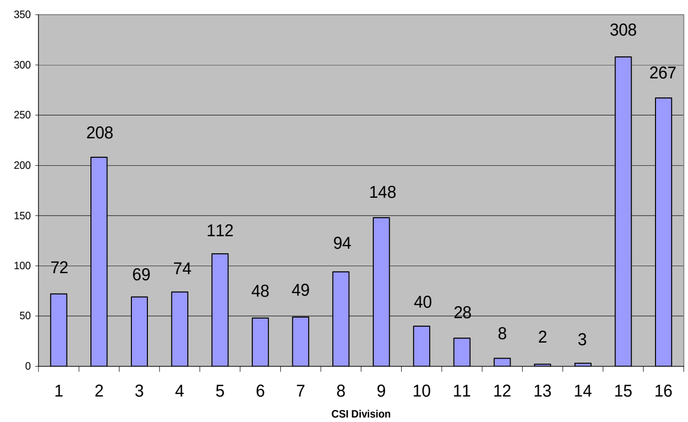

Figure 1.2 Number of Change Order Citations by CSI Division

In an effort to asses change order rates for the various CSI divisions and their proportional impact on overall project cost, the researchers constructed an aggregated schedule of values for the group of projects. The schedule of values was then compared to the impact of each division on change orders. Division 15 was found to account for 29% of overall project costs but only 15% of change order costs, Division 16 was in balance and accounted for about 11% of project costs and about 10% of change order costs.

Division 2 by contrast generated 9% of overall project costs but nearly 30% of change order costs. Interviewees were nearly in full agreement about their perception that division 15 generated the most change orders for projects. The database shows however that division 15 may actually be one of the better performers when comparing its proportional rate of change orders to overall division cost .

CSI Division		Division Amount	%
1	General Conditions	$ 8,609,625	6%
2	Site Work	$ 12,418,425	9%
3	Concrete	$ 9,642,198	7%
4	Masonry	$ 10,388,214	8%
5	Metals	$ 8,626,550	6%
6	Wood & Plastics	$ 2,537,656	2%
7	Thermal & Moisture	$ 4,147,514	3%
8	Windows & Doors	$ 5,766,195	4%
9	Finishes	$ 7,038,028	5%
10	Specialties	$ 718,515	1%
11	Equipment	$ 7,322,868	5%
12	Furnishings	$ 318,157	0%
13	Special Construction	$ 1,226,832	1%
14	Conveying Systems	$ 1,186,312	1%
15	Mechanical	$ 39,156,403	29%
16	Electrical	$ 14,114,828	11%
Total		**$ 133,218,320**	**100%**

Table 1.3 Aggregate Schedule of Values for Project Database

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Division 2 which seems to generate more change order costs than the schedule of values would imply, was heavily influenced by a preplanned high cost scope increase change order for the Bio-physical Science Building. That change order is seen by the researchers as value adding. The researchers want to stress that all change orders are not bad. Many projects have scope and value-adding change orders that the owner is happy to purchase. If this change order item is removed, division 2 would be closer to balance.

The CSI divisional analysis also showed that the causes of change orders vary with CSI division. A reason code analysis was conducted of each CSI division. Each project, change order and change order item was found to have its own story and each CSI division had its own signature. Understanding the signature of a division can be used to develop targeted strategies that could have the biggest impact on reducing the number and costs of change orders. Change order items occurring in division 15 were more likely to be caused by document errors. Fifty four percent of the change order items in this division were caused by document errors. For division 2 the largest generator was field changes. Division 12 was almost entirely caused by scope changes. Strategies for reducing change orders may include increased rigor of plan review for divisions 15, 16 and 2, as well as increased coordination of these divisions with architectural drawings,. For division 2, increasing pre-design field testing may be warranted along with continuing to improve the MSU information base on existing underground utilities and buildings. Division 16 could be improved by closer communication between the end user department and the electrical designer during the design and contract document development stage, as well as increased plan review. Finally, change orders in some divisions, such as division 12, could be reduced by policies that make it more difficult to spend project contingency on scope increases.

The researchers also examined the points in project progress when change orders were most prevalent, in order to determine if there was a point in a typical project when the project parties could be confident that they had seen most change orders on a given project. Knowing this point would help project managers in deciding when to use, release or give back contingency. The research showed that change order items tended to be somewhat balanced throughout a project. Later change order items tended to cost more than early change order items. The overall message is that the project parties (and their cost controllers) should not feel comfortable at any point in a project that they have seen all of the change orders that are likely to arise. Change orders seem to be almost as likely to develop in the later stages of a project as they are in the beginning.

Development of Pre-construction Plan Review Checklists

An important part of the development and analysis of the database was to gain a perspective on causes of change orders and to develop strategies for preventing them. Toward this end, the researchers developed a pre-construction change order checklist for use in plan review at the design and contract document stages. The purpose of the checklist is to reduce document related oversights that may generate change orders. After completing the broad scope and CSI divisional analyses, the researches conducted keyword searches of narrative descriptions of items in the database to find recurring elements. Recurrent items were then tested against a checklist of elements identified by Civettelo (2002). These keyword searches along with the literature review, interview data and a checklist furnished by Notre Dame were used to construct plan review checklists. These check lists were then presented to MSU construction administrators to gain feedback and to assess how they could be implemented.

The checklists are organized for use during the following project stages; conceptual design, schematic design, design development and contract documents. Additionally, the checklists are based on design discipline and include architectural, structural, mechanical and electrical reviews. Figure 1.3 represents the suggested checklist developed by Yelakanti (2004).

