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Construction scheduling for urban freeway renewal projects:

A case study

by

Dong Chen

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Civil Engineering (Construction Engineering and Management)

Program of Study Committee: Charles T. Jahren, Major Professor Russell C. Walters Mervyn G. Marasinghe

Iowa State University

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Graduate College Iowa State University

This is to certify that the master's thesis of

Dong Chen

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy

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ABSTRACT

Keep the project on schedule is one of the most widely understood goals in the construction industry. How does one accomplish this completely subjective statement in a complex urban freeway renewal project like the I-235 Reconstruction? A fully integrated computer-based Program Master schedule should not only be developed, but also should be updated, customized, and implemented on a regular basis. Updating the schedule keeps the schedule with the latest project status; customizing the schedule satisfies clients' different levels of demands; implementing the schedule makes users of it. These three sequential steps help to make management decisions and thus end up helping a project keep on schedule. The objective of this thesis is to detail key elements involved in updating, customizing, and implementing an urban freeway renewal project schedule.

CHAPTER 1: INTRODUCTION / JUSTIFICATION

1.1 Background

The reconstruction of Interstate 235 (I-235) is a budgeted \$426 million project managed by the Iowa Department of Transportation (Iowa DOT). As one of the most expensive road projects in the Iowa DOT's history, it began in 2002 and is scheduled to be completed in 2006. The I-235 project is located and adjacent to Des Moines, Iowa and has been divided into ten sections for organizational purposes. The first four sections, Sections 1-4, are located west of downtown Des Moines, and will be widened from the current configuration, essentially a four-lane roadway, to a six-lane configuration. The entire sixlanes will then be resurfaced with hot-mix asphalt. The last three sections, Sections 8-10, located north of downtown Des Moines, will be upgraded in precisely the same manner. The middle three sections, Sections 5-7, located in downtown Des Moines, will be totally reconstructed and paved with Portland cement concrete. 71 bridges and 21 interchanges on this 14-mile corridor need to be rebuilt. The reconstruction of I-235 is a comprehensive multifaceted project with multiple contractors, multiple jobs, and cost-valued tasks.

The general construction timeline for the reconstruction is as follows:

- 2002 ~ 2004: Utility Relocation, Bridge Widening and Replacements, Median Paving, Temporary Paving, Interchange Reconstruction.
- 2005 ~ 2006: Mainline Paving.

Starting in August 1999, Iowa State University researchers began working with the Iowa DOT to develop better methods to schedule highway renewal projects and using I-235 as a case study site. Considerable effort has been invested in developing a computer-based conceptual schedule, calculating production rates, and loading resources. This researcher will present the procedures and key elements involved in updating, customizing, and implementing the I-235 schedule in this paper.

1.2 Problem Statement

Due to the complexity of the I-235 reconstruction project, this researcher created a schedule with the appropriate amount of details so that it could serve the purposes of all parties who need corridor level information.

For the schedule to provide the appropriate amount of information needed to fulfill the expectations of all parties, several questions must be addressed:

- What information can be obtained from the schedule? How is the layout of a schedule organized?
- What type of reporting will be required?
- Who will use the schedule, and what training do they have or need? If clients are unfamiliar with the layout of a schedule, must they be trained how to read and interpret it before it goes into effect?
- Will additional information or interfaces be needed?

1.3 Objectives

In order to answer these questions, this researcher developed a system to determine and satisfy the levels of detail needed for each client. This thesis will focus on this system, which includes:

- Update of the schedule
 - o Procedures of updating
 - Schedule layout and special considerations for this layout
- Customization of the schedule
 - o Development of the Outline Code System
 - o Customization of the schedule
- Implementation of the schedule
 - Publishing of the schedule
 - Client trainings

1.4 Thesis Organization

Chapter One introduces and discusses the objectives of this thesis; Chapter Two summarizes the Literature Review; Chapter Three expatiates procedures of updating, customizing, and implementing the schedule, and Chapter Four presents the research conclusions and recommendations for future scheduling work on the urban highway renewal projects.

CHAPTER 2: LITERATURE REVIEW 2.1 Definition

A dictionary definition [1] of a schedule for one single task is a plan for performing work or achieving an objective for the assigned task, specifying the order and allotted time for each part. For multiple tasks, schedules can also be used to identify conflicts, such as when an entire working space (for example, an exit ramp) is required for separate groups of equipment of more than one task (for example, utility relocation and grading) at the same time.

Managing a project without a schedule reduces the likelihood of accomplishing project goals, such as staying within budget or on schedule. If it is difficult to track who is doing what, or when tasks should be finished, chances of meeting those goals will be jeopardized. And if something goes wrong — a deadline is missed or a task takes longer than it should— needless difficulties may be encountered in determining the problem's source, as well as its impact on the schedule.

Good project scheduling helps projects succeed.

2.2 Types of Schedule

Since this thesis will focus on the update, customization, and implementation of a schedule for a highway renewal project, the questions that naturally arise are, "How many types of schedule are available?" and "Which type of schedule is suitable for specific clients?"

Mike Weiss concluded that there are five common types of schedules [2]:

- **Calendar** Calendar is the most basic schedule. It usually is kept in a central location and has little client. It also does not allow updating. The schedule is simply redone to take changes into account.
- Schedule board A dry-erase board or chalkboard is suitable for a smaller custom builder or multipurpose contractor. Frequent changes to assignments are likely, so a dry-erase board or chalkboard would be the minimum requirement. This application usually is used at the mobilization point for workers rather than posted on site.
- Spreadsheet A spreadsheet is likely the minimum acceptable format if a schedule needs to be posted on site to keep the owner and other participants advised of coming events. In this case, the schedule is to be used more as information than as a management tool. Updates can be made manually if progress is noted on the schedule.
- **Basic Gantt chart** If the primary objective is the duration of the project and its tracking, a more basic computer-type scheduling program should satisfy this need. A basic Gantt chart will meet the criterion. This schedule will deal with dependency relationships and lead and lag times. This is an on-site schedule to be used by all involved personnel.
- Integrated computer-based schedule In the case of comprehensive scheduling with wide management information output, only a fully integrated computer-based schedule is suitable. This schedule
 - Can create a full level of details with maximum reporting capacity.

- Can be used by several facets of the organization for decision input and implementation.
- Can help avoid resource conflicts when multiple resources and jobs may be present.

In Noel Harroff's article [3], two categories of schedules are defined: Program/Project Level and Detailed Schedules.

- Program/Project Level Schedules are either Program Master Schedules or Work Breakdown Structure (WBS) Intermediate Schedules.
- 2. Detailed Schedules are either Task Plan* Schedules or Work Package** Schedules.
 - a) Task Plan Schedules
 - 1) Have milestones applicable to responsible organizations.
 - Are developed by the organizations to extend interfaces to lower task items.
 - Are at the level at which status is normally reported monthly to the program office for updating of higher level schedules.
 - Will correlate with the Task Manager, Work Breakdown Structure, Scope of Work, and with reports to client.
 - 5) Document the scheduled baseline for the program.
 - b) Work Package Schedules:

^{*} The Task Plan is the focus for planning, monitoring and controlling because it represents work within a single Work Breakdown Structure (WBS) element, and it is the responsibility of a single organizational unit.

^{}** A Work Package is a detailed job that is established by the Task Manager for accomplishing work within a Task Plan.

- Provide milestones and activities required to identify specific measurable tasks.
- Supply the framework for establishing and time-phasing detailed budgets, various status reports, and summaries of cost and schedule performance.
- Are the level at which work package status is normally discussed; and provide input for performance measurement.
- 4) Are the responsibilities of a single organization.
- Provide a schedule baseline against which each measurable
 Work Package must be identified.
- Require formal authorization for changes after work has started, or the work package is within the frozen baseline period.

Only a fully integrated computer-based Program Master Schedule can provide a full level of details for the whole I-235 project. Because not only can it be used by the Iowa DOT, Federal Highway Administration (FHWA), and contractors for decision input and implementation, but it can also help resource conflicts when multiple resources and jobs (for example, Iowa DOT inspectors, materials, utility relocation and bridge construction, etc.) may be present.

In order to develop a master schedule for the I-235 project that works within strict time, cost, and resource constraints, appropriate scheduling software must be selected. Primavera Project Planner (P3) is one of the most powerful scheduling software. However, the high purchasing cost limits its popularity. The relatively inexpensive Microsoft Project turned out to be a good planning tool because its ability to show details of project relationships and dependencies allows researchers to create a scheduling model that accurately reflects these constraints.

Since August 1999, researchers have been developing and maintaining a computerbased master schedule using Microsoft Project. In order to monitor the construction progresses of particular projects, detailed schedules have also been created prior to a project's start. These schedules were then published to the Iowa DOT, FHWA, and contractors to help project management.

2.3 Schedule Implementation

Mike Weiss [2] considers all work wasted if the schedule is not used and therefore, for a schedule to be of maximum benefit, it is very important to:

- Post the schedule and instruct clients in its proper interpretation.
- Communicate the schedule to all involved parties.
- Advise and get recommendations from the participants.
- Monitor progress of actual against projected completion of work units.
- Manage production rates (making adjustments to gain or make up time).
- Use scheduling information to assist in management decisions.

CHAPTER 3: UPDATE, CUSTOMIZATION, and IMPLEMENTATION of the SCHEDULE

A project schedule can help enormously when it is updated, customized and implemented. As a case study, from August 1999 to December 2000, researchers developed a computer-based conceptual schedule for the I-235 project [Figure 2]. Then the schedule was further developed by applying a new Work Breakdown Structure (WBS), and refining existing logical relationships [Figure 3]. Since January 2002, the schedule has been refined to the extent that it can be updated and published regularly.

3.1 Update of the Schedule

In order to make the I-235 schedule an effective and valuable managing tool, the researcher has updated it regularly and consistently at a set interval — every week — and has stuck to it since the I-235 project began in March 2002. Relevant information about project progress is collected and compares what has occurred with what was planned.

The procedures the researcher used to update the schedule can be illustrated by the flow chart shown below:

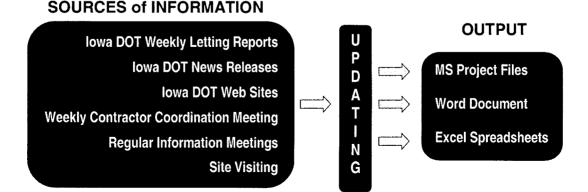


Figure 1: Flow Chart of Schedule Updating

3.1.1 Iowa DOT Letting Process

Currently Iowa DOT's Office of Contracts has 10 highway lettings each year. Starts from 2003, there will be 12 lettings each year. These lettings give contractors the opportunity to bid on highway projects. On the first Monday of each month, The Des Moines Register is used to advertise letting dates for bids because it has the widest circulation of any newspaper in Iowa. A detailed listing of projects to be bid each letting is published in the Weekly Letting Report. This report includes a notice to bidders and itemizes the major quantities of work as they will appear in the proposals. The Weekly Letting Report can be ordered from the Office of Contracts. It is also available on the Internet (www.bidx.com). After bids are received and reviewed, a project will be awarded to the lowest responsible bidder. There are more than 100 projects in I-235 reconstruction, and these projects are not let one by one. Sometimes several projects are let under on project number. In this case, they are called "tied projects", which will be addressed later.

3.1.2 Sources of Information

Where does the information come from?

The key to updating progress is accurate information about each project, resource, and cost. The researcher needs information such as each project's completion percentage, remaining work, project progress, and project costs to date.

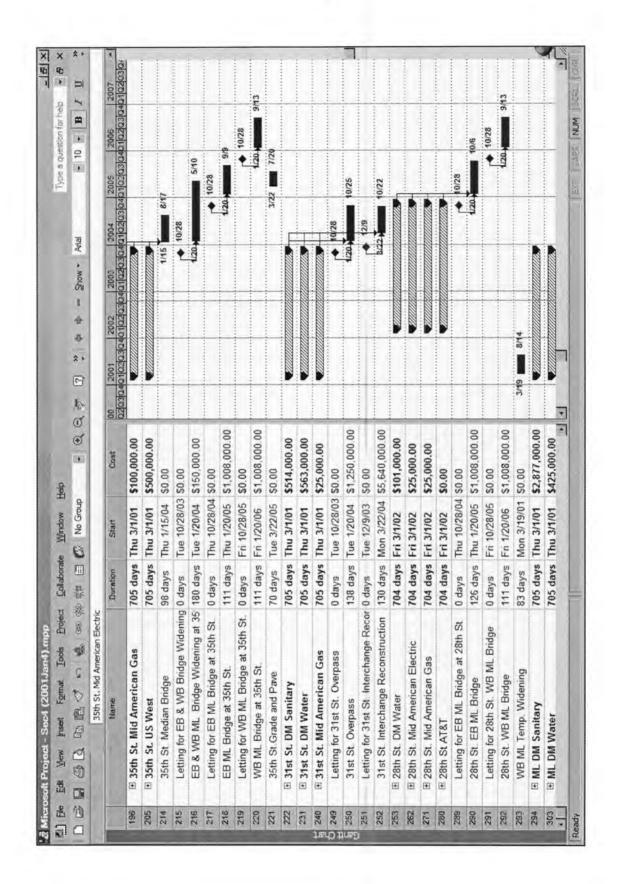
In a large project like I-235, it is hard for the researcher to collect information on project progress himself. Therefore, an easier way to collect timely information is to look through Iowa DOT documentation, attend construction coordination meetings, and get necessary information from those closest to the work who know best the status of the projects

they are working on.

The following are sources of information for the I-235 schedule updating:

- 1. Iowa DOT Weekly Letting Report [Figure 4]: This is an official weekly publication from the Iowa DOT. It includes up-coming letting dates, descriptions and parenthesis numbers * of projects that will be let on these dates, project late start dates, and expected durations. It tells the researcher if the schedule needs to be adjusted so that the project can keep to the original deadline. For example, by default, according to Iowa DOT's regulation, a project's start date is sixty days after its letting date. It usually takes about six months for bridge steel to be fabricated. Utilities need to be cleared before relevant projects start. From information provided by the Letting Report, the researcher is able to judge if milestones are correct in the schedule.
- 2. Iowa DOT News Releases [Figure 5]: In order to reduce congestion, the Iowa DOT sends out News Releases to the public via Email several times a week. Latest traffic control information, for example, locations and time periods of lane closures, and what projects will be performed during lane closures are provided. This information enables the researcher to track the actual construction progress of projects.
- 3. **Iowa DOT web sites**: www.I235.com is a resource for the latest, up-to-date information on I-235 construction. It provides traffic control and overall project

^{*} Parenthesis numbers: Project numbers that Iowa DOT has been using to identify individual projects. Researchers also use the same parenthesis numbers in I-235 scheduling work to ensure the consistency. Details see later Section 3.2.2.2.



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information. www.ia.dot.gov.us is yet another site from where bid letting and contractor information can be found.

- Regular meetings (Contractor Coordination Meeting at Des Moines, meetings with the Iowa DOT design personnel, information meetings, Iowa State University graduate student meetings):
 - Contractor Coordination Meeting at Des Moines: Every week the Iowa
 DOT holds a meeting with contractors to discuss I-235 construction issues.
 This meeting covers traffic control, utility issues, and construction
 progress. Meeting minutes will then be sent out to each attendee. This is
 a "primary" of information regarding project status.
 - Meetings with Iowa DOT design personnel: Every Friday researchers meet with an Iowa DOT designer to discuss project staging, changes in letting dates, etc. This weekly meeting enables the researcher to get the latest project information.
 - Regular information meetings: From time to time, researchers meet with people from different Iowa DOT offices and utility companies to obtain project information.
 - ISU graduate student meetings: Researchers meet as a group to exchange information among each other. This meeting time keeps the research group current.
- 5. Field visiting and talking with on site personnel: Every week on job sites, researchers talk with contractors and inspectors to understand the real-time

construction status, construction procedures, and production rates. Pictures and

videos are taken on-site to monitor construction progress.

