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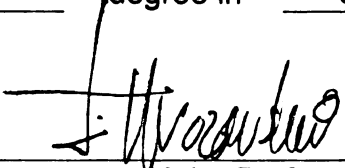
**A FRAMEWORK FOR REDUCING CHANGE ORDER
PROCESSING TIME IN UNIVERSITY CONSTRUCTION
PROJECTS**

presented by

POOJA MECHANDA

has been accepted towards fulfillment
of the requirements for the

M.S. degree in Construction Management



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**A FRAMEWORK FOR REDUCING CHANGE ORDER PROCESSING TIME IN
UNIVERSITY CONSTRUCTION PROJECTS**

By

Pooja Mechanda

A THESIS

**Submitted to
Michigan State University
In partial fulfillment of the requirements
For the degree of**

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ABSTRACT

A FRAMEWORK FOR REDUCING CHANGE ORDER PROCESSING TIME IN UNIVERSITY CONSTRUCTION PROJECTS

By

Pooja Mechanda

The process of administering change orders is an integral part of construction project management. This process is time consuming and, if not organized or streamlined, may result in delays. This thesis offers a framework that could be used by universities to reduce change order processing time; it briefly describes types of change orders, presents change order management practices and process mapping techniques. The researcher mapped and analyzed the change order process of a case study university, identified areas of improvement, and suggested strategies for reducing change order processing time. Information on 159 change orders with approximately 1675 change order items from 19 past construction contracts were organized in a database and statistically analyzed. In addition, interviews were conducted with construction professionals: architects, engineers, contractors, subcontractors and university administrators. Some of the areas for improvement the researcher identified were: reducing levels of approvals for simple change orders, reducing approval time, and reducing the number of items packaged into a single change order. After describing a generic framework, which universities could use to reduce processing time for change orders, a broad set of recommendations are presented.

Dedicated to my mother, who stood by me and had faith in me, who made the long journey to the United States possible, who made every dream achievable, to my father for being an inspiration, and to my brother for being my strong support and confidante.

To HIM who gives life and enough courage to live it, and all the colors in it so we may enjoy it in all its brilliance.

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ABBREVIATIONS

A/E	Architect/ Engineer
AIA	American Institute of Architects
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
ASME	American Society of Mechanical Engineers
CGA	Contract and Grant Administration (www.cga.msu.edu)
CII	Construction Industry Institute
CIID	Change Item Identification Number
COAA	Construction Owners Association of America
COID	Change Order Identification Number
CPP	Campus Park and Planning (www.cpp.msu.edu)
CSI	Construction Specifications Institute
EAS	Engineering and Architectural Services (www.eas.msu.edu)
EJCDC	Engineers Joint Contract Documents Committee
HFS	Housing and Food Services (www.hfs.msu.edu)
K-12	Grades Kindergarten Through Twelfth
MSU	Michigan State University (www.msu.edu)
RFI	Request for Information
RFP	Request for Proposal
US	United States (of America)

Chapter 1

Introduction

1.1 Introduction

The process of administering change orders is an integral part of construction project management. This process is time consuming and, if not organized or streamlined, may result in delays. This thesis offers a framework that could be used by universities to reduce change order processing time; it describes types of change orders, presents change order management practices and process mapping techniques.

Universities are typically experienced and knowledgeable owners and have a host of construction representatives, project managers, and designers as well as established systems for budget approval and administration. Typically university processing times for change orders are lengthy because of diverse project types, complex utilities and administrative requirements.

Universities fall under the category of institutional construction, which includes K-12 schools, universities, and prisons. This institutional sector makes a significant contribution to total construction value in the United States (US). “The institutional sector is the most stable nonresidential sub-sector in the construction industry, with its share of total construction spending ranging from 52% to 58% during every year since 1994.” (Delano, 2003). Table 1.1 shows approximate annual construction expenditure at certain universities. Universities in the table are members of the Big Ten conference.

Annual construction expenditure (physical plant) approximate (millions)	Division One Universities	Year
140	Pennsylvania State University	2003-2004
125	University of Iowa	2003-2004
117	Indiana University	2003-2004
100	University of Minnesota	2003-2004
80	Northwestern University	2003-2004
88	Michigan State University	2003-2004

Table 1.1 Approximate annual construction spending of universities

Source: Budget information on university websites¹

Change orders can have significant administrative and financial impact on projects. At MSU, (Michigan State University) preconstruction project contingencies are typically assigned at five to ten percent of project budget and may be largely consumed by change orders on a given project. These change orders result from unanticipated project conditions, document or process deficiencies, or by scope changes. Change orders at MSU may equate to three to ten million dollars of change orders annually. It is the author's opinion that streamlining a change order management process can reduce impacts and administrative costs for all project participants.

¹ <http://www.budget.psu.edu/factbook/Finance2004/Expense200405.asp?> (Accessed 2nd June 2005).
<http://www.uiowa.edu/%7Eour/fact.book/> (Accessed 2nd June 2005).
<http://www.indiana.edu/~vpcofo/> (Accessed 2nd June 2005).
<http://www.budget.umn.edu/budget/archive.htm> (Accessed 2nd June 2005).
<http://www.northwestern.edu/accounting-services/Annual%20Report.htm> (Accessed 2nd June 2005).
<http://opbweb.msu.edu/> (Accessed 2nd June 2005).

1.2 Need for this research

Change orders impact all participants in construction in some way. At a presentation for the Associated General Contractors, Michigan Chapter, Prof. Timothy Mrozowski AIA, professor in MSU's Construction Management Program, discussed some of the impacts on construction project participants¹. The following list is an excerpt from his presentation.

Impacts on contractors

- Disruption of project flow.
- Reduction in productivity.
- Increased project management time.
- Uncompensated management time.
- Breakdown in project relationships.
- Insufficient compensation for indirect costs.
- Personnel, equipment and bond capacity tied up on project.
- Disruption of cash flow.
- Coordination difficulties.

Impacts on design professionals

- Increased contract administrative time.
- Concern for liabilities due to errors and omissions.
- Uncompensated processing time.
- Breakdown in project relationships.

¹ A summary of this discussion is reported in the article "Personal Integrity, a Prime Quality of Proven Leader" available at http://mi.agc.org/PDD_2004.asp. (Accessed 2nd June 2005). Associated General Contractors Michigan Chapter.

- Disruption in project flow.

Impacts on owners

- Increased project costs.
- Project delays.
- Breakdown in project relationships.
- Disruption of project flow.
- Increased administrative costs.

Through this research, the researcher has attempted to develop a framework and recommendations for change order processing suitable for institutional owners, specifically universities, which can help to reduce the impacts and administrative cost to all project participants identified above.

1.3 Research goal and objectives

The broad goal of this thesis was to develop a framework that would help reduce processing time of change orders in universities. The specific objectives of the research were:

1. To develop a framework for reducing change order processing time in a case study organization.
2. To statistically analyze past construction projects within a case study organization in order to determine processing times and identify areas for improvement.
3. To conduct interviews with contractors, architects, subcontractors, and university personnel to gather different perspectives on change order processes, and to identify effective change order management strategies.
4. To develop an alternative process map and provide recommendations, which address change order management strategies for the case study organization.
5. To develop a generic framework for reducing change order processing time that universities can use in construction projects.

In order to help achieve the objectives, the researcher identified previous similar research and their methodology. These studies, described below, were conducted by organizations with bureaucratic levels and approval processes similar to those at universities.

1.4 Comparable studies

Three studies related to processing of change orders and relevant to this research were: the Federal Highway Administration (FHWA) report 2001, Missouri Department of Transportation (MoDOT) audit report 2002, and Performance Evaluation and Expenditure Review-Mississippi Legislature 2002 (PEER).

The FHWA (2001) study analyzed 159 change orders and showed the average processing time of change orders ranged from five to ten days. Processing times for change orders were broken into several groups to isolate trends. These groups consisted of: change order date to contractor's signature date, contractor's signature date to project engineer's signature date, project engineer's signature date to district engineer's signature date, district engineer's signature date to director of operation's signature date, and director's signature date to FHWA's signature date. The simple averages for each respectively were 4.41, 2.25, 4.25, 4.33, and 10.75 days. The total time weighted average was 9.14 days. Although the author did not consider these days comparable to university processes, the methodology used for the FHWA study was adaptable to this research thesis.

The FHWA (2001) study showed 65% of the change orders were processed in five days. Close to 70% of their change orders were adequately documented. In addition to data collection and analysis, the review team put together a short questionnaire designed to get some idea of how the districts felt the change order process was currently working. Although the processes were not mapped and analyzed for causes of delay, the assessment of processing time was very useful to this thesis.

The MoDOT (2002) report did not assess processing time; however the report described an approval process in that organization. In that process, management personnel at lower levels in the organization were authorized to approve change orders of limited complexity and dollar value. As dollar value and complexity increased, higher levels of management were involved. The author recognized this as a possible means for reducing processing time for change orders in a university. MoDOT (2002) utilized four levels of change orders as indicated below:

- Level 1 required a Resident Engineer's approval and involved a change in a contract item of less than \$50,000 or in a new contingent item under \$20,000.
- Level 2 required the approval of a District Engineer and may require approval from the Federal Highway Administration. It pertained to a change in a contract item between \$50,000 and \$100,000, a new contingent item between \$20,000 and \$50,000, or a final change order not meeting the criteria of Levels 3 or 4.
- Level 3, a major change order, required the approval of the State Project Operations Engineer, and also an approval from FHWA. It entailed a change in a contract or contingent item over \$100,000, a new contingent item over \$50,000, a specification change, a revision in contract price, a change in a contract item amount or change in a major item over 25%, a change in design concept, a differing site condition, or any value engineering change orders.
- Level 4, a major change order, required the approval of both the Chief Engineer and the Chief Operating Officer, in addition to all the previously mentioned approval levels.

It entailed additions greater than 50 % if the original contract amount was \$500,000 or less, additions greater than 25 % if the original contract amount was greater than \$500,000, or contract additions greater than \$1,000,000.

In Missouri, the Department of Finance and Administration's Bureau of Building, Grounds, and Real Property Management was responsible for the construction, repair, and renovation of most state buildings. PEER (2002) reviewed the bureau's selection of the architectural and engineering contract professionals who assisted in construction project management. PEER (2002) also reviewed the bureau's management of project change orders. The PEER (2002) report mentioned that they have weak cost analyses of change orders. There was no assessment for processing time of change orders. However, the report identified possibilities for improvement in the change order documentation.

Neither of the studies mentioned above addressed specific complexities of university construction processes. The method used for research however is applicable. Primarily, these were audits of processes that concluded either that their processes needed to be improved, or that they were functioning well. There was no attempt made to map a process, analyze it, and redefine it using the conclusions of their audit reports. Since no complete framework was laid out in the existing literature for this research, it was necessary to establish a research methodology.

In order to develop a framework, the researcher chose to focus on a case study of one university. This allowed the researcher to develop the framework/ methodology specific to the needs of the case study university, conduct the research along the lines of the framework, and identify opportunities for reducing processing time of change orders. The framework was then subsequently broadened based on literature and interview of

outside architects, contractors and administrators from four other universities. Recommendations were made which are applicable to other similar universities.

1.5 Case study: Change order process at Michigan State University

The case study used for this research was a part of a larger research study for MSU. In 2003- 2004, a research project was conducted for the purpose of improving the change order management process at MSU. The overall research objective was to develop strategies for reducing the impact and cost of change orders on MSU projects. The strategies encompassed both preconstruction change order prevention activities and construction phase change order management. Data collected for this larger research study form the basis for the time analysis of this research.

This research project led to three masters theses, which included:

- Statistical analyses of MSU change orders (Gottschalk, 2005- unpublished at the time of this writing).
- Development of pre-construction change order prevention strategies for reducing design errors and omissions in university construction projects. (Yelakanti, 2005).
- A framework for reducing change order processing time in university construction projects. (Mechanda, 2005).

Each researcher conducted a review of existing literature, studied project histories of 16 MSU construction projects to derive results important for their individual research goals and objectives. Project histories were put into a database, which was used by the researchers for statistical analyses. Additionally, researchers conducted interviews with project managers, subcontractors, and designers in the construction industry, as well as

university construction administrators. This helped the research team gain a broader perspective on change orders.

1.6 Methodology

This thesis research work was accomplished through the following three primary steps:

1. Literature review

Literature was reviewed on process models and change order management strategies, as well as comparable studies on change order process improvement.

2. Development of framework for reducing processing time for change orders at a case study organization

MSU was identified as a case study organization. The processes in this organization were studied in detail. An alternate process map and a set of recommendations were developed to reduce change order processing time at MSU. Based on the framework used for this university, a generic framework was developed that can be used by other universities to reduce their processing times.

a. Statistical analysis of database of construction projects to identify trends in the process in this organization

Information from the umbrella project database was analyzed using Microsoft® Excel and Minitab™. Analysis was done to:

- Identify overall process time of change orders at MSU.
- Identify process time between each major milestone (sub-processes) to show which sub-process significantly contributed to overall processing time.
- Removal of outliers from the dataset, using box plots and standard deviation to identify typical projects, change orders and change items.

- Establish correlations between factors using regression analysis. (ANOVA).
- Identify areas for improvement in the process, leading to reduction in processing time.

Analysis tools such as histograms, bar charts, scatter plots, line diagrams, pie charts, Minitab™ functions and MS® Excel functions were used for this purpose.

b. Interviews

Separate questionnaires were developed for university administrators, architects, contractors, and subcontractors for the purpose of gaining an industry perspective of the management of change orders. (Refer to Appendices B, C, D, & E). The responses and opinions aided in identifying change order process improvement opportunities.

c. Mapping of current management process of change orders in a case study organization

The change order process at MSU was mapped using the Graham technique (Graham, 2003). This technique identified each activity in the map by assigning characteristics to each step (value added, waiting, editing, approval etc.). After mapping the process was evaluated for opportunities for improvement using a checklist developed by Smith (2002), which is presented in chapter three.

d. Development of an alternative change order process map

Evaluations of the current process map and the results from the statistical analysis and interviews were used to develop an alternative process map. The Graham technique (Graham, 2003) and MSU interviews identified opportunities for improvement. Statistical regression results established relationships between factors that justified

the need to modify a step in the current process map. The alternative model was developed using these results.

e. Interviews for verification of results

Verification was necessary to confirm the applicability of the alternate process map. Three MSU personnel were interviewed to verify the feasibility of an alternative process map and recommendations.

3. Development of generic framework for reducing processing time for change orders in university construction

Based on the research framework developed for the case study organization, and literature review the researcher developed a generic framework that can be used by other universities for reducing processing time for change orders. Additionally a set of recommendations was also developed.

1.7 Deliverables

Through this thesis, the researcher developed an alternate change order process map, which aims at reducing processing time of change orders in MSU. This map was accompanied by recommendations for process improvement. In addition to the primary deliverable, current processes of three departments in MSU were mapped: Engineering and Architectural Services (EAS), Housing and Food Service (HFS), and Campus Park and Planning (CPP).

The generic map and a set of recommendations, which was developed, based on the framework used for the case study organization, were the primary deliverables of this research.

1.8 Research scope

Within the larger domain of university construction processes, this research focused on change order process improvement. Within this smaller domain of change order processes, this research concentrated on reduction of processing time for change orders.

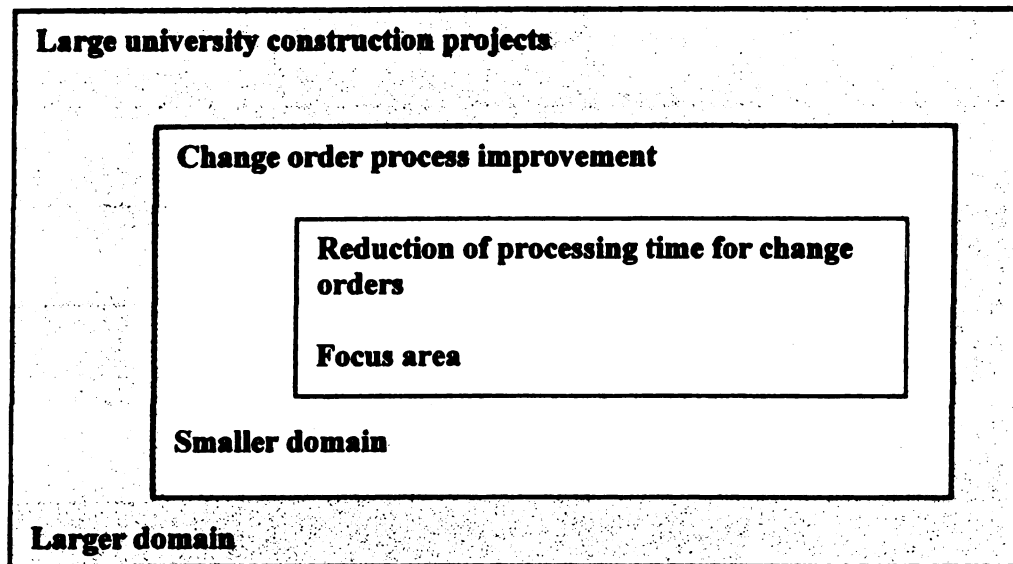


Figure 1.1: Domain and focus area of research

1.9 Limitations of the research

Taking into account the scope and time restriction of conducting such a study, this thesis has some limitations, which should be taken into account in the application of the results.

Sample

A sample of 16 projects was identified for this thesis. Although the projects are believed by the researcher and the oversight committee to be a representative set of

projects, purposive sampling was chosen versus random sampling, due to a possibility of replication of project types. A random sample could bring out a sample with higher percentages of either renovation or new construction, or more projects procured by one of the departments, or of one type. This would not have been representative of MSU projects. The oversight committee developed a list of possible projects that were free of litigation and fairly representative. From this list the researchers selected 16 projects for inclusion in the database. Refer to Appendix A for details of the sample.

The specific statistical results may not be generalized in their totality to other universities. Each university would have its unique processes and project types and a host of different parameters. However the recommendations can be applicable and the methodology can be generalized for process improvement initiatives in other universities.

Project delivery method

The sample did not address all project delivery methods. The sample projects largely used general contract and construction management forms of project delivery. Further research could be done by adding projects that cover other methods of project delivery in the sample, such as design build.

Cost savings

Although reducing processing time alludes to savings in administrative costs, no assessment of cost savings was made in this thesis.

1.10 Chapter summary and thesis organization

This chapter lays out a context for the thesis and introduces terminology that will be used further. It provides an introduction, indicates a need for this research, identifies goals and objectives, deliverables, and the scope and limitations of the thesis.

The thesis is organized in seven chapters and appendices. The first chapter presented an overview of the study. The second chapter presents the literature review, and identifies existing research and studies of change orders and process improvement.

The third chapter discusses the methodology of the thesis. The fourth chapter describes the case study, and how data was handled and reported. Additionally the fourth chapter presents the results of the database analysis.

The fifth chapter describes the framework developed for the case study organization. The sixth chapter presents the generic framework that could be used by universities in process improvement endeavors to reduce processing time for change orders in their organization. The last chapter also presents a summary, areas for future research and conclusions of the thesis.

Chapter 2

Literature Review

2.1 Introduction

Overall, the literature suggests that construction change orders are inevitable. The author concurs with Civitello's (2002) opinion that owners, designers and contractors will be in an advantageous position if they accept the fact that changes are a normal part of every project. Then time and energy can be diverted away from improper arguments and paper shuffling and be devoted to the prompt settlement of the three critical change order components: scope, cost and time.

This chapter presents work by other researchers on the general subject of change orders, as well as studies specifically devoted to the subject of change order management. This chapter also describes process maps and techniques for mapping, as well as related literature. The chapter is divided into three major sections, which include:

- 2.2 Existing literature on change orders.
- 2.3 Literature on change order management.
- 2.4 Process improvement techniques.

2.2 Existing literature on change orders

Change orders can be broadly characterized depending on the way they are addressed in a contract as: unilateral and bilateral. Moreover there are several types of change orders based on the kinds of changes made in contracts. These are described below. The impact of change orders on various phases of construction and on project participants as well as a brief discussion of markup and cost estimation of change orders are also presented.

2.2.1 Understanding bilateral and unilateral change orders

A bilateral change order is an agreement between the owner and the contractor to effect a change. The term used in federal contracts is *contract amendment*. “If the term change order is used in federal projects it generally implies a unilateral agreement, which is usually directed by the owner. This is issued for emergency work and to expedite a process. It has to be supported by a bilateral contract modification. The other terms used for unilateral contract amendment are: Construction Change Directive, CCD, (in AIA documents) and Work Change Directive (in EJCDC contract documents).” (Fisk, 2004). This research uses the term change order as in bilateral contract modification for non-federal projects.

	Change Type	Public (non federal) Contracts and private contracts	Federal contracts only
Contract modifications	Bilateral	Change order	Contract Amendment or supplemental agreement
	Unilateral	Construction Change Directive	Change order

Table 2.1 Bilateral and unilateral changes (Fisk, 2004)

2.2.2 Types of changes

Directed and Constructive Change

“Directed changes are changes ordered by the owner to perform work that differs from that specified in the contract. This can be either additive or deductive (add to or reduce scope). In this type of change there will be no debates on whether a change occurred. The only issues would be financial compensation or the impact on schedule and

that is mentioned in the contract by any of the construction participants. These have to be claimed by the contractor in a specified amount of time. This type of change leads to disputes. Types of constructive changes may include: defective plans and specifications; engineer's interpretation; higher standard or performance than specified; improper inspection and rejection; change in method or performance; change in construction sequence; owner nondisclosure; impossibility/ impracticability of performance." (Fisk, 2004).

The other types of change orders are¹:

- Differing site conditions.
- Acceleration of work.
- Weather conditions.
- Non design-related change order.
- Design-related change order.
- Emergency field condition change orders.
- Scope changes.
- Donation/contribution change orders.
- Value engineering and betterment change orders.

(Refer to Appendix F for explanation of the above terminology).

2.2.3 Project delivery methods and change orders

McCally (1997) studied the relationships between project delivery methods and change orders. The following sections summarize the observations of this research.

¹ From website of Department of Neighborhood development. Housing Policy, City of Boston.
[http:// www.ci.boston.ma.us/dnd/D_2-2_change_order_and_contingency.asp](http://www.ci.boston.ma.us/dnd/D_2-2_change_order_and_contingency.asp). Also refer to appendix F.
(Accessed 2nd June 2005).

Hard-bid contracts and change orders

“Hard-bid contracts are very competitive and are won by narrow margins; therefore they require highly defined scopes. Change-order management on hard-bid contracts can actually start during the bid process. In this type of contract, the issue may often be that the bid documents did not express the owner’s intent clearly. If people who review bid documents are trained in the design disciplines, they may better be able to detect technical flaws. A constructability review, if done by the estimator and constructor, provides an opportunity to point out areas where alternative construction methods of equal soundness could result in lower bid prices. The same principle can apply to specifications for equipment, materials, and even milestone schedules. When specifications are well defined and the owner accepts the bid after thorough review, potential change orders may drop in number.” (McCally, 1997)

Guaranteed-maximum contracts and change orders

“Guaranteed-maximum contracts are usually negotiated and often are based on conceptual documents. When the scope is not well defined changes during the construction phase are likely to occur. Too much drawing information is left to shop drawings to complete. Often the fact that scope revisions are not accounted for in the maximum price fixed is overlooked, and this leads to unsettled issues and disputes.” (McCally, 1997)

Cost-plus contracts and change orders

“Cost-plus contracts are used because the scope of work cannot be defined in some instances. The contractor has to establish a preliminary budget on information made

available at the time and, as work progresses, scope as well as design becomes clearer. This leads to budget revisions.” (McCally, 1997)

2.2.4 Impact of change on productivity

Change, whether during the design phase or during construction, may affect productivity, general conditions, and mobilization costs. It can also cause rework. Changes occurring later in the project have a greater impact; a key variable affecting efficiency is the point in time at which change occurs (Ibbs, 1997). Ibbs used a questionnaire developed with the help of the Construction Industry Institute (CII) Change Management Task Force. A pilot version was tested and then data was collected on cost, labor-hour, schedule, and milestones, at 25, 50, 75, 80, 85, 90, and 95 % completion. 79 statistical analyses were conducted. Responses from 35 different organizations, with 104 projects involving more than eight billion dollars in total installed cost were obtained. Compared to change rates projected by Diekmann and Nelson, (1985), and Hester et al. (1991), the change ratios in the study by Ibbs (1997) were low. This was as a result of private sector projects studied. (Flexibility of negotiations prevented change orders from occurring; hence the ratios were low.) Most projects had less than four percent growth in the design phase. In the combined design and construction phase growth equaled five percent. 20 % of projects showed 11 % or more growth. Ibbs (1997) concluded that every additional 10% of change affected productivity by 2.48% and that construction productivity was equal to planned value at a six percent change level. Additionally, he concluded that lower labor performance was strongly related to presence of change (Ibbs, 1997).

Assem (2000) developed ten neural network models, which estimated productivity losses due to change orders. The models accounted for: type of impact, intensity of change orders, timing of change orders, and type of work executed in the changes. This was used for development of a software application. Data sets that could be used for further research or development of new models were a valuable contribution of this research work.

Research on productivity by Assem (2000) and Abdo (1999) used neural networks. Abdo (1999) developed a series of neural network models that account for change order intensity, work type, and type of impact. Hanna (2002) developed a non-linear regression equation that estimates the ratio of labor productivity to total man hours for both electrical and mechanical work. In mechanical work the equations accounted for change order intensity, timing of occurrence of change orders, and work phase (Hanna et al, 1999 a). In electrical work (Hanna et al., 1999b) the equations accounted for project manager's years of experience, and change order intensity.

Another study that used the support of the CII Change Management Task Force committee was (Hanna et al., 2002). This work specifically studied electrical and mechanical contractor's projects, since their work is labor intensive. The goal was to quantify the impacts and identify projects impacted by change orders. Thirty six electrical contractors provided data on 59 projects and 33 mechanical contractors gave data on 57 projects. Project size was greater than 2000 work hours. Statistical analyses using software and hypothesis testing and regression analysis were conducted. A model was developed to determine if projects were impacted. Validation of the model was done using new data. Findings relevant to the above study are summarized as follows:

Characteristics of projects impacted by change are: (Hanna et al., 2002)

- Impacted projects experience a longer change order processing time. (average more than 28 days).
- Other factors interact with amount of change (such as timing of change, type of change, and project size), or are caused by change (disruptions such as over-manning, overtime and absenteeism) that determines if a project will be or has been impacted.
- Impacted projects show a higher percent of change (mean percentage change was 44.6 %).

Hanna et al., (2002) developed a logistic model to determine probability that a project has been impacted by a change order. Eight different factors identified by Hanna, that might affect a project are summarized below:

- **Planning phase**

Large projects, identified by actual hours, were more likely to be impacted by change orders.

- **Design Phase**

On projects where adequate support was given during construction by the A/E, the design issues were usually coordinated prior to construction. Research conducted (Hanna et al., 2002) also indicated that an average of 50% of change orders in impacted projects were from design problems, while un-impacted projects averaged 38% (Design problems include design changes, coordination, errors by contractor or designer).

- **Construction Phase**

If overtime and over-manning is used to accelerate because of a change order, the project is likely to be impacted. The amount of change itself showed up as a significant factor in determining if a project was impacted by change orders. The more change that occurred on a project, the more likely the project was to be impacted and to have significant productivity losses. Changes lead to absenteeism, which decreased productivity. Processing times of change orders were significantly higher for impacted projects compared to un-impacted projects.

2.2.5 Cost impact determination of change orders

Moselhi et al. (1991) studied productivity losses due to change orders using 90 cases from 57 different construction projects. The model that resulted from this research can be a useful tool for after-the-fact situations and also for front-end cost impact determination. Results indicated a significant direct correlation between labor hours spent carrying out change work and loss of productivity. Productivity losses were shown to be greater in mechanical and electrical work than in civil and architectural work. Another significant finding was that productivity losses were affected by the type of work (fine versus gross motor skills), but not by type of construction (buildings versus industrial facilities).

2.2.6 Markup and cost estimating of change orders

The issue of markup and cost estimating of change orders is a major concern with contractors and owners. Sarvi (1987) concluded that the true cost of a change order could be significantly greater than the cost of labor, materials, equipment and markups. Moselhi

et al. (1999) conducted research on neural networks for estimating costs and Semple (1996) conducted research on markups and other practices through surveys. Both these studies led to results similar to Sarvi (1987). Semple's (1996) thesis was based on construction practices in Alberta, Canada, and discusses markup values, impacts of change orders and the process of change orders. The thesis sought to answer these questions: Did the then-current markup cover costs and time associated with change orders? Was ten percent markup acceptable in Alberta's construction industry? What were reasonable methods for determining change order markup values? Her research focused on studying change order costs and the time involved in processing the change orders. Semple (1996) concluded that a reasonable markup percentage was seven to eight percent. There was little agreement on an average markup value, indicating that markup and profits should not be standardized.

Civitello (2002) suggested that it is advantageous for a contractor to submit a large number of small costs instead of a small number of large costs for approval. This seems like a logical strategy not only from the contractor's perspective, but also from the owner's perspective. It is easier for owners to approve a proposal when it is broken down into smaller components and negotiating time is thereby reduced. Some components can be eliminated, instead of the entire proposal. Civitello (2002) also suggested presenting change order proposals in the three-cost approach: Direct, Indirect, and Consequential costs. In every proposal; each category may not be applicable, however, it gave the owner confidence and made the cost procedure standard.

Moselhi (1999) presented a cost model for pricing change orders, which identified cost components and cost categories. One conclusion similar to Civitello's (2002)

recommendation was that impact costs should be included in change order costs. In contrast to Civitello (2002) both Semple (1996) and Moselhi (1999) do not suggest standardization of change orders. Semple (1996) and Moselhi (1999) recognized that there were too many parameters affecting pricing and it was difficult to quantify costs. Moselhi's (1999) model assessed impact cost through neural networks. His model can also be used during claims to quantify damages.

The following section describes the prevalent change order management practices. It also summarizes relevant research work done in this area.

2.3 Literature on change order management

Responding to the drive for improvement in process and quality, several technical and management journals have published a wide variety of articles on change management and claims prevention. The key to successful management of change orders, as the literature suggests, seems to be good document management and process improvement. The findings from some of the literature on change order management are summarized below.

2.3.1 Nine keys for effective management of change orders

McCally (1997) suggested nine keys for effective change order management:

1. Clearly defined processing procedure.
2. Supervision of processing procedure.
3. Clear instruction regarding scope of changes.
4. Timely issuance of request for proposal (RFP).
5. Timely response by contractor to RFP.
6. Timely review of contractor's proposal.
7. Timely issuance of work authorization.
8. Timely performance of changed work.
9. Prompt payment for change order work.

2.3.2 Timeliness of change orders

Many of the inefficiencies that may result from change orders are related to the timeliness of a change; "How much notice is given between the date the change is identified and the date it is scheduled to start. When the notice period is too small, it affects planned sequencing. If processing time is too long, the contractor has to begin work and move on at his/her expense." (Kasen and Oblas, 1996).

2.3.3 Standardizing procedures

Many organizations in the construction industry view standardization as making a system rigid, resulting in additional paper work. (Supported by interview feedback as shown in appendices B, C, D, and E) Standardization is viewed with skepticism by some. Civitello (2002) suggested that contractors should not underestimate the power of standardized forms. People are hypnotized by forms (Civitello, 2002). Civitello (2002)

urged that standardizing procedures and forms made a system more legitimate and logical, and people rarely challenge such a system. He also specified that the effect is more pronounced when a large bureaucratic organization used such forms or standardized procedures. He advised contractors to understand processes and question authority, if required, rather than be intimidated by them.

Civitello (2002) suggested that standardization is vital to build confidence of project participants. Additionally it ensured that a process was executed in a consistent manner. Bekerman (2003) also suggested that consistency and standardization were vital to avoid errors. "Consistency is one of the significant elements for continuous improvement. One should aim at doing every operation (in the process) the same way every time. A certain degree of standardization is necessary, but without inhibiting innovation. Consistency should not dampen innovation. You need both in order to grow and prosper. Make sure that you have written procedures for all your operations. These procedures should reflect what is really happening; having procedures that are ignored is worse than not having them at all. When a new procedure is developed that is more productive or less prone to error, the whole process of documentation and training should start all over again." (Bekerman, 2003)

2.3.4 Documenting oral discussions

Oral discussions may facilitate quick decision making and the dissemination of information on issues, but such discussions must be confirmed with documents. It is important to understand the seriousness of the written confirmation of quotes (Civitello, 2002). In *Wisch & Vaughan Construction Co. v. Melrose Properties Corp.*, 21 S.W. 3d 36 (Mo.App. 2000), an owner wished to avoid paying for certain extras on the basis that

the contractor had not followed the contract requirement to obtain approval in writing. The court found that the owner had to pay, because by paying for other extras that were only agreed to orally, the owner had waived the right to insist on written approval.

“It is not easy for some contractors to say no when directed to do work in the field. As a result, they are taking a big risk as to which side a court will come down on later if the owner or general contractor decides not to pay. The only way to avoid this is to have a strict company policy, which no one but the owner can waive, that directives have to be in writing before any work will be done that is over and above, or different from, than what is called for in the contract.” (McGreevy, 2001)

2.3.5 Pricing of change orders

Forward pricing is another technique suggested to reduce claims and delays. It is an impact resolution technique that uses formulas to carry out up-front impact estimating of change orders, taking into account various factors. The parties agree upon impact costs for each change as it arises. Kasen and Oblas (1996) put forth a forward pricing formula, that takes into account the sum of direct costs, timeliness (time between notice to proceed and actual-schedule-activity start date), complexity of the disciplines or trades, cumulative impact and future impact on float.

2.3.6 Three-cost pricing of change orders

Civitello (2002) suggests prioritizing items and submissions required in the early stages of construction for early review and approval. He urges that establishing a fixed time for approvals is beneficial to all parties. Civitello's (2002) suggestions for contractors include using detailed proposals that break down large costs into smaller costs. “Three-cost” pricing is suggested for faster approval and for gaining the trust of

owners. The three costs include: direct, indirect and consequential costs. Not all owners may agree to indirect and consequential costs, however. Detailed checklists are offered by Civitello to contractors for good document management, proposal preparation, and tracking of change orders.

2.4 Process improvement techniques

What is a process? A process is a series of activities undertaken to accomplish something. “It has a start point, and an end point between which various items (materials, forms, and records) are worked on usually by a different number of people located in different places using various equipment.” (Graham, 1996)

A process map can be used as a tool for process improvement. “Process mapping is a technique for making work visible. A process map shows: who is doing what, with whom, when and for how long. It also shows decisions that are made, the sequence of events and any wait times or delays inherent in the process. They also can help in the effort to reduce cycle time, avoid rework, eliminate some inspections or quality control steps, and prevent errors.” (Smith, 2000)

2.4.1 Analysis of process

Smith’s (2000) analysis of a process requires considering the process activities and flow by undertaking the following:

Looking at each process step for:

- Bottlenecks.
- Sources of delay.

- Errors being fixed instead of prevented (rework).
- Role ambiguity (we didn't know who...).
- Duplications.
- Unnecessary steps.
- Cycle time.

Looking at each decision for:

- Authority ambiguity (two or more people get to decide...).
- Are the decisions needed at this point?

Looking at each rework loop for:

- Possibly eliminating the step(s).

Using the customer's point of view

- Value-added vs. non-value-added steps.

2.4.2 Process mapping

Because process mapping was used during this research to study current change order practices, the researcher reviewed literature on process mapping. There may be several ways of mapping a process, based on what the goal of mapping is. Snowden (2000) suggested that one could begin by macro mapping and then move to more detailed mapping.

Flow charting is a popular method of process mapping. Snowdon defined different levels of flow charting as: Macro, Mini and Micro (Snowdon, 2000) which are described below:

- **Macro level.** The top leadership may not need the amount of detail required by the workers in a process. A "big picture," or *macro-level*, view of the process may be enough for their purposes. Generally, a macro-level flowchart has fewer than six steps.
- **Mini level.** The term "mini" or "midi" is used for a flowchart that falls between the big picture of the macro level and the fine detail of the micro level. Typically, it focuses on only a part of the macro-level flowchart.
- **Micro level.** People trying to improve the way a job is done need a detailed depiction of process steps. The micro-level, or ground-level, view provides a very detailed picture of a specific portion of the process by documenting every action and decision. It is commonly used to chart how a particular task is performed.

2.4.3 Types of flowcharts

Besides the three *levels of detail* used to categorize flowcharts, Snowdon (2000) described three main types of flowcharts—**Linear, Deployment, and Opportunity**, which have been paraphrased below. The level of detail can be depicted as macro, mini, or micro for each of these types.