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Plan review checklist

Checklist to assist plan review process – Design discipline specific

Purpose

The purpose of this checklist is to assist MSU staff university plan review prior to release of plans for bidding. of plans This checklist will help to identify various design related issues which are sometimes overlooked. This checklist will act as a supplement to your current plan review process and acts as a vehicle for improving plan review processes.

Organization of the document

This document is organized at four broad categories, and is specific to each design discipline level:

Conceptual design development level

Schematic design development level

Design development level and

Figure 1.3 Plan Review Checklist

Reducing Change Order Processing Times

The time it takes to process change orders has a significant impact on all project participants. Impacts may include increased project costs, project delays, breakdown in project relationships, disruption of project flow and increased administrative costs. Additionally, when process times are extended, contractors and subcontractors are adversely impacted by disruption of cash flow, particularly for work already completed via construction change directives. Slow processing and subsequent delays in obtaining payment may result in protective posturing and pricing of change orders as well as in project bidding.

Toward the goal of reducing the impacts of change orders on participants and projects, an analysis of change order management processes was undertaken. The goal of this portion of the study was to develop a change order management approach that could help reduce change order processing times at MSU. During this study, change order processes of EAS, CPP and CMID were mapped. The Formal Process of EAS was then modeled using Graham flow charting techniques in order to find opportunities for process improvement. Concurrent with the process mapping, statistical analysis of the database was conducted which addressed overall processing time as well as times of each sub-process.

Processing Time Details

From the project paper files five key dates were recorded for each change order item and included in the database. These dates included item initiation date, change order date, architect's authorization, contractor's authorization and MSU authorization. These dates are shown in figures 1.4 and 1.5 below.

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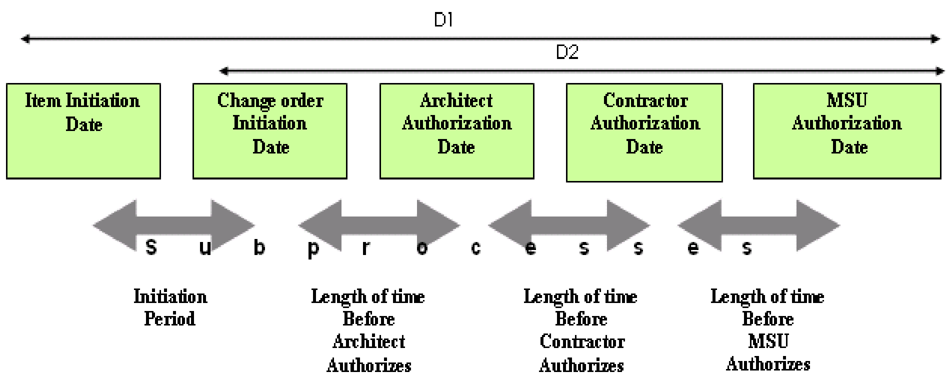

Figure 1.4 Sequence of Dates in Change Order Database

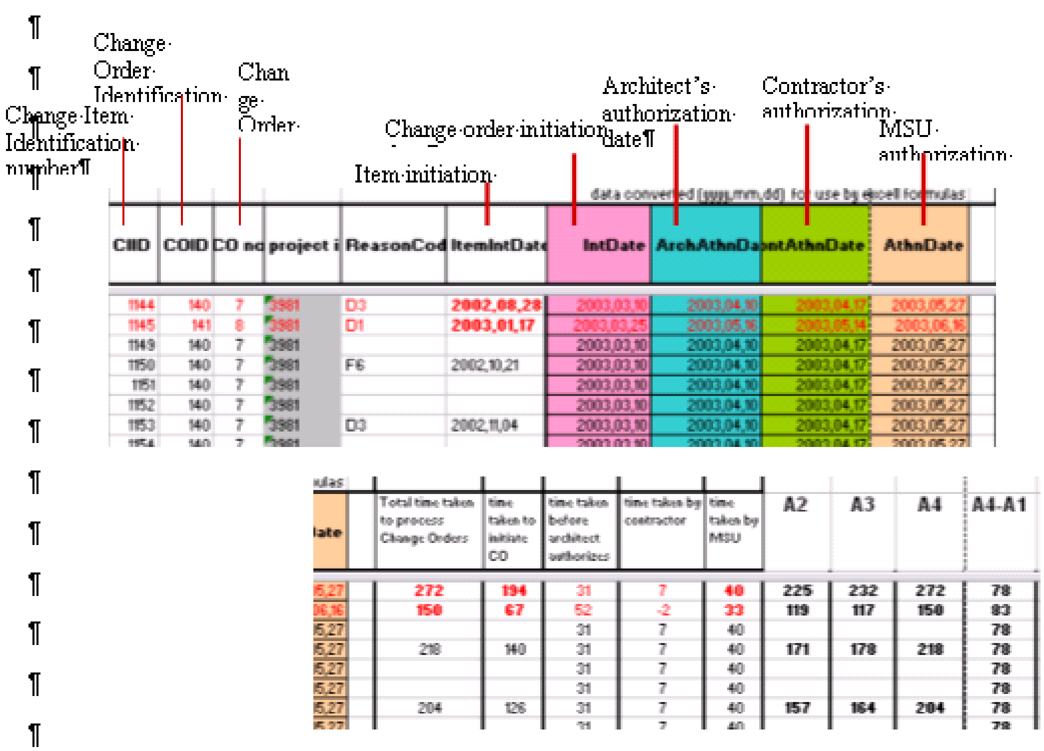

Figure 1.5 Detail of the Change Order Process Time Database

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The D1 duration represents the overall time from when a potential change order item was first recognized by the project parties to the date when which MSU gives final approval/authorization. The period does not include payment processing. The D2 period is the period from which a change order is drafted to final MSU authorization. Each sub-process was defined as the duration between two phases and is shown by the equations below:

