IOWA DEPARTMENT OF TRANSPORTATION

Highway Location Reference Procedure Project

FINAL REPORT

June 28, 1990

By

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TABLE OF CONTENTS

SECTION I - INTRODUCTION

// The purpose of the proposed Highway Location Reference Procedure is stated in the contract as follows:

> "Establishment of a highway network locational reference process that will primarily allow for the proper correlation of pavement management data, and secondarily provide the basis for other existing and future data base integration and for the planned Iowa DOT Geographic Information System. In addition, the locational reference process will be able to correlate network applications with a statewide spatial location method to facilitate the relationship of Iowa DOT data to that of other agencies and to allow for the graphic display of the network in map form." //

The Design Specifications and Implementation Plan, included in this Final Report, are intended to provide the basis for proceeding with immediate development and implementation of the pavement management system. These specifications will also support the future Iowa DOT implementation of other integrated data bases and/or the planned Geographic Information System.

PROJECT BACKGROUND

The Highway Location Reference Procedure (HLRP) project was initiated March 12, 1990. Initial information was provided to CWB prior to the first visit to Iowa. Over 30 interviews were conducted by CWB over three one-week visits to Iowa. CWB interviewed personnel from all of the Divisions within the Iowa DOT and personnel from the Iowa DNR. Each interview was summarized by CWB and presented to the DOT for review and comments. The summaries were then updated to reflect those comments.

A Statement of Understanding of the current conditions was prepared which is a distillation of the interviews, materials provided and many telephone conversations. This document, along with several appendices, was presented to the DOT in draft form. Review comments were included in the Final Statement of Understanding and the document was accepted by the DOT.

CWB then prepared a Recommendation document that addressed the issues raised to date. The 19 recommendations were based on the premise that correlated linear and spatial reference systems are needed. A second premise considered that an adequate linear reference system can be accomplished with modifications and expansions to the current milepost/milepoint reference scheme. The recommendations were presented to the DOT in draft form. Review comments were included in the Final Recommendations and the document has been accepted by the DOT.

Recommendations 1 through 8, 10, 11, 12, and 18 are considered to be within the scope of the HLRP project. This Final Report discusses the Design Specifications and the Implementation of the recommendations in detail in later sections. The remaining recommendations were identified in the progress of the project and are offered for DOT consideration. These recommendations are also discussed conceptually in later sections of this document.

REFERENCED DOCUMENTS

The Final Report, including Design Specifications and Implementation Plan, is considered to be the culmination of the HLRP project. However, other project documents are important and are referenced throughout this Report. The following is a list of these referenced documents:

+ Contract No. 00301 - Parties: State of Iowa, Department of Transportation and C. W. Beilfuss & Associates, Inc.

+ Interviews conducted week of 19 Mar 90

+ Interviews conducted week of 19 Mar 90 (revised week of 16 Apr 90)

+ Interviews conducted week of 9 Apr 90

+ Interviews conducted week of 9 Apr 90 (revised week of 7 May 90, including interview conducted 2 May 90)

+ Statement of Understanding of the Current Conditions - final version 7 May 90

+ Appendices to the Statement of Understanding - final version 1 Jun 90

+ Final Recommendations - 1 Jun 90

REPORT ORGANIZATION

Section II of this report describes the proposed reference system and Section III the proposed roadway network segmentations. Section IV discusses the proposed pavement management system. The Design Specifications and Implementation Plan are discussed in detail in Section V. Section VI discusses additional recommended improvements.

DOT COMMITMENT

The Iowa DOT must make several commitments to ensure the success of the HLRP project. Specifically, the DOT must make commitments for the following:

+ A comprehensive reference system
+ Timely and regulated updates to the reference system
+ Correlation of all route segmentations
+ Complete coordination of geographically based data
+ A firm interagency working relationship

In conclusion, it is extremely important that the DOT be committed to maintaining the reference system once it is implemented. It is equally important that established procedures be communicated throughout the DOT.

BENEFITS OF THE PROPOSED REFERENCE SYSTEM

This project, in accordance with its goals, has produced proposed improvements for locational reference and pavement management systems. These improvements were needed for pavement management purposes and for future GIS implementation. These improvements provide a common locational reference for the highway, taking into account the various data collection methods that exist within the Iowa DOT.

The highway location reference process provides consistent unambiguous data for pavement management. The improvements eliminate discrepancies and hinderances and provide for smoother and more reliable rating activities. They provide the basis for savings that accrue from informed strategic planning regarding construction and maintenance expenditures.

The proposed reference process also provides correlated linear, spatial, and segmental reference procedures that provide a good basis for implementing any GIS software that the Iowa DOT may choose. It also facilitates transfer of geographic based data to and from

other state agencies. The proposed process (implementated for pavement management) reduces the cost of future GIS implementation and transfer of data between state agencies.

In addition, the proposed highway location reference procedure will support:

- New Iowa DOT applications requiring locational reference

  For example, the need for revision of current systems which provide construction and maintenance cost data has been identified. Such revisions could take advantage of the proposed reference procedure.

- Interface with TIGER files

  TIGER files are geographically encoded census files which are being produced from 1990 census data. The proposed reference procedure will support a convenient and reliable interface with these files.