- **Linear flowchart.** A linear flowchart is a diagram that displays the sequence of work steps that make up a process. This tool can help identify rework, as well as redundant or unnecessary steps within a process.

- **Deployment flowchart.** A deployment flowchart shows the actual process flow and identifies the people or groups involved at each step. Horizontal lines define customer-supplier relationships. This type of chart shows where the people or groups fit into the process sequence, and how they relate to one another throughout the process.
- **Opportunity flowchart.** An opportunity flowchart, a variation of the basic linear type, differentiates process activities that add value from those that add cost only.

2.4.4 Graham Flowcharting technique

There are sophisticated versions of flowcharting that are variations of the fundamental types. Graham (1996, 2001, and 2003), for example developed flowcharting techniques for process improvement. These flow charts incorporate some qualities of all the flow chart types described above. Graham process charts provide a picture of a process with enough detail to allow (and stimulate) common sense improvement ideas by the people who do the work. Process charting software developed by Graham is a 32-bit Windows application.

Graham techniques use symbols in the flow charts. Different symbols indicate functions of each step in the process. For example, as shown in Figure 2.1, a value added document edited for some reason, and awaiting approval is indicated by a specific symbol.

	Do	The do operation represents a value added step in the production process. It adds value to the product by physically changing it in the direction of being completed.
	Originate	The origination symbol is used the first time information is entered in a document.
	Add/ Alter	After the item is entered this symbol will show up every time information or document is added to / altered. This is essentially a value added activity.
	Handle	This indicated physical paper shuffling, keying information in electronically, loading, unloading.
	Transport	This symbol represents movement from one work area to another, which are physically separate. These may be time consuming activities.
	Inspect	This symbol represents the activity of checking the item to see if it is right.
	Storage/ delay	Time when nothing is happening to the physical document/ product. It may indicate "waiting for some other information" and delay caused due to it.
	Destroy	This indicates that the activity/ item/ ceases to exist. It identifies items that are in the system to purge and clean the system.

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Figure 2.1 Symbols used in Graham flowcharting technique

Graham's symbols serve as verbs describing the actions. "They are a set of categories that are:

- **Mutually exclusive:** Each symbol represents a distinct type of action. Therefore the categories do not overlap, and this makes it difficult to determine which symbol to apply. An item is either moving (an arrow) or stationary (all other symbols): it is either doing nothing (a triangle) or doing something (all other symbols), etc.
- **Universally applicable:** They occur in all work areas. Therefore it is not necessary to use different terminology in different work areas. (For example sales, engineering, accounting etc.)

- **Comprehensive:** They cover work processes completely.

Each step in a work process is identified by one of eight of the American Society of Mechanical Engineers (ASME) and American National Standards Institute (ANSI) approved symbols.” Graham (2003)

Because of its clarity, this process mapping tool was used to map the prevalent process in the case study organization as well as to construct the alternate process map. The Graham technique of flowcharting was used in this research. The “destroy” symbol was not used and new symbols were added for review and “approval”. These symbols are described in more detail in chapter four.

2.5 Chapter summary

This chapter summarized literature on the subject of change orders related to pricing, documentation, processing time and timelines of change orders. Additionally, prevalent process improvement techniques and tools used to analyze processes were also described.

Chapter 3

Methodology

3.1 Introduction

This chapter describes the methodology adopted to complete this research and how data was obtained, managed and used to draw conclusions related to the research topic. The researcher used a database developed by Gottschalk (2005- unpublished at the time of this writing) for MSU to statistically analyze the processing time of change orders, and to observe trends in the sub-processes. Interviews were conducted with architects, subcontractors, contractors, and owners to gain perspectives on the change order process. Both the statistical analysis and the interviews are described in this chapter. This chapter also describes how the current MSU change order processes were mapped and how they were analyzed. Results are described in chapter four. The mapped processes and the alternate process map are presented and described in chapter four.

3.2 Methodology

As shown in figure 3.1, the research began by first defining the research project, its goals and objectives. This was then followed by literature review of existing studies and articles on change orders and process improvement. MSU was identified as a case study organization for the research. MSU's background information and processes were reported. Interviews were conducted with local architects, contractors, subcontractors, and university administrators at MSU and administrators from other universities. Meanwhile a historical database of sample projects was set up and data was analyzed. In order to understand MSU change order processing activities the prevalent change order processes at MSU were mapped. Based on the results of the process mapping analysis, interviews, database analyses, and process improvement tools identified during the literature review, an alternate process map and recommendations for streamlining the

change order process were developed. The alternate process map and recommendations were evaluated through interviews of MSU administrators.

Based on the framework used for process improvement at MSU and literature review, a generic framework was developed for reducing change order processing time, which can be applicable to other similar universities. Sections 3.3 through 3.14 describe methodology in detail.

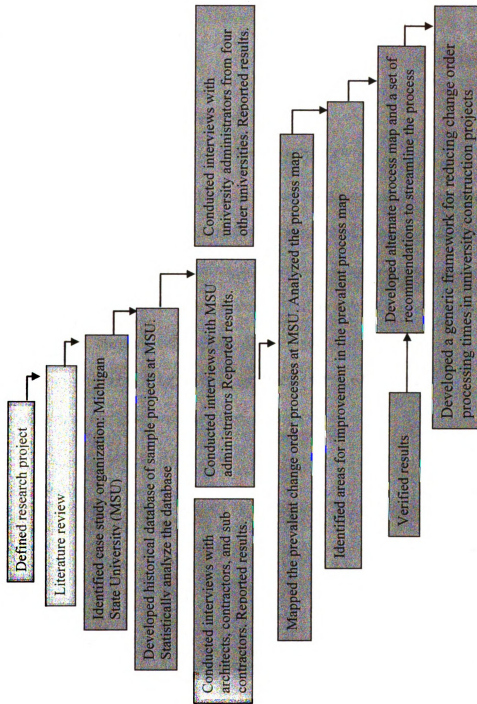


Figure 3.1 Methodology of this research

3.3 Literature review

The literature review covered research projects supported by the Construction Industry Institute (CII) Change Order Management Task Force, masters theses, industry audit reports on change order processing, relevant technical papers and feature articles in journals. Chapter two discusses some of the literature, which the author regarded as more relevant to the change order process.

3.4 Case study organization: Michigan State University

In section 1.5 the researcher provides a background on the change order research project conducted for MSU. This research is a subset of that project. MSU has several departments that can procure construction services. Five of these departments took an active initiative in sponsoring the research as well as serving on the oversight committee for the research. They are: MSU Office of the Vice-President for Finance and Operations, MSU Physical Plant, EAS, CPP, and HFS. CPP administers site planning, site construction, roads, landscape furniture, and storm sewer lines between manholes. HFS oversees interior design, maintenance of residence halls, and housing projects. The Physical Plant at MSU oversees Engineering and Architectural Services (EAS), custodial services, maintenance, utilities, recycling, and waste management, as well as other functions. EAS oversees major campus construction projects. EAS and CGA both review change orders for budget conformance and final approval. While CPP and HFS have fairly simple change order process, EAS has a more complex process and is the primary focus of this research. There are four categories of the EAS change orders, which are as follows:

Major process

The external architect usually drafts the change orders in the Major category.

Formal process

In the Formal process, either the external or the internal architect drafts the change order.

Construction management process

The construction manager drafts the change order in the construction management process.

Purchase order process

The internal architect drafts the change order in purchase orders.

These are classified on the basis of project complexity, dollar amount and other factors. This research emphasizes the Formal process.

3.5 Database

Records of 16 projects, 19 contracts and 159 change orders were included in the database. The database was developed for the overall MSU change order project, and has approximately seventy thousand data entries. The data was obtained from paper files of EAS and incorporated into the database, which was developed in MS® Access. Change order data entry forms, developed by the researchers were used to input all data from the paper records. The information was placed in tables and exported into MS® Excel and analyzed using Minitab™.

There were three forms for data input, including a project form, a change order form, and a change item form, the hierarchy of which is shown in Figure 3.2 below.

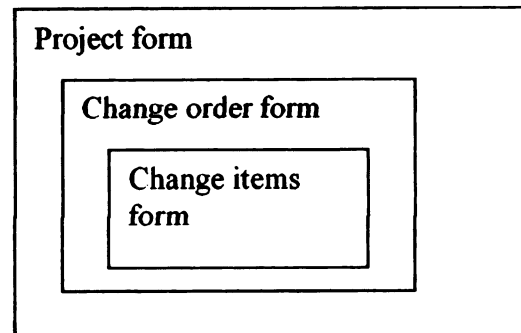


Figure 3.2 Hierarchy of forms

Every project form had several change order forms depending on the number of change orders in a project. Every change order form in turn had several change item forms, depending on number of change items in each change order. There were input fields in each form as listed in figure 3.3

Project form input fields:	Change order form input fields:	Change item form input fields:
Project name	Change order number COID	Change item number CIID
Project number	Change order initiation date	Reason code
MSU project manager	Project contract sum	Bulletin/CCD/ other
Architect name	New contract sum	Item initiation date
Contractor name	Changed contract sum	CSI categories
Contract date	Days affected	Overhead and profit
	Architect's authorization date	Item description
	MSU authorization date	Project progress
	Contractor's authorization date	

Figure 3.3 Fields available in the three forms in the database

In order to differentiate between change orders and change items, it is necessary to define them before discussing them further in the thesis.

Change Order: A change order is a written agreement to modify, add to, or change work that is defined by contract documents. See Appendix A for detailed description of change orders. A change order may consist of a single “change item” or it may have several “change items” incorporated.

Change Item: “Change items” are individual changes generated for various reasons, and may be grouped with other unrelated items for review. Typically, change orders contain multiple unrelated change items.

Each item was identified by the CSI division as applicable. A description of the item, the date when it was recognized, and every date on which the change order was authorized by a person in the change order process, were all noted. In addition to this information, each change item has a reason code assigned to it. These codes are formal classifications of the cause of changes items developed by CGA, in order to help in tracking reasons for change. See Appendix A for reason codes.

In order to calculate durations, a macro level process map was established which defined the sequence of major steps in the change order process. For database analysis as well as process mapping, the researcher adopted the date system from the FHWA report discussed in chapter two. The sequence of significant dates was as follows:

1. Item initiation date (date when the earliest item in a change order was initiated)
2. Change order initiation date (date when the change order document was initiated)
3. Architect authorization date (date when architect authorized the document)
4. Contractor authorization date (date when contractor authorized the document)

5. MSU authorization date (date when MSU authorized the document)

The durations of sub-processes (time frames between two consecutive significant dates) were calculated with respect to the above dates. Change order processes varied within departments in MSU; hence, there were instances when the sequence described above was not applicable.

3.6 Statistical analysis of database

Analysis of 1,675 change order items to draw out useful information involved several steps. First a broad scope analysis was carried out to identify overall average change order processing time at MSU for the project set. Each project was then analyzed separately and finally each change item was analyzed individually. Every change order and change item was analyzed for the length of time taken to process it. Finally each change order was analyzed by sub-processes.

The sub-processes were:

- Time when the earliest item was initiated.
- Change order initiation time (when it was first documented).
- Time taken before the architect authorized the change order.
- Time taken by EAS and the CGA to authorize the change order.
- Time taken by the contractor to authorize the change order.

Durations for each sub-process were calculated and averages were computed.

Data from the set of 1,675 items were statistically filtered using box plots. A box plot is a tool for summarizing a set of observations and variations of a data set. To identify outliers, a percentile range is used for the data set. For the purpose of this research, a percentile range of 20-80 was used. This range was used due to the number of data points

in the data set and the large variations. Table 3.1 below, shows the 20 -80 percentile box plot for the data set. Table 3.2 shows upper and lower limit of values beyond which the data was identified as outliers. The tables show calculations that were done using box plots for filtering data of the set of 1,675 items. Minimum and maximum values and medians were identified for each of the sub-processes and for the total duration. The first quartile and third quartile were calculated for each and $y = 1.5 (IQR)$ was calculated, where $IQR = Q3 - Q1$. Lower fence = $Q1 - y$ and upper fence = $Q3 + y$.

Statistic	Time taken to process change orders (days)	Length of time taken to initiate change orders	Length of time taken before architect authorizes change orders	Length of time taken before contractor authorizes change orders	Length of time taken before MSU authorizes change orders
Min	8	0	0	0	2
Median	146	97	0	4	28
Max	1983	1101	383	106	1553
Q1	98	57	0	2	15
Q3	232	177	4	7	40
IQR	134	120	4	5	25
y	201	180	6	7.5	37.5
Lower fence	-103	-123	-6	-5.5	-22.5
Upper fence	433	357	10	14.5	77.5

Table 3.1 Box plot calculations for 20-80 percentiles

Statistic	Time taken to process change orders (days)	Length of time taken to initiate CO	Length of time taken before architect authorizes CO	Length of time taken before contractor authorizes CO	Length of time taken before MSU authorizes CO
Lower fence	0	0	0	0	0
Upper fence	433	357	10	14.5	77.5

Table 3.2 Upper and lower fence of data set

The analysis was aimed at determining: how long change orders took to be processed, what caused lengthy processing time, and what might help to reduce process time. The results were displayed using pie charts, bar charts, histograms, line diagrams, and scatter plots. All statistical analysis was done using formulas in Microsoft® Excel and Minitab™ functions. The results were summarized and conclusions were developed for each sub-process and the overall change order process.

Concurrent with the statistical analysis, the change order processes at MSU were mapped so that both these activities could beneficially influence each other.

3.7 Interviews and feedback

Interviews were conducted in order to learn how other universities, contractors, design professionals, and subcontractors conducted their construction project management processes in general; and in particular, how change orders were managed. The project Oversight Committee developed a list of local and regional contractors, subcontractors, and architects, who worked with MSU in order to solicit information specific to MSU processes. The researchers selected companies from the list and did not disclose the names to the Oversight Committee in order to maintain confidentiality. Additionally, the Oversight Committee suggested other major universities with characteristics similar to MSU, which were appropriate to include in this research. Questions focused on finding strategies for prevention, management, and process improvement for change orders. Questions included both open ended and single response questions.

Interviewees were given an option of telephone interviews, but all respondents chose to have a face-to-face interview. In order to maintain confidentiality of interviewees, every interview had a code number assigned. In all over 40 individuals were interviewed. In some instances the researcher's conducted interviews with groups of individuals from the same organization. Personnel from four major universities, in addition to project administrators from MSU, provided information on university processes. Seven contracting, three architectural, and three sub contracting companies were interviewed for this research. Responses are discussed in chapter four. Appendices B through E include questions and responses from all categories of interviews.

All responses were paraphrased during interviews by the researcher. The interviews generally took 45-90 minutes. Interview responses were paraphrased and organized in tables included in appendices B through E.

Questions covered demographic data, title, change order rates, information on change orders specific to the interviewee's organization and area of work. Information on methods used within the organization to prevent change orders and to manage them was also gathered. Questions sought perceptions of interviewees in their work with MSU and with other owners, as well as suggestions for possible areas of improvement. Interviews of local and regional contractors, subcontractors and architects included questions about MSU processes. The questions were used to identify patterns in MSU processes and to corroborate the statistical analysis of the database. The interviewees commended some of the management practices at MSU but also identified areas of improvement.

The researcher used this information to identify themes from the responses. Interview feedback along with the results of analysis of the database and mapped process were used to restructure the current change order process map, and to develop an alternate process map and recommendations.

3.8 Current Process map

The current processes of CPP, HFS and EAS were mapped using simple flowcharts. The processes were documented through interviews of MSU project administrators. The purpose of mapping was to determine and develop an understanding of the current change order processes at MSU. MSU document formats were reviewed and MSU personnel were interviewed in order to gain an understanding of the process. The process was mapped in Microsoft® Excel. Upon completion, the process maps were sent to

personnel involved in the change order process, to confirm sequence, clarity, accuracy, responsibilities and the amount of time taken at each step. After editing and further discussion, the process map was finalized and submitted for review to the interviewees to determine if the map accurately represented the process.

The evaluation of change order processing time was broken down into groups to identify trends. These groups (sub-processes) are as follows:

- Change item initiation date to change order date.
- Change order date to architect authorization date.
- Architect authorization date to contractor authorization date.
- Contractor authorization date to MSU authorization date.

For EAS, each of these sub-processes was further broken down while mapping and analyzed using the Graham flowcharting technique described in chapter two. The alternative process map for EAS was then developed using the Graham technique (Graham, 2003) and the BOLO list (Smith, 2002).

Table 3.3 shows this checklist of items to “Be On the Look Out for” (BOLO),¹ developed by Smith (2002) which can be used, when mapping and analyzing any process. Items in the table relevant to this thesis were considered while mapping and analyzing the processes. Chapter four includes explanation of how this BOLO list was used in this research. Each activity in the EAS current / “as-is” process map was analyzed using this list to ascertain if there was an activity that was value adding, or just required, but not necessarily value adding work or just redundant. These activities were then identified

¹ BOLO (Be On LookOut) List for Analyzing Process Mapping
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Michael Lee Smith, the author of this article, is a director of process improvement at ETS in New Jersey.

with symbols and the entire process map was represented using the Graham (2002) flow charting technique, which enabled the researcher to visually locate areas for improvement.

The BOLO list was used by the researcher because:

1. It enables the researcher to analyze each step individually.
2. It enables the researcher to view the process without bias.
3. It does not suggest elimination, but allows the researcher to observe characteristics of each step in a process and then make a judgment after the entire process is analyzed.
4. It is a standard tool for process improvement.

1	Assumptions	Challenge all assumptions: It's easy to forget that a process step was based on one or more assumptions and not fact.
2	Changes	Idiosyncratic change (or) changes made to be creative or for some other reason that is NOT linked to the business plan or a business need.
3	Duplication	Duplicate data entry.
4	Duplication	Duplicate work steps in another group.
5	Flexibility	Can the process respond to changes in customer/technology requirements? Is it flexible?
6	Forgot how, or too complex	Mistakes because of a complex-clerical procedure or mistakes because people forgot what to do: Consider job aids: list, check sheet, flowchart, picture, etc.
7	Intermediaries	When you hear words like "coordinate," "pass it by me first," "expedite" and "liaison," question whether the intermediary step is value added.
8	Lack of consequences	Standards not followed and there is no consequence or negative feedback.
9	Old ways	Tools/software available that is not used because people have not taken time to get trained or do not want to.
10	Old ways with new tools	Lots of steps in software that are just replicating the old by-hand process.
11	Paper records	Is the process adding, maintaining or eliminating paper records?
12	Quality control	QC of work when the "supplier" could have checked and sent 100% ok inputs to you.
13	Quality control	QC is when someone else checks work, not when someone checks their own work.
14	Quality control	When talking about QC consider Poka Yoke – Can the work be mistake proofed to make it impossible for the defect to be passed on?
15	Quality control	Is the QC really needed? Prevention instead of detection is the desired process.
16	Repetition	Can repetitive work be automated?
17	Resistance	Do professionals want to make changes rather than "stick with the standard" or do what they want, saying there is no standard since they did not agree to it.
18	Resistance	Someone continually saying "this won't work, can't make any changes." Focus on objective and say that "changes to improve the process, is why we are here."
19	Scalability	Is the process limited to the current workload? Is it scalable to handle a larger volume of work?
20	Specifications/ every time like first	Developing specifications each time something is done instead of the first time as a standard or template.
21	Supplier input	Input supplier sends inaccurate/incorrect input. Ask if they know what to do.

Table 3.3 BOLO list by Smith (2002)

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3.9 Restructuring the current EAS process map to develop an alternate process map.

An alternate process map was developed using the Graham flowcharting technique. The mapping technique used in this research is a variation of the Graham flowcharting technique (Graham 2003) that was presented in the literature review chapter. The diagram below shows an example of the technique and how it was used to identify delays or areas for improvement. This process map is defined in detail in chapter four.

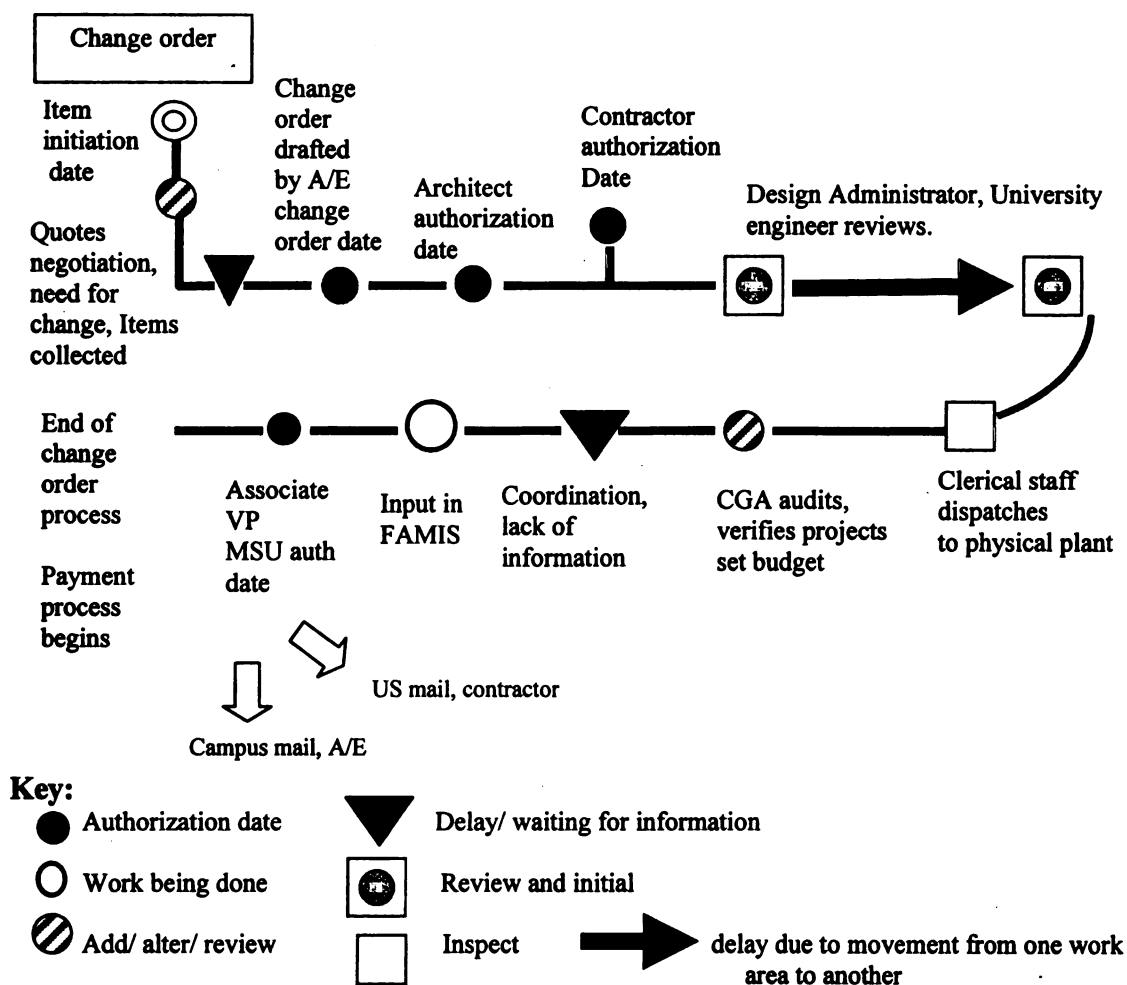


Figure 3.4 Formal process of change order mapped using Graham technique.

The flowchart identified value adding steps, steps or personnel involvement redundancy, delay causing steps, and steps that could be added to improve the process. This was done by taking into account the results of the analysis, the interviews, and overall goals and objectives of the study.

3.10 Development of the alternate process map

An alternate process map and recommendations were developed from the analysis described above, which if implemented could reduce processing time.

3.11 Validation of the alternate process map

In order to obtain practical evaluation the recommendations, the alternate process map, and the current processes were presented to EAS and CGA personnel for review. Suggestions made by the interviewees are reported in chapter seven.

3.12 Development of generic framework

Based on the framework used for reducing change order process time at MSU, the interviews of four other universities and the literature, a generic framework was developed, which can be used by other universities to study and analyze their change order processes. A set of broad recommendations was also developed. These are reported in chapter four.

3.13 Chapter summary

This chapter describes the methodology used in this research thesis. It briefly describes the change order processes at MSU, introduces the different departments, and also describes the database in interview process and process mapping techniques. Details on analysis and results are described in chapters four and five.

Chapter 4

Database Analysis

4.1 Introduction

This chapter presents the database and its statistical analyses. The chapter begins by describing the database and how data was sorted. This is followed by a description of how data was analyzed and the tools that were used for analyses. Relationships between various factors were established by these analyses. Chapter five describes the interview results, process maps, and how the process maps were developed.

4.2 Description of database

The database consisted of sample projects chosen from a list developed by an Oversight Committee from MSU. The sample was purposive, in order to provide diversity of projects in the database. The other criteria used by the Oversight Committee were: complexity, dollar value, and individual handling of projects by the departments sponsoring the research. Projects that had claims or litigation associated with them were excluded. Refer to Appendix A for more information on projects that were included in the database.

Student researchers on the change order project team at MSU developed the database in Microsoft® Access. The author and fellow researchers of the change order research input data into the database from papers records. Relevant information was exported to Microsoft® Excel for sorting and analysis by the author. Refer to Figure 4.1, for an excerpt from the database.

CIID	COID	CO num	Project ID	Reason Code	Item Initiation Date	Initiation Date	Architect Authorization Date	Contractor Authorization Date	MSU Authorization Date
1144	140	7	3981	D3	2002,08,28	2003,03,10	2003,04,10	2003,04,17	2003,05,27
1145	141	8	3981	D1	2003,01,17	2003,03,25	2003,05,16	2003,05,14	2003,06,16
1150	140	7	3981	F6	2002,10,21	2003,03,10	2003,04,10	2003,04,17	2003,05,27
1153	140	7	3981	D3	2002,11,04	2003,03,10	2003,04,10	2003,04,17	2003,05,27
1156	140	7	3981	S5	2002,12,03	2003,03,10	2003,04,10	2003,04,17	2003,05,27
1158	140	7	3981			2003,03,10	2003,04,10	2003,04,17	2003,05,27

Continued

Total time taken to process Change order	Time taken to initiate CO	Time taken before architect authorizes CO	Time taken by contractor	Time taken by MSU	A2	A3	A4	A4-A1
272	194	31	7	40	225	232	272	78
150	67	52	-2	33	119	117	150	83
218	140	31	7	40	171	178	218	78
204	126	31	7	40	157	164	204	78
175	97	31	7	40	128	135	175	78
		31	7	40				78

Continued

Figure 4.1 Excerpt of information in Microsoft® Excel: project 3981 (Michigan State University Cyclotron project) shown above in 2 parts

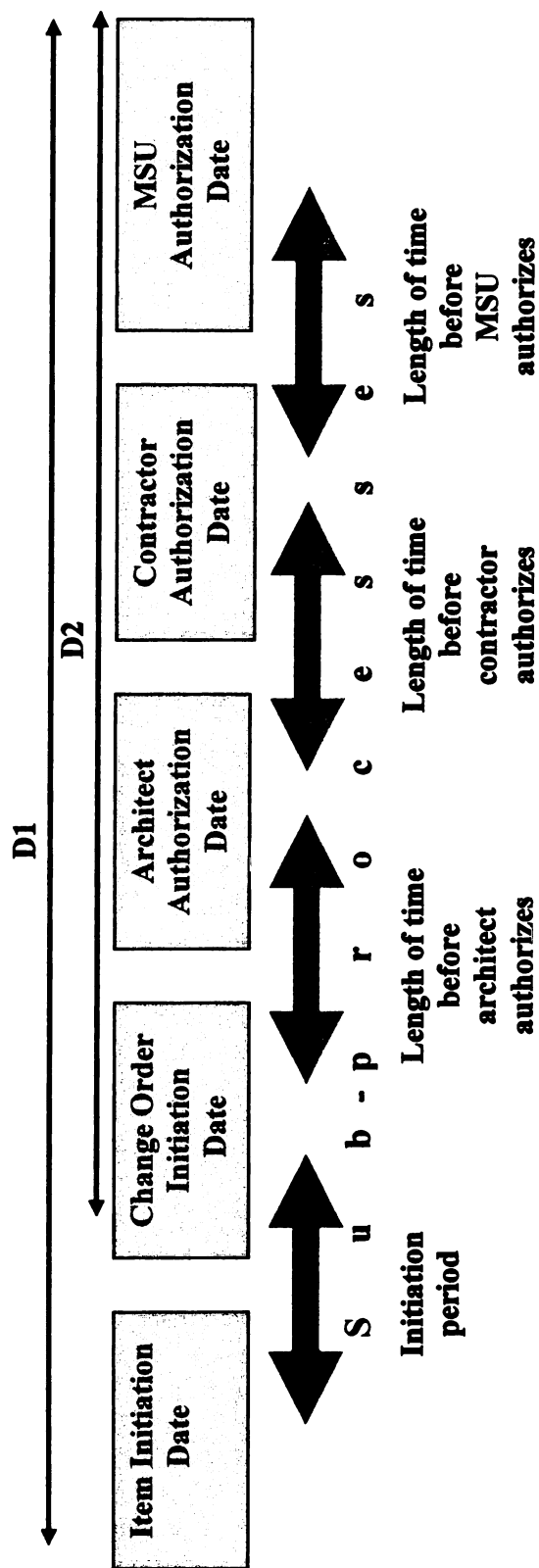


Figure 4.2 Sub-processes and sequence of significant dates

As the aim was to identify what contributes to the overall processing time, the change order process was broken into steps, and the time taken by these steps or sub-processes was calculated.

4.2.1 Sub-processes

The durations of sub-processes were calculated in the following manner:

Initiation sub-process = Change order initiation date - item initiation date.

Architect sub-process = Architect authorization date - change order initiation date.

Contractor sub-process = Contractor authorization date - architect authorization date.

MSU sub-process = MSU authorization date – contractor authorization date.

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

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

Activities in each sub-process

The activities in each sub-process are described below:

Time taken to initiate change order: Change items are evaluated for need for the change, quotes are requested, bulletin estimates are prepared, quotes received from the contractor, negotiation (item initiation to change order date).

Architect sub-process: After a change order is drafted, the architect reviews and authorizes the change (change order date to architect authorization date).

Contractor sub-process: Contractor authorizes change order (architect authorization date to contractor authorization date).

MSU sub-process: Reviews at EAS, reviews at CGA (contractor authorization date to MSU authorization date).

4.3 Explanation of calculations through an example

In this section a representative change item is used to demonstrate how durations of the total time taken to process change orders (D1), as well as the duration of each sub-process, was calculated. For the change item 1153, which is one of the change items in change order number seven in project 3981 (MSU Cyclotron project), calculations are explained. As seen in figure 4.1, the reason code is D3, which is a document error (a constructability issue). The item description of item 1153 is “change in brick selection” (not shown in diagram). The date when this problem was first identified is given by the item initiation date: 2002, 11, 04 (yyyy, mm, dd). The date on which a number of such items were collected and put into a change order is the change order date (2003, 03, 10), which included this item as well as all the other items in change order number seven. Item initiation dates for items 1144, 1145, 1150, and 1153 are the same as shown in figure 4.1. The item initiation dates may be unique for every item in a change order because frequently unrelated change order items are grouped into a single change order for processing purposes.

Calculations of sub-process durations were conducted using the formulas in section 4.2.1. For item 1153 sub-process durations are as follows:

Initiation sub-process	=	(2003,03,10 – 2002,11,04)	= 126.
Architect sub-process	=	(2003,04,10 – 2003,03,10)	= 31.
Contractor sub-process	=	(2003,04,17 – 2003,04,10)	= 7.
MSU sub-process	=	(2003,05,27 – 2003,04,17)	= 40.

Total time taken to process this change order item was 204 days (D1), and 78 days (D2) which is (2003,05,27 – 2002,11,04), and (2003,05,27 – 2003,03,10) respectively.

Item 1145 in change order eight showed the contractor sub-process was a negative value (-2 days). In this case the contractor signed two days before the architect signed the change order. This happened either because there was a deviation from the typical process, or because there was an error in recording the date on the change order (paper document). For example, the architect may have signed the change order before the contractor, but the document was date stamped two days after the date on which the contractor had signed the change order. Such negative values affect averages and could be eliminated, but since there were 73 instances where the architect sub-process had negative values and 162 instances where the contractor signed before the architect, many items would have to be eliminated. To avoid loss of data, another set of calculations was performed with all durations calculated from the item initiation date as the starting datum point.

Figure 4.3 graphically explains how these values were calculated. See figure 4.1 for A1, A2, A3, A4, and A4-A1 values for any item. The values were obtained by the following formulas:

A1 = Change order initiation date – Item initiation date.

A2 = Architect authorization date – Item initiation date.

A3 = Contractor authorization date – Item initiation date.

A4 = MSU authorization date – Item initiation date.

$A4 - A1 = D2$ = Total time taken to process a change item excluding the initiation sub-process.

The calculations were performed on all items in the database, and duration calculations for all change items were executed and recorded. These were subsequently organized in tables to obtain an overview of durations for each project, and for each change order and change order item.

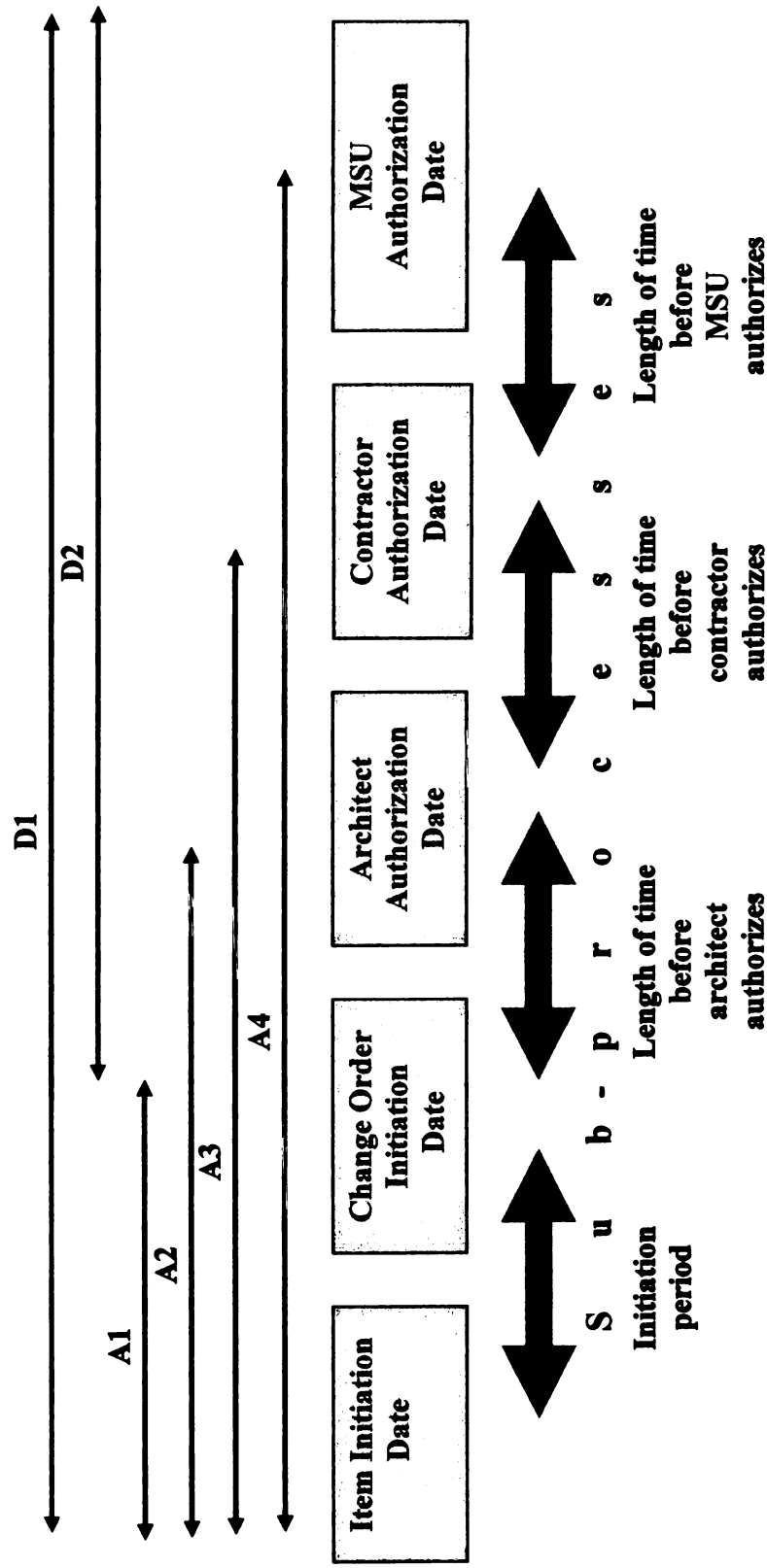


Figure 4.3 Calculations from datum point (item initiation date)

4.4 Data handling and reporting

All calculations were done in Microsoft® Excel and reported using tables, and graphs in Microsoft® Excel®. Pie-charts, line diagrams, scatter plots, bar charts, and histograms were used to report analysis results. Analysis was done using Minitab™ Release 14 for Windows statistical software. ANOVA (analysis of variance) and linear regression functions were run on the database and reported using histograms, scatter plots, individual value plots, box plots and residual plots.