Initiation period = Change order initiation date - Item initiation date

Architect time = Architect authorization date - Change order initiation date

Contractor time = Contractors authorization date - Architect authorization date

MSU time = MSU authorization date - Contractors authorization date

D1 = Total time taken to process change orders (initiation date to MSU authorization date)

D2 = Time taken to process change order (change order date to MSU authorization date, excluding initiation period)

After data for all change orders was extracted, durations for each sub-process were calculated. The data set was statistically filtered using box plots which eliminated outliers.

Table 1.4 shows average time taken to process change orders and average time taken by each sub process considering 1135 change order items with complete data.

D1 **D2**

Total time taken to process change orders (days)	Time taken to initiate change orders (days)	Length of time taken before architect authorizes it (days)	Length of time taken by contractor (days)	Length of time taken by MSU (days)	**Time taken without initiation period (days)**
196	134	8	6	49	**63**

Table 1.5: Total Average Time and Time Taken by Each Sub-Process to Process Change Orders

The 1135 items from 19 projects took an overall average of 196 days (D1) and 63 days (D2). The initiation period took 134 days, the architect sub-process took 8 days, the contractor sub-process took 6 days and the MSU sub-process took 49 days. The initiation period is the most significant period and accounts for over 68% of total process time. Figure 1.6 below shows percentage contribution of each sub-process to overall change order process time.

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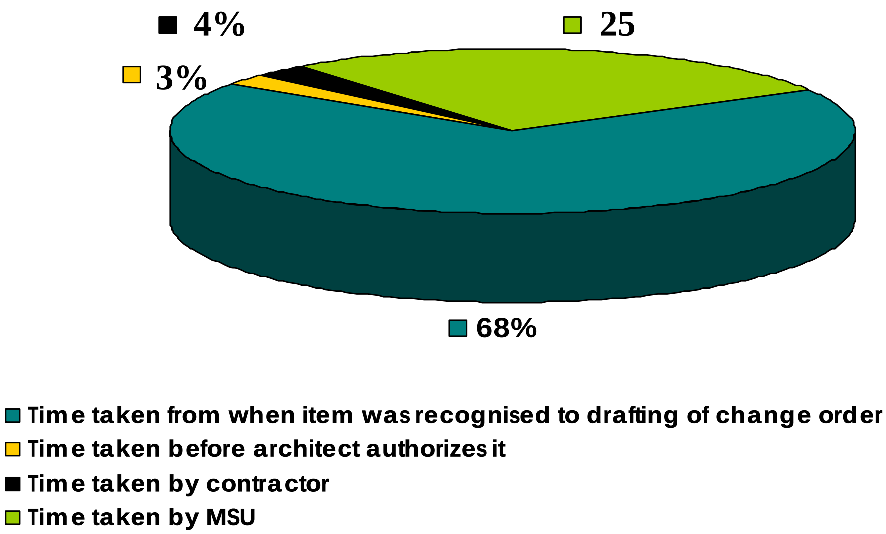

Figure 1.6 Percentage Contribution of Each Sub-Process to Overall Change Order Process Time

The D2 processing times appear to be on par with other universities. Interviews of University of Minnesota, University of Wisconsin, and Purdue Univerity indicated processing times as follows for the D2 time definition.

MSU, 60+ days mean (calculated from database)

Minnesota, 2 months (self-report)

Wisconsin, 2 months to 6 months (estimated State of Wisconsin process)

Purdue, 30 days (self-report)

Despite the fact that MSU may have similar processing times to other universities, interviews with outside architects, contractors and subcontractors revealed that all external contracting and subcontracting parties indicated that overall change order process time for MSU is excessive.

Contractors and subcontractors are most concerned about the D1 times because they know when a problem was identified and how long it took to process that change item and receive payment. This D1 time may be of special concern when the contractor has already performed the work as required by a construction change directive.

The initiation period is influenced by all project parties including the contractor, subcontractors, architect and MSU personnel and cannot be completely controlled by MSU. However, there may be room for improvement in the activities performed by MSU personnel during this period. This was analyzed through process mapping.

Other analysis was conducted on elements that can influence processing time. The database showed an average of 11 items per change order with some including as many as 40 items packaged into a single change order. Multiple unrelated items are accumulated and eventually incorporated into a single change order. Statistical analysis showed a strong correlation of the number of items per change order and overall process time. Figure 1.7 below shows the number of items per change order for the projects database.