PI	800 Lincoln Way – Ames, IA 50010 WEEKLY LETTING REPORT OFFICE OF CONTRACTS none: 515-239-1414 FAX: 515-239-1325 nail address: dot.contracts@dot.state.ia.us	
Volume 90	August 28, 2002	Issue 35
notices over the telephone. December 31 each year is the expirationadvance of that date. A renewal notice always give old address, Address all or	D Lincoln Way, Ames, Iowa 50010, because of the dange of date for all subscriptions to the Weekly Letting Report, will be mailed in advance of the expiration date. In givin mmunications regarding your subscription to lowa Departm Ames, Iowa 50010, phone 515-239-1588. TABLE OF CONTENTS	Subscriptions must be paid in g notice of change of address
		ETTINGS
LETTING INFORMAT EO Section Special Notices/ Fuel Adjustment Sector Adjustment Contracts Accepted SEPTEMBER 27, 2002 Li State Letting Info/Tied Projects/Cross Section troject Detail Addendum Summary Addendum Summary Contracts Accepted OTHER LETTING INFOR! Ward Summary for the August 20, 2002 Lei Contracts Accepted State Letting Details	2 September 27, 2002 (Friday October 29, 2002) 3 December 13, 2002 (Friday) 4 January 14, 2003 23 February 18, 2003 March 18, 2003 March 18, 2003 Prices) COUNTY LETTINGS Hawk County- Bridge Substructur (2 jobs) - Construct Sheel Beam Priche

Figure 4: Iowa DOT Weekly Letting Report

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Label 5 Kathleen Robinson@DOT STATE IA US UT:56 FM 9/20/2002 -0500 a Lahel 5 Kathleen Rohinson@DOT STATE IA US 11:09 AM 9/23/2002 -0500 116/357K/8K [4]	
Subject: Iowa DOT News Release - I-235 closures planned for week of Sept. 22	
1-235 CLOSURES PLANNED FOR WEEK OF SEPT. 22	
DES MOINES, Iowa - Sept. 20, 2002 - There are some closures planned on I-235 the week of Sept. 22 that may affect your travel, according to the Iowa Department of Transportation's I-235 Information Office.	
MLK/COTTAGE GROVE BRIDGES Sunday, Sept. 22 9 p.m 6 a.m The two outside lanes of eastbound I-235 will be closed.	
In addition, motorists should not be alarmed by water coming off the bridge in this area as a result of the deck pour Friday, Sept. 20. The deck must be kept wet for the next several days in order for it to cure properly.	
28TH STREET BRIDGE IN WEST DES MOINES	
Monday, Sept 23 B p.m E a.m I-235 will be closed for periods of up to 20 minutes throughout the night for placement of bridge beams.	
SECOND AVENUE/THIRD STREET INTERCHANGE Friday, Sept. 27 9 a.m The Third Street Bridge over I-235 will be closed, and remain closed until the new bridge is completed in June 2003. 7 p.m The Second Avenue Bridge over I-235 will be closed, and remain closed until the new bridge is completed in June 2003. 9 p.m 6 a.m The two outside lanes of I-235 will be closed.	
Saturday, Sept. 28 9 p.m midnight - The two inside lanes of eastbound and westbound I-235 will be closed.	
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Figure 5: Iowa DOT News Release

3.1.3 Updating Procedures

After creating a schedule and establishing a baseline, the researcher can update the schedule regularly. To update the schedule, the researcher evaluates the status of each project and enters the appropriate information in the schedule.

The detail procedures that the researcher has been updating the schedule with are summarized below:

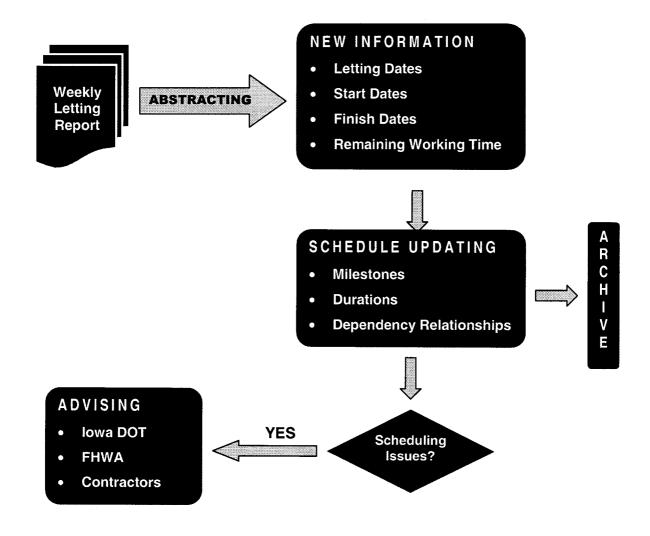


Figure 6: Detail Schedule Updating Procedures

3.1.3.1 Abstracting Information

From information that the researcher collects every week, the following information is abstracted:

- Letting Dates The Iowa DOT needs to adjust letting dates of some projects due to either one of the following reasons:
 - o Delay of predecessors
 - o Right of Way (ROW) issues
 - o Utility relocation issues
 - o Budget concerns
 - o Too many jobs clustering on one letting date

Letting date changes affect project milestones (start date and finish date), and will change the duration of the whole I-235 project if these projects are on the critical path. Therefore, the researcher has been keeping track of letting date changes.

- Actual Start Dates Contractors would start projects less than 60 days after letting, if they have the necessary resources ready and NTP from the Iowa DOT. If this is the case, the Actual Start Date then needs to be updated since projects in the schedule use 60 days after letting as the default Start Date.
- Actual Finish Dates Important milestones to track the status of a project.
- Remaining Working Time Useful information to determine if the project is on schedule.

3.1.3.2 Updating the Schedule

After completing the initial process of creating a schedule (that is, entering projects, establishing dependencies, assigning resources and possibly costs, and checking and adjusting the schedule), a best estimate of how the project will work is defined. But how will the researcher know if the project is proceeding according to plan? How will the researcher know, for instance, if the project can finish on time or within budget? The best way to track what does and doesn't go as planned is to set a baseline after the researcher refines the schedule and before the project begins.

A baseline is a set of key, original project estimates. This set consists of the original project, resource, assignment, and cost estimates that the researcher entered into the schedule. The original estimates it contains are permanent reference points against which the researcher can compare the updated project, resource, assignment, and cost information (including recorded actual information) that the researcher entered into the schedule as the project progresses. Examples of actual information are actual project durations, time phased resource costs, and work completed on an assignment.

Once the baseline is created, the schedule is ready to be updated. It is easy to update projects if they have few dependence relations with other projects. This could be completed by simply assigning new Start/Finish Date to projects. However, updating projects which are more dependent on other projects involves more effort. Because of existing logical relationships, projects keep the same even though they are assigned new Start/Finish dates. Procedures of updating "dependent projects" are shown below:

1. Open the Task Form in the bottom panel (Figure 7).

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		E Polk Blvd Bridge	177 days	NA	2.33 M		-		-
		Damo Concrete Box Beam		NA	0.00 M		1	-	-
		Gemo Concrete Box Beam	14 days	NA	0.00 M		P1		1
2) 54 54 Jen Current Organs (423)4 (234)5 (468), (290)6 1		Polk Blvd overpass, 2 bridges, approaches	100 days	Tue 1/14/03	2 33 M		James		1
		E Utilities - Polk Blvd	360 days	NA	0.00 M	-			1
	-	Mid Am Elec Dist (Default Dur.)	240 days	NA	0.00 M	87/7//////	777		-
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Figure 7: Schedule Updating - Dependencies

- Check project dependencies. Reviewing and analyzing predecessor/successor dependencies is the first step in deciding which action, changing or removing links, needs to be undertaken.
- Change project dependencies. If the current construction situation allows two projects to be started simultaneously, the project dependency can be changed from its previous status, for example, finish-to-start (FS), to start-to-start (SS).
- Remove a project dependency. If a dependency between projects doesn't reflect how the projects will really be done, it should be removed.
- Apply changes to the projects. The projects will be rescheduled based on any existing relationships to other projects or constraints.

3.1.3.3 Archiving Information into the Notes Field

The Notes field in Microsoft Project is designed to contain notes which help maintain the history of a project. Pasting information into a project note is a convenient way to keep track of information related to the schedule (Figure 8). The researcher can copy information from, for example, an e-mail message, a word processing document, a spreadsheet, and even a Web page and paste it into a note. OLE objects, hyperlinks, and bitmaps can also be inserted into the Notes field.

se se		Ne Group	• 9,9,7	a * •	+ - <u>s</u>	how - Arial		•	10 - H	νū
	E6th St Bridge Replimt (Steel)									
Current Original	Tools he ne	Ourstion	Letting Date	Cost	02 03 04	2002	2003	03104	2004	2005
	🛱 Sec 6	1668 days	NA	36.40 M						
(330)-A (326)9	BE6th St Bridge Repl'mt (Steel)	215 days	Tue 2/19/02	1.61 M		-	-		1	
	E6th St Bridge Replint (Steel) Duration Letting Date Dow 1 2002 2003 2004 2004 2004 2005 2004 2004 2004 2005 2005									
	Ciear Utilities	75 days	NA.	0.00 M						
	Letting	0 days	Tue 2/19/02	0.00 M		•				
					11	·		; l		
Start: Toe 1/1/02	Frind: Man 10/22,02 Task hose Task hose Sale	Eard Duration	Complete:	hegt 0% ±						
Jame: E6th St Bidg Stort: Toe 17.82 Iowa DOT New – August 7th – work on the bri Weekly Constr – July 31: Plac – Eco-Tech is	Task the Task t	and WB I-235	will be closed	Negt 0% ±		otes	Fiel	d		

Figure 8: Schedule Updating - Notes Field

During updating, each note is summarized clearly to tell users: What activities are involved, when, where did the activities start/finish, and if applicable, what causes these activities. A typical note is shown below:

Iowa DOT News Release (July 12th, 2002)

-- July 17th ~ 19th: Setting beams for the new East Sixth Street Bridge.

-- July $22^{nd} \sim 24^{th}$: The WB lanes will be closed to finish setting the bridge beams.

Adding information into the Notes field is particularly helpful in documenting construction progress, which requires a lot of this type of information. The status of a project can be tracked then by looking at its notes. Construction templates can also be developed from interpreting these notes after the project is finished.

3.1.3.4 Advising Clients

The ability to look ahead and avoid scheduling problems before they occur can mean the difference between project success and failure. Reviewing the schedule during the schedule updating helps the researcher identify and correct scheduling conflicts that could push out the project deadline; and advising clients of alternative construction options enables them to direct and fine-tune the project. For example, Iowa DOT managers can make midstream changes that will help reach project goals sooner; and adjust cost requirements throughout the project to make sure that no project will be delayed because of a shortage of money.

The project finish date calculated by Microsoft Project gives the researcher a good sense of whether scheduling conflicts exist or not. During the schedule updating, the researcher found that inappropriate links between projects or unnecessary constraints usually caused schedule conflicts. If scheduling conflicts are found during schedule updating, the researcher will inform clients of the impact that such conflicts might have on the schedule, and then provide an alternative solution.

For example, from the baseline, scheduled construction procedures for East 6th Street Steel Bridge are shown in Figure 9:



Figure 9: Example of a Scheduling Conflict

Interviewing with Iowa DOT personnel, the researcher learned that the steel contractor needs six months to fabricate steel elements. Subsequently, when updating the schedule using this information and checking against the baseline, a schedule conflict appears: The demolition of the Old East 6th St. Bridge (Task 2) cannot start on time because of the delay of The Construction of the New East 6th St. Bridge (Task 1). The finish date for the Task 1 is 07/02/2002, which is after the letting date of the Task 2 – 02/28/2002.

The schedule for the Task 1 is shown below (Figure 10):

	Task Hame	Duration	Stort	Finish	2002 Nov Jan Mar May Ju	2003 Sep Nov Jan War Way Jul Sep No
1	Construction New East 6th Street Bridge	372 days	Tue 2/19/02	Wed 7/23/03		Appropriate
2	Letting	0 days	Tue 2/19/02	Tue 2/19/02	€-2/19	Relationship?
3	Fabricate Steel	120 days	Tue 2/19/02	Mon 8/5/02	4	
4	Substructure	80 days	Tue 8/6/02	Fn 1/17/03	4	
5	Superstructure	80 days	Mon 1/20/03	Wed 7/23/03		+ 2/23

Figure 10: Schedule of East 6th St. Bridge (1)

Analyzing the schedule, the researcher finds that the relationship between "Fabricate Steel" and "Substructure" (as shown in Figure 10) causes the delay. Although a finish-to- start (FS) relationship can be used here, a start-to-start (SS) is more appropriate in this case. "Substructure" does not need to wait until the completion of "Fabricate Steel". These two projects can start at the same time. Changing the relationship from FS to SS actually resolves the schedule conflict. The Finish date of the Task 1 is 01/22/2002, which is before the letting date of the Task 2. As shown in Figure 11:

	Task Name	Duration.	Start	Frish	2002 2003 Nov Jan Har Way Jul Sep Nov Jan Mer Mey Jul Sep Nov
1	Construction New East 6th Street Bridge	200 days	Tue 2/19/02	Wed 1/22/03	
2	Letting	0 days	Tue 2/19/02	Tue 2/19/02	¢ 2/19
3	Fabricate Steel	120 days	Tue 2/19/02	Mon 8/5/02	
4	Substructure	80 days	Tue 2/19/02	Mon 6/10/02	
5	Superstructure	80 days	Tue 8/6/02	Wed 1/22/03	1/22

Figure 11: Schedule of East 6th St. Bridge (2)

Then clients will be advised that, in order to finish the demolition of the Old East 6th St. Bridge (Task 2), the best option for the bridge contractor in Task 1 is to work on the

bridge substructure while the steel is fabricated. By the time the substructure is about to be finished, the steels are almost ready for the superstructure.

3.1.4 Lists of Products

After updating the schedule, the following products can be obtained:

Microsoft Project Master Schedule: More than 100 projects under prime ٠ contracts are covered in the schedule. All projects are ordered by sections: from Section 1-4 (west end of the corridor) to Section 8-10 (north east end of the corridor). The schedule is in Microsoft Project 2000 version since the scheduling program that the researcher has been using is Microsoft Project 2000. Then it can be saved as Microsoft Project 98 version and converted into Adobe Portable Document Format (PDF) format (Figure 12). The reason for doing this is that the scheduling program some clients are using is Microsoft Project 98, which cannot open Microsoft Project 2000 version files. For other clients who do not have Microsoft Project software, a PDF file will be sent to them because the Adobe Acrobat Reader is free to download. Although in PDF files, it is impossible to see the Notes field, clients can see most of the content from the Gantt chart view. The layout of the schedule is designed to provide an appropriate amount of information to clients. And this layout will be addressed in the later section (Section 3.2.2).