4.5 Overview of statistical analysis

Interviews, process mapping and statistical analysis were conducted concurrently so that they could beneficially influence each other. Questions raised or suggestions made through the literature review, process mapping and interviews suggested areas that could be considered for statistical analysis.

4.5.1 Overall average time taken to process change orders

The overall time taken to process change orders was calculated twice: once considering 927 items with complete information (all dates available, no negative values) and another considering 1135 items with some missing durations. In the latter, A1, A2 A3, A4 and A4-A1 were used to give durations of processes, so that useful items need not be deleted. Although process time calculations were done using 1135 items, 1675 items were still used for other statistical analysis, such as cost range of change orders, and number of change items in a change order. (Discussed in section 4.14 in support of the recommendations.)

Table 4.1 shows average time taken to process change orders for all projects and average time taken by each sub-process, considering 1135 items only. All 1675 items could not be used here because of outliers, and items with two or more dates missing, were excluded.

Time taken to initiate change orders (days)	Time taken before architect authorizes change order (days)	Time taken by contractor to authorize change order (days)	Time taken by MSU to authorize change order (days)	Average time taken to process change orders (days) D1	Time taken without initiation period (days) D2
134	8	6	49	196	63

Table 4.1: Average time and time taken by each sub-process to process change orders (1135 items)

These 1135 items from nineteen projects took an overall average of, 196 days (D1) and 63 days (D2), to be processed. Sub-processes had average times as follows: initiation period 134 days, architect sub-process eight days, contractor sub-process six days and MSU sub-process 49 days.

Table 4.2 shows the time taken to process change orders and the time taken by each sub-process considering 927 items only. This analysis included thirteen projects and 107 change orders only.

Time taken to initiate change orders (days)	Time taken before architect authorizes change order (days)	Time taken by contractor to authorize change order (days)	Time taken by MSU to authorize change order (days)	Average time taken to process change orders (days) D1	Time taken without initiation period (days) D2
140	4	5	56	205	65

Table 4.2: Total time and time taken by each sub-process to process change orders (927 items)

The researcher was aware that the sample size was relatively small and it might not necessarily be generalized to all MSU projects, hence it was not as important to find exact values. However, the researcher identified a range of days. Here time taken by MSU to process change orders is about 60-65 days, which is comparable to the way other universities operate. The contractor may be more concerned however about the D1 definition, because the contractor knows the date when the problem was identified and the time taken 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. Typical payments may add more than 30 days beyond the MSU authorization date, leaving a substantial period of time from when a contractor performs work to when he/she actually receives payment for it.

One should be aware at this point that the initiation period is influenced by the contractor, architect and MSU personnel and therefore cannot be completely controlled by MSU; however there may be room for improvement in the activities performed by MSU personnel during this period.

4.5.2 Summary of projects and time taken to process their change orders

After the average time taken to process change orders was determined, the researcher determined the average time taken to process change orders for each individual project.

An example of how projects were summarized is shown in Table 4.3. Table 4.3 shows an excerpt of the complete table. The table shows the project identification number (Project ID 3981), the number of change orders in this project (14), time taken to process each change order in this project (D1), average time taken to process change orders in

this project (151 days); initiation period for each change order, average initiation time taken (83 days); time taken by the architect sub-process for each change order, average time taken by architect sub-process (23 days); time taken by contractor sub-process for each change order, average time taken by contractor sub-process (3 days); time taken by MSU sub-process, and average time taken by MSU sub-process, (42 days).

Project 3981

Change order number	Initiation sub-process (days)	Architect sub-process (days)	Contractor sub-process (days)	MSU sub-process (days)	Total time taken to process change order D1 (days)	Total time without initiation period D2 (days)
1	0	0	-	-	-	-
2	86	12	57	-9	146	60
3	34	53	-1	81	167	133
4	155	24	-1	95	273	118
5	168	27	23	7	225	57
6	11	10	-9	55	67	56
7	194	31	7	40	272	78
8	67	52	-2	33	150	83
9	71	13	-1	40	123	52
10	100	17	2	33	152	52
11	29	13	-1	40	81	52
12	80	13	-12	34	115	35
13	81	13	-12	34	116	35
14	0	16	-6	61	71	71

Average time taken for each sub-process:

Average total time taken to process change orders (D1) = 151 days

Average total time taken to process change orders (D2) = 68 days

Average initiation sub-process = 83 days

Average architect sub-process = 23 days

Average contractor sub-process = 3 days

*D1 is time frame between initiation date of the earliest item in a change order to date when the change order was authorized by MSU. When projects are compared the averages of D1 for all change orders will be considered.

Table 4.3 Summary of change order information for Project 3981: Michigan State University Cyclotron Project.

The row containing change order number one was deleted because MSU and contractor dates were not recorded on the change order. The last column shows the duration calculated between the architect authorization date and the MSU authorization date, without considering the contractor sub-process. This was done to eliminate the negative values seen in the contractor sub-process column. Results for project 3981 are as follows: 13 change orders were considered, on average: 151 days D1, 68 days D2, 83 days initiation period, 23 days for architect sub-process and 45 days was the time taken from when architect authorized to the date when MSU authorized change orders.

Figure 4.4 shows a bar chart of total processing time (D1) of each change order in project 3981 and a line indicating average processing time of 151 days. 13 change orders were considered.

Similarly bar charts for all the sub-processes for this project were made. A stacked bar chart was prepared to provide a view of how each sub-process contributed to the D1 time period in project 3981. The time for the initiation period is the greatest contributor to overall processing time of change orders, followed by MSU sub-process, as shown in figure 4.5

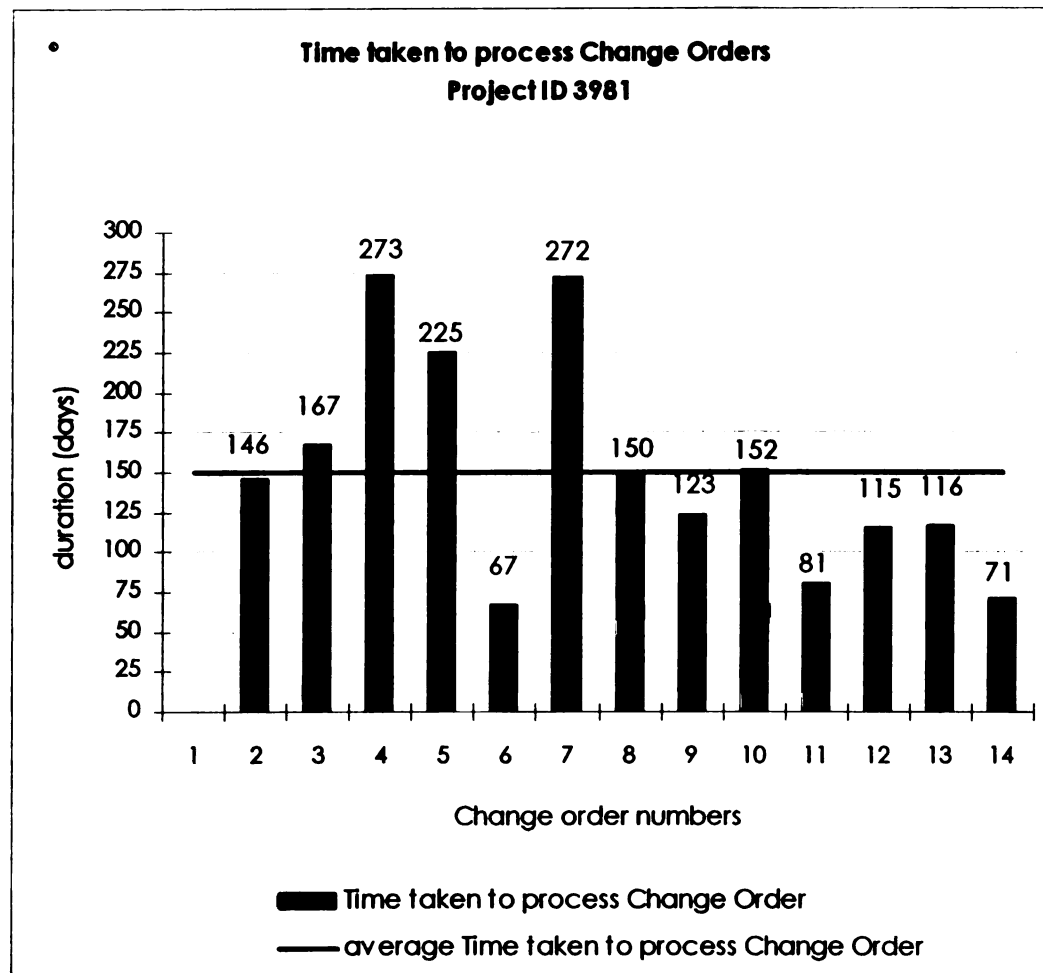


Figure 4.4: Bar chart showing total time taken to process change orders in project 3981 (D1)

All 19 projects were arranged and analyzed similarly. Bar charts and tables were then prepared. See Appendix G for bar charts of sub-processes on all projects. Finally all calculations were put together to give an overall picture of 19 projects. See Table 4.4 and Figure 4.6

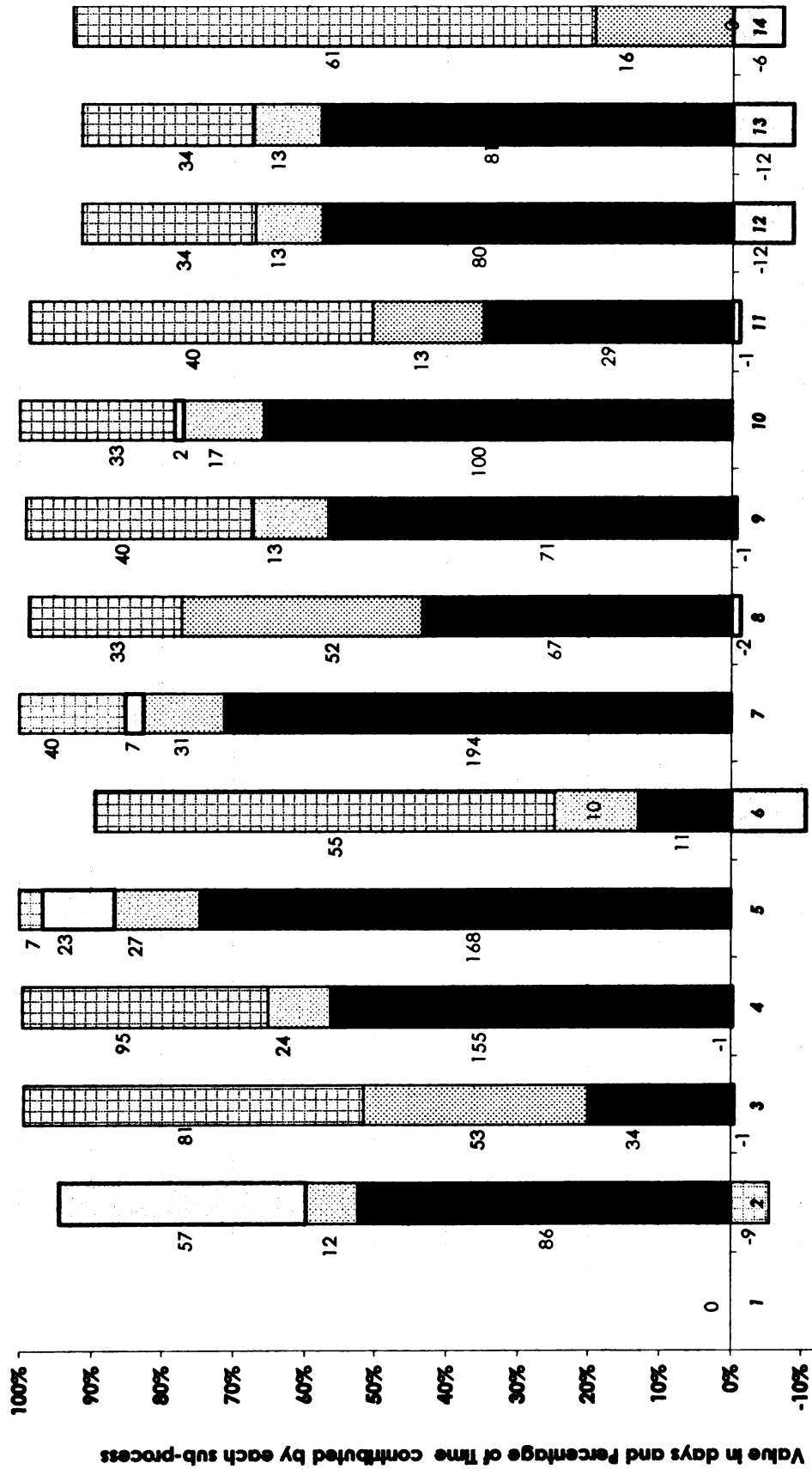


Figure 4.5 : Stacked bar chart showing contribution of sub-process time to overall processing time of change orders (D1):Project

3981

Project IDs	Change order number	Average time taken Initiation period (days)	Average time taken Architect process (days)	Average time taken Contractor sub process (days)	Average time taken MSU (days)	MSU time w/o Contractor sub process (days)	Average time taken D1 days	Average time taken D2 days
3347	4	159	9	6	43		216	57
99072	2	230	0	1	24		255	25
3282	2	83	0			52	134	52
3147	2	75	6			17	97	23
2474B	2	81	2	3	17		103	22
3482	10	184	0	5	34		224	40
1707	11	201	0	5	49		255	54
2474A	6	137	5	5	65		211	74
02140B	8	65	3	1	45		115	50
0684	9	222	4	5	18		249	27
3168	1	129	0			22	151	22
2124	1	299	0			28	327	28
02140A	1	149	12	2	40		203	54
0365	0							0
2474D	40	248	3	8	30		289	40
3067	9	85	0			18	103	19
3119	7	130	2	3	269		404	274
3981	13	83	23	3		45	151	68
3496	2	135	0			24	158	24

Table 4.4: Table summarizing 19 projects

*D1 and D2 are averages for change orders in the given project.

4.5.3 Summary of nineteen projects

Table 4.4 shows a summary of 19 projects. For project 0365, contractor authorization dates were not recorded; therefore average times could not be calculated. The table shows the number of change orders considered in each project, durations of total time (D1 and D2) and sub-processes. Figure 4.6 shows the time taken by MSU and the initiation period are high contributors to the overall processing time of change orders; therefore these processes were mapped simultaneously and their steps were broken into details to understand the reasons for the differences in duration.

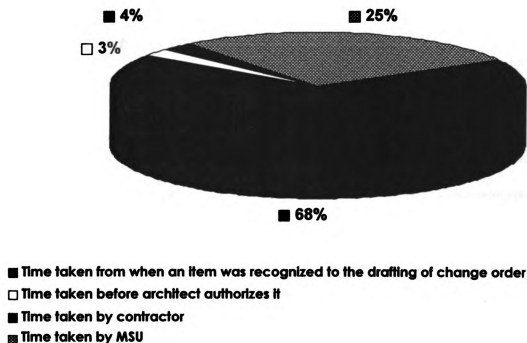


Figure 4.6 Percentage contributions of sub-processes to total processing time of change orders.

4.6 Statistical analysis

After conducting interviews and process mapping discussed below, the researcher sought to find out if there were relationships between the sub-processes, other factors, and the total time taken to process change orders. Therefore statistical analyses were run to identify outliers, correlate factors with each other and to see how one factor affects the other. Software used for this purpose was Minitab™. Linear regression and ANOVA (analysis of variance) were run and results were displayed using box plots, scatter plots, individual plots and residual plots.

4.6.1 Relationship between initiation period and total time taken to process change orders

As seen from Microsoft® Excel graphs and interview results (to be discussed in chapter five), there is a relationship between the initiation period and total time taken to process change orders (D1). The researcher was interested in determining if variation in duration of the initiation period led to variation in D1. ANOVA analysis was conducted for this purpose.

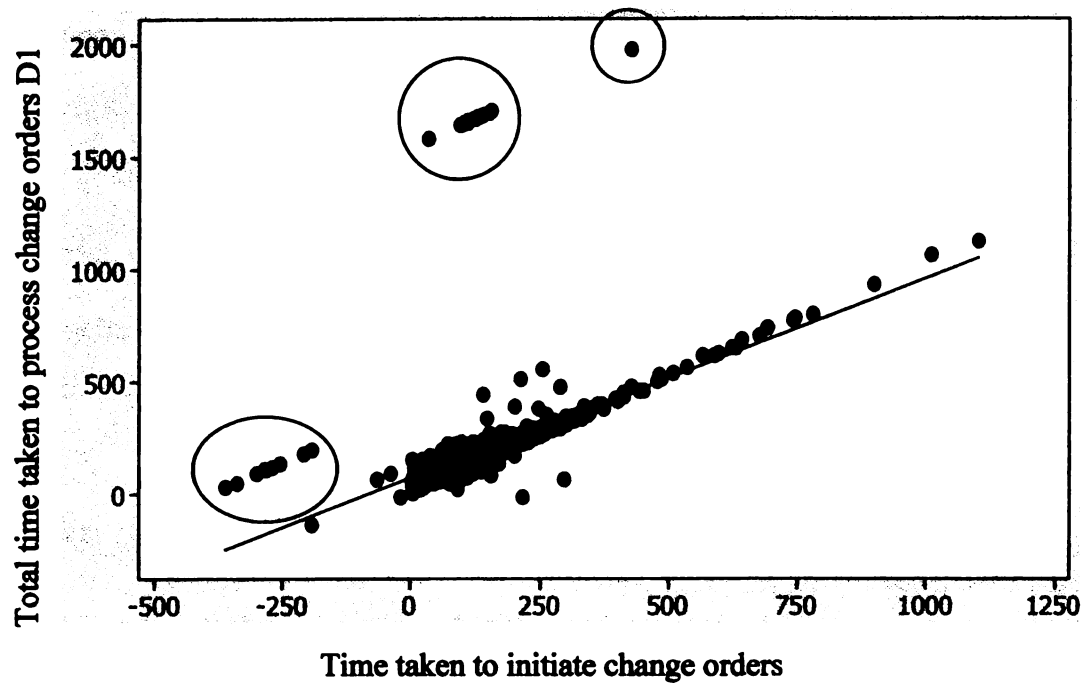


Figure 4.7: Scatter plot of D1 versus time taken to initiate change orders

The scatter plot in Fig 4.7 was generated by Minitab and shows a linear relationship between the two variables. The tightness of the data points around the line indicates the strength of the correlation. The scatter plot shows outliers highlighted by circles; these indicate that for these items D1 varied from the line of regression because there were other factors that influenced D1 in addition to the time taken to initiate change orders.

4.6.2 Relationship between time taken by Michigan State University and Total time taken to process change orders (D1)

If a sub-process is lengthy in a linear process, overall time will increase. The existence of a linear relationship between the two variables was ascertained by ANOVA. The results are as follows: P value 0.000, (α value 0.05). $S = 101.0$ $R\text{-Sq} = 81.94\%$ $R\text{-Sq (adj)} = 80.91\%$. The ANOVA analysis indicates that there is a strong relationship

between time taken by MSU to process a change order and overall time taken to process a change order. When MSU sub-process time increased, overall time to process change orders also had increased: 81.94 % (strength of correlation). This does not mean however that in 81% of the cases where overall processing time was long, it was due to MSU sub-process time. The analysis showed that there is a linear relationship between the two variables and that if MSU sub-process time is reduced it could reduce overall processing time; however there will be other influencing factors that will still affect overall processing time.

In order to find the possible reasons for this time period the researcher correlated the results with interviews. The interviews suggested that there may be too many layers of approval authority and that too many non related items are packaged into each change order which adds to processing time.

4.6.3 Relationship between number of items in a change order and total time taken to process change orders (D1)

ANOVA analysis was run on the database. As Figure 4.8 depicts, there was a relationship between the number of items in a change order and D1. The results were as follows: P value 0.000 (α value) 0.05. The analysis shows that the number of unassociated items packaged in a change order affected the overall processing time of change orders. For the strength of the correlation, see figure 4.9.

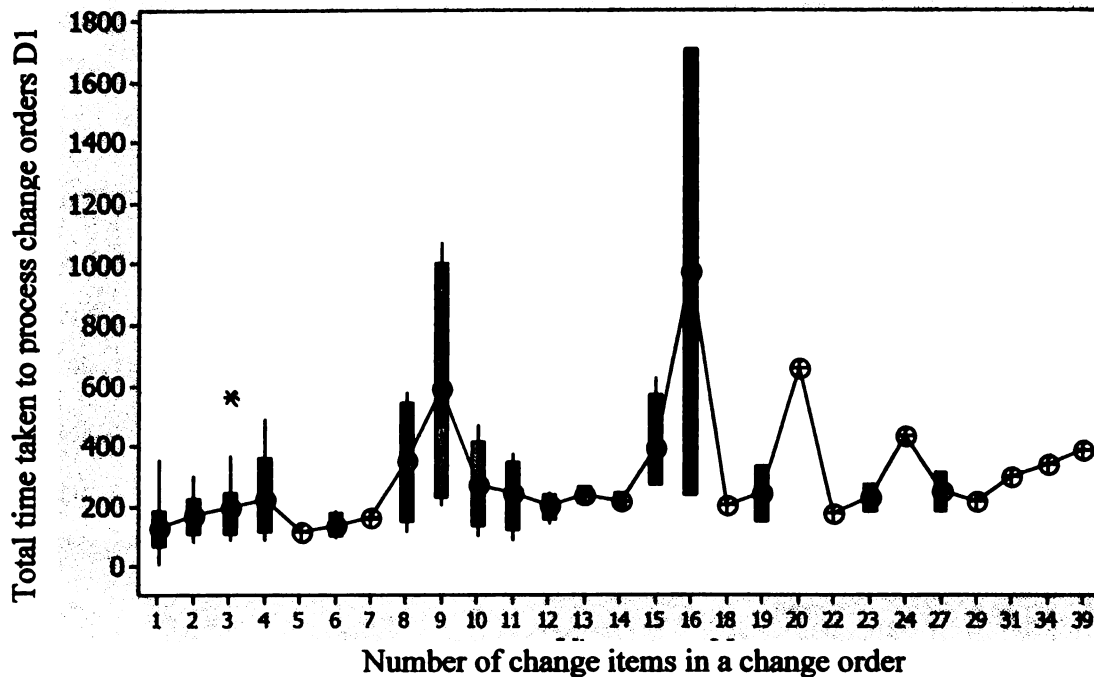
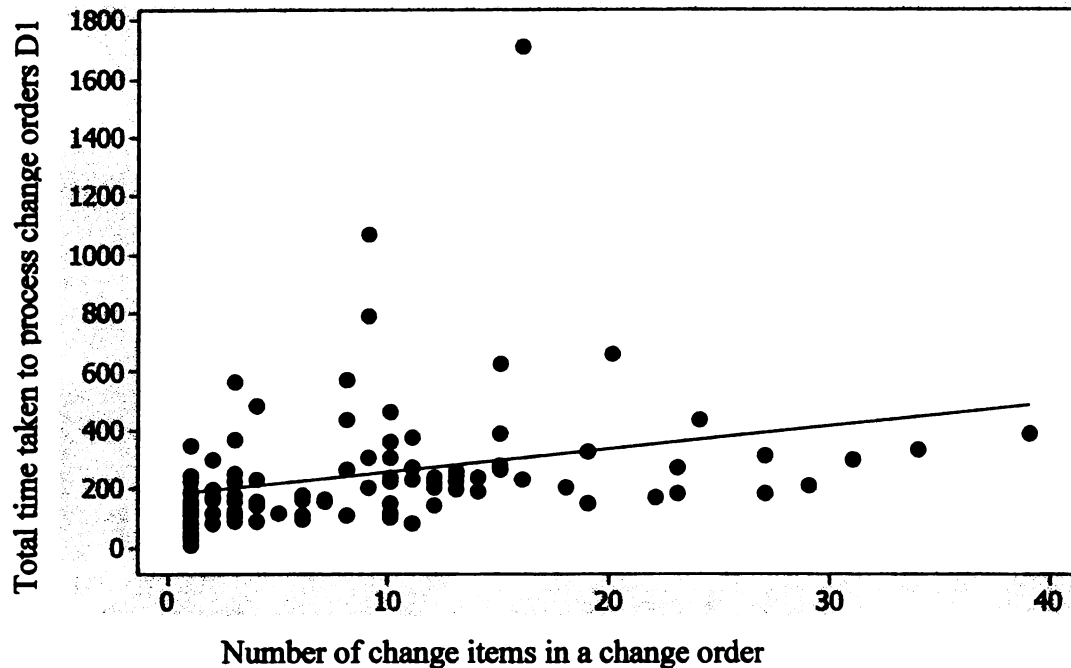


Figure 4.8 Box plots of D1 and number of items in a change order

In the box plot there was an outlier indicated which represented change order six from project 2474A- MSU Biophysical Sciences Building. Change order six had three items but took 564 days for processing (date when first item was initiated to date when MSU authorized the change order) which was an unusually long time. As seen in figure 4.8 there were several items which took more than 564 days to process, however this chart has grouped change orders with a fixed number of items in it and created individual bar charts of those change orders. The average of such groups is indicated by the line joining points indicated by circles. Numbers nine and 16 on the X axis indicate two groups having change orders with nine items and sixteen items respectively. Their processing time in days has a wider range and therefore appears as long boxes; however there are no outliers in that group. Whereas the change order group with three items (indicated by

three on axis) has a small range and any change order in that group falling out of the range stood out as an outlier.



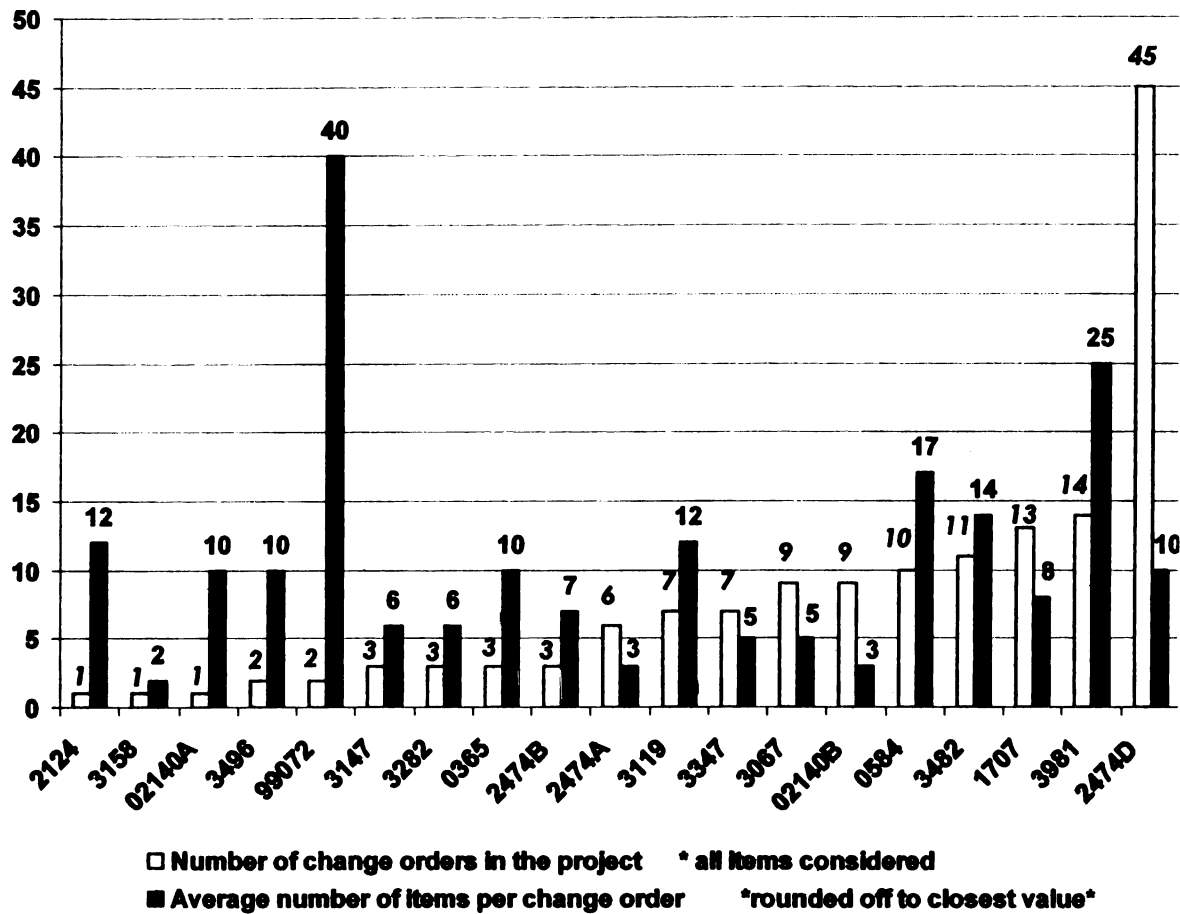


Figure 4.10 Average number of change items per project

The conclusion from these analyses is that there is a relation between the number of items in a change order and the time required to process a change order. 48.57 % of the variability in time taken to process change orders is explained by the number of items in a change order. The interviewees suggested that if there were fewer unrelated items in a change order, that a particular change order would be quicker to review, which appears to be corroborated by statistical analyses.

4.6.4 Analysis of change order cost

In order to identify trends in cost of the change orders, an analysis was conducted. There were 1372 change items that had cost in the database. The distribution of costs of 1372 change items in the database is shown in the scatter plot below.

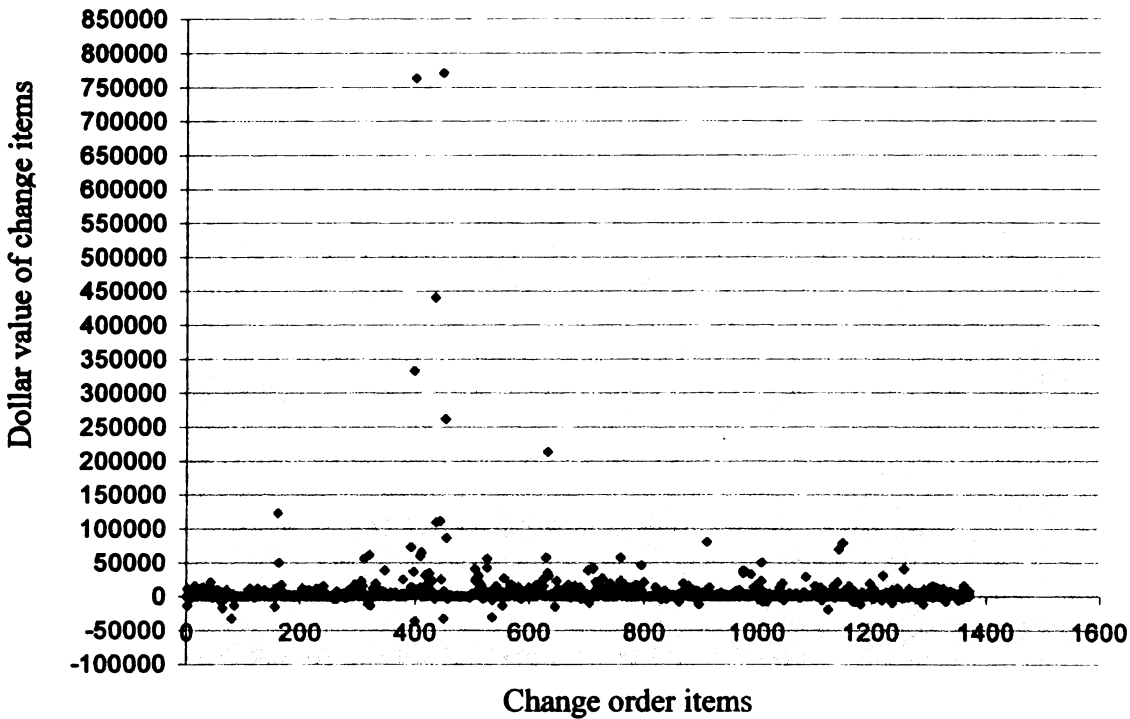


Figure 4.11 Change items and their dollar values

The scatter plot shows the cost of change items. Items below the zero line show deductive change items. The X axis shows every item in the database; (item 600 on the X axis does not indicate CIID 600 in the database). The majority of the items cost under \$50,000. A pie chart of the items shows that 90% of change items are under \$10,000. 10% of the items fall within the \$10,000 - \$100,000 range, which suggests an opportunity for management personnel at lower levels in the organization to approve change orders of

limited complexity and dollar value. As dollar value and complexity increases, higher levels of management could be involved (incremental authorization of change orders).

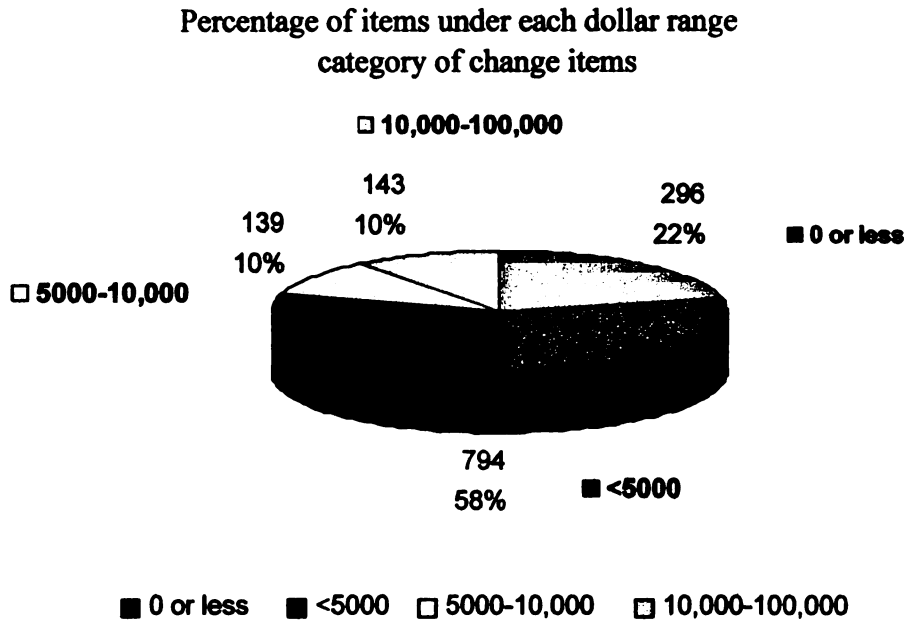


Figure 4.12: Pie-chart of 1372 change items in dollar amount ranges

4.7 Conclusions of statistical analyses

Based on the analyses of the database, the following conclusions were developed:

1. There is room for improvement in the change order initiation and MSU authorization sub-process.
2. The initiation period is the highest contributor to the overall processing time D1; the second highest contributor is the MSU authorization period (includes EAS and MSU time).

3. MSU on an average takes 196 days (D1) and 63 days (D2) to process its change orders. This calculation was based on 1135 items from nineteen projects. D2 time appeared consistent with that of other universities interviewed.
4. The initiation period took 134 days, architect sub-process took eight days, contractor sub-process took six days and MSU sub-process took 49 days. This calculation was based on 1135 items from nineteen projects.
5. Typical payments may add in excess of 30 days after the MSU authorization date, leaving a substantial period of time from when contractors performed work to when they actually receive payment for it.
6. There is a relationship between time taken by MSU to authorize change orders and overall time taken to process change orders (D1).
7. There is a relationship between the initiation period of change orders and overall time taken to process change orders (D1).
8. There is a linear relationship between the number of items in a change order and time taken to process change orders (D1).
9. On an average 11 items per change order are packaged into a single change order.
10. 90% of change items are under \$10,000. Ten percent of the items fall under \$10,000-\$100,000 range, which suggests an opportunity for incremental authorization of change orders by MSU personnel.