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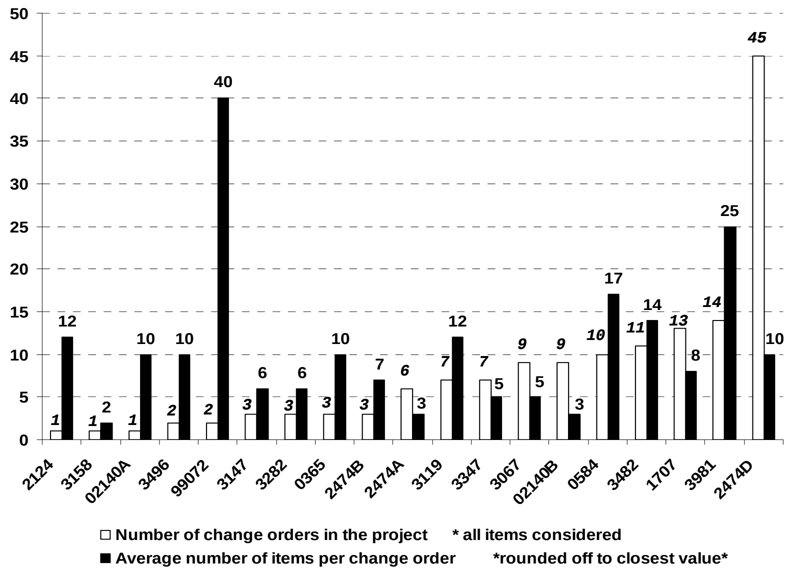

Figure 1.7 Number of Change Order Items per Change Order

Interviews of Minnesota personnel indicated that a system of graduated approvals is used for smaller items. Some items may be approved at the construction representative level. For larger change orders, higher levels of approval are required. As a result of these interviews the researchers ran statistical analyses to see the range of costs for change orders. The data showed that 80% of items were under $5,000 in cost and that 90% of change items were under $10,000. Ten percent of the items fell in the $10,000-$100,000 range. Figure 1.8 below shows the distribution of change order items by costs.

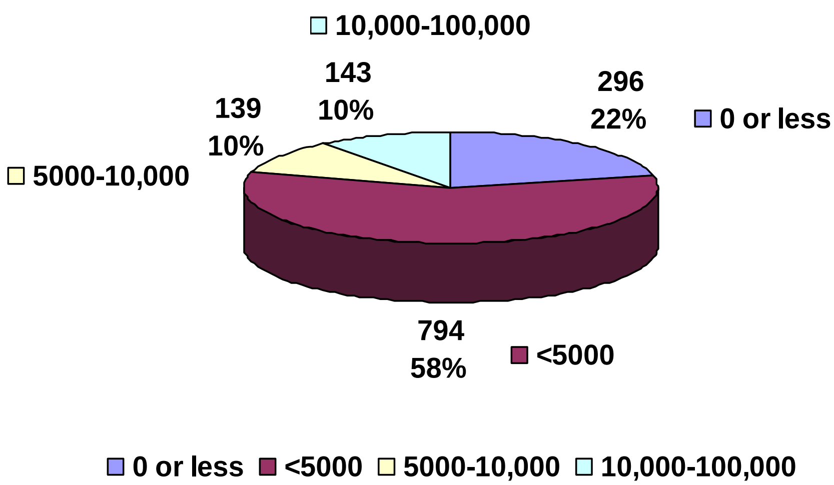

Figure 1.6 Cost Distribution of Change Order Items

Because of the relatively small costs of most change order items, the researchers are proposing that a graduated system of approvals be adopted for MSU.

Current Process Maps and Development of a Proposed Process Map

The statistical analysis of the database, along with the interview data and process flow map for the EAS Formal process were used as the basis for development of an alternative process map for managing change orders at MSU. Graham flow charting techniques were used first to analyze the current change order process, which then led to the development of the alternative map. Figure 1.9 below shows the current change order process and its analysis using the Graham technique.

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After Graham analysis, observations were integrated with the database analysis, process maps, and interviews to develop overall recommendations and an alternative process map. The recommendations are presented in the recommendations section below and the alternate process map is attached at the end of this report.