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-				4-235 Sc	thechile fro	misu (Wed	8/7/02)						1.1		
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	1	6238	1783 days	NA	4 285.00 M	-	1	1	1			1		-	
		Section 1-3	1538 days	NA	32.64 65		*	1	-		l	1		and .	
141	61731	atilaid Sil, Bindige dPD(28) HepPerA., Approximite	65 days	Tun 1/15/09	1 57 6			100		7		1	1		1
(Acith)1		Bridge Forice Aland	5 tlays	Tue science	0.00 M	-	1			1	1	1			
00801		Badge Fence - 50th	40 dage	NA	0.00 M							1			
		42nd HF 119945 - (3/ared -	0 days	NA	0.00.60		1	-	-			1	-		
		35th BL (FPCB)	778. days	NA	8.40 6		*	-	-	-		1	-	-	1
(405)		Rentige Frence	1 days	Insum:	0.00 #		-	-	-	1		1	-	-	
1(12)		Notine Wall (200) to W of 2001.	fif days	Tue 102962	0524		+	+	-			+	-	-	
430)2		S. Gebil SGID SE in WDekl, Brieschange	102 days	Tue 1/14/02	5.16 M				-	1		+			1
1114	<u></u>	Selfa St. Gildge Rispford	30 days	Tue 1/1403	2.49 M				-			-	-	-	-
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		gelightes	430 days	144	0.00 M		1					-		_	-
		Mid Am Eller Din) (Demail) Dur.)	240 days	NA	0.00 45		1	1			1				
		Contend (Chartmuth Char).	450 0939	1	11.00 M			1						-	
		(Ata)	450 days	NA.	5 12 M	10 In 11	-	1	-						
1		WDSM Water (Dotest) Dvil)	480 000	NA	0.00 M		-	1					T		
		WD+M S 5 (Detaill Out)	450 days	NA	0.00 M		E	1				1	1	-	1
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		zem si.	626 days	NA	1.84 M		1	1			-	-			
(885)2		Calvert Extension (2001 51.)	40 49 45	Tun 1/15/02	0.12 M		1	-			1	-	1		
2721	OTS2	2980 St. Bridge (PPCB) Repfinit, Incl. Approaches	No days	Tip 1/15/02	141.0	-	-	10	ten,		1	-	-++-		

Figure 12: Schedule Updating Product - Master Schedule (PDF format)

- Word Document: This document (Figure 13) highlights all new changes since last updating. By looking at this document, clients can quickly access what they need without groping about for information.
- Excel Spreadsheets: Spreadsheets (Figure 14) organize projects by their Letting
 Dates (Sheet 1) and Parenthesis Numbers (Sheet 2). Also a list of tied projects*
 (Sheet 3) is presented in one spreadsheet. These spreadsheets can serve as quick
 references when information of a particular project is needed, if the project letting
 date or the project parenthesis number is known. For example, if clients need to
 know the awarded cost of a project that was let on 08/20/2002, Sheet 1 can help

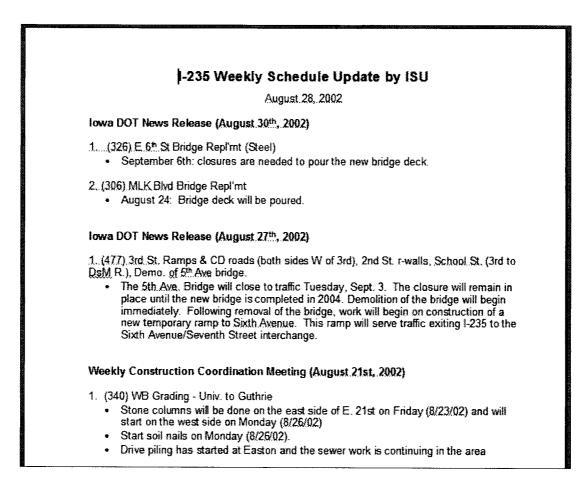


Figure 13: Schedule Updating Product – Highlights of New Changes

locate the information quickly. If clients need to know the awarded cost of a project with parenthesis number (340), Sheet 2 is the appropriate tool to use. Although Microsoft Project is more capable of presenting this project information, clients prefer Excel spreadsheets either because they do not have Microsoft Project or they are not used to finding information using Microsoft Project. An experienced Microsoft Project user can create various kinds of reports from one single schedule file. This customization function will be addressed in the later section (Section 3.2.3). The layout of the spreadsheets is designed to provide an appropriate amount of information to clients. And this layout, almost the same as the layout of the schedule,

will be addressed in the later section (Section 3.1.4).

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Notes: Projects a Current P Orginal P	re color-gro roject # : P roject # : Pr	uped by Letting Date roject No. after project is tied. oject No. before project is tied. s both Current Project # and Orginal Project #, this project is tie	d w/ other proje	• ct(s) ***	1	
Current Project#	Original Project #	Task	Letting Date	Award Cost	Projection Cost (w/ inflation)	Remarks
		2002 Lettings				
(351)11		Noise Wall - Easton to Guthrie (W side)	10/29/02	1	2.20 M	
(359)13		Euclid Ave. Interchange Resurfacing, Bridge Repl'mt., Euclid Ave. Reconstruction	10/29/02		5.60 M	
(465)8		Storm Sewer/Intakes - Birds Run Phase 1 From Des Moines River to 8th & Keo	10/29/02		2.09 M	
(491)		Traffic Signals On Euclid Ave. W & E Ramp Terminals	10/29/02		NA	
(492)		Demolition at Various Locations Parcel No. 93, 105, 110C, 223, 705 221	10/29/02		NA	
					1	
		2003 Letting				
(274)2	1	35th St. Bridge Repl'mt	01/14/03		2.62 M	
			01/14/03		2.33 M	

Figure 14: Schedule Updating Product – Excel Spreadsheets

• Design Schedule: The Design schedule (Figure 15) is different from the project master schedule in that an extra purple bar is added at the same line with the task bar. The purple bar represents the available time from design start date to final plan turn in date for Iowa DOT design personnel. Putting two bars in one line reminds the designer how many design days are left before the project starts. In the Design Schedule, a Design Start date column, a Final Plan turn in date column, and a Design

Duration column are added into the original master schedule. Also a Designer

column is added, which helps the Office of Design to manage its resources.

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	Curren' Origin	Task Kame	Deaga Str	Finel Plant +	Design Durati - Designt -	2002 200	3 2004 H2 H3 H5	2005	2006	2007 200
31		≡ 63rd St. (PPCB)	NA	NA	0 days			1		
82	(364)4	Noise Wall (63rd St. Remp A)	Man 8/19/02	Mon 8/11/63	256 days					
33	(286)4	63rd St. Interchange work	Mon 8/19/02	Mon 7/7/03	231 days	-				
84	(287)4	63rd St. Bridge Work	Mon 8/19/02	Mon 7/7/03	231 days	-			-	
35	(470)	Bridge Fence	Mon 8/19/02	Mon 5/5/03	186 days	8999		1		
36		Cummins Pkwy (PPCB)	NA	NA	0 days			1	-	
87	(289)4	WB Bridge Repl'mt	Mon 8/19/02	Mon 10/10/05	822 days					
58	(409)4	EB Bridge Repl'mt	Mon 8/19/02	Mon 9/6/04	537 days					
39		B 56th St. (PPCB)	NA	NA	0 days		-	1	*	
90	(364)0	56th to 42nd Noise Wall Barrier	Mon 8/19/02	Mon 8/11/03	256 days		1 12			
31	(453)5	Interchange reconstruction	Mon 8/19/02	Mon 8/9/04	517 days			8		
92	(293)5	Bridge Repl'mt	Mon 8/19/02	Mon 8/9/04	517 days					
93	(470)	Bridge Fence	Mon 8/19/02	Mon 5/5/03	186 days	-				
94	(454)5	Culvert Extension (56th St.)	Mon 8/19/02	Mon 8/9/04	517 days					
95	(423)4	Culvert Extension (0.25 km W of	Mon B/19/02	Mon 7/7/03	231 days		-			

Figure 15: Schedule Updating Product – Design Schedule

 Detailed Schedule: Detailed schedules are developed to monitor the construction progress of individual projects. Different from the master schedule, which are shown to strategic managers, detailed schedules provide information that fulfills the needs of Iowa DOT site personnel and contractors. A detailed schedule of 2nd and 3rd Ave area is shown in Appendix B.

3.2 Customization of the Schedule

Typically, a view displays all the projects in the project. That is okay when users really want to see them all, or if there are so few projects that users can see them without much scrolling. However, usually a prime project contains many smaller projects, subsets of which share certain characteristics. For example, some projects might share the characteristic of being construction projects (bridge or interchange works. Not utility works). Others might share the characteristic of being tied together.

Microsoft Project comes with many predefined views, yet the researcher was not able to find the one that displays exactly the information in just the format that is wanted, i.e. projects that share certain characteristics.

In order to see information about projects that only share certain characteristics, the researcher applied a filter (Outline Codes in this paper). For each view, Outline Codes determine which projects or resources Microsoft Project displays or highlights. An Outline Code contains instructions, called criterion, which specify the conditions under which a project will appear. The researcher changes the criterion applied to a view when information about different projects is needed to be seen in the current format.

3.2.1 Understanding Clients' Expectations

Before distributing the schedule to clients, it is important to customize the schedule according to different clients' expectations:

• Strategic managers of the Iowa DOT and FHWA need the specifics shown by including all the summary projects. For example, a review of the schedule for summary projects can tell managers how much cash will be available for these

30

projects in one fiscal year. This information is critical to determining the needs for lines of credit, purchasing decisions and other issues of capital expenditure. Also managers can review the schedule and determine when to advertise, interview and train so that needed engineers will be ready when needed, and the project will not be affected by the personnel turnover.

- Division personnel of the Iowa DOT and FHWA need a schedule showing all subtasks. The level of detail shows performance of intended against actual, selection deadlines for contractors, plan turn-in dates, and demand dates for additional personnel. This division of clients wants to eliminate the summary projects and other relatively independent projects (for example, utility works) from the Gantt chart view to keep the schedule from getting too cluttered.
- Contractors need the portion showing their involvement. Therefore, a detailed schedule which shows projects undertaken by the contractors as well as neighboring projects should be sufficient enough.

Using Custom Outline Codes, the researcher is able to customize a schedule to show the information that needs to be presented.

3.2.2 Schedule Layout

A Microsoft Project file contains vast amounts of information, but users usually work with only a portion of it at any given time. Because projects can become so complex, and because the information to be tracked can vary so widely, the researcher created a specialpurpose schedule layout to display necessary information through the use of filters to modify the information in views.

3.2.2.1 Layout of the Whole Schedule

The layout of the schedule is very important because it is the final product of the whole scheduling/planning process. How much information clients can obtain from the schedule and whether they will actually use the schedule depend on whether the layout can best meet their immediate needs. Using a schedule with an appropriate layout enables clients to perform many project management projects more efficiently.

The layout of a schedule can be divided into two parts (Figure 16). Descriptive project information is shown in Part A. Graphical project information can be found in Part B. What information can be obtained from these two parts will be addressed below.

3.2.2.2 Layout Part A – Descriptive Project Information

A better organized schedule effectively communicates the accomplished projects and those upcoming projects. This is achieved by showing descriptive information (sheet view) in the schedule layout. A sheet view is a spreadsheet-like representation (in rows and columns) of project information. Tasks are arranged vertically, like a list. The categories of information about each task are arranged in subsequent columns, with each column specifying a type of information, such as start dates or costs.

		Mid	Am Elec Dist (Default Dur.)				
	Current	Original	Task Name	Duration	Letting Date	Cost	2001 2002 2003 21 [62] (23 [64 [01] [62] (23 [64
248			B 3rd St.	252 days	NA	9.64 M	at lost as lost at lost at lost at lost at lost
249	(477)	(477)	3rd St. Ramps & CD roads (both sides W of 3rd), 2nd St. r-walls, School St. (3rd to DsM R.), Demo of 5th Ave bridge	89 days	Tue 8/20/02	7.21 M	
250	(477)	(320)8	The second se	246 days	Tue 8/20/02	2.43 M	The second s
251				0 days	NA	0.00 M	*-
252			BALLAN	0 days	Tue 8/20/02	0.00 M	Dont D
253			Part A	120 days	NA	0.00 M	Part B
254				186 days	NA	2.43 M	
:55				75 days	NA	2.43 M	-
256			Superstructure	75 days	NA	0.00 M	
257	(469)		3rd St. Bridge Fence	5 days	Tue 1/14/03	0.00 M	
258			⊟ 3rd St. Bridge Utilities	360 days	NA	0.00 M	
259			DsM W W (Default Dur.)	360 days	NA	0.00 M	197.723.237.797.0238.023
:60			⊟ 2nd Ave.	252 days	NA	2.64 M	
261	(477)	(321)9	B 2nd Ave. Bridge (Steel) Repl'mt.,	246 days	Tue 8/20/02	2.64 M	

Figure 16: Schedule Layout

If the sheet view is not displaying the type of information that the researcher wants to see regarding projects, the entire appearance of the sheet view can be changed by selecting different columns for the view. By switching to different columns, the researcher can view a variety of information related to the work required to complete a project, such as the letting dates and project identification numbers.

	Current	Original	Task Name	Duration	Letting Date	Cost
248			🗏 3rd St.	252 days	NA	9.64 M
249	(477)	(477)	3rd St. Ramps & CD roads (both sides W of 3rd), 2nd St. r-walls, School St. (3rd to DsM R.), Demo of 5th Ave bridge	89 days	Tue 8/20/02	7.21 M
250	(477)	(320)8	⊞ 3rd St. Bridge (Steel) Repi'mt	246 days	Tue 8/20/02	2.43 M
257	(469)		3rd St. Bridge Fence	5 days	Tue 1/14/03	0.00 M
258			🗄 3rd St. Bridge Utilities	360 days	NA	0.00 M
260			🖻 2nd Ave.	252 days	NA	2.64 M
261	(477)	(321)9	Ind Ave. Bridge (Steel) Repl'mt., incl. Approach, School St. (3rd to	246 days	Tue 8/20/02	2.64 M

Figure 17: Schedule Layout - Part A

As shown in Figure 17, the sheet view contains seven columns:

- The ID number can be found in the first column. These ID numbers are generated by the Microsoft Project program automatically.
- The second and the third column list the "Current Parenthesis Number" and the "Original Parenthesis Number", respectively. The reason these two numbers are listed will be addressed later.
- The fourth column gives the description of projects, which are exactly the same as the Iowa DOT terminology. Clients can search the schedule the same way they search Iowa DOT documents.
- The fifth column lists the project durations, which are based on researchers' calculations (Syuin-Chet Tee [4] and Jingxi Li [5]).

- Project letting dates can be found in the sixth column. The researcher found that letting dates are important for clients. Iowa DOT and FHWA use letting dates to plan the primary staging, resources, and money flow. Contractors use letting dates as milestones for utility relocation, material preparation, and workforce management.
- Cost information is given in the seventh column. For previously let projects, awarded costs are listed in this column. Otherwise, projected costs with inflation are shown in this column. The total programmed cost is \$ 426 million. Besides costs for construction, costs for general activities are also listed at the bottom of the schedule. General activities include: Intelligent Transportation Systems (ITS), ROW, Utility Relocation, Traffic Signals, Mainline Lighting, and Landscaping.

Before explaining "Current" and "Original" Parenthesis Number, it is necessary to explain the origin of Parenthesis Number and tied projects.

Parenthesis Numbers – Parenthesis numbers are derived from Project Numbers shown on an Iowa DOT Production Schedule (Figure 18). Project Numbers are used by the Iowa DOT to identify individual projects. As highlighted in Figure 18, the Project Number has a uniform format: IM-235-2 (XXX) YY--ZZ-77. In this format, (XXX) YY is the most important part for differentiating projects within a particular corridor. (XXX) serves as the project ID number, and it is different from one project to another. YY shows the source of funding for this project. Since (XXX) YY is unique for each project, both the Iowa DOT and researchers use it to find projects. For example, (320)8 represent "3rd St. Bridge Replacement". Since (XXX) YY has a parenthesis, it is called a "Parenthesis (paren for short) Number".

ervenise i '								1 1 1 1 1 1 1 1 1	ILE	,		
	TYPE OF WORK		1UDGET (\$1,900)	T		:	FISCAL	• • • • • • • • • • •				
	DESCRIPTION	ROW	CONST	1*	FISCAL	2000	FISCAL	2001	FISCAL 20	AL 2002 FISCAL 2003 F	FRECAL	
POLK -235 IN DES MOINES PR ROM JUST S. OF BUTHRIE AVE. N. TO IP R.R.(SEC. 8-10)	ELIMINARY GINEERING	C	Ō	PS	R2 06/	-	R3 10/1 R4 01/0 R5 03/0 R6 05/1 01/99 -	7/01 7/01 5/01 PROJ DEVE	ECT NO: 11 Lopment So Ion 8-10			13-77
-235 IN DES MOINES BR I GUTHRIE AVE. MEDIAN SEC. 8-10)	• • • • •	• *	* * * *	.	* *		• * * * 01/99 -	* * PROJ DESI MAIN FHWA	* * * * * ECT NO: 11 GN NO: T. NO: NO:	* * * (-235-2		• • • • D4 07, B3 08, L3 10, -13-7

Figure 18: Iowa DOT Production Schedule

Tied Projects – In the I-235 reconstruction project, the Iowa DOT put some projects under one parenthesis/project number, lets them in a single contract on one day, and awards them to one primary contractor. These projects are called tied projects. The reasons they are tied together are:

• Easier management for the Iowa DOT. If there are construction issues about these tied projects, the Iowa DOT only needs to contact one primary contractor, instead of several contractors. Also it is easier for the Iowa DOT to control cash

demands – the Iowa DOT pays only the primary contractor, and this primary contractor will pay all subcontractors.