4.8 Chapter summary

This chapter reports the various analyses run on the database. It began by describing the database and how data was organized. Results of the analyses were reported and relationships between various factors as well as the total time taken to process change orders were reported. The chapter ends by presenting conclusions of the statistical analyses. Chapter five describes interviews, results of interviews and process maps of change order management processes at MSU. Process map analysis and development of an alternate process map are described in chapter five.

Chapter 5

Process maps

5.1 Introduction

This chapter presents the change order process maps for various departments at MSU. The chapter begins by describing the interview process and how it was used to develop current as well as an alternate process map for EAS.

5.2 Interview data handling

As explained in chapter three, interviews were conducted with architects, contractors, subcontractors, MSU construction personnel and construction personnel from four other universities. Paraphrased responses were entered into a spreadsheet format.

Figure 5.1 shows an excerpt of the spreadsheet of interview data from contractors. Six contracting, three subcontracting, two architectural and ten MSU project administrators were interviewed to solicit opinions and identify room for improvement in the change order process. Administrators from four other universities were also interviewed to learn about processes at other universities. In all, 40 construction professionals were interviewed. The five sets of interviews were set up in separate spreadsheets. The responses were coded to maintain anonymity.

Question Code	Question	Response	Response code
Q12	What are the typical durations for processing change orders? Do these durations contribute to additional costs such as for extended general conditions, ripple effects or impact change orders?	60 days typically from date bulletin is approved to MSU authorization date. Yes they contribute, earlier we could accept with 8% O&P, now it is 4% we cannot accept it. Prices increase when executed later.	C1
		Pvt Cos are quick in negotiations due to less hierarchy in approval (1 week processing + 30 days payment). They can contribute to extended general conditions. The 1st CO may not have a major effect but the 5th will have a cumulative effect. Impacts include, financial burden on SC, relationships breakdown, detrimental to administration. Owners have to understand that SC payment is important. If delay in payment is anticipated they include it in their cost. If they trust the process time they will quote realistically.	C2
		90-120 days, without the payment period. Yes.	C3
		4-6 weeks for change order drafting. from time initiated to MSU authorization 3 months. Yes they do. Most other places takes 10-15 days.	C4
		195 days in MSU (payment process is included). Subs are problems. Once a month request for potential CO to Proj Rep to generate a bulletin. In other places it is 30-40 days, State of Michigan 60 days.	C5
		Identification of change to MSU authorization date not including payment is 2 months on an average. Yes absolutely. Higher % of overhead. Negotiation takes a while and as more time is taken, subs tend to charge more for change orders. Very few will inflate change orders though, but business is business. sometimes there is no choice but to do it in order to survive.	C6
			C7

Figure 5.1 Excerpt of interview data of contractors

5.2.1 Overview of interview data

Administrators (at both MSU and outside universities), architects, subcontractors and contractors were interviewed. The questions were tailored as appropriate for each group. Some questions overlapped and were common to all interviews. The number of questions ranged from 30 to 45 for the five sets of interviews. Questions one and two were demographic in nature; the rest of the questions were open ended and single-response type questions. Responses were paraphrased. (Included in Appendices B - F) Reported below is a general overview of the responses expressed by the respondents for various questions.

Generally the architect, contractor and subcontractor interviewees have been actively involved in MSU construction projects and are involved in the process of change orders. The interviewees identified the following types of projects their organizations are involved with: historic preservation, new construction, laboratories, power plants, classrooms, sports facilities, hospitals, retail, industrial, and resorts. The number of projects built annually ranged from 40 projects to 400 projects, worth \$ 20 million to \$1 billion. Most have worked with other large owners and are aware of the processes they work with.

When asked if they conduct any formal post construction analysis of projects with respect to budget, schedule, change orders, or performance of the parties involved, the general response was “informal analysis”. There were some instances of interviewees responding that they conducted formal post-construction analysis.

The general response for change order rates (final cost increase due to change orders) was, 5-10% increasing to 25% in one response reporting on heavy infrastructure renovation.

When asked about the typical durations for processing change orders, the general response was 60 days to three months, followed by 30 days for payments to be issued. Some interviewees responded that other universities or large owners had similar procedures while others differed in their response. The overall theme was that private owners take less time to process change orders, compared to public owners. The interviewees attribute this to bureaucracy.

Regarding the question: “Based on your work with other large owners, what organizational traits or processes contribute to reduced impacts of change orders?” the general response was: “ more defined process with fewer layers of approval and a defined decision maker.” Some responses also suggested that more or less all public owners manage their projects along the same lines and face common issues.

Most respondents agreed that change orders have impacts in the form of productivity losses, extended general conditions and mobilization costs; however many respondents said claims rarely arise for these, and some responded that owners don’t understand these impacts.

Most contractors, architects and subcontractors agreed that change is not welcome to any of them and that most people they work with are fair and trustworthy and that people rarely take advantage of change orders. However there were some responses where the interviewees said that they do consider an ‘MSU factor’ in their bids, taking into account the processing time of change orders.

When asked to comment on the effectiveness of MSU's change order process and what should be changed in it, the responses were as follows:

1. It took too long to process change orders and was ineffective in that aspect.
2. There was a unanimous response that change orders pass through too many hands in spite of being negotiated very well by the MSU's staff.
3. Almost all contractors stated that it was their responsibility to push the paperwork and track change orders.
4. Subcontractors were not aware of what takes so long and whether it was the contractor who delayed payment or the owner.
5. There was a general comment that MSU is understaffed.
6. The interviewees also stated that they considered MSU a fair owner with a good understanding of construction, but the university needs to change some procedures; streamline its processes, and trust decision makers at lower levels.
7. Another comment was that, "MSU is extremely picky, to the extent that it is counterproductive. Time taken to process change orders is so long, that it shows that such an important process is not getting the attention that it requires."
8. There was another comment suggesting that change orders should be issued in a time and material method.
9. Another view was that the owners should change the antiquated system of operating and should internally track their change orders using software.

Administrators of four other major universities were also interviewed. Overall their description of the change order process was similar. Their average change order processing time was closely comparable to MSU's time (D2). University of Notre Dame,

however, extensively tracked its change orders and indicated that most of its change orders were processed in less than two weeks. They did cite instances when the change orders were processed in two months. Purdue issued change orders monthly.

All administrators were of the opinion that the processing time is generally accepted by contractors and subcontractors, but that time could be reduced. The contractors, subcontractors and architects were resigned to the long time it takes owners to process and pay change orders; however, they think that there definitely is room for improvement. Change orders that had scope issues, large dollar amounts, schedule impacts, or were generally complex were scrutinized more closely by owners. Therefore these had longer change order processing times.

Some universities had a different way of processing change orders. For example, Purdue University generally uses change orders containing single items. Purdue also uses reason codes assigned to change orders, from which MSU reason codes were developed. Purdue had a system of approval in place that allowed change orders with certain criteria to be approved at lower management levels. The University of Minnesota had a similar system in place. All administrators generally concluded that there is always room for improvement and that they are interested in effectively managing the construction processes.

5.3 Summary of interviews

Based on the interview responses the following conclusions can be drawn:

1. Administrators in universities agreed that there was room for improvement and a framework to improve the process should be developed by each university that will cater to its own needs.
2. The general consensus of most interviewees was that universities can and should reduce processing time of change orders.
3. Small items sometimes get packaged with critical items and end up taking longer to review and authorize payment.
4. The general view was that unrelated items are packaged together which increases review periods.
5. Interviewees suggested that change order prices are agreed to after negotiations with the owner; therefore it should not take as long for change orders to be reviewed and approved.
6. Some universities have approval systems which allow change orders to be approved at lower management levels.
7. Interviewees suggested that other large owners (other than universities) have more defined processes and fewer layers of approval.
8. Interviewees also suggested that owners should take efforts to internally track change orders.

Section 4.1 to 4.8 explained the manner in which data was organized, handled, analyzed, and reported. Interview responses are provided in appendices B C, D, E, and F. Interview data was used along with the statistical analyses and process mapping, discussed below, to identify areas for improvement, to develop an alternate process map for EAS and to develop recommendations, which are applicable to large universities in general.

5.4 Process map

As discussed in chapter three, the change order processes of CPP, HFS and EAS were mapped using flow diagrams. These initial process maps were developed from information obtained through interviews of MSU construction personnel and administrators. The respective maps were presented to personnel of the appropriate departments and were restructured as required to make them accurate representations of the typical change order process used by each department.

CPP had a simple process with a single person designated to monitor, review and authorize change orders. The current process map for CPP was drawn in Microsoft® Excel and was confirmed for accuracy by the interviewees.

Housing and Food Services, like Campus Park and Planning had a fairly simple process and one person designated to monitor, review and authorize change orders. The process was mapped after an interview and discussions with the designated authority and the current process map for HFS was drawn in Microsoft® Excel. This sequence and accuracy was reviewed and confirmed by HFS staff. Through interviews, database analysis results, and study of the map, it was easy to conclude that this too was a simple process and required very little processing time compared to EAS.

In EAS more people handle change orders when compared to CPP and HFS. The EAS process was mapped in detail using the Graham flowchart method presented in 2.4.4 and 5.4.3 and analyzed.

The formal process of change orders, from the date when the earliest item was identified in a change order to the date when the change order was finally authorized by MSU for implementation, was considered. The payment process was not included. The EAS process activities are described in detail in section 5.4.3. Maps for HFS and CPP are presented first, followed by the EAS process.

5.4.1 Housing and Food Services

The change order process used by HFS is shown in Figure 5.2. HFS can procure construction directly and contracts are usually based on unit costs.

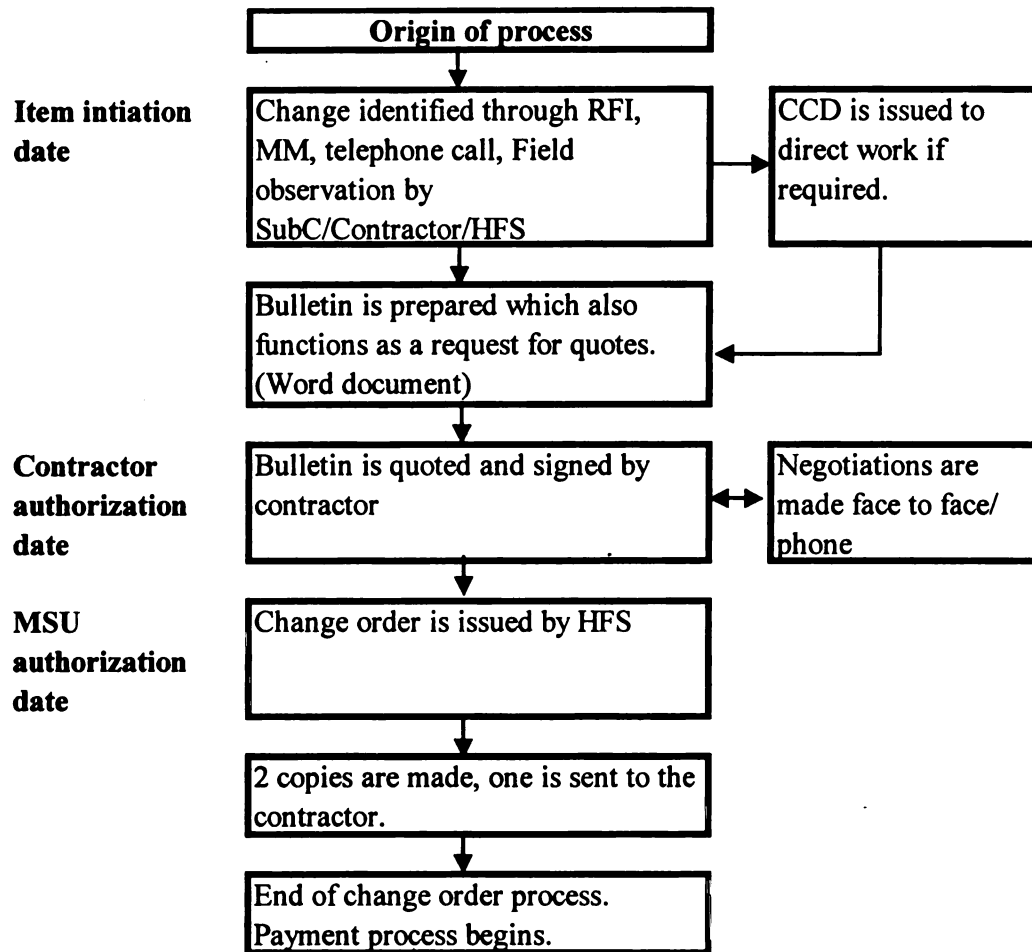


Figure 5.2 Current change order process in Housing and Food Services (process map)

As seen in Figure 5.2 potential changes are identified through meeting minutes and Requests for Information (RFIs) or by field observations by a subcontractor, contractor or HFS. If necessary a CCD is issued, otherwise a bulletin is prepared. A bulletin also

functions as a request for quote. Bulletins are received, quoted and signed by a contractor and returned to HFS. All negotiations prior to signature are either done face to face or by telephone. Finally a change order is issued by HFS and two copies are maintained, one retained by HFS for records and the other returned to the contractor.

There are only three significant dates in this process: item initiation, contractor authorization and MSU authorization date. Through interviews of HFS staff, the researcher ascertained that change orders are processed within a week. The process is streamlined and simple and allows for rapid decision-making. The change order process described above is similar to the EAS purchase order process, except that HFS has a single designated authority who handles changes.

As the process was simple, there were no suggestions for process improvement made by the researcher. However, it was suggested that HFS maintain a process map in writing to ensure standardization of its process.

5.4.2 Campus Park and Planning

CPP can procure construction either through EAS or by itself. The mapped process in this thesis is for projects that are procured directly through CPP rather than through EAS.

CPP generally uses unit cost contracts. Projects and costs are typically smaller and less complicated than those of EAS projects.

As seen in figure 5.3, the change order process begins when a problem or a potential change is identified. A change may be identified either by CPP or by a consultant who has recommended a change. Notification is either made informally or on paper. After a potential change is identified, CPP or the design consultant develops a CCD and initials it. The construction site superintendent at CPP reviews a change order and authorizes it.

The Director is kept informed of approval and authorization of a CCD. Two copies of a CCD are made, one retained by CPP for records and the other issued to the contractor. Occasionally, at intervals, several CCDs are collected and a change order is drafted. More typically all CCDs are collected and drafted into a single change order at the end of the project. This is included as the change order date in the database. The director and construction site superintendent review a change order for content and wording, and send it to the contractor for signature. When CGA receives a change order, it is reviewed for content and accounting purposes. The MSU authorization date is the date when the Associate Vice-President signs the change order.

The change order process used by CPP has a streamlined approval hierarchy; therefore few delays occur during decision making or processing. Processing time is related to project duration, which is five to six weeks. Change order processing occurs during the post construction phase.

The database shows the Parking Lot 89 Expansion Project took 120 and 389 days for processing its two change orders when considering (D1), and 33 and 16 days for processing its two change orders when considering (D2).

The process was simple. The only suggestion made therefore was to maintain a process map in writing to standardize procedures.

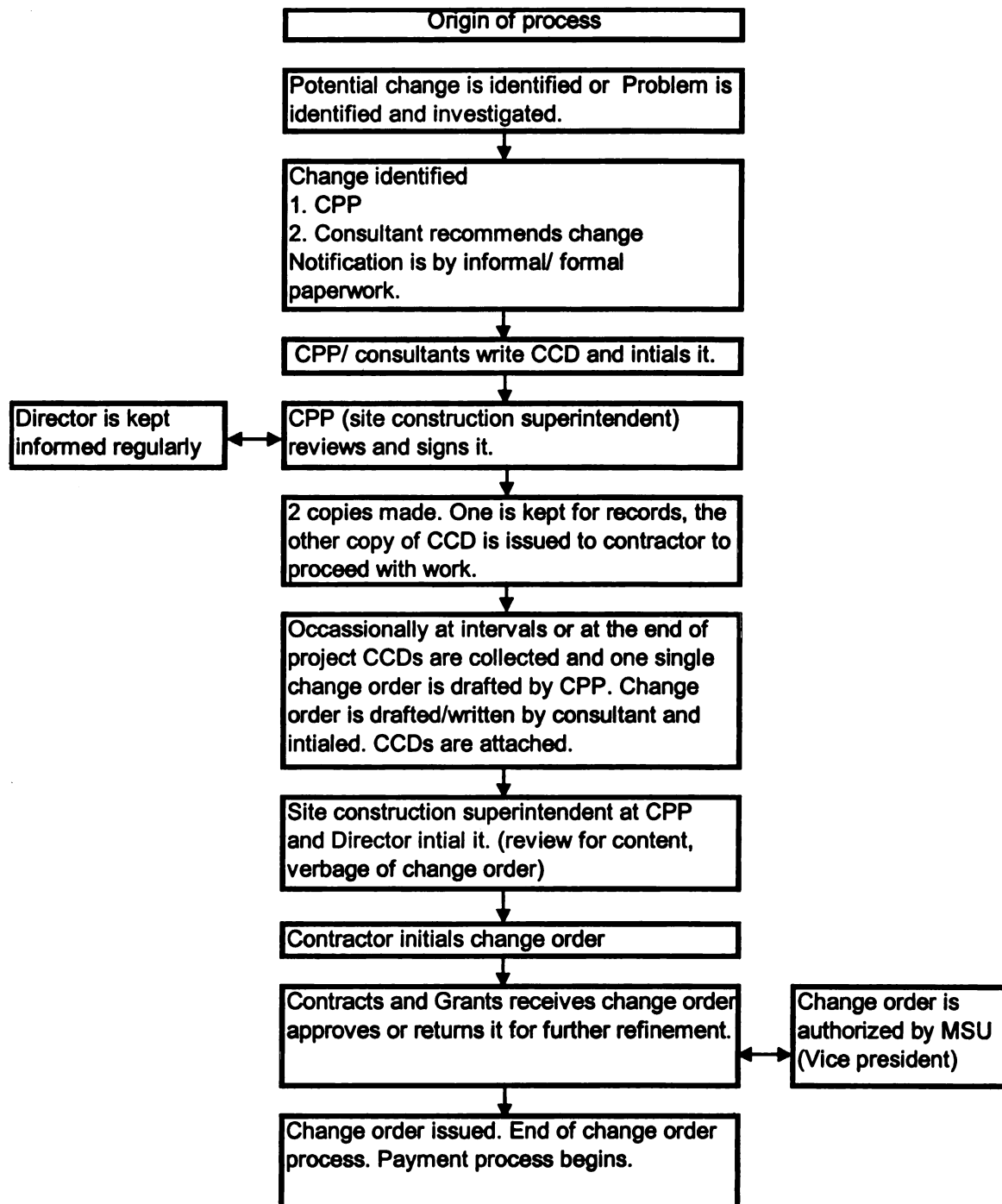


Figure 5.3 Current change orders process in Campus Park and Planning

5.4.3 Engineering and Architectural Services current process map

EAS projects are typically larger and more complex than those of HFS and CPP, and consequently the change order process is more complex. On average, change orders take 190- 200 days D1, 60 -65 days D2 to be processed. Interviews, both internal and external, suggest that the process takes too long.

EAS has four categories of change orders: Major, Formal, Construction Manager and Purchase Order. This thesis addresses the formal process in detail. Figure 5.4 shows that EAS process formal route has all of the five significant dates discussed earlier.

Initiation period: The change order process begins with a potential change being identified thorough RFIs, and meeting minutes. The items may or may not have costs associated with them. As each item is identified by the construction representative (CR), the CR seeks inputs from in-house and outside consultants on details. The need for a change is evaluated by the architect/ engineer (A/E) and CR. If they conclude that there is no need for a change; the rejected items, with or without quotes, are recorded and the contractor is informed. The CR groups a number of such items to prepare a potential change order. The length of this assembly time and the number of items in a potential change order are not standardized and are left to the discretion of the CR. Although, informal quotes may have been requested by this point, a formal request for a quote is made to the contractor, and two weeks are allotted for the contractor to prepare required quotes (although interviews suggest that sometimes it takes longer for contractors to submit these quotes.) When a change is requested by the A/E or owner, a bulletin and estimate are prepared that describe and estimate cost of change orders. At this time, a “Fred note” is prepared, either by the EAS architect or at the CCD stage. (Fred note is a

local phrase: this refers to a note that outlines the reason for change and is used by upper level administrators who must authorize a change order under the current protocol.) Reason codes are also assigned at this point. Meanwhile the contractor obtains sub contractor quotes as required and submits his/her quote to the CR. Some negotiation may occur, which typically takes up to a week. If there is disagreement over price, then a CCD or time and material method may be used. After final negotiation and agreement, a change order is drafted by the EAS architect and this date is recorded as the change order date.

Architect sub-process: After a change order is drafted the consultant architect or in-house architect reviews and signs it, the date when this occurs is the architect authorization date in the database. After the architect authorizes a change order three copies are made, which are sent to the contractor for signatures.

Contractor sub-process: The contractor signs three copies after reviewing them and returns two copies to MSU. The date the contractor authorizes a change order is the contractor authorization date in the database. On occasion a change order was generated by an in-house architect on projects designed in-house. On those occasions the contractor was not required to sign a change order, which led to some missing contractor dates in the database.

MSU sub-process: The design administrator reviews a change order for content; reviews the "Fred note" and initials the change order. Next, the University Engineer also reviews and initials the change order. It is then sent by the university's internal mail dispatch system, to CGA. CGA receives and audits the change order for content, budget conformance, reason codes, and item description. CGA correlates the change order with

relevant CCDs and checks the contingency ledger, bulletins, and other documents. If there is a need for clarification or if some information is lacking, CGA may consult with EAS or return a change order. This step may be lengthy. The staff at CGA enters information into the university information system (FAMIS). The Associate Vice-President authorizes a change order, which is indicated by the MSU authorization date in the database. The database does not include payment dates but they are generally believed to be about 30 days after the MSU authorization date.

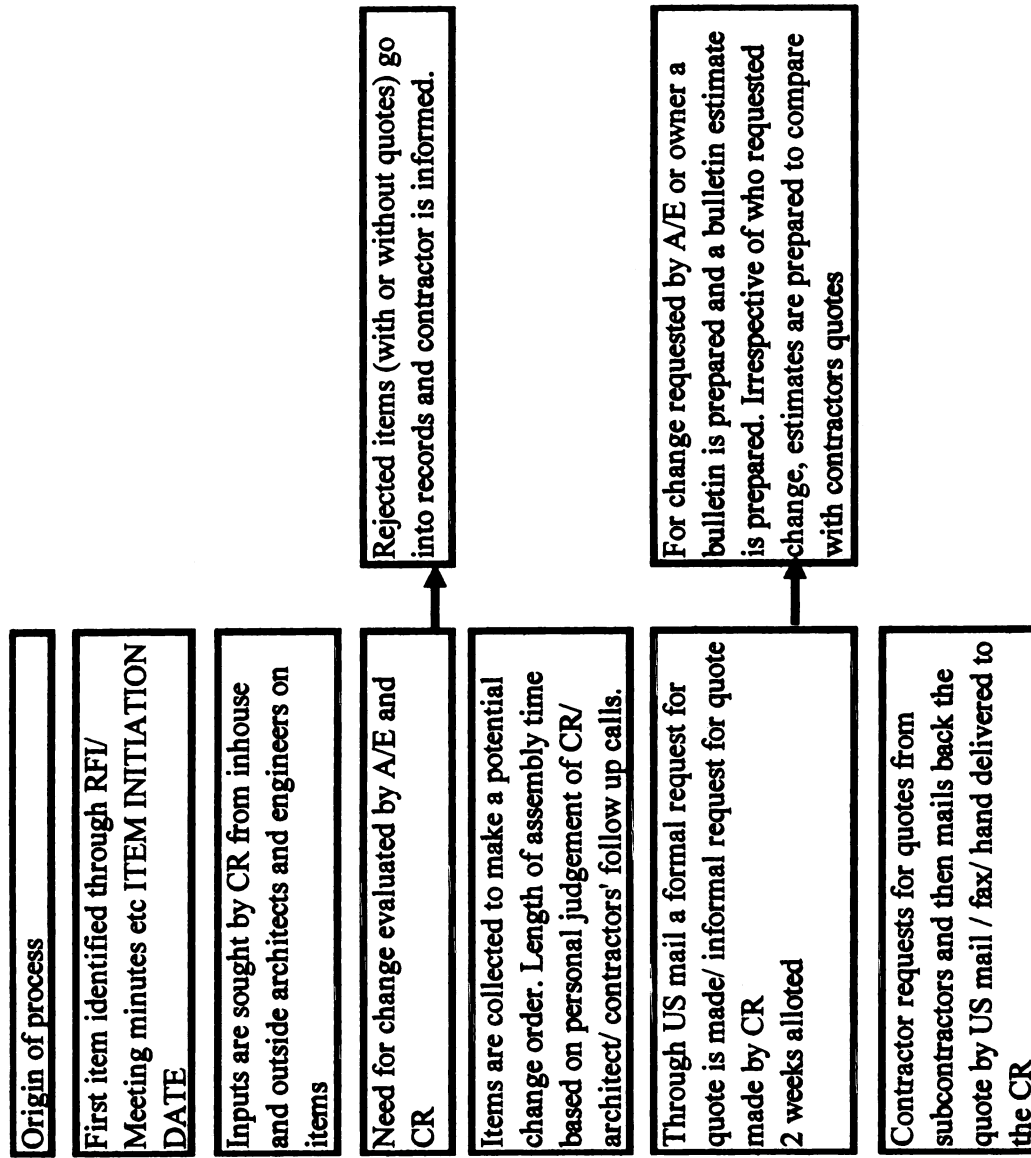


Figure 5.4 Part1 Current change order process in Engineering and Architectural Services (process map)

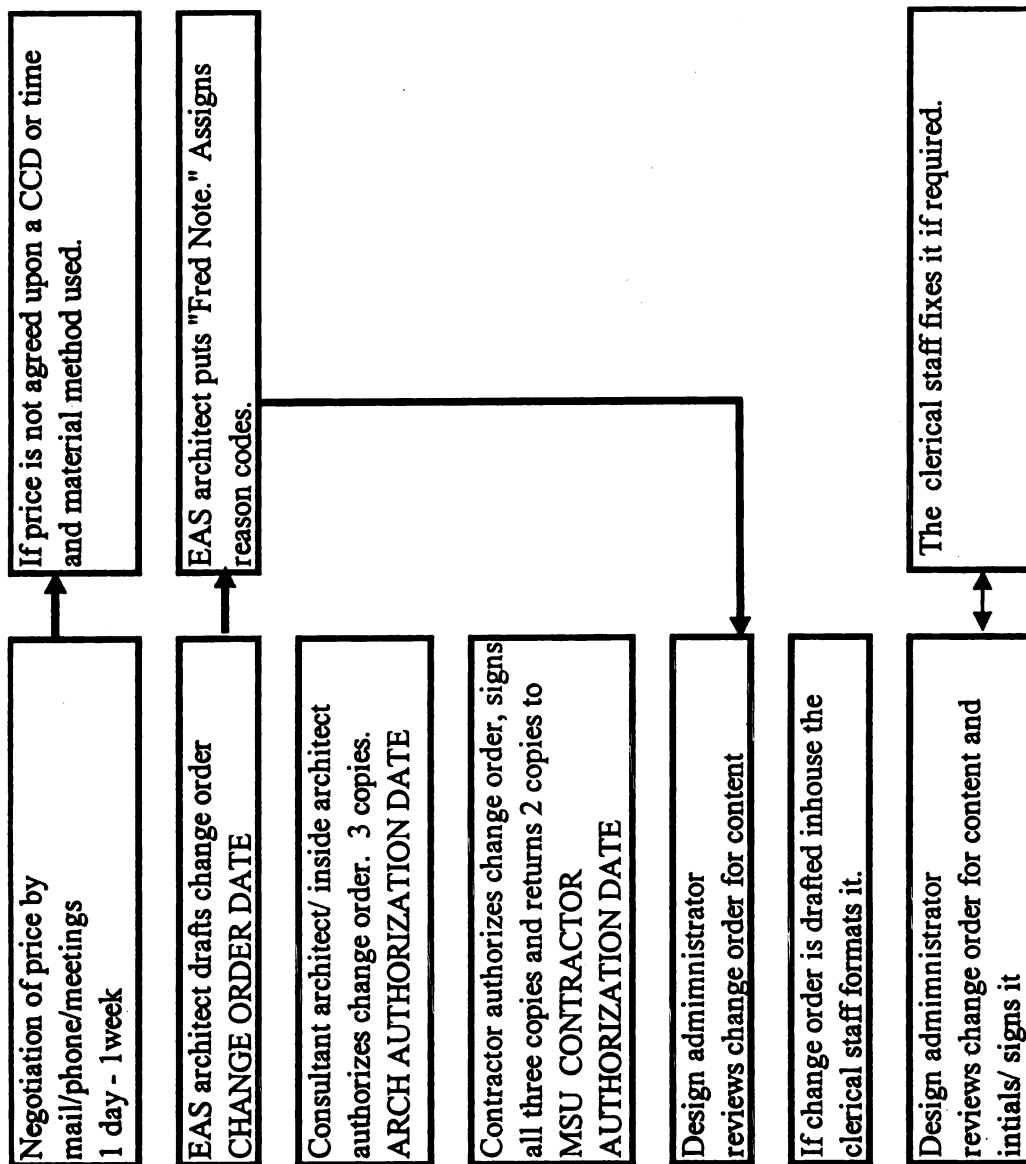


Figure 5.4 Part 2 Current change order process in Engineering and Architectural Services (process map)

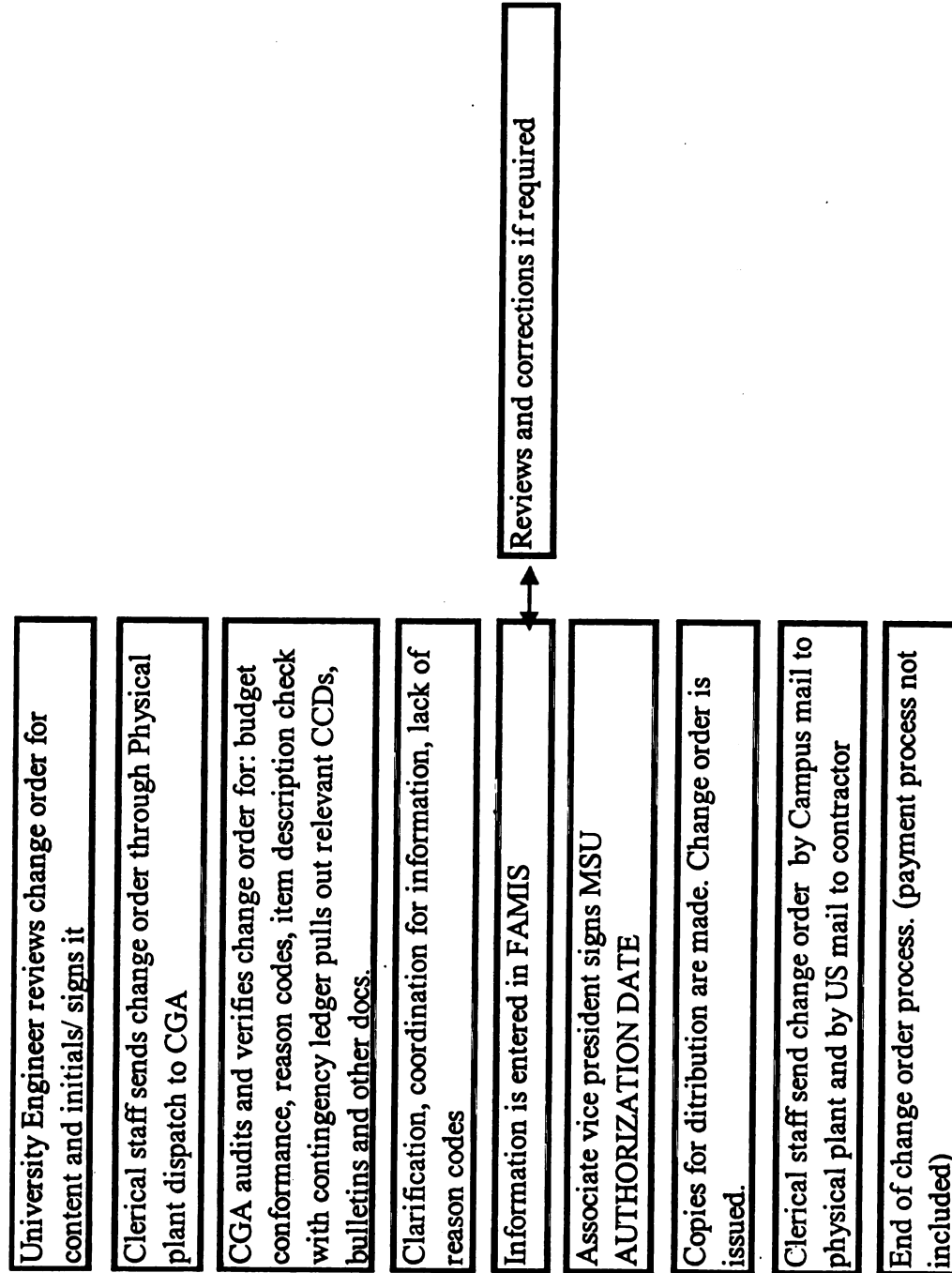


Figure 5.4 Part 3 Current change order process in Engineering and Architectural Services (process map)

The EAS change order process map was scrutinized by construction representatives, and other EAS personnel to ensure that the map was accurate. Figure 5.5 shows the map after it was reviewed and accepted as representative of the process at MSU.

The MSU change order management process was analyzed in order to develop an understanding of each activity and its importance as well as to identify milestone activities and possible improvements. The researcher modified the Graham technique (Graham, 2003, 2000) by introducing new symbols that would identify improvements. The following are symbols used by the researcher for analysis.

-  **Origin of process:** Indicates the beginning of the change order process in the map
-  **Work being done:** Indicates that work which was required was being done.
-  **Authorization dates:** Indicates the date a change order is authorized/ signed
-  **Value added activities:** Indicates that a useful activity occurred, something that added value to the process/ document.
-  **Room for improvement:** Indicates that there were certain activities in the step that have possibilities for improvement.
-  **Review and approval:** Indicates that a person in the process reviewed the document and signed it to indicate approval.
-  **Formatting and review:** Indicates that the document was formatted and reviewed, but no one signed the document.
-  **Delay, room for improvement:** Indicates delay in the manner in which the document moved between departments.