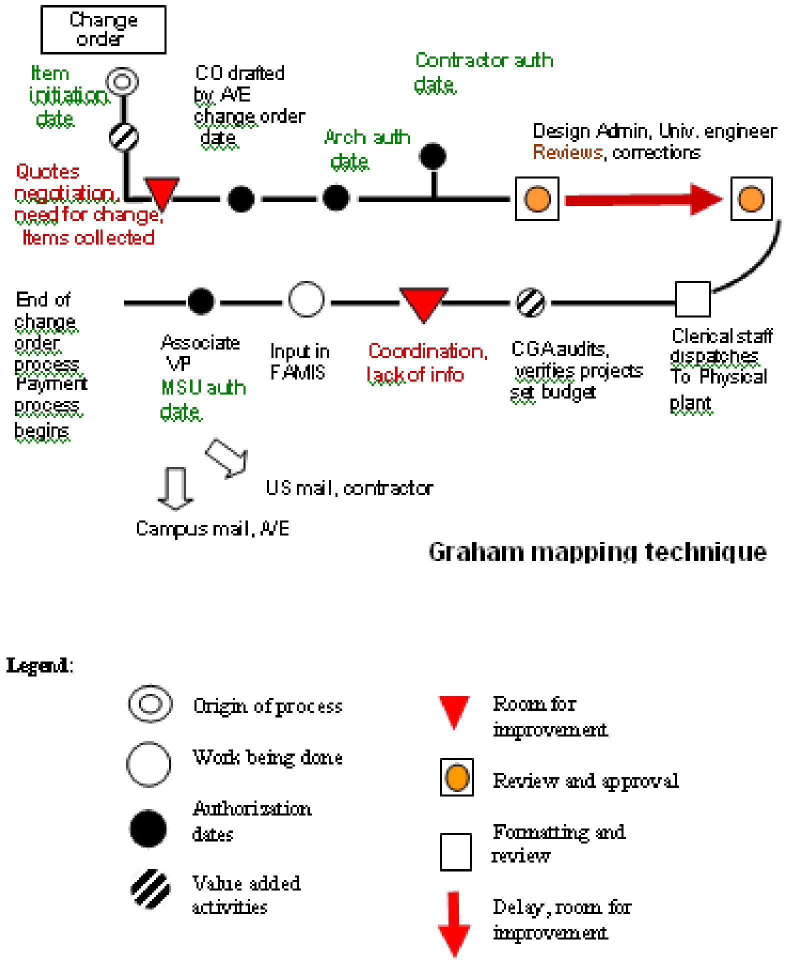

Figure 1.9. Formal EAS Process OF Change Order Mapped Using Graham Technique

Conclusions and Recommendations

The primary goal of this research was to develop strategies for reducing the impact of change orders at MSU through change order prevention and effective management of change orders. Toward this end the researchers developed and statistically analyzed a change order database for 16 recent projects. Additionally, literature reviews of recent research and articles, as well as interviews of outside architects, contractors, subcontractors and construction administrators from four Division One universities were conducted. Through this project the researchers also conducted interviews with numerous MSU staff and administrators. In all, more than 40 individuals were interviewed. The general conclusion from all the research is that MSU appears to be in line with other similar organizations both in terms of number of change orders as well as with overall processing times. However, there is opportunity for improvement. The research data was integrated to develop the recommendations discussed below. The research has led to the

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development of recommendations, a preconstruction plan review checklist and an alternative change order process model. The researchers believe that implementation of the recommendations presented below can have a positive effect on reducing the impact of change orders at MSU.

Overall, MSU averaged approximately 8% of initial contract cost in change orders. Forty two percent of change orders are thought to be caused by document-related causes, 27% by scope changes and 31% by field conditions. Although these conclusions are drawn from a limited set of projects and expanding the database to include more projects might alter the final numbers, the researchers believe that general trends and observations made are valid and are useful in developing strategies for reducing the impacts of change orders.

General Commentary
As a general starting point, MSU could establish specific organizational goals for change order rates and processing times. The researchers believe that establishing a goal of reducing change orders by 25% is not unrealistic. This would reduce overall change order rates from 8% to 6% yielding a potential annual savings from $1.5 million to $2.0 million for typical annual construction volumes of $60-$100 million. Strategies can include a combination of reducing scope changes, improving construction documents and reducing field-related change orders. It may be possible to reduce change orders more than this, but upfront costs of doing so could likely counterbalance any savings through increased design fees, plan review costs or increased initial construction contract costs in response to risk shifting contract clauses.

Organizational Commitment

1. Establish an organizational goal of a maximum aggregate change order rate not to exceed 6% of initial contract price annually. This represents an overall reduction of 25% over current averages

2. Adopt time-related goals for small items, routine change orders or those directed by construction change directive (CCD). A goal of 45 days for the D1 time is suggested.

3. Establish a goal for the D2 sub-processes of 45 days for complex change orders or for scope adjustments.

Reducing Scope Increases
Scope increases accounted for 27% of change order items in the database. The somewhat voluntary nature of these change order items make them obvious candidates in any plan to reduce change orders.

1. Reduce pre-construction project contingencies. Reduction of contingencies will put some pressure on the project team to be aggressive in controlling costs. One possible approach is for projects funded by the university to assign split contingencies, with one assigned to the project and the other held by the university. When a project exceeds its project contingency, overruns could then be funded from the general contingency pool. The researchers' experience indicates that many in the construction industry will readily admit that contingency will almost always be consumed on a project, because the parties have already indicated a comfort level with an overall budget that includes the contingency. If not consumed by field conditions or document errors, it will be consumed by scope changes. While a strategy to deliberately set lower contingencies may seem more like project psychology, an approach such as this may accomplish the entire 25% reduction goal. The researchers suggest that project contingencies for new buildings be

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established at 3%. It is the researchers' understanding that new buildings are currently assigned a contingency of 5%. If the split contingency approach is feasible from an accounting and funding source perspective, 3% would be assigned to the project with the remaining 2% held in the broader contingency pool. A recommendation of 7% average is suggested for renovation projects but because of the diversity of projects included in the database, it is likely that more study might be necessary to come to a final conclusion on this rate. While the eight contracts included in the database indicated an average change order rate of 19%, it seems unrealistic to establish contingencies as high as 15% or 18% on these projects. The database is skewed by the Spartan Stadium Concourse renovations which had a 93% change order rate due to extensive concrete repair. With that project removed, the remaining projects have a rate of 7%.

2. Create policies for when unused contingency can be used for scope increases. The researchers are generally in favor of a strategy which restricts scope increases, however policies should be flexible. It is important to realize that in some instances, restricting scope increases may be counterproductive. For example, some projects may have funding sources which preclude project funds being shifted back to some general university account. For those projects, a "use or loose it" approach might make sense. Secondly, a firm policy might prohibit change order items of opportunity that may arise during the project. Some of these items can truly be value adding. For example, upgrading associated infrastructure or a change order to obtain better equipment may make very good use of extra funds. For projects with funding sources such that saved money can be transferred to other university accounts, it may make very good sense to revert extra money back to the university, rather than allow it to stay with the project. It is the researchers' understanding that MSU has begun to move in this direction and the database seems to support that approach, however any policy should remain flexible as discussed above.