- Better cooperation among subcontractors. After being awarded the contract, the primary contractor will subcontract tied projects to other contractors. For tied projects, contractors are more likely to cooperate with each other. Chances are good that projects will be on schedule and within budget.
- Geographical consideration. Some projects are tied because they are geographically close to each other. For example, 3rd St. Bridge and 2nd Ave. Bridge are located side by side. And 3rd St. Bridge Replacement and 2nd Ave. Bridge Replacement (include approach, School St. (3rd St. to Des Moines River)) are tied together. Contractors for these two bridges can work at the same pace on some activities. For example, one of the advantages is shortened materials/equipment moving in and out time, and thus shorter main line closure time.

"Current" and "Original" Parenthesis Numbers – As seen in previous sections, identifying tied project information (Letting dates, internal logical relationships, etc) helps clients to make management decisions. The layout of the schedule is designed to fulfill this need.

	Current	Original	Task Name	Duration	Letting Date	Cost
248			B 3rd St.	252 days	NA	9.64 M
249	(477)	(477)	3rd St. Ramps & CD roads (both sides W of 3rd), 2nd St. r-walls, School St. (3rd to DsM R.), Demo of 5th Ave bridge	89 days	Tue 8/20/02	7.21 M
250	(477)	(320)8	🖻 3rd St. Bridge (Steel) Repl'mt	246 days	Tue 8/20/02	2.43 M
257	(469)		3rd St. Bridge Fence	5 days	Tue 1/14/03	0.00 M
258			🗄 3rd St. Bridge Utilities	360 days	NA	0.00 M
260			□ 2nd Ave.	252 days	NA	2.64 M
261	(477)	(321)9	Ind Ave. Bridge (Steel) Repl'mt., incl. Approach, School St. (3rd to	246 days	Tue 8/20/02	2.64 M

Figure 19: Schedule Layout – Part A with Highlights

In Figure 19, "Current" represents the Parenthesis Number after the project is tied, if applicable. "Original" stands for the Parenthesis Number before the projects were tied, if applicable. If projects are tied, they should have a same "Current" number in the second column. As highlighted in Figure 19, projects with ID 249, 250, and 261 are tied because they all have the same "Current" Parenthesis Number (477). Notice that the "Original" Parenthesis Number of the project with ID 249 is also (477). This means among these tied projects, this project (ID 249) is the most important, or the most complicated project.

If a project is stand alone, only its Current Parenthesis Number will be displayed. For example, the Current Parenthesis Number is (469) for the project with ID 257.

3.2.2.3 Layout Part B – Graphical project information

The easier it is to follow a schedule, the more it will be used. Gantt chart view provides the desirable way of viewing graphically based information about the project. For example, using Gantt chart enables the schedule to give a graphic answer to inquiries of logical relationships, to the effect of a delayed start or the delayed completion of any activity because of Microsoft Project's ability to produce instant results for "what if" scenarios.

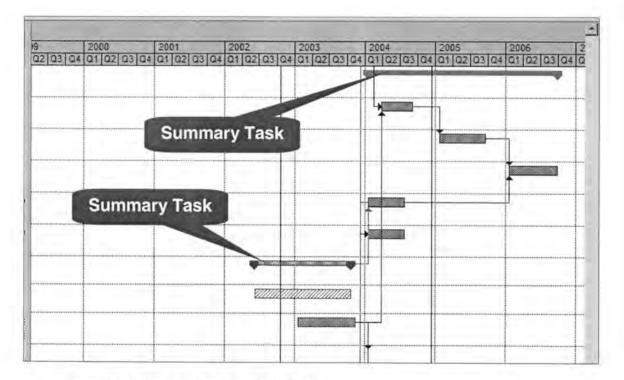


Figure 20: Schedule Layout – Part B (1)

In Figure 20, the time scale for the project is plotted at the top of the schedule, with a unit of measurement (Quarters) clearly stated. Grid lines are used for easy viewing. Project durations are represented by the length of the task bar, with the beginning of a project directly under the start date on the time scale. Blue bars represent construction activities, and

green bars represent utility works. Summary projects representing multiple detailed subtasks can make a schedule simpler to read. The arrows connecting one project to another represent the dependency relationships.

9	2000	2001	2002	2003	2004	2005	2006	12
22 03 04	01 02 03 04	01 02 03 04	01 02 03 0	24 01 02 03 04	01 02 03 04	01 02 03 04	01 02 03 04	a
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Figure 21: Schedule Layout – Part B (2)

To quickly access the project information, point to a task bar and stay the mouse for while, a text box will appear. As shown in Figure 21, Name, Start/Finish Date, and the duration of the project can be found in the box.

The effect of a delayed start or a delayed completion of any activity can be demonstrated graphically by running what-if scenarios. Point to the right end of the task bar that needs to be changed, wait until the pointer changes, then drag to the right to lengthen the duration of the project (Figure 22). Reviewing the changes of successors can tell the researcher how severe the effect would be.

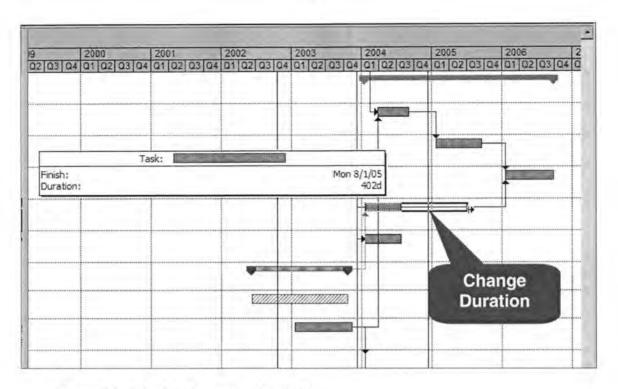


Figure 22: Schedule Layout – Part B (3)

3.2.3 Creating Custom Outline Codes

When a defined subset of the customized schedule layout (shown in previous sections) needs to be seen, a filter can be applied to display only the information that meets the filter criterion. As an interactive filter, Custom Outline Codes give the researcher more flexibility in working with Microsoft Project data.

Custom Outline Codes are tags that are defined for projects that provide an alternate index system in the schedule. After defining and assigning Outline Codes to projects, the researcher can use them to sort, filter, or group projects in the schedule. Each level of an Outline Code can consist of uppercase or lowercase letters, numbers, or characters the researcher enters (any combination of uppercase and lowercase letters and numbers), and a symbol to separate the levels of the code. The total length of an Outline Code can be up to 255 characters.

For example, if an Outline Code is specified with three levels—three uppercase letters in the first level, three numbers in the second level, any number of characters in the third level, and a plus sign as the code separator— it could be entered such as:

• ABC + 395 + Design1

Compared with pre-defined filters that Microsoft Project provides, using Outline Codes to filter/sort projects has the following advantages:

Searching a project using Outline Code takes all criterions into consideration in one step. While using pre-defined filters applies only one criterion at a time. For a large project like I-235, Outline Codes enable quicker searches, and more accurate results. For example, trying to find a project "West Des Moines 28th St. Bridge Replacement", which has two Parenthesis Numbers – (272) and (275) because it was tied with another project. Using pre-defined filters, if the project cannot be found in the second column (considered as one filter criterion in Microsoft Project) of the schedule, clients need to redo the search in the third column. However, using Outline Code to search needs only one step because both Parenthesis Numbers are in the same one Outline Code.

Outline Code is an all-in-one interactive code. With the total length of 255
characters, there is almost no limitation to augment its existing filtering/sorting
capacity by adding various criterions into the existing code. Although it is
possible to add extra filters to existing pre-defined filters, new columns (they are
called "Fields" in Microsoft Project) should be defined and their positions need to
be remembered. Because in the Gantt chart view most of the columns are hidden,
chances are high that clients cannot find them when needed.

Steps of creating Custom Outline Codes in the I-235 schedule are illustrated below:

Step 1: Format of I-235 Outline Codes

After knowing what information should be included in different customized schedules, the researcher defined the content and format of I-235 Outline Codes. Outline Codes consist of eight levels, which look like:

Level 1 + Level 2 + Level 3 + Level 4 + Level 5 + Level 6 + Level 7 + Level 8

Levels 2, 3, and 4 consist of numbers. Levels 1, 5, 6, and 7 consist of letter(s). Meanings of numbers and letter(s) (highlighted with bold italic font in the table) that are used in each level are shown below:

Level 1 – F	Project Details
Project Description	B – Bridge Work
	G&P – Grading and Paving
	RCB - Concrete Culvert Extension

	SS - Sanitary Sewer				
	STS – Storm Sewer				
	U – Utility Work				
	W – Noise Wall				
	WW – Water Main				
	WDM – West Des Moines				
	ATTPH – AT&T Phone Line				
	AmocoP – Amoco Pipeline				
Location and Company Name	MAED – Mid American Electric Distribution				
	MAET – Mid American Electric Transmission				
	MAG – Mid American Gas				
	ML – McLeod				
	QC – Qwest Cable (TV)				
Level 2 -	Current Parenthesis Number				
Level 3 * -	- Original Parenthesis Number				
Level 4 -	Letting Date (In mmddyyyy format)				
Level 5 * -	- Stand Alone or Tied Project				
	TIE - Tied project				
Level 6 * -	- Contractor Undertaking the Job				
Level 6 * -	BECKMAN – BECKMAN CONSTRUCTION				
Level 6 * -					
Level 6 * -	BECKMAN – BECKMAN CONSTRUCTION CRAMER – CRAMER AND ASSOC.				
Level 6 * -	BECKMAN – BECKMAN CONSTRUCTION CRAMER – CRAMER AND ASSOC.				
Level 6 * -	BECKMAN – BECKMAN CONSTRUCTION CRAMER – CRAMER AND ASSOC. DECARLO – DECARLO DEMOLITION COMPANY				

	KRI – KRI COMPANY
	MCANINCH – MCANINCH CORP.
	REILLY - REILLY CONSTRUCTION CO., INC
	SCOTT – SCOTT DILLARD DEMOLITION
	UNITED - UNITED CONTRACTORS, INC.
Level 7 -	- Clients
	Marty – Marty Sankey, Iowa DOT
	Bob – Bob Younie, Iowa DOT
	BOD Tourie, iowa BOT
	Jim – Jim Schonerock
	Jim – Jim Schonerock
	<i>Jim</i> – Jim Schonerock <i>Kevin</i> – Kevin Merryman, Iowa DOT
	<i>Jim</i> – Jim Schonerock <i>Kevin</i> – Kevin Merryman, Iowa DOT <i>Greg</i> – Greg Mulder, Iowa DOT

Figure 23: I-235 Outline Codes

- Note: * in the table means "If Applicable". If a level is not applicable for one project, it will not show up in the Outline Code. For example, for projects that will be let in the future, Level 6 (Contractor Undertaking the Job) is still unknown. Outline Codes for these projects should be:
 - Level 1 + Level 2 + Level 3 + Level 4 + Level 5 + Level 7 + Level 8

Step 2: Creation of Outline Codes in the Schedule

Procedures of developing an Outline Code are explained in Appendix C.

Examples of I-235 Outline Codes are shown below:

- RCB+376+10282003
- B+272+272+01152002+TIE+HERBERGER
- UDSMWW+305+475+03262002+TIE+REILLY+Greg+Short

3.2.4 Customizing the Schedule

Steps of customizing the schedule using Outline Codes are shown below:

(1) Click the filter icon **v** on the Microsoft Project menu to activate filter

function. Then click the down arrow icon on the title bar of the I-235

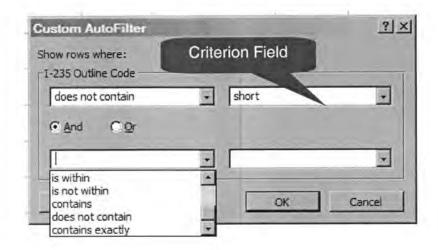
Outline Code. A menu will appear, as shown below (Figure 24):

I-235 Outline	Code 🔽
(All)	<u>•</u>
(Custom)	_
117	
В	
B+272+01152002+TIE+HER	BERGER CONST.
B+272+275+01152002+TIE	+HERBERGER CC
B+274+01142003	
B+277+10282003	
B+278+10262004	-

Figure 24: Outline Code (1)

(2) Then click (Custom...) from the menu to open the Custom AutoFilter

dialog box (Figure 25):





(3) Finally fill out the criterion and click OK to apply the customization.

Repeating (1) - (3) can sort the schedule in different ways:

- (a) Construction schedule Filter out all utility works, and just information of construction projects (Bridge, Interchange, and Soil Nail Wall, etc.) remains.
- (b) Utility schedule Filter out all construction projects, and just information of utility works remains.
- (c) A schedule shows all projects that have the same letting date.
- (d) A schedule shows tied projects:
- (e) A schedule shows all projects that are constructed by one contractor.
- (f) A schedule show only projects that specific Iowa DOT/FHWA personnel would like to review.

An example of a customized schedule the researcher developed for the Iowa DOT is one kind of Construction Schedules (a), as mentioned above. The researcher assigned word "short" to the Level 8 of Outline Codes to all utility relevant projects, including utility project, and then filtered out all projects with "short" in their Outline Codes (as shown in Figure 19. Fill out "does not contain" and "short", then click OK). As a simplified version schedule (researchers call it "Short Version Schedule"), clients can concentrate on construction projects without being disturbed by utility conflicts, which have a lot of uncertain factors.

3.3 Implementation of the Schedule

When the success of the project depends on a group working, it may be vital that each client is able to communicate with one another quickly. Clients can waste valuable time when communications systems are slow or restrictive (for example, the schedule is not published as expected), or they don't know how to use the scheduling software.

Recognizing this, the researcher publishes the schedule every week, and provides training to clients from time to time.

3.3.1 Publishing the Schedule

A schedule is not a schedule until it is published. A published schedule gives a graphic answer to the effect of a delayed start or the delayed completion of any activity. In addition, a schedule that is published for all to see benefits the performance of those involved by exchanging information about their project among clients. Probably one of the best aspects of a published schedule is its impact on clients. It shows clever organization, and that establishes confidence in a client that the schedule can and will perform to expectations.

Starting in January 2002, the researcher has published the schedule to clients via emails every Wednesday. As the researcher keeps updating the schedule, more and more information is added into the schedule. And the size of the schedule file becomes larger and larger. Eventually the schedule file is too big to reach clients because of the size limit of clients' email servers. Realizing that attaching a schedule file to emails and sending it to clients is not an efficient way for electronic file exchange, and also that it is hard to keep the published schedule files for long period of time, in October 2002, the researcher set up a web server at Iowa State University (Figure 26). All I-235 scheduling works are stored in this server. Then a web site (http://erl.cce.iastate.edu/I235) (Figure 28) was developed to show clients latest products. After each updating cycle, an email will be sent to each client reminding that updated schedule files are ready to be downloaded. A link will be provided in the email at the same time. Clicking the link will let the clients download the necessary files whenever they want without worrying about the size of schedule files.