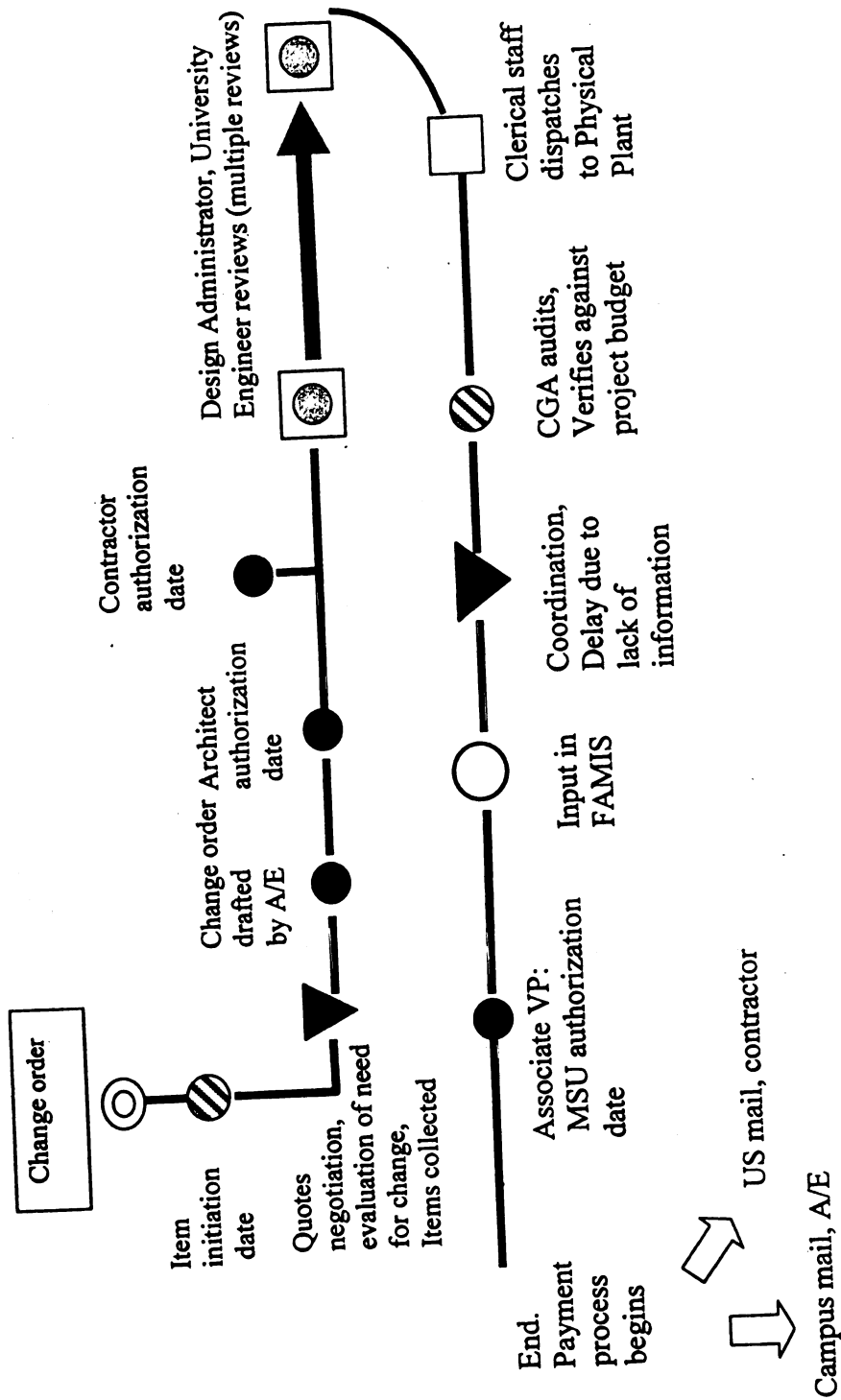


Figure 5.5 Analysis of Engineering and Architectural Services process using Graham mapping technique. (Graham, 2003, 2000)

After the initial process map was developed using the Graham technique (Graham, 2003, 2000), observations were integrated with comments from the interview process. Using the BOLO list (Smith, 2002) room for improvement was identified. BOLO items 1, 2, 3, 4, 6, 7, 8, 13, 14, 15 and 20 were used to evaluate each step in the process map. For example, steps where multiple reviews occur on the process map questions such as “Are multiple reviews (quality control) really required at this point in the process?” – (Item 15 from BOLO list), and “Are these intermediary steps value adding?”- (Item seven from the BOLO list) and “Are these duplicate work steps?” – (item four on the BOLO list) were asked. This was indicated by an arrow in the Graham map, which indicates “delay, room for improvement.” In this manner the process map was analyzed.

5.5 Summary of Engineering and Architectural Services process map analyses

The process map analyses identified areas for improvement. Analyses showed trends in the change order process, and also identified strengths and weaknesses which led to the following conclusions:

1. There was an opportunity for improvement in the change order initiation period and MSU authorization because a number of activities occur in these sub-processes.
2. The initiation period included several activities that could not be tracked for time and were out of the scope of this thesis; however these activities did contribute to overall processing time of change orders.
3. During the initiation period, there was no standard number of change orders that the CR would wait for before preparing a change order; the CR had

discretion to decide how many change items are packaged in a single change order. This observation was made during interviews with MSU administrators.

4. The initiation period was influenced by the contractor, architect and MSU personnel and therefore cannot be completely controlled by MSU; however there may be room for improvement in the activities performed by MSU personnel during this period.
5. MSU authorization time was high because unrelated items were packaged in a change order; also, items insignificant for monetary review were packaged with items that are critical.
6. CGA spends time coordinating with EAS due to lack of information on change order document.
7. Change orders went through multiple layers of approval regardless of dollar costs, contingency amount, project progress, and the fact that the work may have been done before the payment process even begins.
8. The higher the numbers of scope changes, the tighter the purse strings are pulled; and this causes longer and more thorough reviews. This was a response of one of the MSU administrators.

5.6 Alternate process map

The interview results, literature review, statistical analysis, and process map analysis were used to structure an alternate process map. This map was then validated through interviews with MSU construction personnel, and strengths and weaknesses were determined. Figure 5.6 shows the alternate process map. The following suggestions were made in modifying the current process map:

1. Change orders could be issued monthly, as is the practice in some of the universities interviewed for this research. This suggestion reflects best practices described in sections 2.3.1, 2.3.2, and 2.3.3 of the literature review chapter. Consistently issuing change orders at regular intervals ensures that change orders are reviewed at the end of the month and those that have not been processed can be logged as “outstanding.” The log could also show how many days the change order had been in the process. If it exceeded a 30 day processing period, it could be tagged to be released in the next change order monthly cycle. The university representative could then assess the outstanding change orders with the contractor and university administrators. This could standardize the process and also could reassure subcontractors and contractors that they will not be denied payment. And paperwork could be processed regularly. This suggestion was generally accepted by university administrators when they were interviewed to evaluate the alternate process maps.
2. The number of change orders could be restricted to ten items per change order (figure 5.6 part 1). As seen from statistical results, the number of unrelated items in a change order at MSU varied from one to as many as 45 change items in a

change order. This affected processing time of change orders. This recommendation is also the author's interpretation of the suggestion made by Civitello (2002) to subcontractors. Where Civitello described three-cost-pricing, he also indicated that breaking down a larger item into smaller and more detailed items facilitated better review. Although that was in relation to quotes and pricing of change orders, the author perceived this as a valuable suggestion for packaging of change orders. This recommendation was accepted during the verification interviews.

3. In the fifth step (figure 5.6 part 2), the author suggested use of formal requests for quotes. This change was suggested so that the activity could be tracked and recorded; it would also bring a sense of formality to the process. Two weeks could be allotted to the contractor; beyond this time frame, follow-up calls/ letters should be issued. This recommendation was provided based on interview responses of contractors. This recommendation also reflected one of the effective management practices suggested by McCally (1997) in supervising the process.
4. To reduce coordination time, project management software could be used. It could allow use of features such as prioritizing items, tracking time, assigning responsibilities to personnel, reminders, and emails, sending scanned documents, and avoiding loss of paperwork. This recommendation came from the interviewees that used effective software in their organizations.
5. Instead of an open time frame for price negotiation, one week could be allotted. This recommendation was made in response to the view of contractors and administrators that negotiation also can take too long. This negotiation period

could not be analyzed in this research to verify its accuracy. However, based on McCally (1997) nine keys for effective management, this recommendation was made.

6. The architect should be allowed two to three days to review and either authorize, request value engineering options or reject the change.
7. After the architect authorized the change order, the contractor could authorize the change order in two to three days (figure 5.6 part 3).
8. To reduce layers of approval in the owner's organization, change orders could be categorized by dollar amount as shown in figure 5.6 part 4. Possible ranges suggested by the author are: Construction representatives (CR) could approve \$0-\$5000 including deductive items, in coordination with Project Managers (PM). MSU PM could approve \$5000- 10,000, on recommendations from CR. Design Administrator (DA), could approve \$ 10,000 - \$ 50,000 on recommendations from CR and PM. University Engineer (UE), could approve \$ 50,000 - \$ 100,000 on recommendations from CR, PM, and DA. Assistant Vice President (AVP) could approve \$ 100,000- \$ 500,000 on recommendations from DA and UE. Vice President could approve \$ 500,000 and above on recommendation from UE and AVP. This recommendation was made based on practices of other organizations. MSU administrators did not completely accept this suggestion. Some administrators were anxious to include other criteria, such as: type of change and contingency amount. There was a need, expressed by administrators, to evaluate criteria and make this recommendation more defined and also to re-evaluate the

dollar amounts. This assessment could involve several brainstorming sessions and policy evaluations, which was not within the scope of this thesis.

9. The alternate process map suggested removal of some responsibilities from the CGA staff. For example, reason codes could be assigned by EAS, where change orders are drafted. Review for lack of information or incorrect information could be eliminated by the use of a checklist by the EAS staff before the document moved to CGA. CGA staff could review change orders for accounting purposes, and to verify if information.

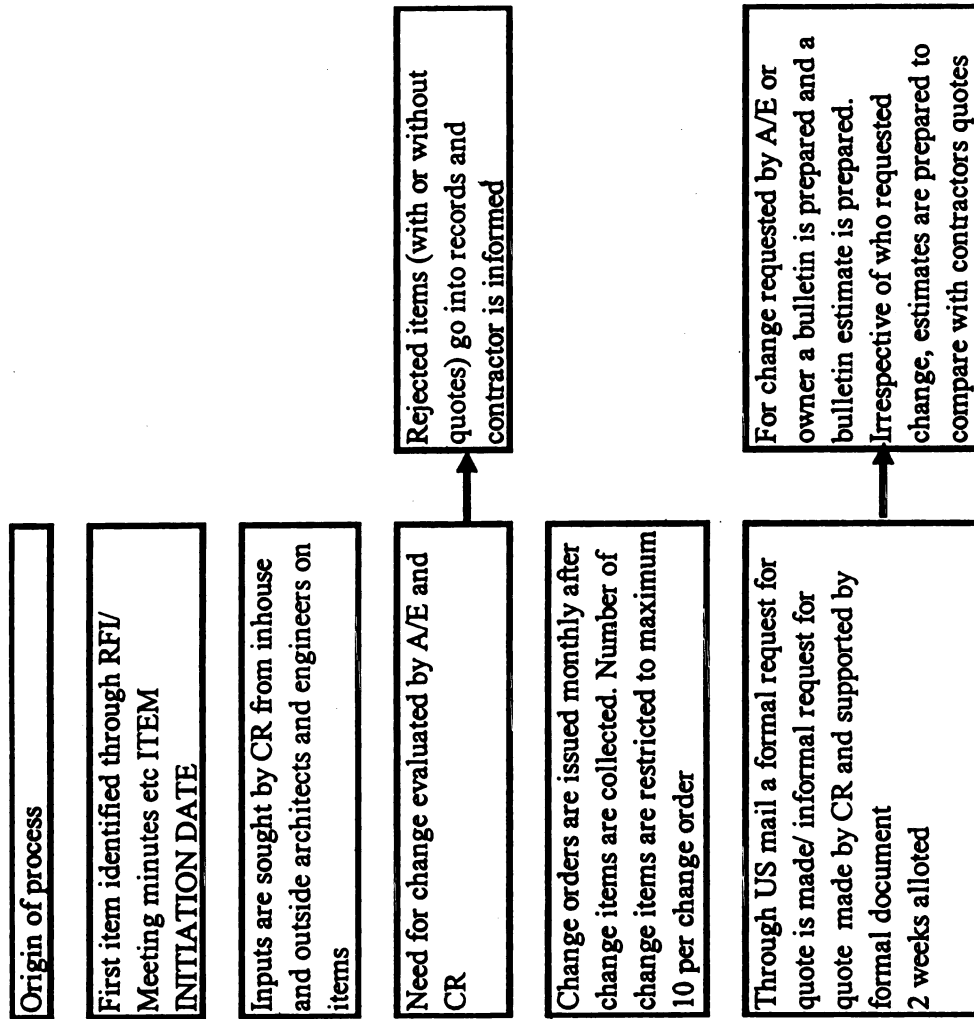


Figure 5.6 Part 1 Alternate change order process map: Engineering and Architectural Services

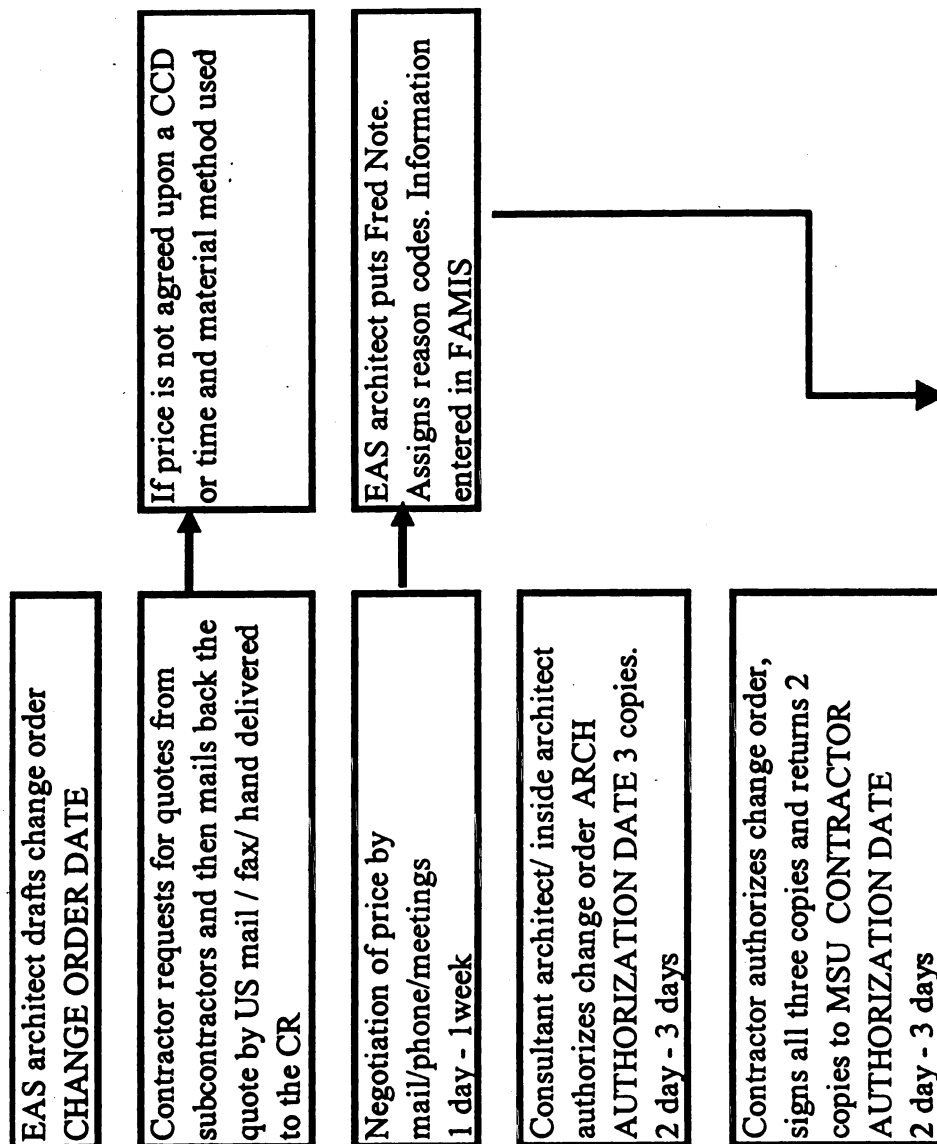


Figure 5.6 Part 2 Alternate change order process map: Engineering and Architectural Services

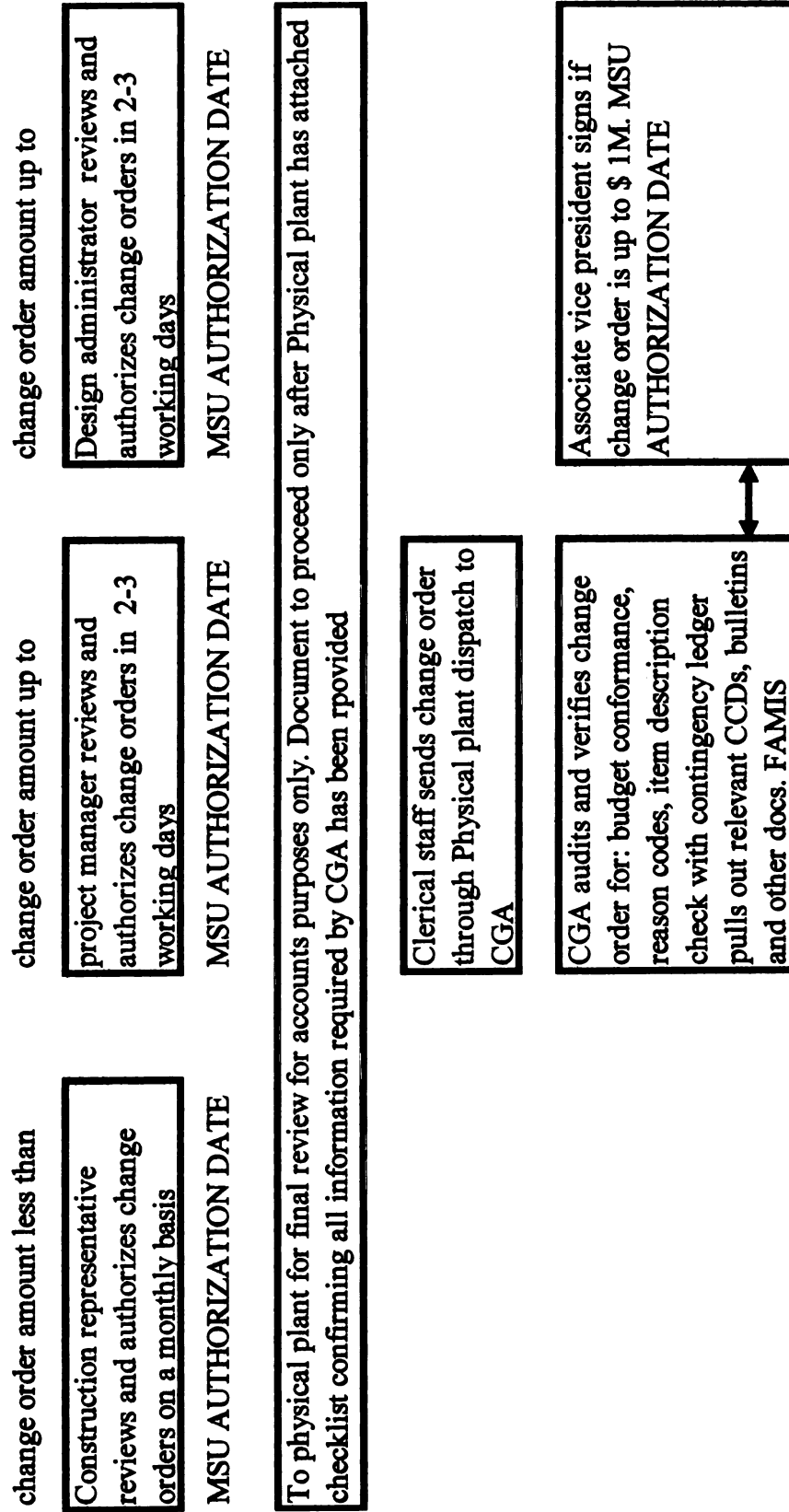


Figure 5.6 Part 3 Alternate change order process map: Engineering and Architectural Services

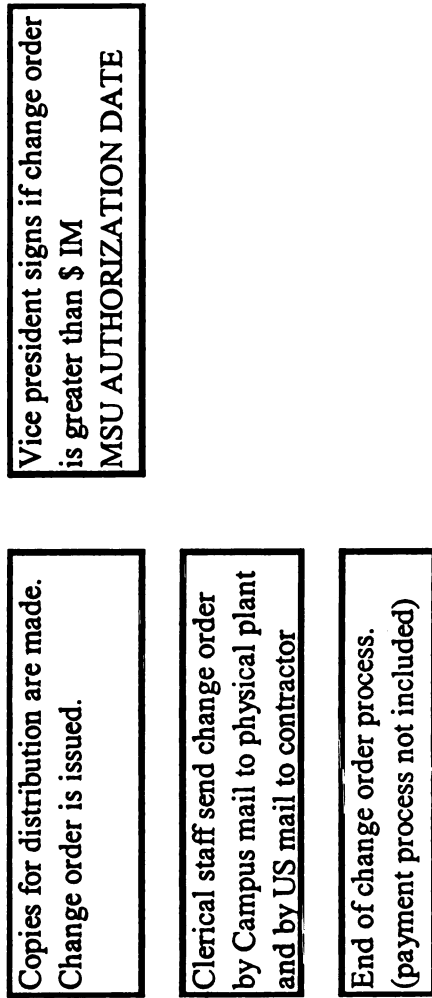


Figure 5.6 Part 4 Alternate change order process map: Engineering and Architectural Services

5.7 Summary of process map analysis and observations

CPP and HFS had a relatively simple and streamlined change order process. EAS in comparison had a complex change order process and areas for improvement were identified in the initiation period and MSU authorization period. Change orders of all amounts go through all levels of review, which seemed unnecessary; hence the alternate process model suggested categorizing change orders by cost and eliminating several levels of review and approval for small change orders. The researcher conducted interviews of MSU construction administrators in order to obtain feedback and review of the alternate process map developed during this research.

5.8 Recommendations to reduce change order processing time for Michigan State University

The following recommendations are made for reducing process time at MSU:

1. Set time goals

In order to enforce accountability and responsibility, the author believes time goals should be determined for each step in the change order process. The aim should be to work with goals rather than not having a specific time frame for every step.

2. Reduce layers of approval

At MSU each change order is approved a number of times, which is seen as a redundant activity by some construction project participants. The researcher considered cost as an important criterion. In section 4.8 of the thesis, the researcher described analyses of cost. Because of the small value of many change orders an opportunity for

incremental authorization of change orders by MSU personnel exists. Similarly universities can group change orders based on cost or other criteria that are important and reduce the number of change orders that would be approved multiple times.

3. Delegate tracking responsibility.

Delegated personnel who handle project controls could track change orders, as an additional responsibility. When time limits are exceeded, a 'late notice' could be issued. Weekly meetings could use a change order status log in order to bring everyone on the same platform. Contractors who track change orders do so through meeting minutes or by displaying them electronically. Project management software could be used to monitor and track individual change orders. At MSU the author suggested that data inputs could be made at Physical Plant instead of being done at CGA. Change order status logs could be printed at Physical Plant.

4. Reduction of time in initiation period could reduce overall processing time of change orders.

Analysis results have indicated that the relation between number of change items and length of processing time is linear. Interviews suggested that it makes it easier for approval if the number of unrelated items in a change order is reduced. Less information has to be reviewed and approval is quicker. The author suggested ten change items maximum per change order. The verification interviews suggested that the number could work, but that this change would have to be tested to ascertain if it would indeed reduce processing time. The author concurs with this opinion. 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 upon can be processed perhaps concurrent with the payment application.

5. Using a checklist before a change order is sent from Physical Plant to CGA for approval.

At MSU the change order is checked for amount tallies, item description, and reason codes and against the budget at CGA. Therefore the last person to handle a change order could check that required fields/ information have been provided before the document leaves Physical Plant for approval. Approval time could be reduced by making use of simple tools such as a checklist to ensure that all required information has been provided.

5.9 Verification interviews

In order to investigate the feasibility of the alternate process model and to identify the strengths and weaknesses of the model, verification interviews were conducted with three administrators at MSU. The interviews consisted of open ended questions. The first two questions were demographic in nature, followed by questions addressing the specific aspects of the alternate process model. See Appendix H for the interview responses.

The interviewees were provided a set of proposed recommendations, the current process map for EAS, and the proposed alternate process map; and then the interview was administered. The interview was voluntary and confidential. Responses were organized on similar lines with the data collection interviews. Responses were keyed in Microsoft® Excel spreadsheets and given codes to maintain the respondents' anonymity.

When asked if the current process map was fairly representative of the current change order process at MSU, the unanimous answer was "yes." However, one response mentioned the limitations of this current map and noted lack of detail in the architect and

contractor activities during the initiation period. However, as explained earlier, the research data available on the database did not include this information.

Concerning the usefulness of the model, the general view was that the alternate process model was useful and would help to reduce process time and streamline change order processes. Interviewees also expected that administrative costs could be reduced. They found the introduction of the stepped levels of authority suggested in the alternate model was useful. However, some interviewees expressed the need to include other criteria for categorizing change orders. Introduction of use of a checklist by the Physical Plant was welcomed, as it would help both CGA as well as Physical Plant in reducing coordination time and avoiding delay.

In response to the question on what factors were required to implement this model by administrators, the general response was that “there will be some difficulty in acceptance of change in the way things move, and further discussions (with people) will enable us to get everyone’s view, like an internal brainstorming session, and would improve the map.”

The weaknesses of this model, as indicated by one respondent, was that it could not provide more detail during the initiation period, but the respondents generally agreed that was not in the scope of this study.

All respondents agreed that fewer layers of approval would help improve processing time; however, there were concerns on lack of owner control in that case. Lack of control could occur when a less experienced CR was given authority to authorize change orders, or when contingency expenditures were not checked before sanctioning changes. One respondent mentioned that giving up control may be difficult. One respondent said it may not be bad, but needs to be evaluated.

Some of the changes in the alternative process map suggested were:

1. Change in the dollar amount of approval authority at lower administrative levels.
2. Consideration of contingencies as a deciding factor as to who should approve the change. More criteria should be included as deciding factors.
3. Project representatives should not be given complete power but should work closely with project managers and design administrators.

When asked about use of electronic document transfer most agreed that it could be useful in reducing processing time; however, there would be a need for clear function and responsibility definition in order to prevent confusion caused due to duplicate documents and printing at multiple locations. MSU already has an information system in place: (FAMIS). However it served CGA primarily for accounting purposes. It may have project management capabilities if other modules are purchased, but at the moment it lacks project management capabilities. When asked about the feasibility of the recommendation for investigating FAMIS and the use of add-on software, the response was that it could not be done in the near future as the owner had only recently purchased FAMIS, however, FAMIS could be investigated for its project management capabilities.

The interviewees did not suggest any changes in the alternate process model. Opinions expressed in the interviews were incorporated into the final recommendations.

5.10 Chapter summary

This chapter described the interview of architects, contractors, subcontractors and university administrators, presented the process maps and analyses. The alternate process map for EAS and a set of recommendations for streamlining the change order management process at MSU have been reported. Results of the database analysis

described in chapter four and interview results described in the beginning of chapter five were used in conjunction with the literature review and process map analyses to develop the alternate process map and recommendations. Verification of results through interviews with MSU administrators was also reported. Chapter six describes the generic framework for reduce processing time and a broad set of recommendations that can be used by other universities. It summarizes the thesis, presents contributions and conclusion of this research.

Chapter 6

Summary and Conclusion

6.1 Introduction

Chapter four described the database, analyses, and tools for analyses. Chapter five described process maps, analyses and an alternate process map for the organization. The development of the generic framework and its description are presented in this chapter. Cautions to consider while conducting process improvement research and studies are also addressed in this chapter. Chapter six also concludes the thesis, presents areas of future research, limitations of this research, and reiterates goals and objectives of the research.

6.2 Research objectives

The objectives of this research were:

1. To study prevalent change order processes in universities.
2. To document industry perceptions on the change order process best practices, and to review and summarize literature on change orders and process improvement.
3. To study a case study organization in detail with regards to past construction projects and prevalent change order processes, analyze it, and streamline it.
4. To develop generic framework and recommendations that can be used by other universities for process improvement endeavors.

The overall goal of this research was to develop a framework for streamlining change order processes in order to reduce processing time. Based on the steps used to analyze the case study organization, a generic framework was developed. The framework used to improve change order processes at MSU was generalized to develop a generic framework applicable to other universities. Literature on process improvement (McCally, 1997;

Graham, 2004; Graham, 1996; Kettlewell, 2003; Civitello, 2002; Belle, 2002; Edward, 2003) was also used to develop this framework.

6.3 Framework for streamlining the change order process in order to reduce processing time in university construction projects

The first step in an improvement process is to understand that the aim is to review the current process and make necessary changes to it in order to streamline it, not to re-do the entire process (Graham, 2004). Management consultants are often hired for renewal of a process/ complete process re-engineering. The framework presented here is for process improvement endeavors.

A team within the organization may be formed for process mapping, analysis, and improvement or one person may discuss it with several others, as was done in this research. The people involved in this endeavor will have to familiarize themselves with the process, make detailed notes on the sequence, areas of concern, opinions, facts, quantified/ estimated time in the major sub-processes in the change order process. Figure 6.1 shows a generic framework that can be used by other universities to evaluate their change order processes. As done in this research, one could begin with a macro map. This gave a 'larger picture' of the process to the researcher. In this map one can identify the sub-processes, and the general sequence of events. It is important to identify time related steps, such as documents being generated, approval from an authority etc. The map can then be detailed to form a micro map by incorporating information from people in various departments of the organization. If there is an existing detailed change order process map it should be reviewed to verify that it is being followed just as it is mapped. Any variations should be recorded, and a new map should be generated if required. This will

serve as “detailed current process map” or “as-is” map (shown in bold letters – step 5). The map should then be presented to the team members of the organization to check for accuracy and revised if necessary. Simultaneously data can be gathered on past projects. Information on type of change orders, number of items in a change order, project types, contract amounts, dates when the document was initiated, authorization by various personnel, amount (dollar value) of change, actual description of change items etc can be entered in a database. “A relational database model (such as Sybase, Oracle, IBM DB2, MS SQL Server and Microsoft® Access) allows data to be stored in tables and relationships may be established between columns. Such databases can be useful to run statistical analysis.” ¹The researcher used Microsoft® Access to set up a database for the case study organization data. Statistical analysis of this database gave time-related information. Other important relations such as: which sub-process impacted the overall processing time in the past and possible reasons why this happened may also be projected through analysis, for example, too many scope changes caused a sub-process to take a longer time to scrutinize change orders. Apart from helping contributing to identify areas for improvement, these results were also useful for validating results of process mapping. How statistical analysis can be done and which tools can be used was explained earlier in this chapter.

¹ Microsoft Access Tutorial, Microsoft® Access 2002. Copyright © Microsoft Corporation 1992- 2001. All rights reserved.

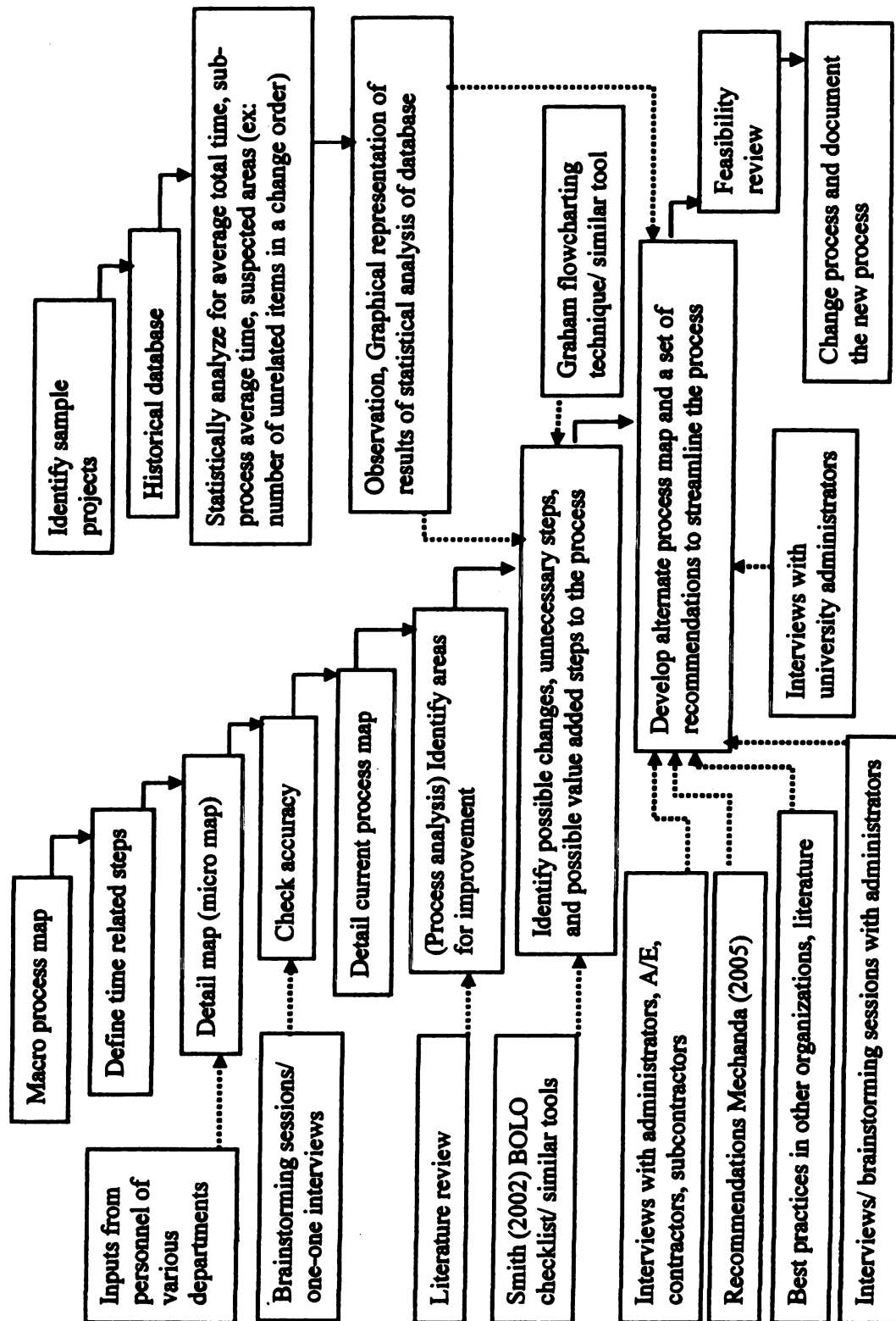


Figure 6.1 Framework to reduce change order processing time in university construction project

The next vital step in this framework is to analyze each step in the process for its usefulness and necessity. The BOLO list (Smith, 2002) described in section 3.8 was a useful tool to identify the value of each step. This list was used by the researcher because:

1. It enables the researcher to analyze each step individually.
2. It provides answers to the five essential process improvement questions: what, when, why, where, who.
3. It enables the researcher to view the process without bias.
4. It does not suggest elimination, but allows the researcher to observe characteristics of each step in a process and then make a judgment after the entire process is analyzed.
5. It is a standard tool for process improvement.

This tool was used by the researcher, but any other tool that will give similar results may be used for process analysis. After each activity is analyzed, the process map may be graphically represented using the Graham technique (Graham, 2002). This tool was used by the researcher because the technique uses symbols that are:

1. Mutually exclusive: Each symbol represents a distinct type of action. Therefore the categories do not overlap and make it difficult to determine which symbol to apply. An item is either moving (an arrow) or stationary (all other symbols): it is doing nothing (a triangle) or doing something (all other symbols), etc.
2. Universally applicable: They occur in all work areas. Therefore it is not necessary to use different terminology in different work areas. (For example, sales engineering, accounting, etc.)
3. Comprehensive: They cover work processes completely.

4. Each step in a work process is identified by one of eight ASME and ANSI approved symbols.

This tool was used by the researcher, but any other tool that will give similar results may be used for the same purpose. After areas for improvement are identified and visually represented, the results from statistical analyses of a historical database can be compared to the process analysis observations and, at the research team's discretion, the activities may then be changed/ deleted/added to the process to improve it. For example, as in the case study, figure 4.14, using the Graham symbol of "triangle" indicates a delay towards the end of the process. This came as a result of notes taken during process mapping interviews in the case study organization, where personnel mentioned that considerable time is spent when there is lack of information on a document, or there are unclear descriptions of change items, or disagreement over choice of reason codes. It takes time to coordinate, get the right information, revise the document, and then send it for approval. In addition, if there are too many unrelated items, coordination and review time increases. A lot of time is spent waiting for responses between departments.

The BOLO list helped the researcher analyze this step. BOLO items 6, 7, 13, 14, and 15 are applicable here. The researcher analyzed this step as follows:

- a. Someone forgot to input valuable information required by another department on the document.
- b. This step is intermediary and required to coordinate something that could have been done earlier in the process. This step is non value adding and also causes delay.
- c. This is a Quality Control (QC) step.

- d. This step could have been avoided if the process was “mistake proofed” in the previous department. A possible tool which could be used to remedy this is a simple checklist.

The Graham symbol of non value adding and delay causing activity was used to identify this activity. This visually identifies it as area for improvement. The results of statistical analysis of the database showed that time taken by MSU (CGA and EAS combined) impacts overall processing time of change orders. The results also showed that there can be as many as 40 unrelated items in a change order. Another relevant result is that number of unrelated change items in a change order affects overall processing time of change orders. The researcher concluded that this step should be improved/ deleted. A change was made to the process map, and recommendations were made to avoid this step and streamline the process. Similarly, areas for improvement can be identified and analyzed and changes can be made to processes in other universities.

The results of analysis can be presented by interviews or in brainstorming sessions that are part of a process to obtain the views and suggestions of the research team and organization personnel. Conclusions can be drawn on which activities are to be deleted/ modified/ added or moved. In this manner the alternate process map can be developed. To ensure that this improved map is feasible and applicable, a feasibility review should be done. Any changes that come as a result of the review can be incorporated and the process can be changed. This changed process should then be documented for reference in the future, and also to ascertain that the process is followed as a standard procedure.