3. Some scope changes in the database seem to arise from misunderstandings between the end-user department and the design consultant. These scope changes can flow from miscommunication during project programming, lack of information or because the end-user doesn't fully understand what the consultant has designed. MSU programming activities seem to be adequate and similar to those of other universities. Probably the best approach is to encourage more time be spent by the consultant in explaining the design to the end-user. The University of Wisconsin has instituted a "Design Charette" process for evaluating and reviewing architectural, mechanical and electrical plans prior to issuance for bidding. Various parties including the project manager, design consultant, physical plant specialists and users are brought together to evaluate and review the design. While their process is more focused on uncovering errors or deficiencies in planned systems, a similar process could be used with MSU end-users.

Reducing Field Changes

Approximately 31% of the change order items in the database flowed from field-related issues. These changes result from a variety of causes identified below:

- Flow from conditions discovered in the field that were not consistent with the plans or conditions usually encountered for a similar situation (differing site conditions)
- Unexpected poor soils, undiscovered hazardous materials
- Unmapped utilities or infrastructure
- Existing building information used for design and contract documents was wrong (Incorrect As-built documents or inadequate or inaccurate field investigation and measuring)

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- Aspects of the existing building were not accessible during designer's or owner's field investigation

Reason Codes used by CGA categorize field changes and are grouped as environmental, soils, hidden conditions, allowance adjustment, changes in code and other. Division 2 was most heavily influenced by field changes with 66%, but divisions 3 (41%), 5 (35%), 15 (36%), 16 (25%) were heavily impacted by field changes as well. Divisions 6,7 and 9 had between 20% and 25% of items caused by field issues. Divisions 4, 8, 10,11 showed less than 10% of the items were classified as field issues. Because a significant amount of work on campus involves existing facilities as well as underground work, this category of changes may be the most difficult to address. There is no one broad recommendation which can be made from the database. Some reduction in this category of changes could be generated by having better information available during design. Increased testing and field investigation could help. There is some indication that plans of existing older buildings may not be accurate, so increased field measurement and documentation of existing conditions might be appropriate. Increased soils investigation could help particularly for projects which may use deep foundation systems or have known fill areas, as some 37 items in the database related to soil borings or testing.

Decreasing change orders caused by field related issues will require increased expenditures on soils and field investigation. This strategy is referred to as “spend to save”. Spending to save is a risk/reward decision, similar to buying insurance. How much additional soil testing and field measurement to buy will have to be made on a case by case basis. On one hand we know approximately $3.0 million was spent on field related change order issues, but on the other, how much extra should be spent on testing was not determined. Probably the best approach is to continue to hire competent parties, but also to involve university personnel in furnishing all background information necessary to determine the testing or field investigation program. In the universities interviewed for this study, it was typical for the engineering consultants to determine the testing program. The researchers’ recommendation is that knowledgeable MSU staff familiar with the local campus site conditions or a particular building be rigorously consulted and furnish information to make certain that engineering consultants are aware of this background information. This process is analogous to a physician taking medical history prior to testing and treatment.

Reducing Document Errors

Change orders which flow from document issues accounted for 42% of the change order items in the database. This rate appears to indicate a smaller percentage of items from this cause than what was found in other studies. Diekman indicated that 65% of items on private sector projects came from design-document-related issues. None the less, the researchers believe that there is room for improvement and have prepared a pre-construction plan review checklist process which if implemented along with the recommendations below can be helpful in reducing the number of change order items on projects:

1. As a condition for selection of consulting architects and engineers, require that they have stated company processes/policies which articulate their plan review and coordination protocols. These policies should be considered in selection of consultants. Additionally, require a senior officer of those firms to certify that the protocols have been followed prior to release of documents for bidding. The database shows that many of the document-related change order items flow from a lack of coordination between architectural, mechanical, electrical and structural plans. The researchers initially thought that questions on change order rates could be included in the qualification sections of proposal responses to RFPs, but the interview respondents generally were not in favor of this approach. Either because they don’t maintain this data or because of

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variations of data or definitions that different parties would use. Therefore, the researchers are proposing the requirement described above. It seems entirely reasonable that a company should be able to describe its quality control practices, and that MSU should consider them in hiring.

2. Construction managers should also be able to respond to how they prevent and manage change orders. The University of Minnesota uses a series of fairly rigorous questions in their CM proposal request, which could be considered for use or modification.

3. Track performance of design and construction firms with respect to change orders. Most organizations interviewed were only informally doing this. Some organizations did end of project post mortems which look at budget, schedule and quality performance of the project team, but typically did not maintain a formal process or database for aggregating results. Minnesota has a "vendor performance" system but it is cumbersome to use and interviewees indicated they are evaluating other systems

Specific recommendations for MSU plan review

Although reducing errors and omissions on contract documents is primarily the task of the outside design consultant, MSU can and should take an active role in plan review. The following recommendations are directed to EAS staff and administrators.

1. Define plan review protocols which are suitable for projects based on complexity and size. A checklist approach was developed through this research and provides for separate checklists for the conceptual design, schematic design, design development and contract documents stage.

2. Hold periodic work/training sessions addressing known problem areas.

3. Elevate plan review as a priority and make it an important activity for staff.

4. Provide ample time for university personnel to review plans and specifications.

5. Consider adding one FTE to EAS for conducting plan review. An individual employed for this position should be highly experienced in interpreting architectural, mechanical and electrical plans and should have a good understanding of MSU infrastructure.