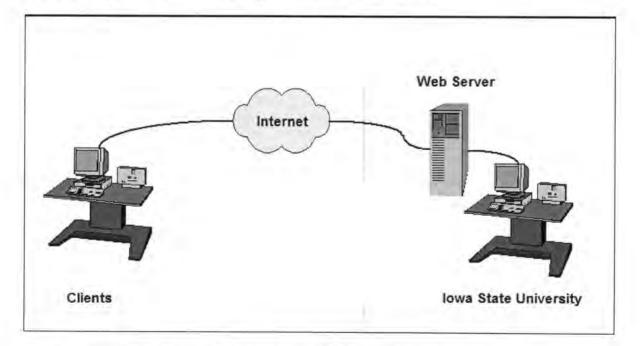


Figure 26: Web-based Publishing of I-235 Schedule

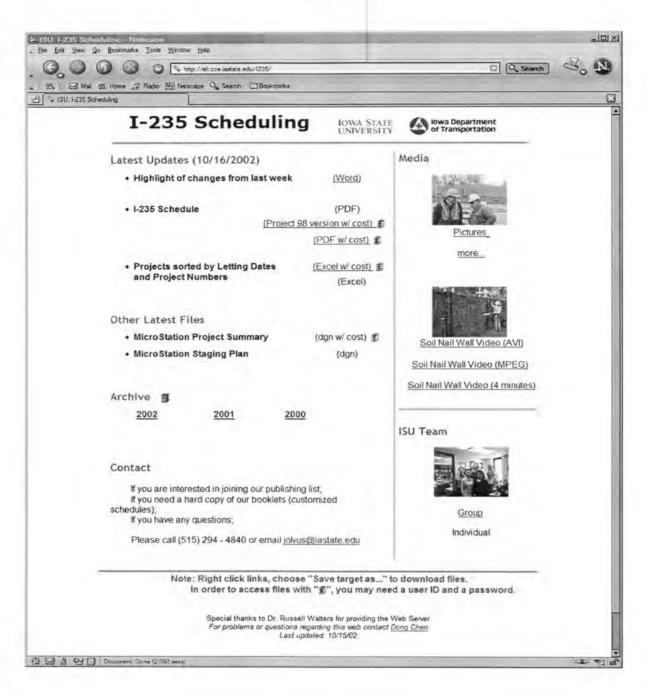
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During the construction of the web server and the web site, the researcher found that several points needed to be considered:

- Safety of the web server. In order to well serve the I-235 project, it is important to protect every single schedule file from hackers, viruses and computer system failures. The researcher chose a computer with a Linux operation system as the I-235 web server. Compared with a Windows server, a Linux server is not vulnerable to hacker attacking and virus infection. Besides the stability of a Linux server is much better than a Windows server.
- Protection of particular files. Iowa DOT cost information in schedule files is sensitive to contractors. Therefore, how to protect these particular files when designing the I-235 web site must be considered. The researcher established a protection mechanism for the web site. In order to access these files, a User ID and a password will be needed (Figure 27). By assigning different clients different User IDs and passwords, the researcher is able to control the accessibility of these sensitive files.

Connect to enic	ce iastale edu	<u>? ×</u>
11		
Restricted to team	members	
User name:	8	•
Password:		
	Remember my passw	orđ
	OK	Cancel

Figure 27: Protection of Sensitive Files.



3.3.2 Training Clients

Training in the use and understanding of a schedule is essential to its effectiveness. Otherwise, a schedule will wind up as a scratch pad in the contractor's truck or a wall decoration in the project manager's office.

The researcher found that the most important and the most sophisticated level of training is for strategic management and planning. This level requires the greatest understanding of the scheduling document. Therefore, a schedule needs to be prepared in plain view so that it effectively communicates the accomplished projects and those upcoming projects.

The researcher begins training by explaining the terminology used in the schedule: projects, milestones, durations, resources and dependency relationships.

Next, the researcher points out that projects typically are listed on the left side of a page (Schedule Layout Part A, Figure 17) and in the order of sections. Summary projects representing multiple detailed subtasks can make a schedule simpler to read. Detailed explanations of columns in the layout are provided.

The time scale (Schedule Layout Part B, Figure 20) for the project is plotted at the top of the schedule, with a unit of measurement (weeks or quarters) clearly stated. Grid lines typically are used for easy viewing. Project durations are represented by the length of the task bar or line, with the beginning of a project directly under the start date on the time scale. Milestones can be shown by task icons. The arrows connecting one project to another represent the dependency relationships. Blue task bars represent construction projects, and green task bars represent utility projects.

Procedures of opening Notes field and how to use project notes are explained in detail.

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Applying Outline Codes to display only projects that meet the criterion clients specify is illustrated.

The researcher gives different emphasis to different clients. For example, training utility personnel focuses more on how to find and use information about utility projects.

Training the users of a schedule will make believers of them. The I-235 schedule includes all important project information, and it is updated every week. As a good project management tool, it improves the clients' ability to manage more construction projects with fewer efforts.

CHAPTER 4: CONCLUSION and RECOMMENDATIONS

4.1 Summary

Keep the project on schedule is one of the most widely understood goals in the construction industry. How does one accomplish this completely subjective statement in a complex highway project like the I-235 Reconstruction? A fully integrated computer-based Program Master schedule should not only be developed, but also should be updated, customized, and implemented on a regular basis. Updating the schedule keeps the schedule with the latest project status; customizing the schedule satisfies clients' different levels of demands; implementing the schedule makes users of it. These three sequential steps help to make management decisions and thus end up helping a project keep on schedule. The objective of this thesis is to detail key elements involved in updating, customizing, and implementing the I-235 schedule.

Updating the schedule – From all information obtained from various sources, the researcher summarizes critical project information such as Letting Date changes, Actual Start/Finish dates, and remaining working time. Then the schedule is updated and checked against the baseline. If schedule conflicts are found, clients will be advised of an alternative construction option, so that they can make corresponding management decisions that will help keep the project on schedule. Project information is also converted into an appropriate format and pasted into the Notes field in Microsoft Project. This is a convenient way to keep track of information related to the schedule.

Customizing the schedule – Based on clients' different expectations, the researcher is able to customize the schedule in different ways. Strategic managers need the specifics shown by including all the summary projects. Division personnel need a schedule showing all subtasks. Contractors need just the portion showing their involvement. The researcher developed a customized schedule layout which can meet general needs from clients. When a specific subset of the information needs to be seen, Custom Outline Codes can be applied to display only the information that meets the filter criterion. As a specially defined interactive filter, the I-235 Custom Outline Codes can be used to create various kinds of schedules from the master schedule for clients.

Implementing the schedule – The researcher has been publishing the schedule to clients via Email since the I-235 project started. Due to the volume of the schedule file, conventional Email would not suffice. A secure, protected web site was set up for the needs of exchanging electronic files while protecting some sensitive files, and storing published schedule files for long period of time. All work wasted if clients don't know how to use the schedule file. Therefore, different trainings were provided to different clients for their special needs. This makes believers and thus users of the schedule.

4.2 Benefits

Updating, customizing, and implementation of a schedule are essential to its effectiveness. By doing this, the researcher is able to:

- Keep the schedule up to date with actual data.
- Compare baseline data to actual data to help identify and solve problems as they occur.

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- Produce status reports for management and project participants.
- Maintain historical data to help plan future projects more accurately.

4.3 Recommendations

It is recommended that future research be accomplished in the following areas:

- Statistical analysis of project data. Conclusions from completed I-235 projects should be drawn to provide guides for the rest of the I-235 projects and national highway renewal projects.
- Links between the schedule file and Iowa DOT design files. Effort should be invested in easing clients' workload by keeping them working with Iowa DOT design files with which they are familiar. Updates in the schedule file can then be transferred to design files automatically.
- Connections between the master schedule and detailed schedules. Further
 investigation should be conducted to connect currently separate detailed schedules
 and the master schedule. Putting all level of project information on a single
 schedule is of great value to management.

APPENDIX A. Iowa DOT Documentations

1. Background of the I-235 Reconstruction Project (Text courtesy

www.l235.com)

Why Rebuild?

The goals of I-235 reconstruction are to improve safety, update the facility to current roadway design standards, reduce congestion, and improve mobility.

Constructed in the 1960s, I-235 is seriously outdated. It reflects 40-year-old design standards, and is wearing out.

- The pavement is beyond its 30-to 40-year life expectancy and rapidly deteriorating.
- Because of their low clearance, bridges are frequently hit by highprofile vehicles.
- Interchanges are too closely spaced.
- The limited number of traffic lanes causes congestion during peak travel periods.
- The highway fails to meet present traffic demands, and those predicted for the future.
- Even with improvements to city streets and other state highways, the area can't handle the projected traffic over the next 20 years.

As the major transportation corridor through the Des Moines metropolitan and state capitol areas, the 14-mile freeway carries significantly more traffic than any other corridor in the state, and is critical to the economic development and growth of the area.

I-235 also has a higher-than-average vehicle crash rate. The crash toll continues to rise, averaging 850 collisions per year along the entire length, including the 21 interchanges. The new freeway could save lives and head off serious crashes.

Planned Improvements

• The rebuilding project will reconstruct I-235 to current design standards.

- At least six through travel lanes (three in each direction) will be built the entire length of the freeway.
- In some sections there will be an additional lane, or four lanes in each direction.
- · The entrance and exit ramps will be lengthened.
- · Bridges with low clearances will be rebuilt.
- The appearance of the corridor will be enhanced with lighting, plants and color variations on the bridges.



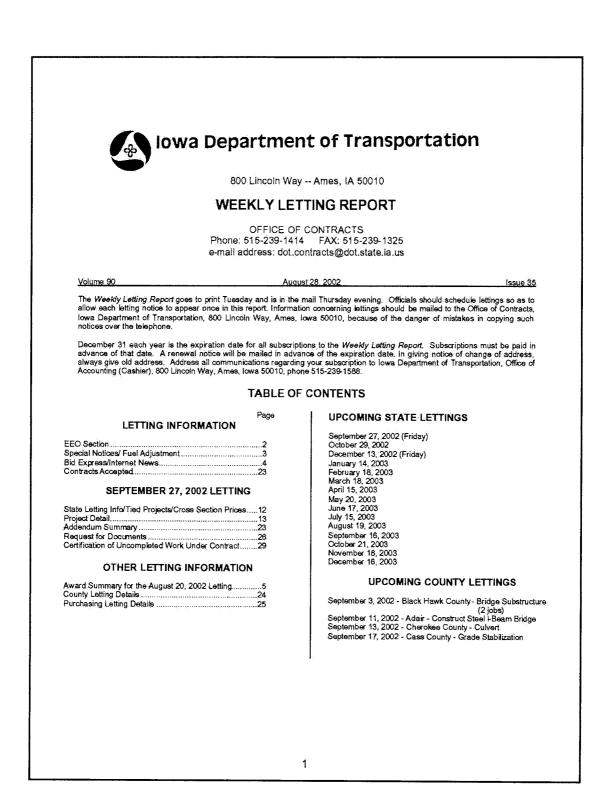
2. I-235 Project Map (Photo courtesy www.l235.com)

3. I-235 staging schedule by year

The general construction timeline for the reconstruction is as follows:

- 2002 ~ 2004: Utility Relocation, Bridge Widening and Replacements, Median Paving, Temporary Paving, Interchange Reconstruction.
- 2005 ~ 2006: Mainline Paving.

4. Iowa DOT Weekly Letting Report



5. Iowa DOT News Release

I-235 News Release

Subject: Iowa DOT News Release - I-235 closures planned for week of Sept. 22

I-235 CLOSURES PLANNED FOR WEEK OF SEPT. 22

DES MOINES, Iowa - Sept. 20, 2002 - There are some closures planned on I-235 the week of Sept. 22 that may affect your travel, according to the Iowa Department of Transportation's I-235 Information Office.

MLK/COTTAGE GROVE BRIDGES Sunday, Sept. 22 9 p.m. - 6 a.m. - The two outside lanes of eastbound I-235 will be closed.

In addition, motorists should not be alarmed by water coming off the bridge in this area as a result of the deck pour Friday, Sept. 20. The deck must be kept wet for the next several days in order for it to cure properly.

28TH STREET BRIDGE IN WEST DES MOINES

Monday, Sept 23

8 p.m. - 6 a.m. - I-235 will be closed for periods of up to 20 minutes throughout the night for placement of bridge beams.

SECOND AVENUE/THIRD STREET INTERCHANGE Friday, Sept. 27

9 a.m. - The Third Street Bridge over I-235 will be closed, and remain closed until the new bridge is completed in June 2003.

7 p.m. - The Second Avenue Bridge over I-235 will be closed, and remain closed until the new bridge is completed in June 2003.

9 p.m. - 6 a.m. - The two outside lanes of I-235 will be closed.

Saturday, Sept. 28

- 9 p.m. midnight The two inside lanes of eastbound and westbound I-235 will be closed.
- Midnight 2 p.m. Sunday, Sept 29 I-235 will be closed. Traffic will be rerouted via signed detours utilizing the on and off ramps in the area.

Sunday, Sept. 29

2 p.m. - 6 a.m. - After the freeway is reopened, some lane closures will be in place until 6 a.m. Monday.

Motorists should expect some short-term closures in other construction areas of I-235 during the week. The times for these have not been determined. When they occur, they will be in place for one to three hours. These closures are needed to move equipment and materials

Information about I-235 work is available on the I-235 Web site at www.i235.com.

Motorists are urged to use caution when driving through the work areas, slow down and obey all construction zone signing.

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Printed for Dong Chen <chdong@iastate.edu>

6. Iowa DOT Contractor Coordination Meeting Minutes

Construction Coordination Meeting August 14, 2002

Present:

Kevin Merryman, Iowa DOT Marty Sankey, Iowa DOT Bob Younie. Iowa DOT Steve Hubler, Iowa DOT Stoney, Iowa DOT Rich Hedlund, Iowa DOT Dirk Zaiser, Iowa DOT Don Glenn, Iowa DOT Kathie Robinson, Iowa DOT Jon Allen, United Contractors Chuck Jahren, ISU Todd Sirolak, ISU Max Groog, FHWA David Van Hauen, Van Hauen & Assoc. Vince Glass, Reilly Construction Jonathan Kipp, Reilly Construction

Wes Musgrove, Iowa DOT Bill Lusher, Iowa DOT Greg Mulder, Iowa DOT Doug Erickson, Iowa DOT Larry Torrence, Iowa DOT John Heggen, Iowa DOT Don Meeker, Iowa DOT Brian Jacob, Iowa DOT Brian Jacob, Iowa DOT Tami Bailiff, Iowa DOT Dan Cramer, Cramer & Assoc. Melissa Leek, ISU Mary Rukashaza, ISU Kyle Danley, DSM Water Works Wayne Hennesett Reilly Construction Justin Lechtenberg, Reilly Construction

Utilities

Kyle Danley reported that Des Moines Water Works is investing a water line leak at a property near E.9th on the north side. If the leak is before the meter, then Des Moines Water Works will replace it. If the leak is beyond the meter, it will become the property owners responsibility. The water line is located in the same area that a broken cover was discovered earlier and it's possible the line was damaged because of construction. It was decided that Kyle report the findings to Kevin and DOT staff will review the findings.

The Day St. project is progressing. Greg reported that one parcel was holding things up, but should be resolved and moved soon.

Guthrie/University

Jon reported that the east pipe should be done by Friday, drive piling will start on Monday and the stone column work is continuing.

E. 21st Street is cracked and is continued to be monitored. Jon asked if it would be possible to close E. 21st again after the Fair to have more room for delivery of supplies. Kevin will review the request after the Fair has ended.