6.4 Recommendations for reducing change order processing time for MSU and other similar universities

1. Set time goals

The author believes that, if a university wishes to reduce processing time of change orders, it has to set time goals for each step and monitor process activities. This may be easier said than done, as personnel approving change orders have more responsibilities than mere approvals. However, it may be better to set time targets and attempt to achieve them, rather than working without time goals. The intent would be to enforce accountability and responsibility.

2. Reduce layers of approvals.

If the presentation of a change order including its cost components were to be clearly defined, the approval or rejection may be accelerated. If the policies of a university require these layers of approval, the university could classify change orders and identify those that should pass through every layer of authority for approval. Once the change order price is agreed upon and the need for this change is fully justified, the system of multiple approvals becomes a repetitive activity.

3. Delegate tracking responsibility.

It is important to see that tracking of a change order is followed through the life of the change order process up to its conclusion. Even though responsibilities are assigned and approval time goals are set, implementing them may require systematic tracking of change orders. Delegated personnel who handle project controls could track change orders, as an additional responsibility. When time limits are exceeded, a 'late notice' could be issued. Weekly meetings could use a change order status log in order to bring

everyone on the same platform. Contractors who track change orders do so through meeting minutes or by displaying them electronically. Project management software could be used to monitor and track individual change orders.

4. Reduction of time in initiation period could reduce overall processing time of change orders.

Analysis results have indicated that the relation between the number of change items and length of processing time is linear. Interviews suggested that it makes it easier for approval if the number of unrelated items in a change order is reduced. Less information has to be reviewed and approval is quicker. The author suggested ten change items maximum per change order. The verification interviews suggested that the number could work, but that this change would have to be tested to ascertain if it would indeed reduce processing time. The author concurs with this opinion. 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 upon can be processed perhaps concurrent with the payment application.

Universities could analyze their change order process in a manner, similar to that explained in this research, and identify sub-processes that could be improved. At MSU there was an opportunity in the initiation sub-process by preparing a potential change order that includes fewer unrelated items.

5. Using a checklist before a change order leaves one department to another for approval.

A change order may not be processed immediately if it lacks required information. Personnel from various departments have different responsibilities and when responsibilities begin to overlap a delay may occur in processing. Approval time could be reduced if change orders were checked for all the required fields before being sent from one department to another for final approval, using tools such as checklists.

6. If an organization tends to package several items in one change order consider the following:

- a. Limiting number of unrelated items in a change order.
- b. Issue change orders periodically.

When several unrelated items are packaged together, chances are that because one item is not approved several other simple change items are held up. Delay in approval and payment of simple items or if work is already executed, brings discomfort to project participants. If change orders are issued regularly, the contractors and subcontractors can be sure about the approval period and anticipate the date when they could be paid for changes.

7. Entering data in software and information systems.

Using software and information systems could also eliminate misplacement of paper documents in the chain of personnel handling documents. It could also be checked for its potential to track change orders at the Physical Plant level. This would allow the project participants to know where (whose desk) the document is on a particular date, and if

timely notices are issued if delays occurred. Layers of security filters could restrict/ allow editing rights to selected individuals.

At MSU, although FAMIS is not in its final stage of implementation, it has some potential to monitor change orders. Data in FAMIS should be entered at the Physical Plant. Currently, reason codes as well as other information are entered in FAMIS at CGA. There may be administration requirements for this approach, but there is a possibility that all information could be entered directly by a construction representative. CGA could retain its right to change reason codes after consulting with the CR.

6.5 Contributions of this research

Contributions of this research towards streamlining the change order process at universities are:

- The prevalent change order process at a case study organization was mapped, verified for accuracy, and documented. This map can be used for reference for similar studies. The map can also be included as a part of a training manual or induction manual for management personnel at MSU.
- An alternate change order process for the case study organization for possible reduction of processing time was developed and documented. Some of the changes were considered useful, others were debated.
- Recommendations for possible reduction of processing time at MSU and other similar universities serve as “ideas for improvement”.
- Tools for statistical analyses, process mapping and analysis of process were presented. These could be used for any process improvement studies.

6.6 Limitations of this research

Taking into account the scope and time restriction of conducting such a study, this thesis has some limitations and the results should be applied taking these limitations into account.

Sample

A sample of sixteen projects (nineteen contracts), from one organization was used. A purposive sample was chosen, versus random sampling, due to a possibility of replication of project types. A random sample could have brought out a sample with a larger percentage of either renovation or new construction. It could have included more projects procured by one of the departments only, or of only one type, for example, laboratories. This would not have been representative of MSU projects. The Oversight Committee developed a list of possible projects that were free of litigation and fairly representative and sixteen projects were selected by the researchers from the list. See appendix B for details of the sample.

The statistical results may not be able to be generalized to other universities. Each university would have its unique processes and project types and a host of different parameters. However the researcher believes that recommendations and methodology can be generalized for process improvement initiatives in other universities.

Project delivery method

The sample did not address all project delivery methods as most projects used general contracts or construction management. Further research could include other project delivery methods.

Case study

A single case study was conducted for this thesis. However, through interviews, change order processes of other universities were understood and documented.

Cost savings

Although reducing processing time alludes to savings in administrative costs, no assessment of cost savings were made in this thesis.

6.7 Areas of future research

This research studied one organization. Future research could include multiple organizations. The sub-processes in the organizations can be studied in further detail, particularly the initiation period where multiple project participants play a role. Both time and cost savings of change orders could be evaluated. If cost savings are actually measured, it could build confidence in the framework for streamlining the process.

Recommendations made in this research could be expanded. Detailed checklists and forms can be developed which will be suitable for universities. These can serve as templates that any university can work with to make it applicable for their organization.

6.8 Benefits of streamlining a change order process to reduce processing time

The benefits of streamlining a change order process for reducing processing time are:

- Possible reduction of administrative costs.
- Reduced impact on project work flow and contractor's cash flow.
- Better project relationships.
- Reduced impact on competitive bidding.
- Saved project management time could be used beneficially elsewhere.

6.9 Cautions to consider in process improvement studies

While the researcher conducted this study some discretion had to be applied while making observations or while conducting interviews. If a respondent is very cautious while giving responses, it may be necessary to assure that the responses are completely confidential and that the study is not an audit. Some of the observations made during interviews by the researcher were:

1. Perception of interviewee that organization is being audited.
2. Respondent may “tell you what you want to hear” or give the “right” or “politically correct” response.

There is no “right” or “wrong” answer and a researcher must avoid using his/ her interpretation while paraphrasing responses. While probing to get relevant responses, the interviewer should avoid directing a response in a certain direction.

In the author’s opinion while mapping a process the researcher has to be careful and accurately document the process. It may be possible, that an existing map of a process may have variations in practice. It is therefore important to actually observe the process and record it carefully to verify the accuracy of the process. Whatever level of detail of mapping is required should be determined at the beginning of the study. While improving the process, it is important to differentiate between process improvement and process re-engineering (Graham, 2004). Process re-engineering is a different approach and will involve more time and a far greater number of changes, possibly in different departments as well.

6.10 Research conclusion

This research has used simple tools to analyze the change order process at a university. Statistical analysis of a historical database of sample projects was carried out, processes were mapped and analyzed and interviews with architects, sub contractors, contractors and university administrators were conducted to gain different perspectives on the change order process. An alternate process map was developed based on the results of the above analyses. Using best practices suggested by the literature review and the case study, a generic framework to reduce change order processing time in universities was developed and presented. This framework can be used by universities to study their change order process and reduce processing time. Useful tools like the Graham flow charting technique (Graham, 2000, 2003) and the BOLO list (Smith, 2002) were presented. These tools could be used for process improvement endeavors.

The findings of this research were that organizations may perceive that including several approvals will ensure good control over a process. This may be true if every step is value added. It is important for organizations to reassess processes and identify and eliminate redundant steps. When project participants are assured that a certain change order will be processed in a committed and consistent time period, it builds trust and confidence. Ensuring that a step is done right the first time would eliminate several reviews and coordination for lack of information. Standardization may prove vital in streamlining a change order process. Reducing the number of items in a change order, periodically processing change orders, tracking the change order

process and establishing time goals for every step were some of the recommendations made in this thesis.

In conclusion the author would like to say that although process improvement is recognized as necessary by several organizations, the time involved, documentation involved and additional responsibility to people who possibly may be overloaded with work discourages many process improvement endeavors. What people may sometimes forget is that analyzing the way things are done now could save a lot of time and money by avoiding redundancies, unnecessary activities in a process. It is vital to challenge, from time to time, the way things are being done and look for ways and means of improving the process.

3.11 Chapter summary

A generic framework for streamlining the change order process to reduce processing time in university construction projects was presented and explained. The chapter presented a general set of recommendations for change order process improvement in universities. Limitations of the research and areas for future research were also presented.

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APPENDIX A

Details of sample

Details of the sample

The oversight committee developed a list of projects that could be studied. 16 projects (19 contracts) were chosen from this list and are shown below.

Change Order Summary of Project Percent Change				
Project ID	Project Name	Initial Cost	Ending Cost	% Change
0365	Hannah Administration	\$217,000.00	\$243,548.29	12.23
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	\$1,662,272.00	0.93
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	\$76,124,074.60	\$78,164,009.00	2.68
2124	Nisbet Building Chiller Installation	\$385,000.00	\$396,501.34	2.99
3067	Spartan Stadium-East Concourse Restoration	\$2,565,000.00	\$4,955,991.54	93.22
3119	Breslin Center - Berkowitz Addition	\$6,138,747.95	\$6,359,798.69	3.60
3147	Chemistry 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	\$2,028,923.00	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	\$265,776.00	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	\$18,813,068.00	0.40
99072	Parking Lot #89 Expansion	\$3,020,000.00	\$3,433,123.58	13.68
				10.64
	Totals	\$137,701,060.55	\$144,761,528.62	avg
			Total Project % Change	5.13

Change Order Summary of Project Percent Change: New vs. Renovations

<u>Renovations</u>				
Project ID	Project Name	Initial Cost	Ending Cost	% Change
0365	Hannah Administration	\$217,000.00	\$243,548.29	12.23
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
				17.51
				average
				%
	Totals	\$17,486,720.00	\$20,905,476.05	change
			Total Project % Change	19.55

<u>New</u>				
Project ID	Project Name	Initial Cost	Ending Cost	% Change
2474A	MSU Bio-Physical Science Bld.	\$1,647,000.00	\$1,662,272.00	0.93
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	\$76,124,074.60	\$78,164,009.00	2.68
3119	Breslin Center - Berkowitz Addition	\$6,138,747.95	\$6,359,798.69	3.60
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	\$2,028,923.00	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	\$265,776.00	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	\$18,813,068.00	0.40
99072	Parking Lot #89 Expansion	\$3,020,000.00	\$3,433,123.58	13.68
				5.63
				Average
				%
	Totals	\$120,214,340.55	\$123,856,052.57	Change
			Total Project %	3.03

APPENDIX B

Interview responses from contractors

Feedback from Contractors		
Q	Question	Response
Q1	What is the title of your position within your firm?	PM and safety administrator.
		Vice presidents preconstruction, estimating, area).
		Project Director.
		Senior Estimator, Project Manager for GC.
		Project mgr.
		Licensed structural engineer. Sr Project Mgr & VP & Project Eng.
Q2	Can you provide approximate recent construction data for your company (or department) such as approximate number of projects, types of projects, dollar value and or project profiles?	35M, Institutional, hospitals, prisons, schools, mostly hard bids.
		40 projects, 300M annual volume. Health Care, Historic preservation, Heavy Commercial, K-12, Institutional, 2,6,8,10,11,7 CSI divisions. #5% of construction volume subcontracted.
		250 million in place annually. K-12, retail, commercial, industrial and resorts. No residential.
		290 million, Hospital, Industry, K-12 and universities, no residential and less detail.
		—
		100- 200 projects. 1 billion. Education, health, sports, industrial.
Q3	Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders, or performance of the parties involved? Describe. Are project records aggregated for the purposes of determining average change order rates?	Every project >\$10,000. Use master builder software. Process of formally keeping records.
		Formal Analysis at preconstruction, misconstruction, post construction. Not aggregated post construction. Financial status
		Yes, Gather info for future projects. Analyze sqft cost, man hrs, reevaluate the schedule, informally find out causes of CO
		Internally Yes, not formally. When owners ask for CO, you tend to push more number of CO's, which is not a good thing.
		No autopsy done
		No formal program. Quality analysis. Lessons learned on job in general, not specific to Change orders.
Q4	Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented?	Not as a company, but individually PMs have. Have studied about 500 items for negotiation.
		No.
		not really, errors & omissions, poor quality design, owner scope, field conditions, site work. Give arch ample time to follow, pay architect upfront for more detailed analysis, Contract language doesn't require architect to do any detailed analysis. Give university personnel ample time for detailed analysis.
		No formal analysis. Lessons learnt report.
		No.
		dwgs, lack of coordination of dwgs, owners scope changes, field conditions.

Feedback from Contractors		
Q	Question	Response
Q5	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	Reason codes being assigned. Mostly same: scope, doc, field.
		No.
		Yes, all 3. Done only for marketing purposes. Owners ask for CO% and where the costs can be reduced.
		No.
		No. A/Es cause errors and omissions. Personally I classify as owner, field and scope.
Q6	Have you drawn any conclusions with respect to the dominant causes of change orders? What are they?	No because we don't want to get into finger pointing at to who was at fault.
		Owners change scope, lack of info/ contradiction/vagueness, field conditions, no of layers of people who make changes but arrive late on projects, not updated standards.
		Scope changes, Field conditions, document errors. Varies with jobs and parties. Usually projects for big owners have scope changes. For bonded projects usually we have field changes and errors. Scope changes depend on end users involvement in programming and architects. More time required on planning and mock up construction would bring in end user input.
		-
		Lack of information and details, (smaller dollar amount), Architects drawings, coordination between A/E and M,E. Scope changes by owner large dollar amount).
Q7	If you can either from statistical data or from your experience indicate the usual change order rate percentages of original project budget for some of the following project types?	CM more, GC, DB least. Method of contracting is major source. Dimension issues. 3 weeks - 1 month time given to contractor. CM cant check the drawings as well as A/Es.
		Lack of skill in drafters, people unaware of building systems. Coordination is biggest problem in fast track projects. Same details are put in and are used over and over again, without thinking if they are applicable. Documents are not laid out in a way that it is easy to verify.
		new 3, complexes 6, remove 7, science 7.
		a = 2.5% d = 7%.
		5-10%.
Q7	If you can either from statistical data or from your experience indicate the usual change order rate percentages of original project budget for some of the following project types?	5, 7-10, 7-10, 7-10, 2, 5, 5-7%.
		10, 12-13, 12-13, 15-17, 25, 25.
		8, 10-15, 10-15, 10-15, smaller amounts, smaller amounts. Sports 12-20 depends on quality of docs.

Feedback from Contractors		
Q	Question	Response
Q8	Has any analysis been conducted which helps you to predict change order rates for projects? If so can you describe your process or methods? What are your change order rates?	Not typically. While bidding consider 7% contingency, we don't bid for extras. Photocopying costs alone are a lot. Not a predictor.
		Variability is accounted for in bids.
		Define the change order process, define change orders
		No detailed analysis. We look at contingency of a project. Analysis done job specific, for ex depends on what time of a year, schedule constraints, rule of thumb.
		No, Details missing, may be more errors in drawings.
		No.
Q9	Is that rate of changes orders seen as acceptable by owners? Explain.	No.
		Don't know.
		Some may see it as acceptable, some don't.
		Sophisticated owners accept change order.
		Knowledgeable owners accept it, now and then it's a problem
		Yes, A/Es are considered for changes, as it reflects their design. Volume of change orders, speed of processing is important.
Q10	Are you aware of any published industry average rates for change orders?	No. but money is an issue with them.
		3% perhaps.
		CII don't know what the rate is actually.
		Don't know. There might be published data, but we won't rely.
		No, may be meaningless, it depends on how contractors report it. There is no point in just reducing change orders, the quality has to improve first.
		No.
Q11	Are performance records of subcontractors and trade contractors monitored or tracked formally or informally with respect to change orders? If yes, can you describe how they are monitored by your organization?	Maybe.
		Informally.
		End of project review of Subcontractors not specific to CO. Informally assess SC for CO and work ethics .
		Yes, more informally. For unfamiliar contractors, we ask references.
		No, Subs are monitored for finance and performance. Their references are checked, ISO form is used and tied with AIA prequalification documents.
		Yes, Constantly. If reason for change is legitimate, how does it matter to have many changes? In performance records, look for organization, financial stability, past performance and quality.
		On perception. Performance is not necessarily a measure. Based on previous work. Not keeping track of Change orders.

Feedback from Contractors		
Q	Question	Response
Q12	What are the typical durations for processing change orders? Do these durations contribute to additional costs such as for extended general conditions, ripple effects or impact change orders?	60 days typically from date bulletin is approved to MSU authorization date. Yes they contribute, earlier we could accept with 8% O&P, now it is 4% we cannot accept it. Prices increase when executed later.
		Pvt Cos are quick in negotiations due to less hierarchy in approval (1 week processing + 30 days payment). They can contribute to extended general conditions. The 1st CO may not have a major effect but the 5th will have a cumulative effect. Impacts include, financial burden on SC, relationships breakdown, detrimental to administration. Owners have to understand that SC payment is important. If delay in payment is anticipated they include it in their cost. If they trust the process time they will quote realistically.
		90-120 days, without the payment period. Yes.
		4-6 weeks for change order drafting. from time initiated to MSU authorization 3 months. Yes they do. Most other places takes 10-15 days.
		195 days in MSU (payment process is included). Subs are problems. Once a month request for potential CO to Proj Rep to generate a bulletin. In other places it is 30-40 days, State of Michigan 60 days.
		Identification of change to MSU authorization date not including payment is 2 months on an average. Yes absolutely. Higher % of overhead. Negotiation takes a while and as more time is taken, subs tend to charge more for change orders. Very few will inflate change orders though, but business is business. sometimes there is no choice but to do it in order to survive.
Q13	Are project contingencies established by owners generally reasonable or are they unrealistic?	How they are spent is important. Maybe spent on scope changes not having enough on docs and errors. No but don't think it should be. If they had passed through the process, they should not be disputed.
		Reasonable but should be quoted upfront.
		Hard bid (owners wont disclose contingency). CM projects owner, architect, CM decide contingency)
		Reasonable.
		Generally reasonable.
		Reasonable.

Feedback from Contractors		
Q	Question	Response
Q14	When owners award construction contracts, are change order histories of general contractors considered in determining if they are "qualified" for the work. How is this information solicited?	No
		No. although there is a question on budgeted cost and actual cost, which is not enough to draw conclusions and hence is inappropriate.
		No performance data is solicited. Informal information is sought.
		No of CO's cant determine the quality of GC's. For CM Yes. Yes.
		No.
		Not really. Personal experience, size, finances. Want t know original budget and change orders which is unfair. What about scope changes due to owners, that isn't a fair representation of our reputation.
Q15	In your opinion do construction or design firms which participate in ISO programs usually have reduced change order rates on projects?	No.
		No. Probably more since it institutes a more rigid process. Cannot afford to have relationship based decisions.
		Its relatively new to construction. Yes, it should reduce change orders.
		No, not at all. If architects implement, then it may improve change orders.
		No.
		Not really, Can reduce errors maybe. ISO cannot control change order process as it has many variations. Nobody knows right answers in construction industry. A Framework does not really apply.
Q16	When interviewing for construction management services, are performance records for change orders usually considered by owners when making their selection? How is that information solicited?	Yes, unfair.
		Pvt. owners don't ask for questions regarding change order history as they expect change orders. When there is a lump sum fee there is no need for change orders by construction management services.
		Questions are barely related to analytical data. Performance records are answered by owners (informal, like how will you protect me from CO, saving costs?).
		Same as before.
		No.
		Yes. But the best thing to do is Give the best to the owner in terms of quality and money, not just educe change orders or payment.

Feedback from Contractors		
Q	Question	Response
Q17	Do you have any opinion or analysis on whether the project delivery method such as design build, construction management or general contracting influences change order rates? Explain.	Yes. Gc more, then CM, then DB.
		Design build- least only scope changes but owners have less control on design. CM more than DB less than CM. Plan review is better, owners control is more. In GC most number of Cos. Plans and specs are black and white.
		Yes, got analytical data. CM, DB, GC (Lowest to highest), CM is cost effective, level of service, program management is better. GC's look for profitability. DB reduces finger pointing.
		1GC, 2CM,3DB high to low.
		No.
		Cant compare and doesn't matter. The dialogue between parties is important. However in DB owner has less control on projects.
Q18	Do you have any opinion on whether the spread (variation) of bids received influences change order rates? Are they a good predictor of change orders on a project?	Should be intuitively, but ideally it wont happen.
		GC will scrutinize scope incredibly. CM will scrutinize more on change order process. SC will locate potential change orders but will not inform GC & will show on bids. Variation is a red flag- need to keep it in mind but is not necessarily a good predictor.
		Yes. Not sure regarding good predictors, large spread indicate unclear drawings. In low bids, bidder will look for opportunity for Cost
		No, not really, but there is a perception that very low bidder can dig for change orders. If there is an error, we will aggressively follow it to makeup for losses, if we are low bidders or we made a mistake on bid day.
		No
		Sometimes it is indicative. Poor set of drawings indicate change order rates better.
Q19	How common is it for change orders to be caused because the designer and owner failed to communicate on aspects of the design, leading to scope changes necessary to make the design work properly for the owner?	Most common.
		—
		Fairly common.
		Its common.
		35% are due to bad programming. Frequent.
		Common. 20% - 30% of changes.

Feedback from Contractors		
Q	Question	Response
Q20	Are construction documents including engineering documents adequately reviewed by A/E firms prior to bidding? Explain.	Nobody's perfect. Standard of care of architects is very high. With budget cuts it is difficult. Coordination however is always an issue.
		Its getting increasingly worse. QC is poor. MSU does a good job on choosing A/E.
		Depends, they look at it differently compared to contractors. Architects look for completion and if their designs are efficiently expressed.
		They do a good job, but they have their stumbling blocks. Coordination with other designers is poor.
		No.
		No. more time should be allotted to A/E.
Q21	On university projects, are construction documents formally reviewed by the university in detail prior to bidding? Explain.	Yes, multiple layers of review, not adequate though.
		MSU better than most owners. Its good.
		They can do better job, they don't have enough time. PP and CG are understaffed.
		Assuming so.. Not sure.
		No.
		Yes, but they still have problem with conformance to drawings with standards. Subs recognize nonconformance early.
Q22	Has your organization been involved with projects which have used commissioning services? Have these been effective in reducing change order rates?	No.
		Not analyzed with CO. They have been effective in customer satisfaction. Commissioning finds out flaws & more money is spent on CO & fixing goes over the years and is paid later. Testing brings out more Cos but its not bad.
		Yes, not sure. I don't think they reduce CO, its more quality related issue.
		Increases actually. Quality and testing changes to achieve the ultimate design goal.
		Yes, No. Actually increases CO's. Commissioning services have gone from giving an owner a serviceable product to expecting it to perform to the ultimate design.
		Yes. Don't like it. Just one more increase in cost. Commissioning services have no real responsibilities.

Feedback from Contractors		
Q	Question	Response
Q23	If you have used "partnering" agreements on projects, have those projects typically experienced lower change order rates than others? Has partnering been effective in reducing change orders?	Yes, no benefits.
		Good at negotiating CO. OK-but may not reduce CO. SC and owners benefit from it.
		Yes, good and bad experiences. If taken seriously its good.
		Yes, No, No.
		Yes, No, No.
		Yes essential. Partnering fails at times. Formal partnering sometimes. Yes reduces change orders, as miscommunication is reduced.
Q24	Are prebid meetings or walkthroughs conducted for university projects? Always? Describe? Have they been effective in reducing change order rates?	Yes, sometimes.
		Yes. Yes.
		Yes, Yes.
		90% of time, effective and important, but in reality No, during bidding it only raises questions during bidding.
		Yes, not sure, No.
		Yes. Yes. Not sure as design intent is clearer.
Q25	Which CSI divisions seem to cause the most change orders for your organization? Explain.	15
		15,16, 2, 9.
		15,16 because of complexity.
		15
		M/E, and general trades. Depends on type of projects.
		M, E, P.
Q26	Which design professions cause the most change orders for your organization? Explain.	Mechanical.
		M, E, P. lack of coordination between these three parties and with A/E. They are not involved in design process early on. Unforeseen conditions.
		15,16.
		Architects, coordination between design interfaces. 15 causes more, but arch changes happen to accommodate.
		15,16, Lack of coordination, lack of detail. Lack of attention to dimensions.
		Architects.

Feedback from Contractors		
Q	Question	Response
Q27	Which construction trades tend to be most frequently involved with change orders for your organization?	M and E.
		-
		2,15,16
		7,15,16. Drywall and acoustical.
		Architectural. M and E.
		All of them.
Q28	Based on your work with other large owners, what organizational traits or processes contribute to excessive numbers of change orders?	Multiple rings of authority delay work.
		Clearly defined decision network. CM allowances. 100% free discretion of owners. Should be used to handle changes.
		Not understanding what they are buying. Not involved with design, reduce levels of decision making. Decide who will be assigned.
		Too many bosses. Scope changes, decision making powers, end user involvement.
		Method of contract, over management. Layers of approval, shouldn't be power struggle in the organizations
		Bad communication process. Approval with respect to dollar amounts of change orders. Have less processing time, less layers of approvals and have more trust.
Q29	Based on your work with other large owners, what organizational traits or processes contribute to reduced impacts of change orders?	Lack of info, mechanical eng changes equipment without updating standards. Talk more.
		Define process.
		Level of expertise of owners and personnel. Ability to make decisions. Less levels of approvals. Not a clear process, antiquated process. Tends to change. People don't follow procedures.
		Decision should be fixed. And reduce levels of approvals.
		Same as before.
		Speed up processing, give more authorization to proceed. Owners have to be more responsible and also follow time commitments.

Feedback from Contractors		
Q	Question	Response
Q30	What impact do the design/construction standards of Michigan State University have on the number and types of change orders? Explain.	Pricing strategies. MSU doesn't pay for difference on items if there is a deductive change.
		Needs updating but they are fairly ok. Reduces CO, less guessing by A/E, contractors and owners.
		Standards are outdated, some material and equipment are not used today. A/E should check the standards.
		No impact on CO's. New designers has more problems, MSU standards are flexible and good. Some designers don't read standards.
		No impact. Standards refer to AIA 1982, which has been revised thrice now.
		Not very clear, not black and white, no communication between architects and MSU standards. They are frequently updated.
Q31	How are overhead and profit normally determined on your university projects? Are rates typically allocated in the construction contract? Are disagreements over the contractor's mark-ups for overhead and profit on change orders common?	In contracts.
		Dictated by contract. Causes disputes sometimes.
		Negotiated a fee for profit. Size of project smaller. Less duration of projects. Markup is in contracts, so no conflicts.
		No, YES, not common
		Don't know. Yes, generally 15% OH & P, No.
		Yes. Yes. 15 % is a small margin. That is not enough profit to keep a company going.
Q32	Are disagreements over extended general conditions costs, mobilization costs or loss of productivity common? Do owner's generally understand indirect costs which you incur on changes? Explain.	Common. Remobilization and productivity are legitimate.
		Productivity losses common. Affects sequencing. General conditions always .
		Yes, owners don't understand. Most GCs prefer no changes.
		Yes, They don't. Owners don't understand extended General Conditions, they don't understand how much it cost to be on a job. Inability to process CO's quickly impacts us (Contractors), not owners. Difficult to pay Subs.
		Not very common, and they don't understand.
		Yes. Gen conditions costs are tough to prove, mob costs can be validated, loss of productivity are not paid by owners.

APPENDIX C

Interview responses from sub-contractors

Feed back from SubContractors		
Q	Question	Response
Q1	What is the title of your position within your firm?	President.
		CEO.
		Divisional manager.
Q2	Can you provide approximate recent construction data for your company (or department) such as approximate number of projects, types of projects, dollar value and or project profiles?	7 million annually, 100 projects, roofing, masonry restoration, concrete restoration.
		20M. 100 -300 projects. Heavy commercial, industrial, institutional, historic preservation. Estimator, material person (purchase), project foreman, Trades people. PM heads all of them on a job.
		25-30 million annually, 400, 450 projects, 30% county work, 25% state and federal, of the rest half if commercial and half is retail.
Q3	Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders, or performance of the parties involved? Describe. Are project records aggregated for the purposes of determining average change order rates?	No.
		Yes. Put jobs in archives. Send a 2 page survey to owners to get information on the company (performance, fairness on change orders, working with other trades, if we were thinking ahead). Yes Daily. We use timberline PM module (since 2 years) and have daily reports on job sites. Actually owners must put everything on the internet too :RFIs, invoices, all documents.
		Nothing formal, daily review of job cost, daily loss and profit is detailed. Nothing on change orders.
Q4	Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented?	No, Informally YES. In new projects for roofing the design did not meet the standards of the university. Designers have to pay more attention to MSU standards.
		PM and estimators compare change orders to bids. We look at it for : request for change (money change), no change (no change on money. For example shift doors before wall is built) and N/A change orders (ones which do not affect us). This is the only classification we use.
		Yes, not formal, missed on plans, specifications are not an issue. Some contractor review can help. Experience people are required, better training of design Engg.
Q5	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	No.
		No.
		No.
Q6	Have you drawn any conclusions with respect to the dominant causes of change orders? What are they?	No.
		Not enough time to bid. Not enough time for architects to prepare drawings. RFI should be answered. Poor communication. Use of Construction management instead of General contracts.
		Designs work on paper, not on field. Lack of experience in design and require constructability reviews.

Feed back from SubContractors		
Q	Question	Response
Q7	Has any analysis been conducted which helps you to predict change orders rates for projects? If so can you describe your process or methods? What are typical change order rates?	No.
		No. Most contractors do not want change orders contrary to owners beliefs.
		No.
Q8	Is that rate of changes orders seen as acceptable by owners? Explain.	Sophisticated owners understand, I don't know.
		Maybe.
		They get surprised, but no problems with MSU. Dealing with one of MSU's organization directly or through a GC on EAS projects.
Q9	Are you aware of any published industry average rates for change orders?	No.
		No.
		No.
Q10	Are performance records of your lower tier subcontractors formally or informally considered with respect to change orders? If yes, can you describe how they are monitored by your organization?	N/A. MSU does good job, it is very thorough and stream lined.
		No. But we rate the other people we work with and our competitors. We have set up a database of costs, markups, bids, who were the people involved in each job within our firms and other project participants. We use a weighted rating system that rates them for performance, fairness, schedule, estimated project profit. Then we add a factor in our bids depending on all this.
		Yes, through job costing. No work is done unless change orders are signed and approved. Change orders are not tracked.
Q11	What are the typical durations for processing change orders? Do these durations contribute to additional costs such as extended general conditions, ripple effects or impact change orders?	Way too long, 60-120 days from discovery of change including payment process. Problems are in MSU authorization time. Durations contribute to extended general conditions, but we don't increase cost.
		6 -10 months. Identification of change to MSU authorization. It affects our morale more than anything else.
		Depends on the schedule, processing happens quickly if it will hit the schedule. Takes 2-3 weeks from identification of change to MSU authorization date. CO's don't impact us much.

Feed back from SubContractors		
Q	Question	Response
Q12	When general contractors or construction managers award construction contracts, are change order histories of subcontractors considered in determining if they are "qualified" for the work. How is this information solicited?	To a very small extent, no experience as such, low bid is the only factor.
		I don't know, but like I said we do.
		No.
Q13	In your opinion do subcontracting, construction or design firms which participate in ISO programs usually have reduced change order rates on projects?	No.
		No not consistently. ISO is highly over rated. Quality is very important, having a quality plan is more important than using ISO.
		What is ISO? N/A.
Q14	Do you have any opinion or analysis on whether the project delivery method such as design build, construction management or general contracting influences change order rates? Explain.	GC 1, CM 2, DB 3 High to low.
		Negotiated General contract is the best in my opinion. Gneeral contracts were always better. GCs bid the job hard dollar, more time was given o bids, trained skilled people were there to answer questions and they knew what they were doing. CMs when they began were GCs doing CM jobs and they still employed skilled experienced people on jobs. Now that generation has retired. We have fresh graduates with little experience brought onto jobs with no training. They should be tapped for other skills, not field skills. We need answers to open items and incomplete drawings. CMs do a poor job and work for the owner, not for the project. I dont know much about design build but I guess owner has poor control on these projects.
		Yes. Lowest DB, CM, GC. CMs have better field of civil.
Q15	Do you have any opinion on whether the spread (variation) of qoutes received from subcontractors influences change order rates? Are they a good predictor of change orders on a project?	Yes, by rule of thumb. If low bidder misses something who would ask for change orders, but it isnt a good predictor of change orders.
		-
		Effects a lot. Lower bidder will markup change orders. I don't like the low bid system. Its better to have prequalification system.

Feed back from SubContractors		
Q	Question	Response
Q16	How common is it for change orders to be caused because the designer and owner failed to communicate on aspects of the design, leading to scope changes necessary to make the design work properly for the owner?	Big one, very often.
		Very common. Owner need to take responsibility and commit to time. They should hire experienced architects not people who have never worked with MSU before and put them on important jobs.
		n/a.
Q17	Are construction documents adequately reviewed and coordinated by A/E firms prior to bidding? Explain.	There is a room for improvement. In few projects, MSU didn't detail the projects enough. They dint had enough time to finish drawings.
		There is not much time given for that. RFIs don't get answered prior to bidding. Drawings are always hastily prepared. 20 years ago and architect would discuss problems before the bid. Now with CM jobs architects are no longer doing that job and don't take any calls. Opportunities to get answers for better bids, better details, completed drawings are lost. MSU is preventing getting a better deal for itself by blocking direct communication with architects by use of CM jobs. Specifications are not specific anymore. You're letting contractors bid on chances instead of reality. Ambiguity goes in favor of trade contractors and not owners. they must understand that. Give more time to architects and let them directly communicate. Speed isn't everything, speed on drawings affects quality. People aren't given enough time to think.
		Yes and No. We basically verify the quantities.
Q18	On university projects, are construction documents reviewed adequately by the university in detail prior to bidding? Explain.	No, MSU doesn't understand a lot about *****. Architects don't design as per MSU standards, more conflicts with Architectural trades. Don't know constraints of ***** projects. Original standards are Ok!
		They spend time on it. But somehow things always slip through. Like I said give architects their powers like earlier, don't shift these vital responsibilities to Construction managers. Sometimes architects don't even come on site, they are out of state and never communicate. What answers will new hires on CM teams give us?
Q19	Has your organization been involved with projects which have used commissioning services? Have these been effective in reducing change order rates?	No
		Yes worked very well. Also involve more experienced people when drawings are at 80% completion stage bring qualified people, job site people and some subcontractors. Get people talking like before.
		n/a

Feed back from SubContractors		
Q	Question	Response
Q20	If you have used "partnering" agreements on projects, have those projects typically experienced lower change order rates than others? Has partnering been effective in reducing change orders?	Yes, worked on partnering. Not effective in reducing change orders.
		Yes. It works. But nobody partners with employees. Get everybody involved, it saves time in the long run.
		No.
Q21	Are prebid meetings or walkthrus conducted for university projects? Always? Describe? Have they been effective in reducing change order rates?	Yes, nearly always. They have been effective in reducing CO's. An addendum or preconstruction meetings need to be published. This helps in coordination.
		Yes. Yes. Sometimes they are not very good.
		Yes, sometimes. They are not always effective in reducing CO's. many may not point out deficiency in cashing out CO's later. If there was a glaring error, contractor will not bring it out. If clarification is required, they will ask, for example. Material already present in built work.
Q22	Which design professions cause the most change orders for your organization? Explain.	Architecture profession. More the experience of architects, the better it is.
		N/A.
		Site work.
Q23	Based on your work with large owners and contractors, what organizational traits or processes contribute to excessive numbers of change orders?	Don't know. Design should be closely watched
		Define the leader, who is making all the decisions and what kind of decisions. MSU has made good progress over the last 5 years. The PRs and PMs are very good assets now. It wasn't so earlier. But they need to make more progress. They should define their processes clearly. Its nothing to do with organization. it's everything to do with people and attitude.
Q24	Based on your work with large owners and contractors, what organizational traits or processes contribute to reduced impacts of change orders?	Don't know. Too many people in the pie may not talk enough.
		Large owners have talented and experience people. They are supposed to make quicker decisions. Why debate on prices over and over again after negotiations. Even after work is done we cant bill for it and for so long. Someintimes in large organizations documents even get lost. Subs are not allowed to directly communicate with owners so no body knows if the GC is messing up or the owner. "talk more within departments" and define processes. Assign defined responsibilities and trust them with it.
		Lack of experience in site work. qualified field supervisor and construction reps. Don't start work unless change orders approved. ***** has a good process.