6. Require that documents prepared by outside design consultants be complete and received sufficiently in advance of the date for release of documents for bidding to provide adequate time for review.

7. Focus plan reviews on the following key areas:

    Coordination of structural, mechanical and electrical plans with architectural plans
    Increase review of mechanical plans
    Increase review of electrical plans
    Increase review of Division 2 related items

8. When EAS staff is not available, utilize third party outside plan review organizations for complex projects.

9. Most of the parties interviewed including architects, contractors, subcontractors and university personnel were not in favor of strict or rigorous attempts by owners to obtain

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cost recovery from design consultants. There seemed to be general agreement that on complex projects with time pressures, that some errors were bound to occur in the documents. This is viewed as a standard of care issue, where industry standards do not dictate perfection. There may clearly be times when the level of error is excessive and beyond the standard of care. In those cases, the owner may want to pursue cost recovery. It was generally believed that design fees would need to be increased if designers were held strictly responsible for all change items generated by the documents.

Conclusions on Reducing Change Order Processing Times

Based on results of the statistical analyses and process maps, interview responses and literature review the following conclusions and recommendations were made for reducing processing time. These recommendations are embodied in the proposed process map included at the end of this report.

Overall, D1 and D2 processing times were found to be 196 and 63 days respectively for the 1135 change order items in the database. The D2 times appear to be consistent with that of other universities but no determination could be made from the interviews with regard to the D1 time. Overall, both internal and external interviewees indicated that the change order process takes too long.

Statistical analysis shows that 80% of the change order items were less than $5,000 and 90% under $10,000. The database shows that each change order averaged over 10 unrelated items, which the researchers believe slows processing times. Interviews at Minnesota indicated the use of a graduated system of approval and, the researchers recommend MSU consider the same for modification and adoption. Purdue typically uses one change order per change order item.

Process Recommendations

1. Set time goals for sub-process.

2. Reduce layers of approvals for small change order items

3. Change orders currently go through multiple layers of approval regardless of dollar amount, contingency amount, project progress, and the fact that the work may already have been done before the payment process even begins. Consider adopting a protocol for lower level authority for approval of change orders based on the possible ranges suggested below:

    • Construction representatives (CR) could approve $0-$5,000 including deductive items, in consultation with Project Managers.

    • MSU Project Manager (PM) could approve $5000-10,000, on recommendations from CR

    • Design Administrator (DA) could approve $ 10,000 - $ 50,000 on recommendations from CR, PM

    • University Engineer (UE) could approve $ 50,000 - $ 100,000 on recommendations from CR, PM, DA

    • Assistant Vice President (AVP) could approve $ 100,000- $ 500,000 on recommendations from DA, UE.

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• Vice President (VP) could approve $ 500,000 and above on recommendation from UE, AVP

4. Create a reporting system for notification of all parties up the chain of command when a change order has been approved. This could be based on a system of monthly project reports or immediate upon approval.

5. Delegate tracking responsibility. Delegated personnel who handle project controls should track change orders as an additional responsibility. When time limits are exceeded, "late notice" could be issued. Weekly project progress meetings could use a change order status log to document and inspire progress.

6. Limit the number of items in a change order. A monthly schedule of change orders could also reduce waiting time before formal paper work begins. Change orders and any accumulated items that have been agreed to can be processed perhaps concurrent with the payment application process. Alternatively, consider one item per change order, and process an item as soon as it is agreed to.

7. Scope changes typically receive more scrutiny and require greater approval times than other types of change order items. Consider putting scope changes in separate change orders to facilitate processing of the other items.

8. Before a change order leaves Physical Plant for approval from CGA, use a checklist. Approval time could be reduced if change orders were checked for all the required fields before being sent to CGA for final approval.

9. Adopt project management software such as Prolog or Expedition for tracking change orders and other project documents. Alternatively, develop the project management features of FAMIS.

Other Recommendations

The following recommendations are general or contractual in nature and flow from the industry and university interviews but don't generally fit under the above categories.

1. Use specific alternates during bidding to obtain competitive pricing prior to contract execution for possible scope changes. Alternates require the contractor to bid portions of a project in two ways, one for a base bid and one that either adds or reduces scope. When the owner anticipates possible scope changes, the use of alternates during bidding can help to obtain competitive pricing. MSU already does this. The use of alternates is problematic for bidders however as it complicates bidding. The low bidder is usually not known until the owner selects which, (if any) alternates it wants to accept. When the owner does not provide a priority listing of alternates, contractors may also be fearful that a project could possibly be steered to a particular contractor by picking and choosing alternate items to (in effect) create a low bidder.

2. Consider a graduated percentage overhead and markup provision for change orders. Research by Semple (1996) showed that typically contractually established markup percentages rarely fully compensate a contractor for administrative costs of small change orders. Alternatively, Semple's research showed the contractor may receive a windfall for large change orders. The MSU database shows that 84% of change order items are less than $5000. The researchers believe that the current 5% markup on subcontracted work and 15% on self performed work probably does not cover the true cost to the contractor of change order items of this scale. Minnesota uses a graduated percentage markup for

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O&P. Additionally it establishes that markup is to be shared between the general contractor and subcontractor. MSU may want to evaluate Minnesota change order provisions for use on MSU contracts.