A safety fence should be placed along Maple after removal is done and it was asked if this would be in the way for Reilly. Reilly asked if the fence could be on the north side, but after discussion, it was decided the fence would be placed as much as possible on the north side and the fence would be permanent after the construction is done.

E 6th/E 9th

Jon reported that a lane closure for tonight is scheduled. It will be a double inside lane and would be both east and west bound lanes.

The pier cap on E. 9th will be poured on Friday and the north end of E. 9th will be trimmed this week and ready to be paved next week.

Next week lane closures will be needed to set beams on E. 9th. On Tuesday, Wednesday and Thursday a single outside east bound lane closure will be needed and the Penn Ave on ramp will also need to be closed.

MLK/Cottage Grove

Stoney has received the soil contamination results and has passed on the results and solution to the contractor.

The house at Atkins and MLK has not been removed yet. Stoney has talked to DOT's Property Management office and hasn't heard anything. The parcel number is 375. Kevin will look into it.

Next Tuesday the curb and gutter will be paved and asphalt done on Friday.

The parking lot to the apartment building needs to be finished soon.

Dan Cramer reported the deck on MLK will be poured on Thursday and Tuesday.

Stoney reported that Jensen is having a problem with a slope protection panel and is concerned about the slope moving. Larry Torrence will call Jensen after the meeting.

The Cottage Grove deck should be ready to pour in 2-3 weeks.

Also, there is graffiti on the Cottage Grove bridge beam that needs removed.

42nd/28th Street

John reported that work on 28th St is continuing on the slope protect. There is a hold up on the center pier and they are re-checking the soil.

The Douglas Ave bridge beams on 1 35 are all set.

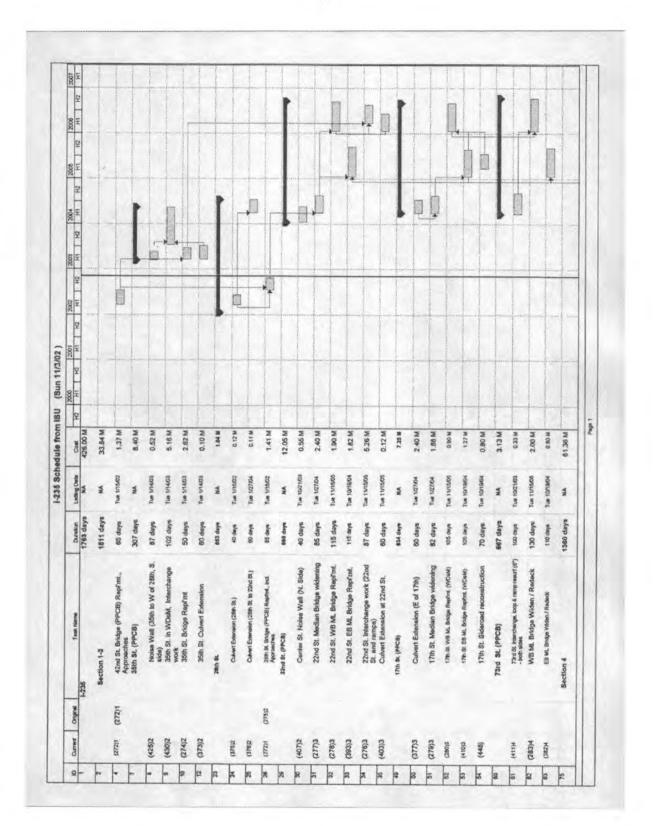
Meeting Adjourned.

APPENDIX B. Iowa State University I-235 Scheduling Products

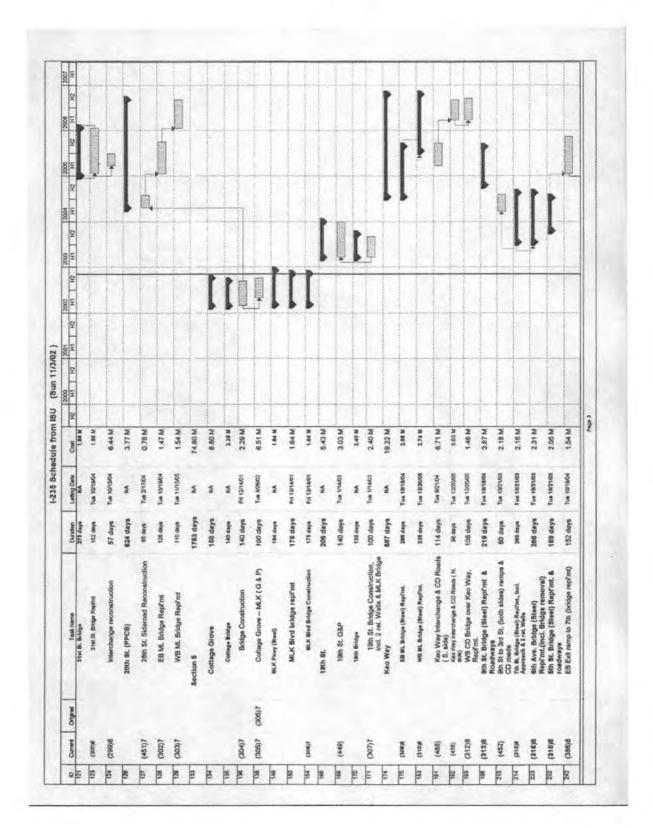
1. Schedule Review Checklist

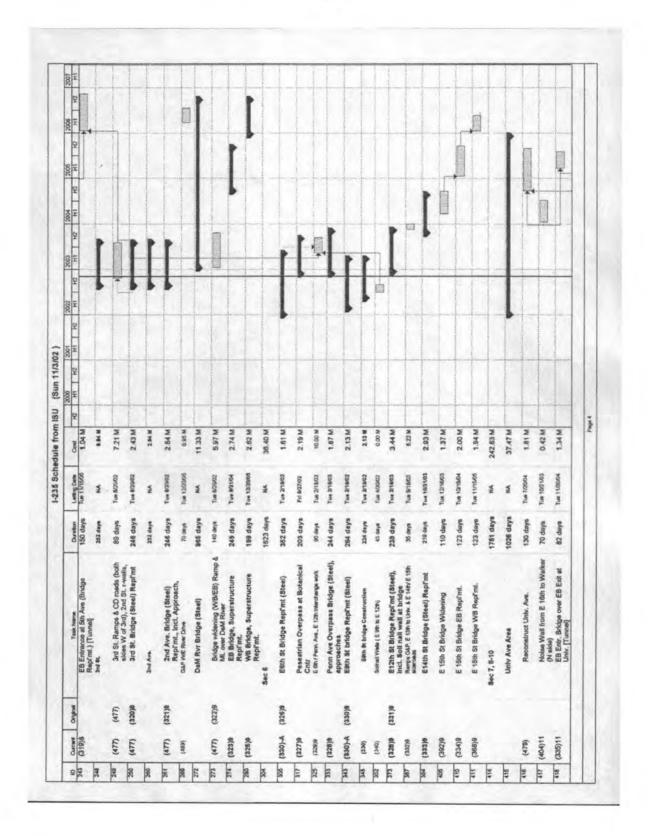
- 1. The project start and end dates have been approved.
- 2. Working time calendars have been adjusted for the project, all groups, and each individual.
- 3. The task list is complete.
- 4. The resource list is complete.
- 5. At least one resource is assigned to each task (except milestones).
- The workload is evenly distributed by resolving any resource overallocations.
- 7. The critical path has been shortened as much as possible.
- 8. Each project link reflects the true project sequence. For example, if two projects can start at the same time, they are linked with a start-to-start dependency.
- 9. No unnecessary constraints have been applied to any projects.
- 10. All unnecessary slack time has been cut from projects, and slack remains only in those parts of the schedule where it's needed.
- 11. Estimated project costs are within budget.

2. I-235 Schedule File (Microsoft Project 2000 version)

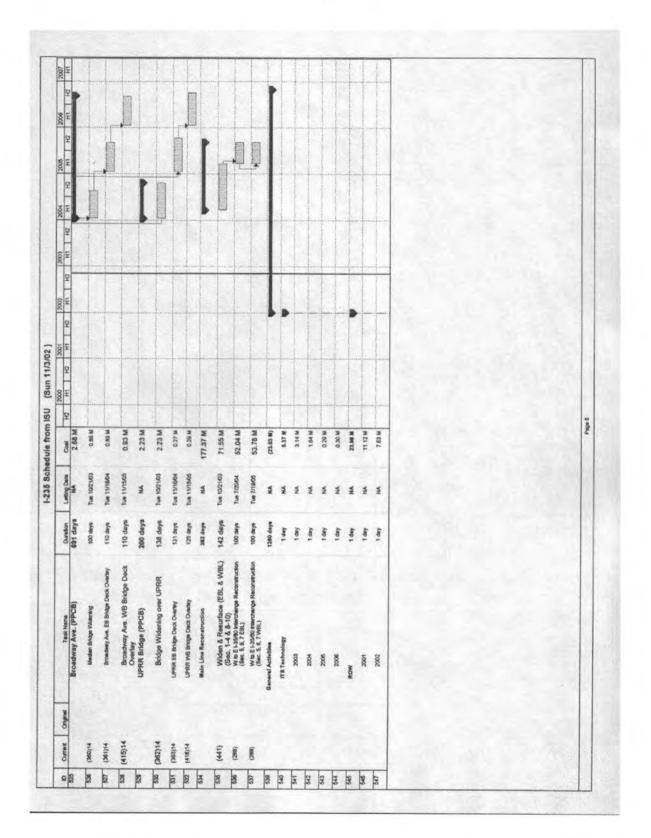


|--|





R2 Baye Imation Imation 13 Baye Imation Imation 28 days Imation Imation 28 days Imation Imation 28 days Imation Imation 13 days Imation Imation 13 days Imation Imation 14 days Imation Imation 15 days Imation Imation 16 days Imation Imation 17 days Imation Imation 18 days Imation Imation 19 days Imation Imation 11 days Imation Imation 12 days Imation Imation 13 days Imation Imation 14 days Imation Imation 15 days Imation Imation 16 days Imation Imation 16 days Imation Imation 16 days Imation Imation 1



3. Highlight of Changes (Word Document)

I-235 Weekly Schedule Update by ISU

08/07/2002

Weekly Construction Coordination Meeting (July 31st, 2002)

1. (272) 42nd/28th St. Bridge (PPCB) Repl'mt. Incl. approaches

- 42nd Street is still waiting for the fencing, which is thought to be delivered about September 1st.
- · July 31 to August 1st: Drilling shafts on 28th Street.
- 2. (304) Cottage Grove Bridge Construction
 - July 31 August 1: Setting beams
 - · Week of August 5th: Need individual lane closures to set over hangs.
- 3. (326) [tied w/ (330)] E 6th St Bridge Repl'mt (Steel)
 - · July 31: Placing the over hang.
 - Eco-Tech is working on the storm sewers and manhole and should be ready to pave on Friday or Monday.
- 4. (340) WB Grading Univ. to Guthrie
 - July 31: The surveyor staked paving this morning and the paving will go 4 meters into the stone columns.
 - E. 21st would be paved and opened by August 8th. On August 1, the rock bed will be put in.
 - St S on E 21 St.:
 - o Storm sewer work should be completed in about 3 weeks.
 - The stone columns are to be put in, but because of the existing storm sewer that is there, the columns can not be done. Discussion followed on how to work this out. It was decided that the contractor needs to send an amended plan showing they will not put in those columns that have the storm sewer near them until the existing storm sewer taken out
- 5. (305) Cottage Grove MLK (G & P)
 - It was asked when A Dong Restaurant will be moving out. DOT has been told they
 have another building to move into by the first of September.

Iowa DOT News Release (August 2nd, 2002)

1. (304) Cottage Grove Bridge Construction

 August 6th - 7th: Lane closures are needed to finish setting beams on the new Cottage Grove Avenue Bridge.

- 2. (326) [tied w/ (330)] E 6th St Bridge Repl'mt (Steel)
 - August 7th 8th: The two inside lanes of both EB and WB I-235 will be closed for work on the bridge deck.

Meeting w/ Jim (08/02/2002):

- 1. (380) WB Exit ramp to Univ. G&P is not a project. This work will be included with (479) Reconstruct Univ. Ave.
- According to IDOT Weekly Letting Report, (473) Traffic Signals Lighting MLK Blvd. & Cottage Grove is no longer tied with (449) 19th St. G&P.
 - · The reason is MLK temporary signals were needed for this stage.

IDOT Letting Report (07/31/2002):

- 1. (328) Penn Ave Overpass Bridge (Steel), approaches
 - Letting date changed from 02/18/2003 to 10/29/2002.
- 2. (331) E12th St Bridge Repl'mt (Steel), incl. Soil nail wall at bridge
 - Letting date changed from 02/18/2003 to 10/29/2002.

3. (483) Pleasant St Sanitary Sewer Relocation

· New project. It is added into the schedule.

4. Excel Spreadsheets

2. Current Pr 3. Orginal Pr	oject # : Pro	ped by Letting Date. ject No. after project is tied. ect No. before project is tied. both Current Project # and Orginal Project #, this project is tied w/ o	ther project(s) *			
Current Project #	Original Project #	Task	Letting Date	Award Cost	Projection Cost (w/ inflation)	Remarks
		2002 Lettings				
(351)11		Noise Wall - Easton to Guthrie (W side)	10/29/02		2.20 M	
(359)13		Euclid Ave. Interchange Resurfacing, Bridge Repl'mt, Euclid Ave. Reconstruction	10/29/02		5.60 M	
(465)8		Storm Sewerilntakes - Birds Run Phase 1 From Des Moines River to 8th & Keo	10/29/02		2.09 M	
(491)		Traffic Signals On Euclid Ave. W & E Ramp Terminals	10/29/02		NA	
(492)		Demolition at Various Locations Parcel No. 93, 105, 110C, 223, 705 221	10/29/02		NA	

		2003 Letting		
(274)2		35th St. Bridge Repl'mt	01/14/03	2.62 M
(294)5		Polk Bivd Bridge Repl'mt, Incl. Part of ret. Wall	01/14/03	2.33 M
(307)7		19th St. Bridge Repl'mt, Incl. 2 ret. Walls & MLK Bridge removal	01/14/03	2.40 M
(373)2		Culvert Extension - 35th St. (W DsM)	01/14/03	0.10 M
(425)2		Noise Wall (35th to 28th, S. side)	01/14/03	0.52 M
(430)2		Reconstruction 35th St. Interchange	01/14/03	5.16 M
(449)8	(449)8	19th St. G&P	01/14/03	3.03 M
(469)2		Bridge Fence - In WDsM E to E 12th St in DsM (8 Bridges)	09/27/02	NA.
(329)9		Ramps & CD Roads between E 6th & E 15th St., incl. Sideroads (E 6th, Penn., E 12 th)	02/18/03	10.00 M
(329)9	(328)9	Penn Ave Bridge Repl'mt (Steel), incl. E 6th Bridge removal	02/18/03	1.87 M
(329)9	(331)9	E12th St Bridge Repl'mt (Steel), Incl. Soil nail wall at bridge	02/18/03	3,44 M
(329)9	(463)11	Sanitary Sewer - Along Lyon St. To E. 13th SL(S. Side)	02/18/03	NA
(341)11		WB Paving - Univ. to Guthrie	03/18/03	2.82 M
(467)		ST S/Intakes Deans Lake outfall. Along UPRR to Deans Lake	06/17/03	4.70 M
(470)		Bridge Fence (63rd, St., 56th St., 31st, St, 9th St., 7th, St., 6th, Ave., E14th St.)	07/15/03	NA
(466)		ST S/Intakes Birds Run Phase II (from DsM River to 8th & Keo)	08/19/03	4.37 M
(286)4		63rd St. Interchange reconstruction	09/16/03	4.93 M
(287)4		63rd St Bridge Repl'mt	09/16/03	2.77 M
(332)9		Ramps G&P, E 13th to Univ. & E 14th/ E 15th sideroada	09/16/03	6.22 M
(423)4		Culvert Extension (0.25 km W of 56th)	09/16/03	0.11 M
(290)6		Pedestrian Overpass at 44th St.	10/21/03	1.86 M
(291)6	-	Pedestrian Overpass E of 42nd St.	10/21/03	1.86 M