Feed back from SubContractors		
Q	Question	Response
Q25	What impact do the design/construction standards of Michigan State University have on the number and types of change orders? Explain.	Large impact. Archiects use incorrect material or designs to some degree on every job. Don't know about number of changes.
		MSU has good standards. Of all the universities MSU understands its projects better. But the architects that are employed, does MSU make sure they understand them too?
Q26	How are overhead and profit normally determined on your university projects? Are rates typically allocated in the construction contract? Are disagreements over mark-ups for overhead and profit	Not in contract. For change orders- it is dictated in the contract. Disagreements are common, 15% is not fair.
		By contract. MSU has been a good teacher. 15% is fine, but when owners extend processing time and dont consider you on your years of experience and loyalty on bid day, it shows disrespect.
		Yes, Yes. No disagreements with MSU.
Q27	Are disagreements over extended general conditions costs, mobilization costs or loss of productivity common? Do owner's generally under stand indirect costs which you incur on changes? Explain.	Not an issue. Not a factor except delivery change.
		Yes but we don't charge them to MSU.
		No, MSU understands well.
Q28	Can you comment on the effectiveness of Michigan State University's change order process? What should be changed?	Don't know the total process. Proj rep doesn't process paper work. Need commitment on time. Penalty charge for late payment will force them to approve.
		We don't know if MSU sits on change orders or the contractor is not paying us. Other owners care for project relations. If contractors put unrelated items in change orders and due to some problem on some other subs items our items get held up. Both contractors and owners should be good leaders. If you expect 110% , you get it only if you treat people with respect for their time and work. Dont disprepect RFIs.
		works pretty well. We work closely with one of the departments and we have no complaints.

Feed back from SubContractors		
Q	Question	Response
Q29	From your perspective do you have any suggestions that could be employed by Michigan State University to reduce change orders or their impacts?	Better review or architectural documents. Closer coordination of MSU and architect. Requires more clearer design intent. Respect everyones time. Trust more. Define your responsibilities as leaders. Define your process. Have prequalified contractors for certain projects and look at the subs they bring to the table before accepting. Low bid isnt everything. Clean your documents and specs and have open communication. soil conditions improve
Q30	Do you provide construction services for universities other than Michigan State University or other large public sector owners? Can you comment on what aspects of their change order management processes should be considered for adoption by Michigan State University? Explain.	Yes, more commitment. Yes. Inviting bids from prequalified contractors and subs for certain projects. Let the people who just entered as bidders for MSU learn and aim for performing better and to get into the prequified list. MSU understands its project very well, better than most others. N/a. MSU does good job, it is very thorough and stream lined.
Q31	Do you have any other comments regarding change orders that you would add?	No. Incomplete drawings. Approval should be done with more authority, such that payment process should not be delayed. Define what CO's are, so that it will be easy to bid for changes on incomplete drawings Vs more complete drawings. Payment process is reasonable. MSU is estremely picky, to the extent that it is counterproductive. Time taken to process change orders is so long that it shows that such an important process is not getting the attention that it requires. Don't avoid necessary changes. The product should satisfy the end user, those are legitimate. Avoid unnecessary changes like drawings errors, ommissions. MSU interferes in the cosntruction a lot, which is good and bad. But when youre done youre done, why argue over changes then, you were involved so closely. Change orders are an indication of an unclean system of contruction management and drawings. No problems with CO's Soil testing is a big area. From A/E's of the owners. Timing of soil tests are important. MSU accepts the problems.

APPENDIX D

Interview responses from architects

Feed back from architects/ engineers			
Q	Question	Response	R
Q1	What is the title of your position within your firm?	VP.	A1
		Senior associate. (civil engineer).	A2
Q2	Can you provide approximate recent construction data for your company (or department) such as approximate number of projects, types of projects, dollar value and or project profiles?	20 million, 100 projects. Mostly commercial, industrial (dry wall, plaster, restoration, partitions and lathes) No residential work.	A1
		285 employees, 30 M (design fee) not sure about other work. 300 -400 projects. Site work, utility, steam tunnel, ramps, mechanical, waste water plants.	A2
Q3	How are typical design projects staffed when working on university projects? What are the specific responsibilities of the offices or individuals involved in your construction project administration process?	Estimating, proj mgmt, engineering is outsourced, project supervision project controller, safety rep and warehouse control. Proj mgr, controller involved in change order tracking.	A1
		PM, Lead discipline, (structural, engineering, architectural etc) . Generally all projects are staffed like this. For MSU projects specially we use people who are familiar with MSU jobs.	A2
Q4	Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders, or performance of the parties involved? Describe.	No.	A1
		Yes internal. Post project evaluation, peer review of project all looked at. Written and documented.	A2
			A3

Feed back from architects/ engineers			
Q	Question	Response	R
Q5	To what extent does your office monitor change orders on projects? Are project records aggregated for the purposes of determining average change order rates?	Yes, we record everything we quote. When a CO comes in, we check with quote. Check outstanding items before it is too late to get paid for. Items notified earlier, but are not approved like field orders.	A1
		Project representatives from owners side take a lot of responsibility. We still take responsibility to monitor change. We keep track of it for use on proposals. Owners ask for it in proposals.	A2
Q6	Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented?	No.	A1
		Informally. Our goal is to keep change order to minimum. Aggressive on documentation. Analysis is not client specific. Projects vary so much that we don't track causes. Continuous improvement process program is used to implement some recommendations.	A2
Q7	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	Field work orders, but don't get addressed to CCD, change order.	A1
		Clients have classification. We only track dollar amounts and how they relate to our CIP.	A2
			A3
Q8	Have you drawn any conclusions with respect to the dominant causes of change orders? What are they?	Errors, omission, incomplete drawings. scope changes, end user changes. Jobs where bids are called with incomplete drawings will have field changes, and too many RFIs are brought out, that are not even answered.	A1
		Not necessarily dominant. General trend is that schedule driven, fast track projects, push change orders up. Design process, reviews, bid processes are shortened in such projects.	A2

Feed back from architects/ engineers			
Q	Question	Response	R
Q9	If you can either from statistical data or from your experience indicate the usual change order rate percentages of original project budget for some of the following project types?	Less than 5, <5, 20, 5, na, na.	A1
		5, 5,10, 10-12, 15, 15.	A2
			A3
			A4
			A5
			A6
			A7
Q10	Has any analysis been conducted which helps you to predict change orders rates for projects? If so can you describe your process or methods? What are your change order rates?	No.	A1
		Yes there are statistical summaries. % given earlier or lower than that.	A2
			A3
			A4
			A5
			A6
Q11	Is that rate of changes orders seen as acceptable by owners? Explain.	Pricing is a problem, 15% overhead is poor. State of MI is 27.5% .	A1
		Yes and no.	A2
Q12	Are you aware of any published industry average rates for change orders?	No.	A1
		AIA, EJCDC have lots of data. % given earlier would be comparable.	A2
Q13	Are performance records of consultants (engineering, landscape architects, etc monitored or tracked formally or informally with respect to change orders? If yes, can you describe how they are monitored by your organization?	n/a	A1
		Yes we ask for changeorders. Based on previous work, based on relation, quality reputation is more important than change orders. We don't work with new contractors. Will work only through some previous contact, experience or known member of that organisation.	A2
			A3

Feed back from architects/ engineers			
Q	Question	Response	R
Q14	What are the typical durations for processing change orders? Do these durations contribute to additional change ordersts such as for extended general conditions, ripple effects or impact change orders?	60-90 days, sometimes 4-5 months. Bulletins are faster, takes 30 days. CCDs and bulletins force us to work ahead, but payment is late, therefore we need to markup more on change orders, deduct change orders.	A1
		Depends on amount and complexity of change rder. Between identifying problems to MSU takes froma a couple of days (purchase order) to couple of months (For formal/major projects).	A2
Q15	Are project contingencies established by owners generally reasonable or are they unrealistic?	Don't know.	A1
		We try to advise on what is realistic. But they insist on zero and zero is not reasonable.	A2
			A3
			A4
Q16	Who determines the testing program for elements such as soils testing, environmental conditions? How are they determined? Have testing programs generally been adequate or is this an area of concern or cause of change orders?	n/a	A1
		Joint decision. MSU provides.	A2
			A3
			A4
			A5
			A6
Q17	How are your design consultants hired for projects? When selecting or considering design professionals are their performance records for errors, omissions and change orders considered? If they are considered when hiring, how is this information solicited?	Only for specializations, check on quality of drawings.	A1
			A2
			A3
			A4
			A5
			A6
			A7

Feed back from architects/ engineers			
Q	Question	Response	R
Q18	When advising owners on award of construction contracts, are change order histories of general contractors considered in determining if they are "qualified" for the work. How is this information solicited?	n/a	A1
		It is certainly a factor. Contractors sometimes have very aggressive reputations for change orders, but their work is good quality and good on schedule. So it is only an awareness factor. NO. Change is nothing more than an indication of the circumstances in the project.	A2
			A3
Q19	In your opinion do construction or design firms which participate in ISO programs usually have reduced change order rates on projects?	Not at all, like partnering it's a dog and pony show - only marketing strategies.	A1
		Same parallel as CIP. Firms that aggressively involve a quality program makes things good for everybody.	A2
			A3
Q20	When advising owners in awarding construction contracts or trade contracts, are change order histories of specific subcontractors or trade contractors considered in determining if they are "qualified" for the work. How is this information solicited?	n/a	A1
		Not much info on that.	A2
			A3
			A4
			A5
			A6
			A7
Q21	Are you ever involved in assisting the owner in selecting construction managers? When selecting or considering construction managers are their performance records for change orders considered?	Yes, no.	A1
		Yes. Yes.	A2
			A3
			A4
			A5
			A6
			A7

Feed back from architects/ engineers			
Q	Question	Response	R
Q22	Do you have any opinion or analysis on whether the project delivery method such as design build, construction management or general contracting influences change order rates? Explain.	Yes, CM has less change orders, they work for owners, but more disagreements with subs, bids will be higher. GC bids are better, but have more change orders, GC thinks for subs, better drawings, subs would rather work for a GC. DB has less change orders, only change orders. Changes, prices are higher, less change orders.	A1
		Yes. GC is good is adequate time is given to designers to do their jobs. In DB owners are not involved when job begins later as awareness increases scope changes come in.	A2
Q23	Do you have any opinion on whether the spread (variation) of bids received influences change order rates? Are they a good predictor of change orders on a project?	-	A1
		No, owner may think that way, if bidder is low on a job or misses an item, they will try to make it up.	A2
			A3
			A4
Q24	How are building programs (needs briefs) established and documented? Are misunderstandings about program occasionally or commonly a cause of scope changes by the end user department? Describe.	Could be, it shows on the job. Occasionally to often, not consistently.	A1
		Very strong emphasis of our approach to design. Direct meetings with owners, written responses to review comments. Most projects we've worked on we had direct contact with end user.	A2
			A3
Q25	Are construction documents including those of your design consultants formally reviewed by your organization in detail prior to bidding? Are checklists used? Describe this process.	n/a	A1
		Yes. Different levels of review, discipline specific, independent review, QA QC, standards and design document clash checks, constructability reviews.	A2
			A3
			A4

Feed back from architects/ engineers			
Q	Question	Response	R
Q26	On university projects, are construction documents formally reviewed by the university in detail prior to bidding? Describe this process.	Yes, errors and drawings. Conflicts between standards and drawings. No language in contract that says what takes precedence.	A1
		Yes. When time is available they do a thorough job. Follow up is usually face to face. Multi disciplind review team. If there is something done that confounds MSU standards it is notified in written format.	A2
Q27	Has your organization been involved with university projects which have used commissioning services? Have these been effective in reducing change order rates?	No.	A1
		Yes. Yes effective in getting the system working properly. Not change orders.	A2
			A3
			A4
			A5
Q28	If you have used "partnering" agreements on projects, have those projects typically experienced lower change order rates than others? Has partnering been effective in reducing change orders?	Yes. Not at all. Partnering is introduced after bidding, but discrepancies will remain and change orderst you money. More communication will help, partnering does discuss on approval time, but doesn't get implemented .	A1
		Few projects. Good idea to improve project communication. I don't know about changeorders. Procesisng time is discussed in these meetings, how to reduce change orders, it also defines accountability and responsibilities. Set expectations on timely communication. People follow it to the end.	A2
Q29	Are pre bid meetings or wakthrus conducted for projects? Always? Describe? Have they been effective in reducing change order rates?	Yes, always, only if its mandatory it will help. Spend more time on preconstruction stage, better to qualify contractors and negotiate with them. Sometimes owner force with out a bid date.	A1
		Necessary for contractors to submit a better bids. Its to everybody's advantage . If contractors asks for information prior to adenda date.	A2

Feed back from architects/ engineers			
Q	Question	Response	R
Q30	Which CSI divisions seem to cause the most change orders for your	9 to 16	A1
		Don't know.	A2
Q31	Which design professions cause the most change orders for your organization?	Schedule impact is more.	A1
		Biggest challenge is scope change. Anything you can do in design process works to everybodys advantage. Most of the times end user is not a technical person and doesn't see a adifference till it is built.	A2
Q32	Which construction trades tend to be most frequently involved with change orders for your organization?	Carpenters.	A1
		Don't see a trend. Every trade has its own challenges.	A2
Q33	Based on your work with other large owners, what organizational traits or processes contribute to excessive numbers of change orders?	Yes, MSU has most number of Change orders, walk through should be mandatory. Specify who reviews at MSU. Specifically on renovations projects, so many things go unnoticed. Architects need to be more thorough. Owners know more about the building than architects, therefore they must communicate. walkthroughs should be mandatory for GCs and Subs while considering bids.	A1
		Owner scope change. Poor set of construction drawings. If bids come low owner tends to brings in things that they it could not afford earlier. Scope changes increase. Nothing to do with organization I guess.	A2
Q34	Based on your work with other large owners, what organizational traits or processes contribute to reduced impacts of change orders?	More time in bidding, not get bulletins, CCDs at end of projects, answer them upfront.	A1
		Large owners may have poor communication. They should have internal commitment to go through changes fast. Sheer volume of projects handled by MSU makes them different from other large owners. Possibly they are understaffed as well.	A2

Feed back from architects/ engineers			
Q	Question	Response	R
Q35	What impact do the design/construction standards of Michigan State University have on the number and types of change orders? Explain.	Not really, subs don't get standards. Mention that standards on specifications are online at meeting minutes and walk through.	A1
		Helps reduce them if owner Clearly communicates with consistency and designers know what MSU needs. Standards are also present online.	A2
Q36	How are overhead and profit normally determined on your university projects? Are rates typically allocated in the construction contract? Are disagreements over the contractor's mark-ups for overhead and profit on change orders common?	Yes, should get more, state of mi 20%	A1
		Yes. Based on prevalent wage rate and business requirements. There are but it is a reason for disagreement all the time. 15% is enough. With state projects maybe contractors make less money and hence need more profit on change orders. MSU allows reasonable markup, but if contractors are upset over processing time they should voice their concerns clearly to MSU.	A2
Q37	Are disagreements over contractor's extended general conditions or loss of productivity claims common? Explain.	No, mainly it spoils customer relations.	A1
		Yes but not prevalent. It could also be due to contractors poor intital schedule. Contractors deal with projects pretty aggressively if they still see a problem with these things and don't discuss it, it is their problem.	A2
Q38	Can you comment on the effectiveness of Michigan State University's change order process? What should be changed?	Refer to previous answers.	A1
		Process is good. Needs to be documented and needs speed in processing. For each department define an acceptable period of time for processing and strive to reach it. If contractor is too laid back intially it turns into a problem later on and then they pursue it, when it is too late.	A2
Q39	From your perspective do you have any suggestions that could be employed by Michigan State University to reduce change orders or their impacts?	Preconstruction and walk thrus, architect should be pre qualified like subs and GCs.	A1
		Its is a balancing act. Go through a thorough design process and give time change orders go down, but if you take away the schedule in doing so change orders go up. I think one sholud not push the schedule too hard. They must also spend time on review process.	A2

Feed back from architects/ engineers			
Q	Question	Response	R
Q40	Do you provide architectural or engineering services for universities other than Michigan State University or other large public sector owners? Can you comment on what aspects of their change order management processes should be considered for adoption by Michigan State University? Explain.	Process takes too long, there is something wrong.	A1
		Yes. Pvt sector are budget driven and hence are more competitive. If there is an open item they will discuss it and fix prices aggressively. Public owners take their money lightly.	A2
Q41	Do you have any other comments regarding change orders that you would add?	If liquidated damages are there and not meeting contract time, they should pay premium for acceleration, give incentives for finishing early. Prequalification of architects.	A1
		Everybody in process has a responsibility and when we have adequate/ reasonable time for design, our statistical data show that change orders are low. We look forward to fast track projects, but risks go up and everybody should be more responsible and alert.	A2

APPENDIX E

Interview responses from university administrators

Feed back from MSU administrators		
Q	Question	Response
Q1	What is the title of your position within your firm?	**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
		**** response not reported but available ****
Q2	Can you identify the offices or departments which procure construction services for your university (or department)?	Response already given.
		40 projects, 300M annual volume. Health Care, Historic preservation, Heavy Commercial, K-12, Institutional.
		EAS, housing, construction and design, and land management.
		purchasing contracts and grants, land management, interior design, housing and food services, maintenance.
		University housing and interior design, CP& P, Physical plant, power plant, land management.
		Information already provided.
		Info provided earlier.
		Info provided earlier.
		Info provided earlier.
		Info provided earlier.
Q3	Can your office provide general recent construction data for your university (or department) such as number of projects, annual dollar value and/or project profiles? If not, where could we obtain this information?	Unofficial, yes. Just informal discussions.
		Formal analysis at preconstruction, midconstruction, post construction. Not aggregated post construction. Financial status exports go through change orders, schedules, projects.
		Information already provided.
		Given earlier.
		Information already provided.
		Information already provided.
		Information already provided.
		Info provided earlier.
		Info provided earlier.
		Info provided earlier.

Feed back from MSU administrators		
Q	Question	Response
Q4	Does an organizational chart exist which outlines your university's (or department's) construction project management parties? If so, can we obtain a copy of this chart? If not, can you identify the offices which are involved?	Yes, Reason codes. A/E or CR assigns Reason code.
		No
		Information already provided.
		already given.
		Given eralier.
		Information already provided.
		Information already provided.
		Info provided earlier.
		Info provided earlier.
Q5	What are the specific responsibilities of the offices or individuals involved in your construction project management process?	Yes, Reason codes????
		No
		Information already provided.
		.
		Architect, designer, PIA, open orders most, bid work for \$8000+, all paper work is performed by PIA.
		Yes, priliminary planning after programing is developed for occupany,several org consulted.
		Procure projects, montior budget, prepare contracts for signature.
		Info provided earlier.
		Info provided earlier.
Q6	Has your office conducted any analysis or review of its construction project management processes? Can you describe this analysis process? Were recommendations made and implemented? Will you describe this process and its findings? Is it a report available for review?	Discipline coordination. Non-compliance to university construction standards. Missing code compliance issues. Field conditions. Level of scope of execution by contractor. Industry understanding on projects.
		Scope changes, Field conditions, document errors. Varies with jobs and parties. Usually projects for big owners have scope changes. For bonded projects usually we have field changes and errors. Scope changes depend on end users involvement in programming and architects. More time required on planning and mock un construction would bring in end user input.
		No.
		No.
		Informally.
		Nothing formal main stream system
		No formal, the construcion process is reexamined on ongoing bases, YES.
		Yes, informal studies, having PO issued in direct pay vouchers.
		No. informally.
		Informal, discuss to find easiest ways consistent evaluation. Yes, FAMIS.

Feed back from MSU administrators		
Q	Question	Response
Q7	Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders or performances of the parties involved? Describe. Are findings or a report available for our review?	No answer.
		a = 2.5% d = 7%.
		No.
		No formal.
		Yes. Project closeout debriefing, physiscal plant with client. No.
		Nothing formal.
		Yes on projects that exceptionally good and bad. NO
		Yes, less things learnt. Final budget report excess funds to appropriate parties.
		No.
		Yes, informally. YES.
Q8	If an analysis has been conducted, can you describe, in general terms, its findings?	No.
		Define the change order process, define change orders.
		N/A
		N/A
		No.
		N/A
		Solicited ideas about what factors went well contractors thrown on a project they don't have the experience, poor design docs, incomplete and inattention by A/E.
		See above.
		No.
		Charges posted to the wrong accounts, things shouldn't be there, errors.
Q9	To what extent does your office monitor change orders within your department or process? Are project records aggregated for the purposes of determining average change order rates? Are these change order rate statistics or analysis available for our review?	No answer.
		Some may see it as acceptable, some don't.
		Don't.
		What they are and how much they are. No . N/A
		For every item. No. No.
		review/discucss questions wihin dept. No.
		For budget impact, type scope, design, etc., YES, not this dept, NA.
		Start with attending progress meetings, bulletins and CCDs are logged in excel and famis. Reason codes track time. YES.
		A lot manged directly. NO. NA
		Fully total against ledger, total against contractor >NO.

Feed back from MSU administrators		
Q	Question	Response
Q10	Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented? Is a copy of the report available?	CII don't know what the rate is actually.
		No.
		Response given. Discussed with firms.
		Yes. Done by consultants reason codes. Skewed based on source (who assigns the codes) no.
		No.
		Yes
		No.
		Scope changes by client, unforeseen conditions, consultants poor design.
		?
Q11	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	Design engineers—very informally (known for missing contract items.). University project managers—informally.
		End of project review of Subcontractors not specific to CO.
		Informally assess SC for CO and work ethics
		Yes, reason codes
		Yes.
		Yes.
		No.
		Yes.
		Yes.
		No.
Q12	Have you drawn any conclusions with respect to the dominant causes of change orders? What are the dominant causes?	Information already provided.
		No answer. No
		Put Cos are quick in negotiations due to less heirarchy in approval (Iweek processing + 30 days payment). They can contribute to extended genereal conditions. The 1st CO may not have a major effect but the 5th will have a cummulative effect.
		Impacts include, financial burden on SC, relationships breakdown, detrimental to administration. Owners have to understand that SC payment is important. If delay in payment is anticipated they include it in their cost. If they trust the process time they will quote realistically.
		Unforeseen conditions, errors and omissions, scope
		Document errors.
		Field conditions, documents.
		Field conditions
		Depends on proj, customer change scope, renovations, hidden conditions, new designe error.
		All play a role
		Scope chagnes, consultant design.
		Scope, field conditions.

Feed back from MSU administrators		
Q	Question	Response
Q13	If you can, either from statistical data, or from your experience indicate the usual change order rate percentages of original project budget for the of the following project types?	Experience/Rule of thumb. 10-15%
		Reasonable but should be quoted upfront.
		3-4%, 3-7%,3-20%,3-12%,10,12.
		2-3, 3-4, 2-3, 3-4, N/A, N/A.
		5, 5010, 10, 10+, 10 or less, 10+
		No,no,10,no,no,no.
		4-5,4-5,7-8,7-8,10 and 8.
		4-5,6,7-8,10,3,5-6.
		No, no, 10-15,no,no,no
		n/a.
Q14	Has any analysis been conducted which helps you to predict change order rates for projects? What are your change order rates?	No
		No. Although there is a question on budgeted cost and actual cost, which is not enough to draw conclusions and hence is inappropriate.
		No.
		No. consultants are informally asked their experience with change
		No.
		historical data,perform lots of same type of buildings
		No.
		Yes,historical data, 7%
		Nothing formal.
		No, 5-6% small projects.
Q15	Is that rate of change orders seen as acceptable? Explain.	No.
		No. Probably more since it institutes a more rigid process. Cannot afford to have relationship based decisions.
		N/A.
		N/A
		N/A
		Yes.
		N/A
		No could be lower, trying to avoid scope changes.
		N/A
		yes.

Feed back from MSU administrators		
Q	Question	Response
Q16	Are performance records of project parties monitored or tracked formally or informally with respect to change orders? If yes, can you describe how they are monitored for the following groups of project participants?	No. N/A.
		Pvt owners dont ask for questions regarding change order history as they expect change orders. When there is a lumpsum fee there is no need for change orders by construction management services.
		Informally, mentally.
		No.
		Informally for all listed.
		No,no,no - only negative performance,no neg per, no neg per, NA
		Informal
		No, informally
		No.
		No.
Q17	Please outline the process of receiving, reviewing and approving change orders within your organization.	No answer
		Design build- least only scope changes but owners have less control on design. CM more than DB less than CM. Plan review is better, owners control is more. In GC most number of Cos.
		Plans and specs are black and white.
		Chart.
		Already provided.
		Given eralier.
		bulletin, quote, review, pay or reject
		na.
		Info already provided.
		Items discovery, discussion, issue change orders or reject or
Q18	What are the typical durations for processing change orders? Do these durations contribute to additional costs such as for extended generally condions, ripple effects or impact change orders?	No, experience tells you what the spread
		GC scrutinise scope incredibly. CM more scrutiny on change order process. SC locate potential CO but will not inform GC & will show on bids. Variation is a red flag- need to keep it in mind but is not necessarily a good predictor.
		2 months, yes sometimes.
		2 months, yes.
		2-3 months. Yes.
		2days, no
		3-4 months, usually not, primarily contractor is authorized to proceed via CCD.
		Two weeks is what we try, 80% of them, No, not directly. Rarely pay extended general conditions.
		2days.
		1-2 weeks or as long as one month, NO.

Feed back from MSU administrators		
Q	Question	Response
Q19	How are project contingencies established for projects? What are typical rates?	
		Based on MP's of project, approved budget allowance, 8-15%.
		Designated by borad of trustess to have 10%, may increase if unknown conditions exist.
		By designer, new 5%, renovation 10%.
		10% based on historical data.
		sometimes, nature of the project, new = lowest 5-7, renovation medium 8-12, underground high 10-15%.
		Proj manger recommends a number.
		10% or less, historical data.
Q20	What happens to unspent project contingencies as the project progresses? Are they generally available for use with the later project phases to allow for changes in scope?	Info already provided.
		Comments from management often submitted to A/E. A/E responds in writing to each issue.
		Its getting increasingly worse. QC is poor. MSU does a good job on choosing A/E.
		Sits there. Depends on funding sources.
		Don't know. Not generally.
		Sits there. Yes.
		Sits there, possible.
		Remain in construction account until project complets, YES.
		Sits there. Depends on from where funding comes from. 30+ sources.
Q21	Who determines the testing program for elements such as soils testing, environmental conditions, or hazardous materials? How are they determined? Have testing programs generally been adequate or is this an area of concern or cause of change orders?	Sits in account, yes.
		Info already provided
		Not all. Schematic review. Design and development review. 30%, 60% and 90% review.
		MSU better than most owners. Its good.
		EAS, stds, adequate.
		A/E. based on soil borings. Ok.
		A/E in consultation with Univ construction supervisor. Past experience. Empirical inormation. Inadequate for complicated underground work.
		Go through phys plant, go through phys plant, great.
		Architect, code requirement, adequate usually included in contract for controlling, contract doesn't chance on testing.
		Designer.
		Phys plant, adequate.
		?

Feed back from MSU administrators		
Q	Question	Response
Q22	How are design professionals hired for projects? When selecting or considering design professionals are their performance records for errors, omissions, and change orders considered? If they are considered when hiring, how is this information solicited?	Yes. No answer.
		Not analysed with change order. They have been effective in customer satisfaction. Commissioning finds out flaws & more money is spent on change order & fixing goes over the years and is paid later. Tetsing brings out more Cos but its not bad.
		A quality based selection process. Yes. Ask about claims outstanding, change orders rate done during the interview.
		Based on fee. Below 50,000 dollars. Selection based on experience and availability. Above 50,000 there is a specified formal slection process advertised in Michigan contract and builder. Experience based on building type. 6 % present, reduced to 6-4% and they are interviewd. informally.
		Qualification based selection. Yes. Throught he request for proposal and past experiences.
		Yes at phys plant, informally.
		QBS, YES, determine based on contact with previous clients.
		n/a
		Information already provided.
		?
Q23	When awarding construction contracts, are change order histories or general contractors considered in determining if they are "qualified" for the work? How is this information solicited?	No answer.
		Good at negotiating CO. OK-but may not reduce CO. SC and owners benefit from it.
		No.
		No.
		No.
		No.
		No.
		No.
		Yes, opinions from previous projects.
		?
Q24	In your opinion, do construction, design or construction management firms which participate in ISO programs usually have reduced change order rates on projects undertaken for your university when compared to non ISO firms?	Yes. Yes. A published time for pre-bid walkthru is established.
		Obligatory attendance.
		Yes. Yes.
		N/A.
		No.
		No.
		No.
		No.
		No.
		More.
		No.

Feed back from MSU administrators		
Q	Question	Response
Q25	When awarding construction contracts or trade contracts, are change order histories of specific subcontractors or trade contractors considered in determining if they are "qualified" for the work? How is this information solicited?	No answer.
		15,16, 2, 9.
		No.
		No.
		No.
		Informally.
		No, cm be considered.
		No.
		Yes, opinions from previous projects.
Q26	How are construction managers hired for projects? When selecting or considering construction professionals are their performance records for errors, omissions and change orders considered?	?
		No answer.
		M, E, P. lack of coordination between these three parties and with A/E. They are not involved in design process early on.
		Unforeseen consitions.
		Quality based selection process.No. Advertising, Solicit proposals, shortlist.
		Same as A/E process. No informally.
		Qualification based selection.No.
		quality based selection process. Informally.
		QBS, based on info from past clients.
Q27	Has your organization used design build firms for projects? If so, describe frequency and project types.	No.
		n/a.
		?
		Yes. Very inefficient depends on nature of project.
		Yes. Rarely, for simple structures DB will be used.
		Yes. Once, specialised construction, where there is limited designers and contractors with that expertise.
		Once.
		Yes. One.
		No.
Q28	Rarely, pole barns, specialized medical facilities.	Rarely, pole barns, specialized medical facilities.
		Yes, pharmaceutical, polebarns.
		Once, bad experince.
		?

Feed back from MSU administrators		
Q	Question	Response
Q28	Have you been generally satisfied with projects delivered through the design build project delivery method? Explain.	Yes and No. as long as we can maintain control. There are problems with sharing control.
		Clearly defined decision network. CM allowances. 100% free discretion of owners. Should be used to handle changes.
		No. Very little control over the process. They pay for change orders they didn't believe were warranted.
		No. No selection process told who to use. There is a tough time buying into MSU construction standards.
		n/a
		No, owner had less day to day control of project, bad for knowledgeable owners.
		No, GMP, disputes in scope.
		No, DB team is thrown together.
		Hard to control.
Q29	Do you have any opinion or analysis on whether the project delivery method, such as design build, construction management, or general contracting influences change order rates? Explain.	
		Define process.
		Yes. More change orders with GC. They throw the bids together and it is more adversarial by design.
		Process doesn't influence much as the team.
		No.
		No.
		design build the nature pay for CO in advance, hidden contingencies built in. Neither reduce owners cost.
		Can't guarantee CM will come less than GC. Far less likely to bust the budget.
		All can have CO problems, has more to do with design time spent preconstruction.
		No, not much difference.
Q30	Do you have any opinion on whether the spread (variation) of bids received influences change order rates? Are they a good predictor of change orders on a project?	No. Experience tells you what the spread is. Project specific.
		Needs updating but they are fairly ok. Reduces CO, less guessing by A/E, contractors and owners.
		No. No.
		Yes, can be.
		Yes. No.
		Yes, yes.
		Yes, it's an indication of document quality.
		Not really.
		No, no.

Feed back from MSU administrators		
Q	Question	Response
Q31	Is the contractor's overhead and profit mark up typically contractually specified? What are the standard specified rates? If not, how is overhead and mark up incorporated into the contractor's change order pricing?	Yes. 15 and 5. 15% on self performed work. 5% on subcontracted.
		Dictated by contract. Causes disputes sometimes.
		Yes. 15 and 5.
		Yes. 15 and 5.
		Yes. 15 and 5.
		Yes, 5% on subs, 20% materials.
		Yes, 15, 5.
		n/a.
		Yes, 5% subs, 20% materials.
		Info already provided.
Q32	Has overhead and profit mark up been a source of dispute on projects? Explain.	Occasionally, some contractors think it should be higher. productivity losses common. Affects sequencing. General conditions always.
		Yes. Contractors feel it is inadequate.
		Yes. Contractors don't read the contract.
		Yes. Contractors feel it is inadequate to cover costs.
		No.
		Yes, not adequate of co for work to be done out of sequence.
		No.
		Not generally, contractually no when going into a project.
		?
Q33	How are extended general conditions items or reduced productivity claims incorporated into change order pricing? Has this been a source of dispute on projects? Explain.	
		Natural distrust. Reduce negotiation time by having upfront costs.
		Negotiated a s separate change oafter the fact. Yes, difficult for a contractor to prove his case, sets the stage for conflict.
		Try not ot do/ negotiate. Varies by project.
		Can the contractors justify time? Yes justifying the true impact of scope or work.
		No.
		Reluctant to add time for CO/issue which ignored. Yes, bemore deligent about time impact.
		Make contractor show there is a problem. YES, but few.
		Historical relationships.
		n/a
		?

Feed back from MSU administrators		
Q	Question	Response
Q34	How are building programs (needs brief) established and documented? Are misunderstandings about program occasionally or commonly a cause of scope changes by the end user department? Describe.	Description at conceptual stage, how much dialogue exchange between parties. Meeting minutes, problems statements, memos, reports, emails. Personnel turnover, how instigated. GCs track change orders, PRs have to push. Too many layers of approvals. MSU must plan for change orders. Sometimes takes about 6 months to process change orders. Established by department and documented in word form their needs. Yes. Not a total understanding of what the needs are. A document is written. No, unless you have personnel changes. A/E and end user. Occasionally A/E didn't explain or capture the intent. meetings, memos, email. YES, expectation is the architects know what to do. Done by facility planning and space mgmt process. NO. Contractually adding to project completion date for each persons piece as designated amount of time. Limit the number of bulletin items on a bulletin and should have the change orders processed in a certain amount of time. Consultants should know. YES, people clients don't know exactly what they want. ?
Q35	Are construction documents formally reviewed by your organization in detail prior to bidding? Describe this process.	Not all. Schematic review. Design and development review. 30%, 60% and 90% review. Comments for maintenance are submitted to A/E, who respond to each issue. See other interview responses, and not always done. Yes. Each discipline goes through the documents for completeness. Information was provided earlier. Done at the 50 -90 %. No longer at 30, 60, 90 % design completion stages. Distributed to staff positions, (M,E,S) also to shops, telecom, fire marshal, custodial, client. Its done in a meeting with all parties. Yes. A/E walkthru to the university and then break up into disciplines. Yes, PIA and architect review and comment. Yes, reviewed by A/e and maintenance shop supervisor. Large projects and independent review firm. expected time we offer them equals quality. big projects self performed. ?

Feed back from MSU administrators		
Q	Question	Response
Q36	Does your organization have published construction standards or specification which establish requirements for design and specification of projects by designers? Is failure to follow these standards by designers a frequent source of change orders? Explain.	Yes. Yes most projects have atleast one.
		Decentralize control on CO. too many levels of authority and approvals.
		Yes . Occasionally.
		Yes. No. Occasionally.
		Yes. No.
		Phys plant, can be.
		Yes, yes they deviate from our const standards.
		No.
		Phys plant, yes, contractors think their work superior to
		?
Q37	Do you believe there is a difference in change order rates designed within your organization when compared to when you use outside design firms? Explain.	Yes. Higher when used outside, because of filure to use standards. Not familiar with our buidlings, they don't spend enough time assessing historical data.
		Yes. Much lower when designed in house.
		Yes. We review our stds and recurring desing firms, familiar are better.
		Yes. Interior designer, single designer, no miscommunication between buildings.
		Same.
		Inhouse lower, no const standards.
		No.
		Yes, experince take time to ask questions to design and solve problems.
Q38	Has your organization utilized commissioning services? Have these been effective in reducing change order rates?	Yes, outside larger projects, more things easily missed.
		Yes. Don't know.
		Yes. No. Problems are flushed out in designs thatare incorrect and don't work as intended.
		Yes. No. Adds due to problems that are identified duryring start up phase.
		Yes. No comment.
		Yes. Yes.
		No.
		Yes, yes
		Yes, reduces them if agent use them in design
		No.
		No.

APPENDIX F

Types of Changes

Types of changes

What is a Change order?