3. Eliminate or reduce the use of allowances on general contracts or keep allowances on the project ledger but don't assign them to the contract. In examining the database it was observed that whenever an allowance was exceeded on a project, MSU paid the 15% markup for overhead and profit (O&P) on the contract adjustment. But whenever an allowance was not completely spent MSU did not receive a credit for O&P on the deductive change. MSU as well, as most owners, typically does not collect back O&P on deductive changes, and the researchers certainly agree with that approach. Testing is one example of an allowance item for which MSU could assign a $0 value for an allowance and pay for by change order with the contractually agreed O&P markup. It should be noted that this currently is not a frequent or terribly significant issue. But, as MSU moves to more use of Construction Management on campus projects, it may be worth considering. It is typical for construction managers to use allowances with a variety of trade contracts to provide for ease of minor scope adjustments. It may be worth examining how much O&P MSU pays to trade contractors on work that never materializes. The researchers want to stress that they are very strong advocates of CM as a project delivery method. This O & P issue is only raised because, with CM projects, there will typically be more allowances than formerly used on campus projects.

4. Extend bidding periods, by perhaps one extra week to allow for more interaction during bidding between bidders, the university and design professional. Expanding the bid period will also give bidders time to consider new information issued by addenda. New information issued late in the bidding period can confuse bidders and lead to mistakes. MSU establishes timelines for issuance of addenda and for receiving and responding to bidders questions in the Instructions to Bidders, but the researchers question whether they are followed.

5. Continue to use prebid meetings and walk-throughs, but make it mandatory for all bidders to attend them.

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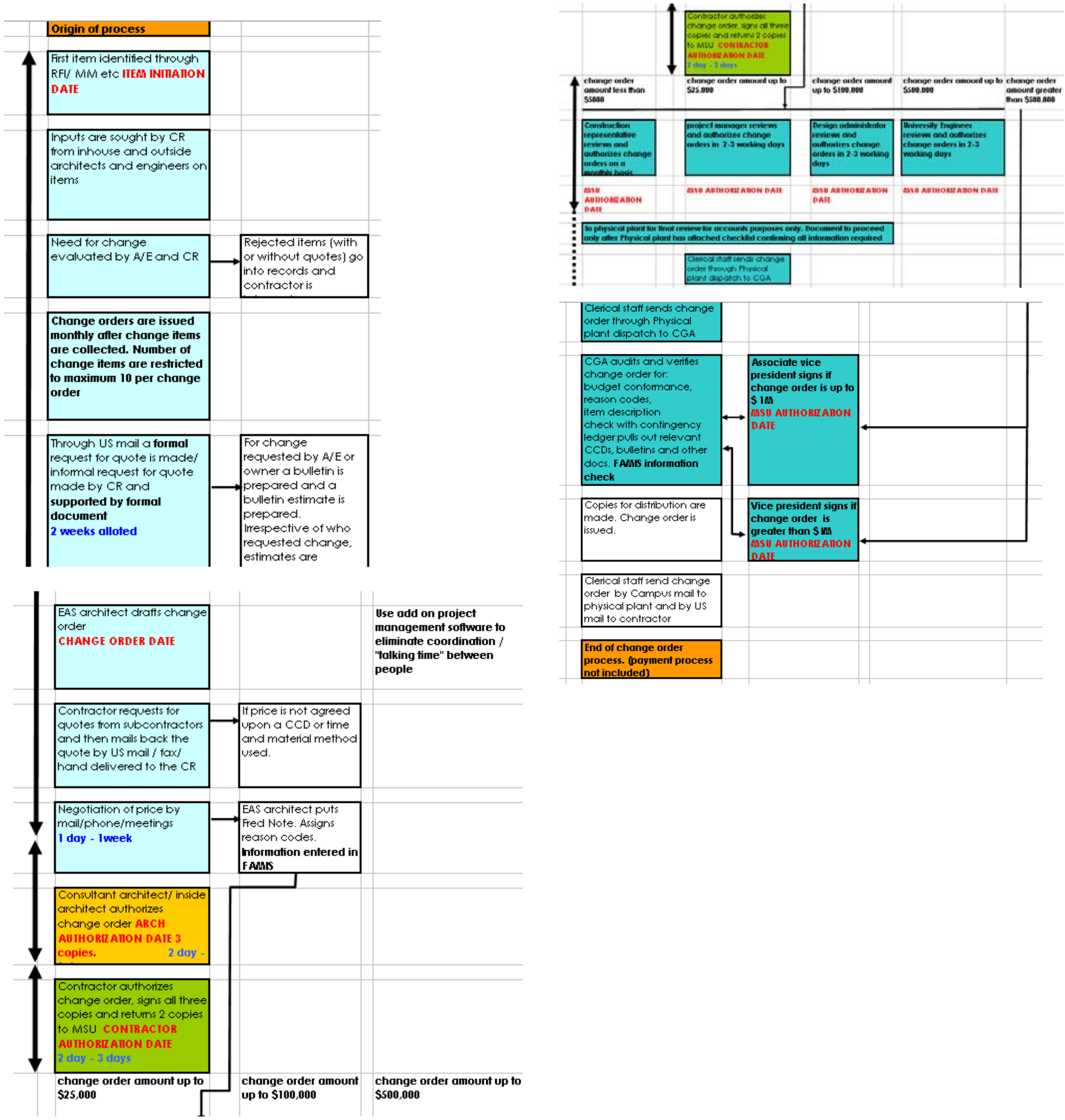

Alternative Process Model

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