I-235 projects sorted by Letting Dates

Current Project #	Original Project #	Task	Letting Date	Award Cost	Projection Cost (w/ inflation)	Remarks
(295)6		42nd Interchange reconstruction	10/21/03		7.68 M	
(296)6		42nd Bridge Repfimt	10/21/03		1.76 M	
(297)6		35th St WB ML Bridge Widening (temporary)	10/21/03		0.33 M	
(315)8		7th St. Bridge (Steel) Repl'mt., Incl. Approach & 2 ret. Walls	10/21/03		2.16 M	
(318)8		6th Ave. Bridge (Steel) Repfmt(incl. Bridge removal)	10/21/03		2.31 M	
(318)8		6th St. Bridge (Steel) Repl'mt., incl. Approach	10/21/03		2.06 M	
(333)9		E14th St Bridge (Steel) Repl'mt	10/21/03		2.93 M	
(338)		University Ave WB Bridge Replacement	10/21/03		6.18 M	
(346)14		WB Bridge over UPRR, Repfimt	10/21/03		1.47 M	
(362)12		Guthrie Ave. Median Bridge	10/21/03		0.94 M	
(356)12		Hull Ave, Median Bridge	10/21/03		1.29 M	
(360)14		Broadway Ave. Median Bridge Widening	10/21/03	1.0	0.86 M	
(362)14		Bridge Widening over UPRR	10/21/03		2.23 M	
(364)0		Noise Wall from 56th St. to 42th St. (S. side)	10/21/03		3.03 M	
(364)0		Noise Wall (63rd Ramp A)	10/21/03		0.96 M	
(364)0		Noise Wall (42th St. Ramp A)	10/21/03		0.99 M	
(364)0		Noise Wall (31st to 29th, both side)	10/21/03		0.96 M	
(372)11		WB ML G&P thru Univ. Int (Incl Bridge over Univ & UPRR, different contractors)	10/21/03		1.38 M	
(379)11		EB Exit ramp to EB Univ G&P	10/21/03		NA	
(404)11		Noise Wall from E 16th to Walker (N side)	10/21/03		0.42 M	
(405)12		Noise Wall - S. of Hull Ave. (E. side, Morton to Sheridan)	10/21/03		0.44 M	
(405)12		Noise Wall - S. of Hull Ave. (W. side)	10/21/03		0.44 M	
(407)2		Center St. Noise Wall (N. Side)	10/21/03		0.55 M	
(411)4		6" Resurfacing of 73rd St. Interchange - both sides	10/21/03		0.33 M	
(441)		ML Widen and Resurfacing (8*) (EB/WB) [RUBBLIZING]	10/21/03		NA	
(452)8		Ramps & CD Roads between 9th St. and DsM R.	10/21/03		2.18 M	
(392)9		E 15th St Bridge Widening	12/12/03		1.37 M	

(277)3	 22nd Median Bridge	01/27/04	2.40 M	
(279)3	17th St Median Bridge	01/27/04	1.88 M	
(375)2	Culvert Extension (28th St. to 22nd St.)	01/27/04	0.11 M	
(377)3	Culvert Extension (E of 17th)	01/27/04	2.40 M	
(451)7	28th St. Sideroad Reconstruction	02/17/04	0.76 M	
(268)	EB ML (incl. Median Fill G&P) (RECONSTRUCTION)	07/20/04	52.04 M	
(479)	 Reconstruction University Ave.	07/20/04	1.81 M	

I-235 projects sorted by Letting Dates

Current Project #	Original Project #	Task	Letting Date	Award Cost	Projection Cost (w/ Inflation)	Remarks
(323)9		DsM River EB Bridge, Superstructure Repl'mt.	09/21/04		2.74 M	
(488)		Keo Way Interchange & CD Roads (S. side)	09/21/04		6.71 M	
(282)4		73rd St EB ML Bridge Widen / Redeck	10/19/04		0.80 M	
(284)4		Walnut Creek EB Bridge Widen / Redeck	10/19/04		2.46 M	
(293)5		56th St Bridge Repl'mt	10/19/04	1.00	2.40 M	
(299)6	_	31st St Interchange reconstruction	10/19/04		6.44 M	
(300)6		31st St. Bridge Repl'mt	10/19/04		1.86 M	
(302)7		28th St EB ML Bridge Repl'mt	10/19/04		1.47 M	
(309)8		Keo Way EB ML Bridge Repfint.	10/19/04		2.88 M	
(313)8	-	9th SL Bridge (Steel) Repl'mt	10/19/04		3.87 M	
(334)9		E 15th St Bridge EB Repi'mt.	10/19/04		2.00 M	
(386)8		EB Exit bridge to 7th, 6th, 5th St, Repl'mt.	10/19/04		1.54 M	
(393)3	:	22nd St EB ML Bridge Repl'mt	10/19/04		1.82 M	
(410)3		17th St EB ML Bridge Repf mt. (WDsM)	10/19/04		1.27 M	
(412)6		25th St EB ML Bridge Repfint	10/19/04		1,45 M	
(448)		17th St. Sidetoad reconstruction	10/19/04		0.80 M	
(453)6		66th St Interchange reconstruction	10/19/04		3.87 M	
(454)5		Culvert Extension (56th St.)	10/19/04		0.11 M	
(335)11		ES Entr. Bridge over EB Exit to Univ.	11/18/04		1.34 M	
(337)11		2 - WB Entr Ramp Bridges from Univ., Repi'mt.(Univ. Ave Area)	11/16/04		1.34 M	
(339)11		Univ. Ave EB Bridge Repf.mt.	11/16/04		4.96 M	
(345)14		EB Bridge over UPRR, RepfmL	11/16/04		2.32 M	
(348)11		E 21 St. EB Bridge Repl'mt Incl. Ramp bridge	11/16/04		1.45 M	
(350)11		Easton EB Bridge (Steel) - New	11/16/04		2.31 M	
(353)12		Guthrie Ave.EB Bridge Repi'mt_	11/16/04		0.96 M	
(387)12		Hull Ave EB Bridge Repl'mt.	11/16/04		1.18 M	
(361)14		Broadway Ave, EB Bridge Deck Overlay	11/16/04		0.89 M	
(363)14		UPRR EB Bridge Deck Overlay	11/16/04		0.27 M	
(381)11		Easton Blvd. & ramps G&P	11/16/04		1.37 M	
(409)4		Cummins Pkwy EB Bridge Repl'mt	11/16/04		1.97 M	

(342)11	Ramp G&P, WB exit to (& entr. From) WB Univ., EB exit to Univ.	01/25/05	1.40 M
(378)11	WB on Ramp from WB Univ- G&P	01/25/05	NA
389)11	Easton to Guthrie Noise Wall (E side)	01/25/05	2.40 M
(269)	WB ML (incl. Median Fill G&P) [RECONSTRUCTION]	07/19/05	53.78 M
(276)3	Reconstruction 22nd St. Interchange (22nd St. and ramps)	11/15/05	5.26 M

I-235 projects sorted by Letting Dates

Current Project #	Original Project #	Task	Letting Date	Award Cost	Projection Cost (w/ inflation)	Remarks
(278)3		22nd St WB ML Bridge Repl'mt.	11/15/05		1,90 M	
(280)3		17th St WB ML Bridge Repfint. (WDsM)	11/15/05		0.90 M	
(283)4		73ed St WB ML Bridge Widen / Redeck	11/15/05		2.00 M	
(285)4		Walnut Creek WB Bridge Widen / Redeck	11/15/05		2.72 M	
(298)6		35th St WB ML Bridge Replimt	11/15/05		2.13 M	
(303)7		28th St WB ML Bridge Repl'mt	11/15/05		1.54 M	
(319)8		EB Entrance between 5th Ave. & 4th St. Bridge Repl'mt.	11/15/05		1.04 M	
(368)9		E 15th St Bridge WB Repl'mt.	11/15/05		1.94 M	
(403)3		Culvert Extension at 22nd St.	11/15/05		0.12 M	
(414)12		Hull Ave. WB Bridge Repl'mt.	11/15/05		1.23 M	
(415)14		Broadway Ave. WB Bridge Deck Overlay	11/15/05		0.93 M	
(415)14		UPRR WB Bridge Deck Overlay	11/15/05		0.29 M	
(487)		35th St. sideroad reconstruction	11/15/05		0.48 M	
(289)4	11.000	Cummins Pkwy WB Bridge Repl'mt	12/20/05		2.13 M	
(310)8		Keo Way WB ML Bridge RepfmL	12/20/06		2.74 M	
(312)8		WB CD Bridge over Keo Way, Repf mt.	12/20/06	12.254	1.46 M	
(325)9		DsM River WB Bridge, Superstructure Repfint.	12/26/05		2.62 M	
(413)12		Guthrie Ave WE Bridge Repf mt.	12/20/06		1.01 M	
(455)8		Keo Way Interchange & CD Roads (N. side)	12/20/06		5.63 M	
(489)		G&P W/E River Drive	12/20/05	1.1.1.1.1.1.1	0.96 M	

2001 Lettings							
(304)7	Cottage Grove Bridge Relocation, incl. Bridge removal	12/14/01	2.29 M	2.46 M	Previously Lat		
(306)7	MLK Blvd bridge repl'mt	12/14/01	1.64 M	2.07 M	Previously Let		

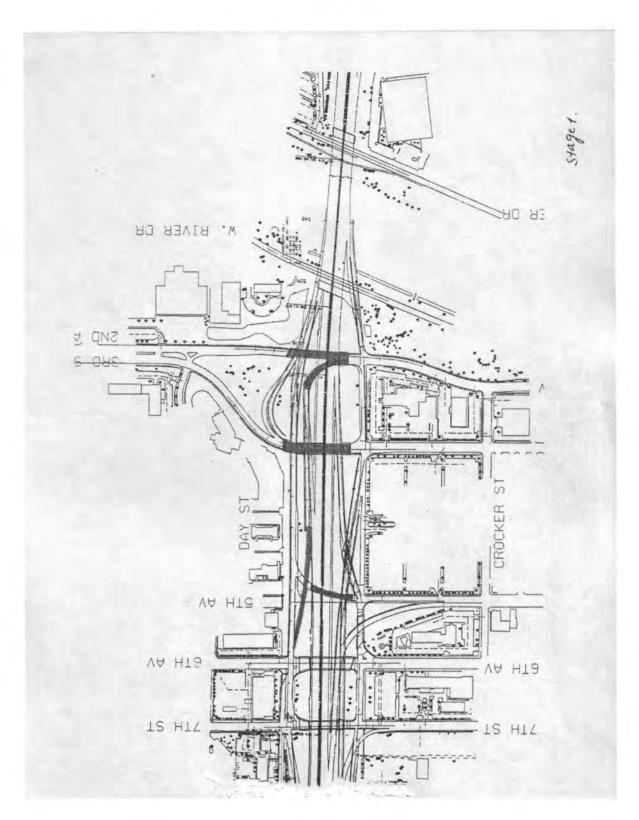
		2002 Lettin	gs			
(272)1	(272)1	42nd St. Bridge (PPCB) Repl'mt., Incl. Approch	01/15/02	1.37 M	1.48 M	Previously Lat
(272)1	(275)2	28th St. Bridge (PPCB) Repfint., incl. Appro.	01/15/02	1.41 M	1.45 M	Previously Let
(272)1	(375)2	Culvert Extension (28th St.)	01/15/02	0.12 M	0.10 M	Previously Let
(330)-A	(326)9	E6th St Bridge Repl'mt (Steel)	02/19/02	1.61 M	1.46 M	Previously Let
(330)-A	(330)9	E9th St bridge Repl'mt (Steel)	02/19/02	2.13 M	2.57 M	Previously Let
(305)7	(305)7	Cottage Grove - MLK Blvd G&P	03/26/02	6.51 M	5.30 M	Previously Let
(305)7	(475)8	Water Work @ Cottage Grove	03/26/02	NA	NA	Previously Let
(458)		Storm Sewer @ Maple	03/26/02	1.02 M	NA	Previously Let
(468)		Bridge Fence - E 6th	03/26/02	0.49 M	NA	Previously Let
(474)		Water Work @ Washington Ave.	03/26/02	0.11 M	NA	Previously Let
(476)		Demo, Parcel 470	03/26/02	0.02 M	NA	Previously Let