“A change order is a written agreement to modify, add to, or change work that is defined by contract documents. There may be different reasons to have change orders in a project. Some of them are: Owner initiated changes; errors or omissions in the drawings, misinterpretation of the contract language or specifications; noncompliance of specifications or drawings by the contractors or subcontractors, substitution of materials, price changes, and schedule variations, changes in order of work or methods of construction. Although change order and addenda are close when it comes to the function they perform, they differ by the time they occur in a project life cycle. (Refer Fig 1) Although change orders may have their root causes to a time before signing of agreement, changes by change orders occur only after signing of contract, (as shown in Fig. 1) unless there are other provisions in a contract. Usually a price change accompanies change orders.” (Fisk, E. 1997)

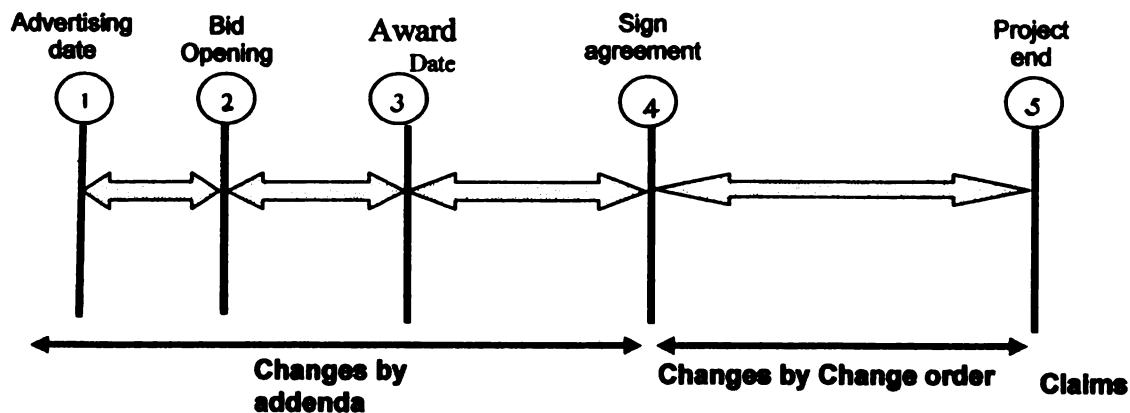


Fig. 1. Addenda and Change order. (Modified. Edward R. Fisk 1997)

Explanation of terms:**Differing site conditions**

This term is usually seen in federal contracts. It is also referred to as 'changed conditions' or 'unforeseen conditions'. These are changes that arise when during progress of work subsurface conditions differing materially or of unknown nature are encountered. Sometimes differing site conditions (actual conditions differ from contract represented conditions) and unforeseen conditions (unusual situation not reasonable anticipated) are categorized separately. Although a differing site condition typically occurs below surface grade, there exist certain contract instances whereby such a circumstance may be encountered above site surface. *W.H. Armstrong v. United States*, 302 So. 2d 1009 -1978 (Jensen, D. 2001). It is fair on the part of the owner to share risks of unforeseen site conditions.

Acceleration of work

"Acceleration may be owner initiated (directed acceleration) or when a contractor attempts to take extra measures to make up for delays, by using extra resources to accomplish the objective (constructive acceleration)." (Dept of Neighborhood development. Housing policy. City of Boston)¹

Weather conditions

"Changes that occur due to weather conditions qualify for claims only if the weather conditions are abnormal or unforeseen. Irrespective of severity or destructive nature of weather, if it could be anticipated by the contractor or is not unusual for the season, the

¹ from website of Dept of Neighborhood development. Housing policy. City of Boston. See housing development – housing policies – Change orders http://www.ci.boston.ma.us/dnd/D_2-2_change_order_and_contingency.asp * note links may not remain active always*

contractor is not entitled to claim for excusable delay or extension of time. It is therefore essential for the owner/ architect/ engineer to maintain weather records for any delays caused by weather. AIA A201 Article 4.3.7.2 requires documentation of unusual weather by data that "weather conditions were abnormal for the period of time, could not have been reasonably anticipated and had an adverse effect on the scheduled construction." (Dept of Neighborhood development. Housing policy. City of Boston)²

Non Design-related Change order:

"These Change orders include unforeseen conditions, code-related issues, and building inspector changes." (Dept of Neighborhood development. Housing policy. City of Boston)²

Design-related Change order:

"These Change orders include unforeseen conditions that affect the appearance, layout, functionality, dimensions, and/or quality of the project." (Dept of Neighborhood development. Housing policy. City of Boston)²

Emergency Field Condition Change orders:

"These Change orders include any condition that causes an emergency situation where safety or other immediate losses may occur." (Dept of Neighborhood development. Housing policy. City of Boston)²

Scope changes:

"These include changes in the scope of contract that may occur due to the owners need or due to misinterpretation of contract documents by any of the parties in contract. This type

² from website of Dept of Neighborhood development. Housing policy. City of Boston. See housing development – housing policies – Change orders http://www.ci.boston.ma.us/dnd/D_2-2_change_order_and_contingency.asp * note links may not remain active always*

of change can be additive or deductive in nature. Additive may not necessarily be beneficial to the contractor and deductive may not necessarily be harmful.” (Dept of Neighborhood development. Housing policy. City of Boston)³

Donation/Contribution Change orders:

“These Change orders include changes resulting from the donation of materials or labor. Some contracts recognize donations and contributions and require them to be processed as a Change order. Any savings realized could be added to the hard cost contingency.” (Dept of Neighborhood development. Housing policy. City of Boston)⁴

Value Engineering and Betterment Change orders:

“These Change orders include those upgrades in equipment and materials deleted for budget reasons during final construction contract negotiations.” (Dept of Neighborhood development. Housing policy. City of Boston)⁵

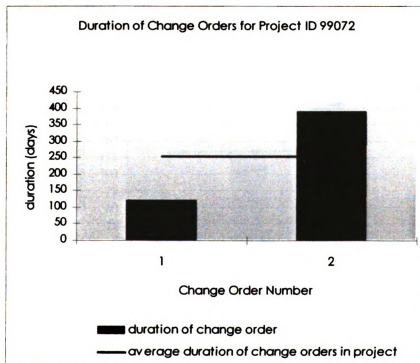
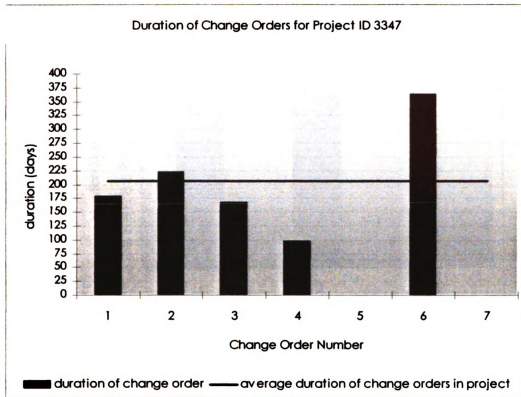
³ and ⁴ from website of Dept of Neighborhood development. Housing policy. City of Boston. See housing development – housing policies – Change orders http://www.ci.boston.ma.us/dnd/D_2-2_change_order_and_contingency.asp * note links may not remain active always*

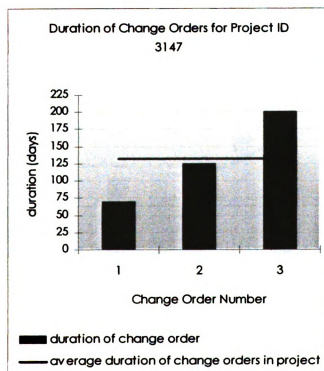
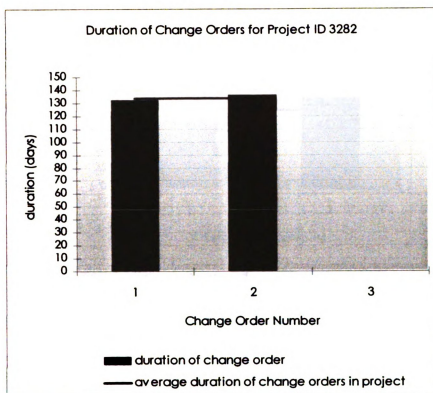
⁴ and ⁴ from website of Dept of Neighborhood development. Housing policy. City of Boston. See housing development – housing policies – Change orders http://www.ci.boston.ma.us/dnd/D_2-2_change_order_and_contingency.asp * note links may not remain active always*

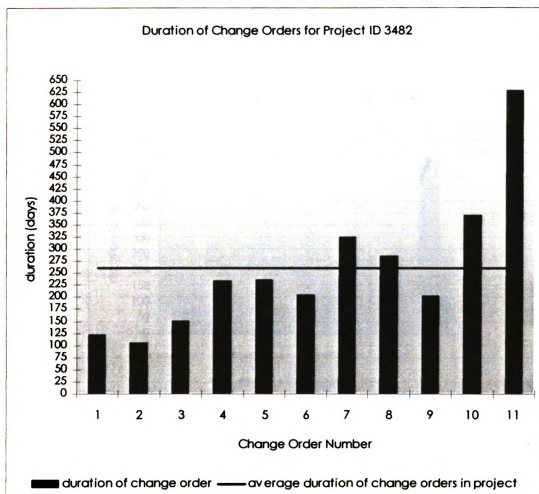
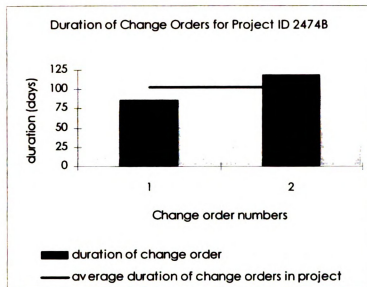
APPENDIX G

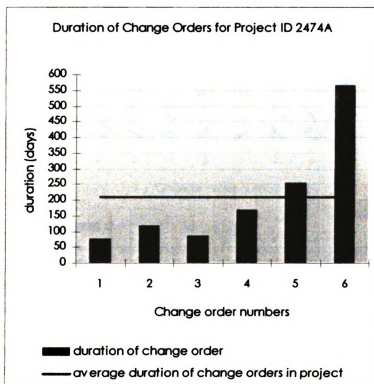
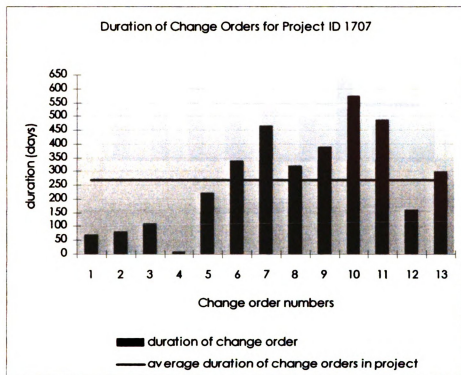
Sub-process charts

Total time taken to process change orders D1

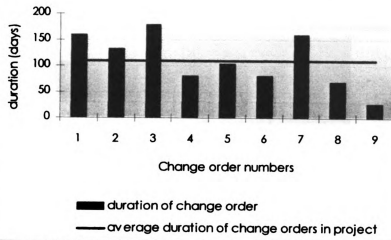




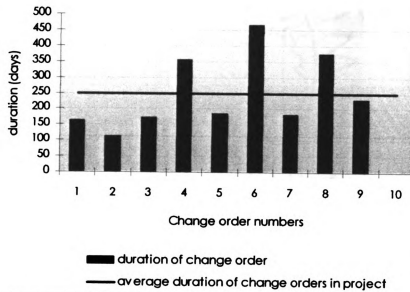




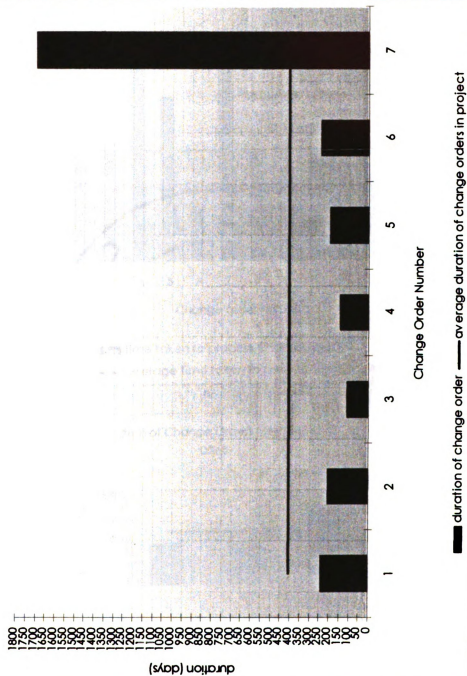
Duration of Change Orders for Project ID 021408

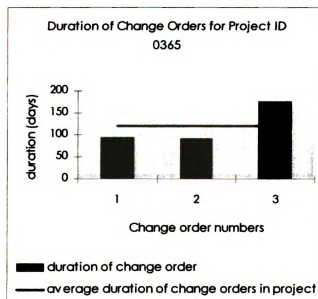
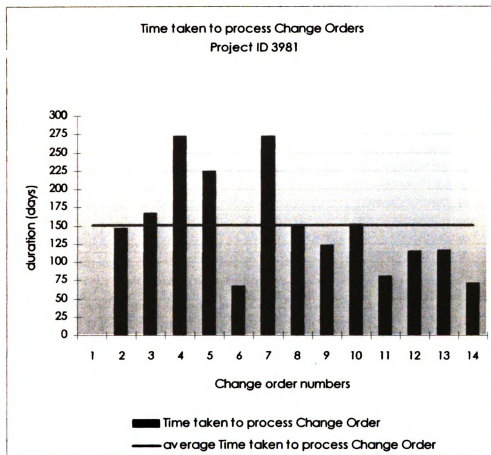


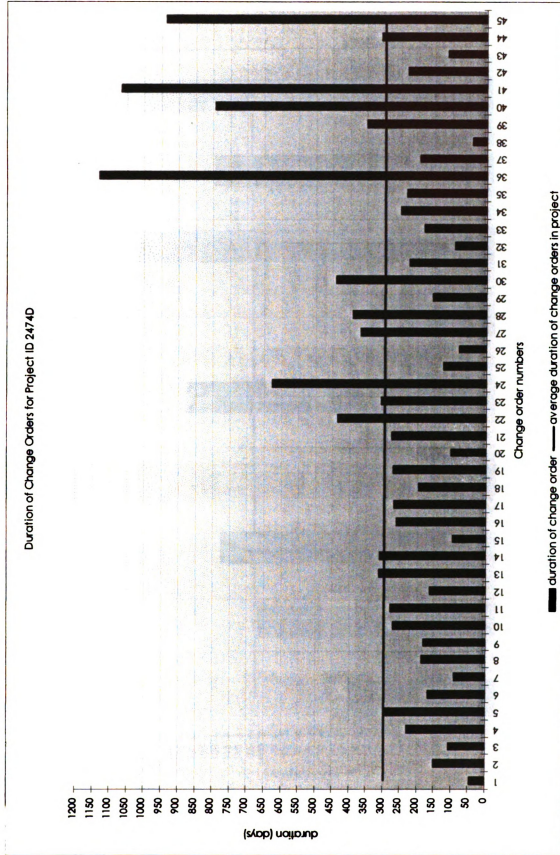
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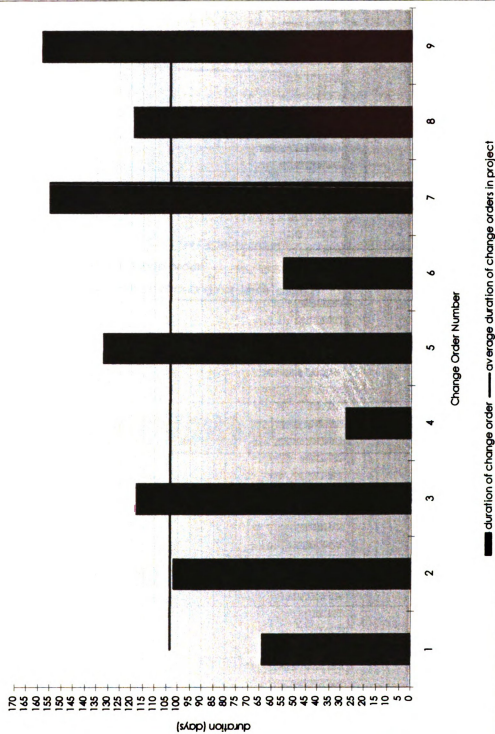
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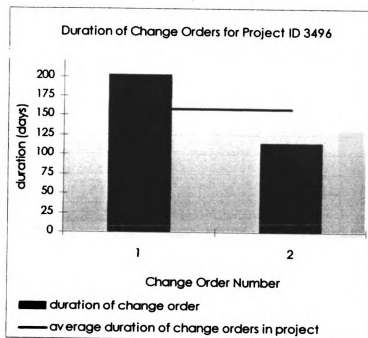




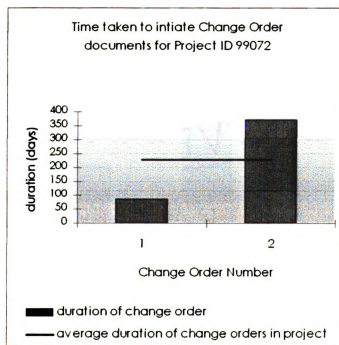
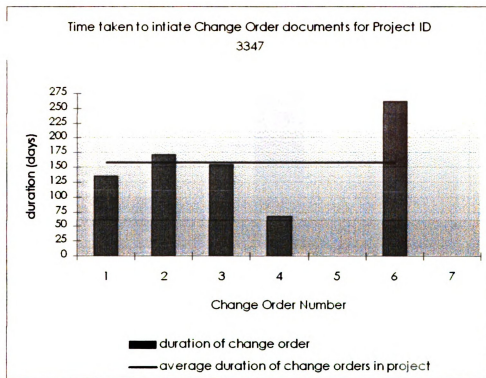


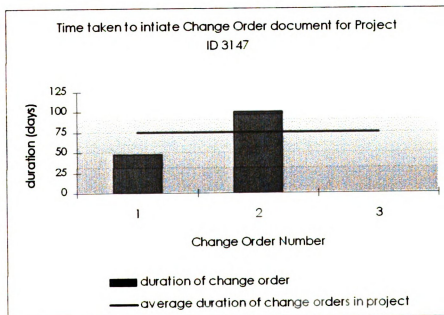
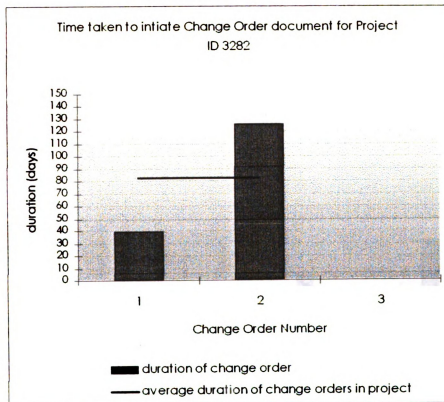
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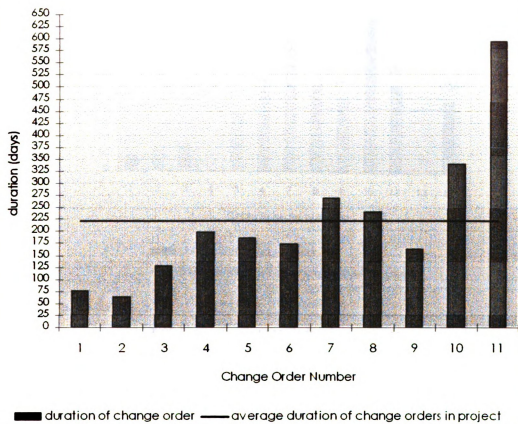


Initiation sub-process

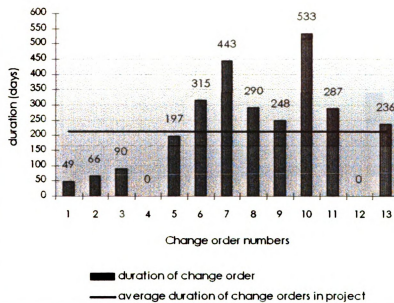




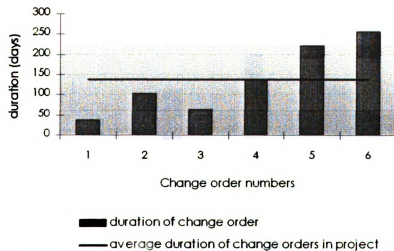
Time taken to initiate Change Order document for Project ID 3482



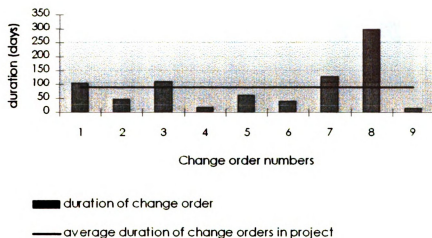
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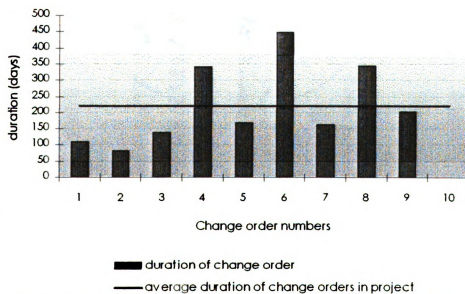
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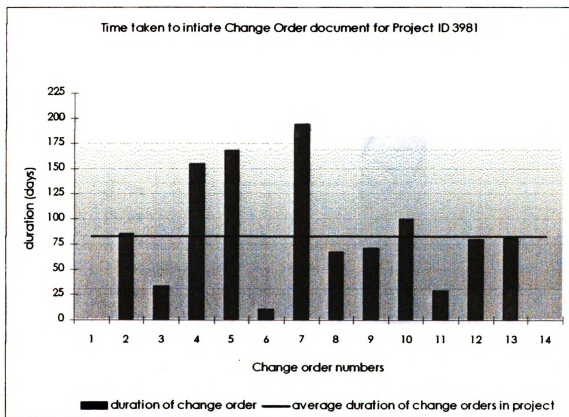
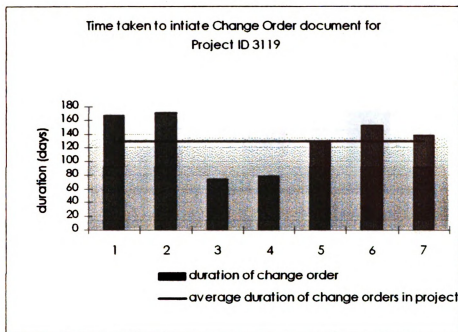


Time taken to initiate Change Order document
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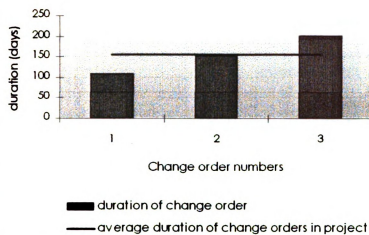


Time taken to initiate Change Order document for Project ID 0584

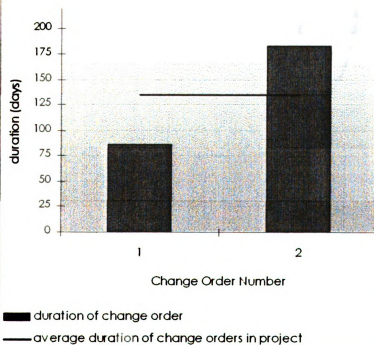




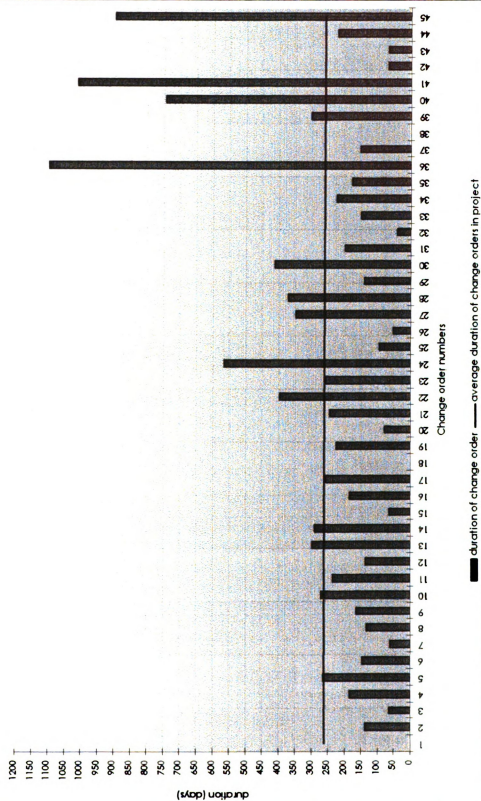
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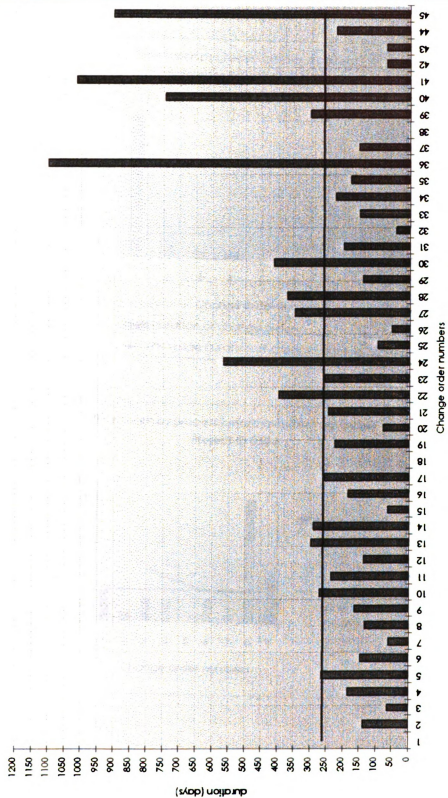
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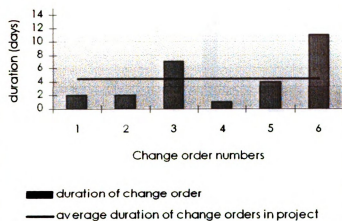
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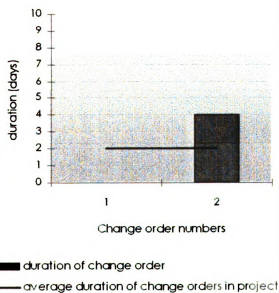
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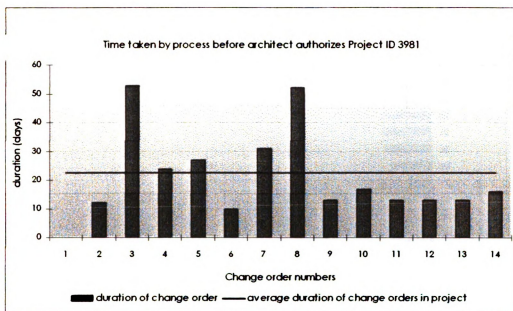


Time taken by process before architect
authorizes Project ID 2474A

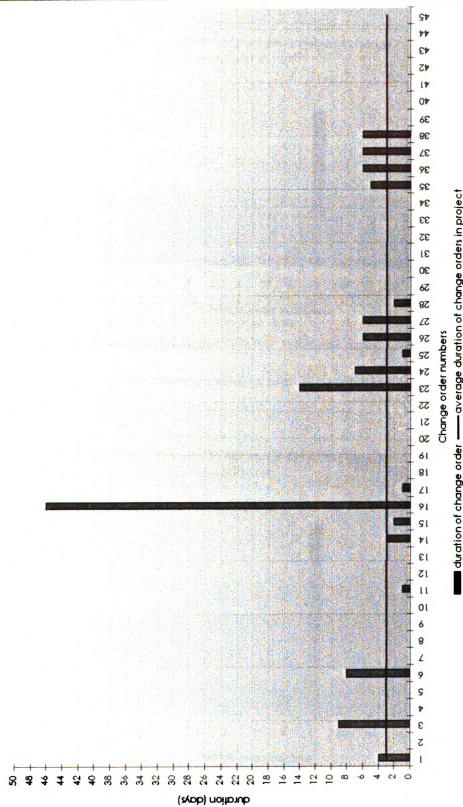


Time taken by process before architect
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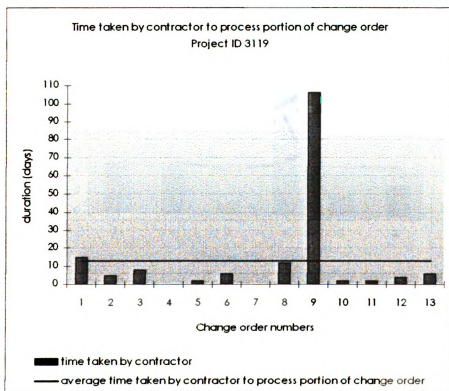
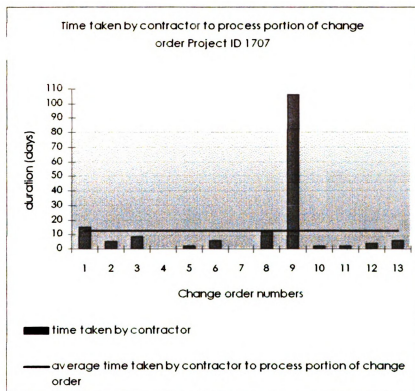




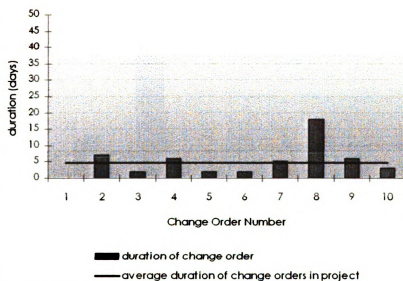
Time taken by process before architect authorizes Project ID 2474D



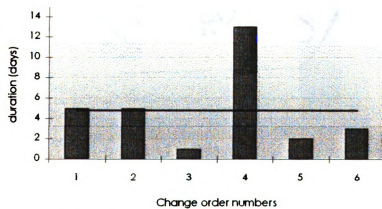
Contractor sub-process

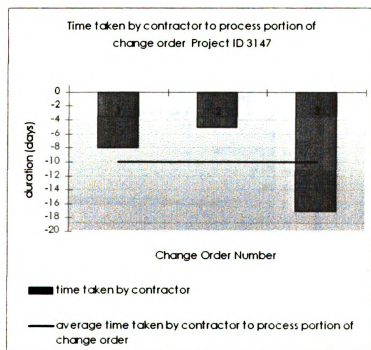
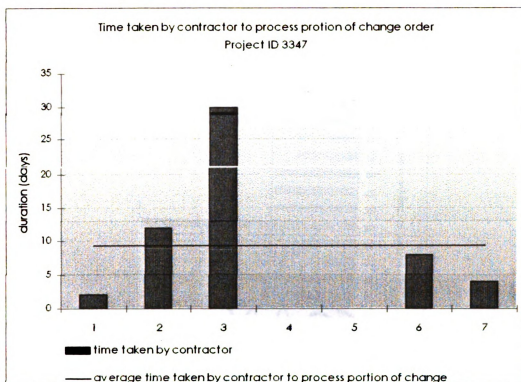


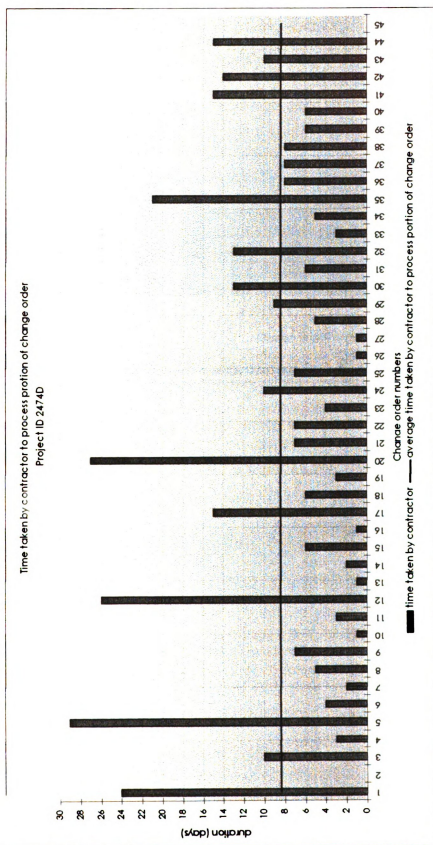
Time taken by contractor to process portion of change order
Project ID 3482

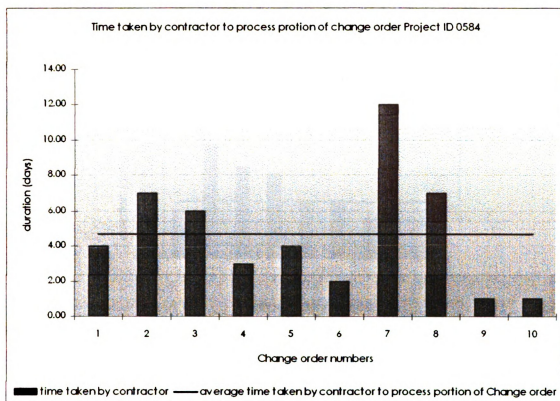


Time taken by contractor to process portion of change order
Project ID 2474A

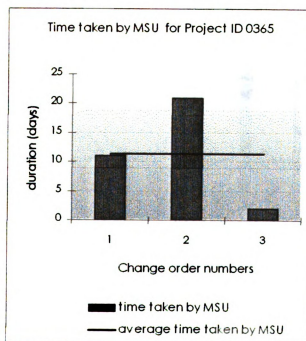
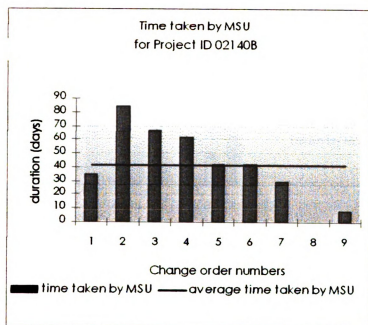




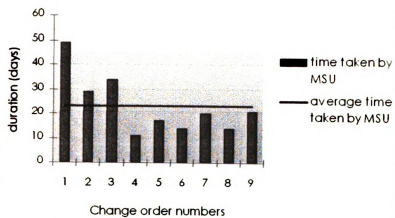




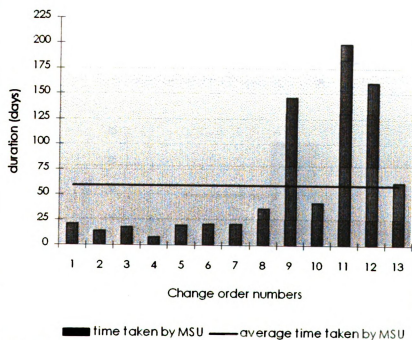
Appendix: MSU sub process bar charts



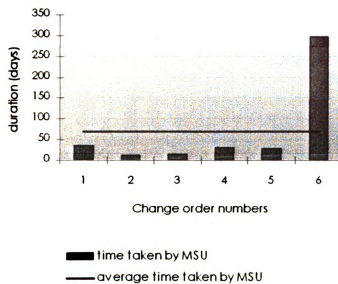
Time taken by MSU for Project ID 0584



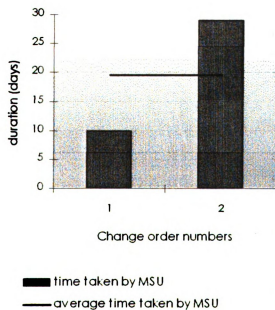
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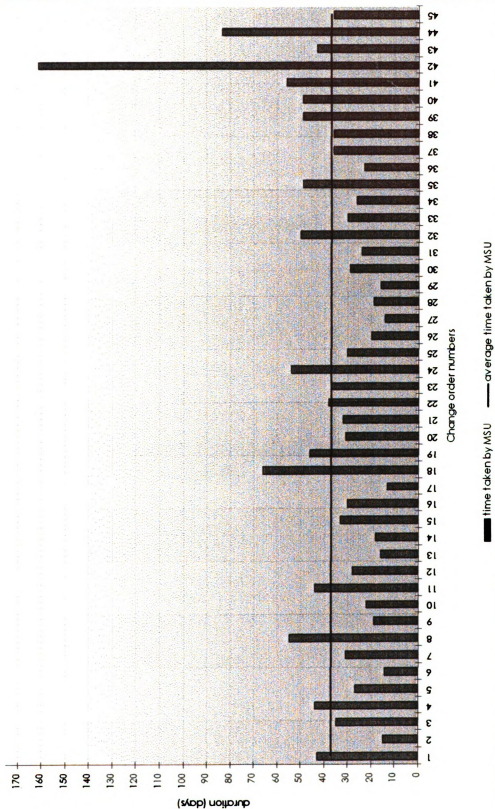
Time taken by MSU for Project ID 2474A



Time taken by MSU for Project ID 2474B



Time taken by MSU for Project ID 2474D



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