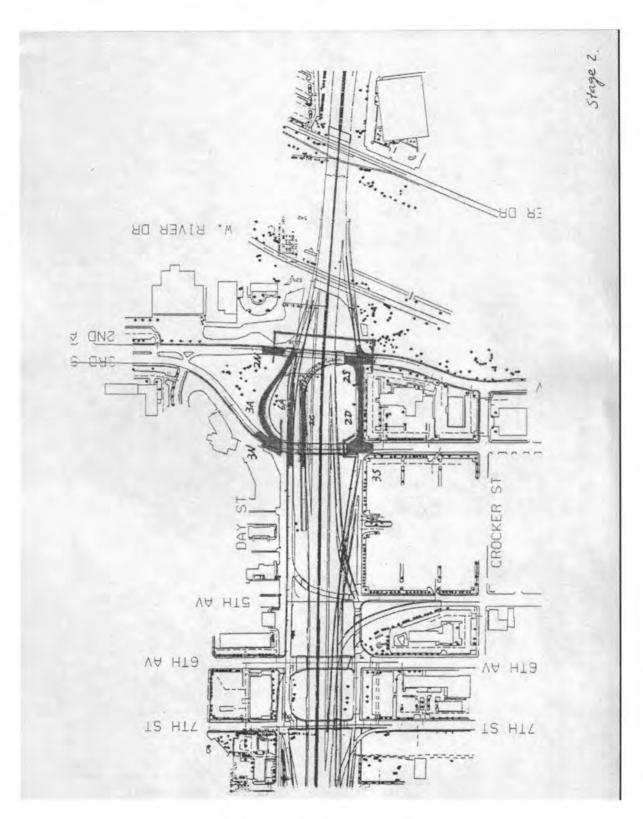
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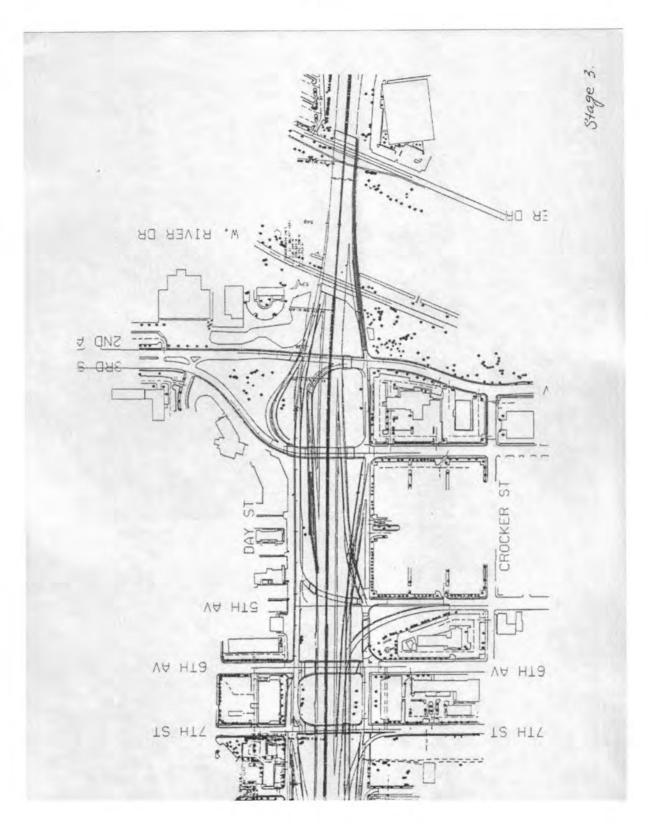
Current Project #	Original Project #	Task	Letting Date	Award Cost	Projection Cost (w/ inflation)	Remarks
(478)		Demo Parcel 003-007	03/26/02	0.03 M	NA	Previously La
(340)11	(340)11	WB Grading - Univ. to Guthrie, Incl. Ret. Walls (E 9th to E 14th)	04/30/02	9.08 M	5.70 M	Previously Le
(340)11	(344)11	WB Exit at Univ, Bridge (over RR) Replimt.	04/30/02	0,96 M	0.77 M	Previously Le
(340)11	(347)11	E 21 St. WB Bridge (PPCB)Repl'mt.	04/30/02	0.54 M	1.09 M	Previously Le
(340)11	(349)11	Easton WB Bridge (Steel) - New, Incl. Pedestrian Overpass at Washington, Removal	04/30/02	0.95 M	2.06 M	Previously Le
(340)11	(406)12	Traffic Signals - at Guthrie Ave. (Ramp Terminais)	04/30/02	NA	NA	Previously Le
(340)11	(472)11	Sanitary Sewer - Near Easton Blvd. & E 21 St.	04/30/02	NA	NA	Previously Le
(456)12	1	Sanitary Sewer - On Thompson/Tichenor St.	06/04/02	0.37 M	NA	Previously La
(462)10		Sanitary Sewer - At East High School & E. 14th St.	06/04/02	0.21 M	NA	Previously Le
(482)		Demo 1050 16th, 1030 17th, 1701 WALKER, Des Moines. Specific locs are shown elsewhere in the contract documents	06/04/02	NA	NA	Previously Le
(460)8		Sanitary Sewer - Along School St From Keo To 18th St. (S. 5ide)	07/16/02	0.47 M	NA	Previously La
(461)8		Sanitary Sewer - Along Day St. From Keo To MLK(N. Side)	07/16/02	0.75 M	NA	Previously Le
(484)8		Demolition - 1055 MLK & 1034 17th St, DsM.	07/15/02	NA	NA	Previously La
{473}7		Traffic Signals Lighting - On MLK Bivd. & Cottage Grove	08/20/02	0.19 M	NA	Previously Le
(477)8	(320)8	3rd St. Bridge Repf'mt	08/20/02	*****	2.43 M	Previously Le
(477)8	(321)9	Znd Ave. Bridge Repl'mt, incl. Approach, School St. (3rd to DsM river)	08/20/02		2.64 M	Previously La
(477)8	(322)9	Bridge widening (WB/EB) Ramp & ML over DsM River	08/20/02	16.78 M	5.97 M	Previously La
(477)8	(477)8	Pavement(Replace) - At 2nd Ave,/3rd St. & Ramps	08/20/02		7.21 M	Previously Le
(477)8	(485)	Roadway item @ 2nd Ave/3rd St. & ramps	08/20/02			Previously Le
(486)		Demolition - in Des Moines at various locations. Parcel no. 60, 100b, 100c, 104, 111 & 406	08/20/02	0.04 M	NA	Previously La
(327)9	Sec. 20	Pedestrian Overpass at Botanical Cntr	09/27/02	2.06 M	2.19 M	Previously La
(490)		Demolition at River Hills APTS, 6th St & Easton, DsM.	09/27/02	0.03 M	NA	Previously Le

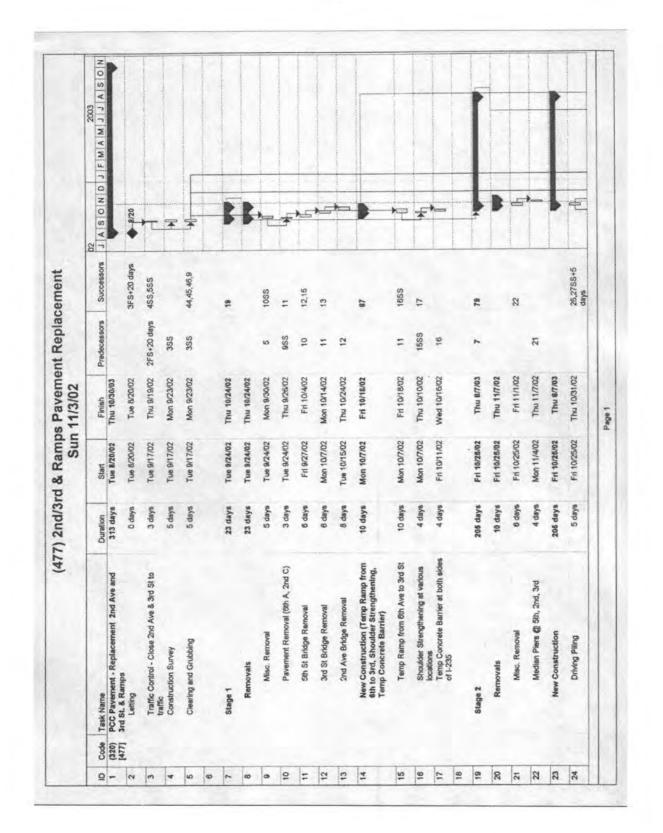
1-235 projects sorted by Letting Dates

5. Detailed Schedule of 2nd and 3rd Ramps Pavement Replacement



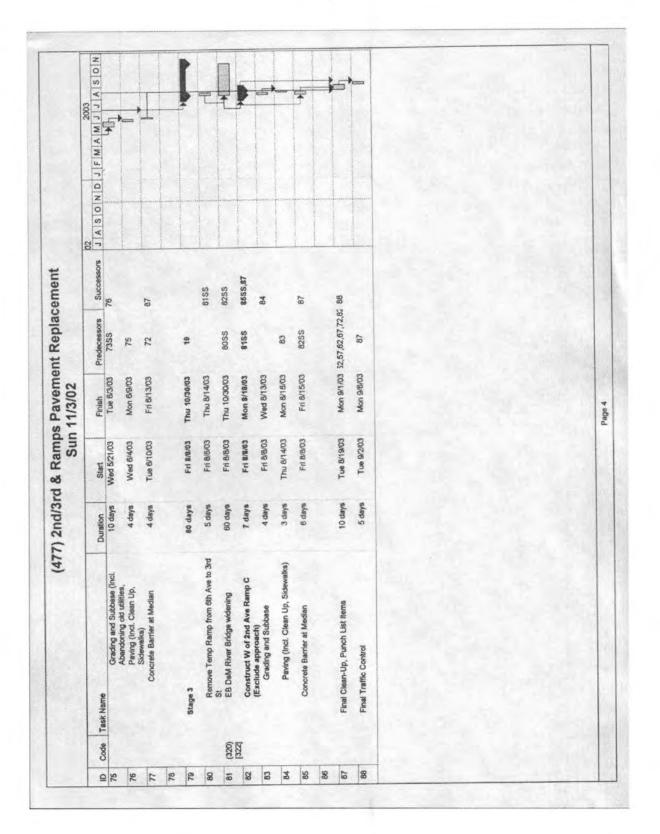






	Cruta Tack Manua		Disation	Start	Finish	Predecessors	Successors	02 2003 J A S O N D J F M A M J J A S O N
'	-	MSE Wall near 2nd Ave Bridge	20 days	Fri 11/1/02	Thu 11/28/02	24	28	
CI	(320)	Construction of 2nd Ave Bridge	180 days	FH 11/29/02	Thu 8/7/03	12		
		Driving Piling	5 days	Fri 11/1/02	Thu 11/7/02	24SS+5 days	28	
	-	MSE Walls near 3rd St Bridge	15 days	Fri 11/8/02	Thu 11/28/02	27	29	
01	(320)	Construction of 3rd St Bridge	160 days	Fri 11/29/02	Thu 7/10/03	28	30SS+20 days	
	Inve	Transmission circuit outages for the	3 days	Fd 12/27/02	Tue 12/31/02	2955+20 days	31	
01	(320)	Droge construction WB DsM River Bridge widening	60 days	Wed 1/1/03	Tue 3/25/03	30		
inter	3N	Construct 3rd St from N end to	14 days	Fri 10/26/02	Wed 11/13/02		87,37	
		the Bridge Approach Install Storm Sewer	4 days	Fri 10/25/02	Wed 10/30/02		34,3555	
		Install Intakes and Martholes	4 days	Thu 10/31/02	Tue 11/5/02	8		
		Grading and Subbase (Incl.	10 days	Fri 10/25/02	Thu 11/7/02	3355	36	
		Abarroonarg od utimes, Paving (inci. Clean Up,	4 days	Fri 11/8/02	Wed 11/13/02	35		
	35	Sidewaiks) Construct 3rd St from S end to	14 days	Thu 11/14/02	Tue 12/3/02.	32	87,42	
		the Bridge Approach Install Storm Sewer	4 days	Thu 11/14/02	Tue 11/19/02		39,40SS	
		Install Intakes and Manholes	4 days	Wed 11/20/02	Mon 11/25/02	38		
		Grading and Subbase (Incl.	10 days	Thu 11/1 4/02	Wed 11/27/02	3855	41	
		Abandoning old utilities, Paving (Incl. Clean Up.	4 days	Thu 11/28/02	Tue 12/3/02	4		
		Utility Work near 2nd Ave	43 days	Wed 12/4/02	Fri 1/31/03	22	47	
		Mid American Gas	10 days	Wed 12/4/02	Tue 12/17/02		4555	
		Sta 10+00 to Sta 10+50 - Open	10 days	Mon 1/20/03	Fri 1/31/03	5,45	52,57	
		Cut Sta 10+50 to Sta 11+68 - HDD	33 days	Wed 12/4/02	Fn 1/17/03	5,4355	62,67,44,46	
		w/ Casing Sta 11+68 to Sta 12+05 - Open	10 days	Mon 1/20/03	Fri 1/31/03	5,45	47	
	2N	Cut w/ Casing Construct 2nd Ave from N and to	14 days	Mon 2/3/03	Thu 2/20/03	46,42	87,62	
89		the Bridge Approach Install Storm Sewer	4 days	Mon 2/3/03	Thu 2/6/03		49,5055	
		Install Intakes and Manholes	4 days	Fri 2/7/03	Wed 2/12/03	48		

								m 2003
Code	Task Name		Duration	Start	Finish	Predecessors	Successors	ASONDJFMAM
		Grading and Subbase (Incl. Abardoning old stitities	10 days	Mon 2/3/03	Fri 2/14/03	48SS	51	-
		Paving (Incl. Clean Up,	4 days	Mon 2/17/03	Thu 2/20/03	8		
25		Construct 2nd Ave from 5 end to	14 days	Fri 2/21/03	Wed 3/12/03	14,47	87,57	
		Ine Bridge Approach inetall Storm Sewer	4 days	Fri 2/21/03	Wed 2/26/03		54,5555	
		tristali Intakes and Manholes	4 days	Thu 2/27/03	Tue 3/4/03	83		
		Grading and Subbase (Incl.	10 days	Fri 2/21/03	Thu 3/6/03	5355	8	
		Paving (Incl. Clean Up,	4 days	Fn 3/7/03	Wed 3/12/03	8		
30		Construct 2nd Ave Ramp D	14 days	Thu 3/13/03	Tue 4/1/03	44,62	87,62	
		(txciude approacn) Install Storm Sewer	4 days	Thu 3/13/03	Tue 3/18/03		88,6055	
		install intakes and Manholes	4 days	Wed 3/19/03	Mon 3/24/03	33		
		Grading and Subbase (Incl.	10 days	Thu 3/13/03	Wed 3/26/03	5855	61	
		Abandoning old utilities, Paving (Incl. Clean Up,	4 days	Thu 3/27/03	Tue 4/1/03	8		
3A		Sidewalks) Construct 3rd St Ramp A	14 days	Wed 4/2/03	Mon 4/21/03	45,67	87,67	
		(Exclude approach) Install Storm Sewer	4 days	Wed 4/2/03	Mon 4/7/03		64,6555	
		Install Intekes and Manholes	4 days	Tue 4/8/03	Fri 4/11/03	8		
		Grading and Subbase (Ind.	t0 days	Wed 4/2/03	Tue 4/15/03	6355	99	
		Abandoning old utilities, Paving (ind. Clean Up.	4 days	Wed 41603	Mon 4/21/03	8		
6A		Sidewalks) Construct 8th St Ramp A	21 days	Tue 4/22/03	Tue 6/20/03	46,62	87,72	
		(Exclude approach) Install Storm Sewer	5 days	Tue 4/22/03	Mon 4/28/03		69,7055	
		install intakes and Manholes	5 days	Tue 4/28/03	Mon 5/5/03	68		
		Grading and Subbase (Incl.	15 days	Tue 4/22/03	Mon 5/12/03	6855	11	
		Abandoning old unities, Paving (Incl. Clean Up,	6 days	Tue 5/13/03	Tue 5/20/03	22		
20		Sidewatks) Construct 2nd Ave Ramp C	14 days	Wed 6/21/03	Mon 6/8/03	67	87,77	
		(Exclude approach) Install Storm Sewer	4 days	Wed 5/21/03	Mon 5/25/03		74,7555	
		Install Intakes and Manholes	4 days	Tue 5/27/03	Fri 5/30/03	13		



APPENDIX C. Procedures of Creating an Outline Code

Text courtesy Microsoft Project 2000.

- 1. Open the program Microsoft Project.
- On the View menu, click a sheet view that contains the tasks or resources you want to organize with an Outline Code, such as the Task Sheet or Resource Sheet.

To use a view that is not on the View menu, click More Views, click the view you want to use in the Views list, and then click Apply.

- 3. On the Tools menu, point to Customize, and then click Fields.
- 4. Click the Custom Outline Codes tab.
- 5. Under Outline Code, click Task or Resource, and then click the Outline Code you want to define, such as I-235 Outline Code.
- 6. Click Rename.
- 7. In the New name for box, type a name for the custom Outline Code you want to create, and then click OK.
- 8. Click Define Code Mask.
- 9. To specify the Outline Code for first-level tasks or resources, in the Sequence column, select the character type.
 - Click Numbers to show a numerical Outline Code for this level.
 - Click Uppercase Letters to show uppercase alphabetical Outline Codes; for example, A, B, and C for the first three summary tasks in the project.
 - Click Lowercase Letters to show lowercase alphabetical Outline Codes; for example, a, b, and c for the first three summary tasks in the project.
 - Click Characters to show any combination of numbers and uppercase and lowercase letters; for example, Arch1, Const1, and Insp1 for the first three summary tasks in the project. Choosing characters gives you the most flexibility for entering customized Outline Codes.

Microsoft Project displays an asterisk (*) in the Outline Code field until you define a string of characters for this level of the Outline Code.

10. In the Length column, select the number of characters you want to use in the first-level Outline Code.

For example, type 3 to make three characters the mandatory number of characters to enter in this level of the Outline Code. The total length of an Outline Code can be up to 255 characters.

11. In the Separator column, type or select the character you want to use for separating Outline Code levels.

By default, the separator character is a period.

Tips

- You can specify different separator characters for each code level.
- You can type other separator characters, such as an ampersand (&) or a number sign (#).
- You can display code levels without a separator character. In the Separator column, select the character, and then press DELETE.
- 12. Repeat steps 6-8 for each Outline Code level you want to specify.
- 13. To restrict Outline Codes to those with values in all levels of the Outline Code mask you have defined, select the Only allow new codes with values in all levels of mask check box.

When you select this check box and Outline Codes without a value in each level of the Outline Code mask are entered, Microsoft Project displays a message stating that the Outline Code is not valid.

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