- Interface with other addressing systems

  There are current and proposed systems for rural residence addressing. To the extent that such systems are geographically based, the proposed reference procedure will lend itself to interfacing with such systems.

- Applications needing complete network descriptions of the highway system.

  Applications such as permit routing, interactive display of pavement ratings, or construction conditions; and various research activities could be enhanced by making use of the highway network established as a part of the reference procedure.

The proposed pavement management improvements enhance the reliability and consistency of current procedures. They facilitate interaction between the offices involved in pavement management and serve to consolidate activities into the same computer systems. A significant result will be a pavement history data base which provides ready access to pertinent historical data. This data may be used in continuing efforts to improve routing and projection techniques. It may also be used to investigate performance pursuant to improved design procedures.

In summary, the results of the project provide the foundation for effective statewide pavement and other highway management information systems. The results also provide the means to correlate and exchange information between the Iowa DOT and other agencies that might locate their information by spatial means.

SECTION II - PROPOSED REFERENCE SYSTEM

A robust Highway Location Reference Procedure must provide a common and precise location scheme for data which can be located along, or on, the road network, but which may have been referenced by different measuring schemes. In addition, the locational reference process must be able to correlate network locations with a state-wide spatial location method to facilitate the relationship of Iowa DOT data to that of other agencies and to allow for the graphic display of the network in map form. The location reference of the data must be unique and unconditionally repeatable, regardless of the data collection procedures or changes in the network over time.

A robust procedure must also include the following elements:

+ The method or methods of expressing the location (either geographically or along the route) of physical features, data or assigned positions.

+ The conventions required to state locations and interpret statements of location.

+ The processes required to convert between alternate location methods.

+ The procedures required to update and maintain the reference system and notify all concerned of pertinent changes.

The proposed reference system meets these requirements and contains these elements.

CURRENT REFERENCE SYSTEMS

Three specific categories of reference systems are being used currently within the Iowa DOT - Linear, Spatial and Segmental. Each of these categories and the specific types of reference system within each category is discussed in detail in the Statement of Understanding of the Current Conditions. Briefly, the DOT currently uses three types of linear reference schemes - Milepost, Milepoint and Stations. Likewise, the DOT uses four spatial schemes - Latitude-Longitude, Accident Nodes, Political Subdivision and X-Y Cartesian Coordinates. Segmental reference schemes are employed in the base records, the pavement management IPMS results and the accident records.

All of the current reference procedures and methodologies will be retained in the proposed reference system; but some modifications will be required. The most significant change involves the Milepost referencing scheme and the addition of a comprehensive cross-reference scheme.

PROPOSED HIGHWAY LOCATION REFERENCE PROCEDURE

The proposed Highway Location Reference Procedure includes the same categories of reference systems as currently employed within the DOT - Linear, Spatial and Segmental. All three of these systems will be completely correlated in the proposed scheme. This correlation is considered to be essential to addressing the combined needs of the DOT and the DNR.

Linear

Linear systems reference information by distance from some reference point along a route. Distances can be measured in miles, feet, or stations and fractional parts of these units. The Iowa DOT has extensive data that is referenced in this fashion along routes in the highway system. The DOT currently uses three types of linear reference schemes - Milepost, Milepoint, and Stations. (Stations will continue to be an informal reference system.) The proposed system uses the same schemes; the difference lies in the implementation.

Mileposts

The Iowa DOT's current mileposting scheme was initiated in 1973. Mileposts are physical entities set along side the route at approximate one mile intervals. Mileposts for each route begin at the state line or beginning of the route and proceed incrementally from south to north or from west to east. All primary roads (interstate, US numbered routes, Iowa numbered routes and some unnumbered primary routes) are mileposted. Secondary roads, ramps and connectors, municipal roads, and park and institutional roads are not mileposted at this time.

Mileposts are a very valuable reference system for the Iowa DOT. They are easy to identify in the field and are convenient reference markers. Most of the reported problems regarding mileposts reflect the way they are used. The proposed reference procedure eliminates "fractional milepost values" as a reference system and replaces the practice with a milepost and displacement nomenclature for locational reference purposes; mileposts should be thought of as monuments. Displacement (positive or negative) along the route from the monument precisely defines a location. In essence, the user would identify positions along the route by referencing the nearest milepost, then measuring the distance (positively or negatively) from the milepost. The position would be reported as milepost number plus or minus displacement; for

example: 12 + 0.33 or 14 - 0.21. To determine distance between two reported positions, the new milepost/milepoint/segmental cross reference scheme, discussed later, would be used.

Publications which use the "fractional milepost" nomenclature will be reissued to reflect the milepost and displacement scheme. These publications include the following:

+ Milepost Maps (Office of Maintenance)

+ Test Sections by Milepost (Office of Materials)

+ Maintenance Area Responsibility Maps (Office of Maintenance)

All reporting in the field will reflect the new scheme. Likewise, all mileages or section lengths reported in these publications will be calculated using the new milepost/milepoint/segmental cross reference scheme. The Milepost Policy and Procedure document describes the use, purpose, and reestablishment procedures for mileposts.

Pavement management sections will be revised to reflect the new referencing scheme as well. Likewise, all computer processes which use fractional mileposts either as input or output will be revised to reflect the new scheme. This will also require file modifications to accommodate the two component milepost references. The Office of Maintenance will mark duplicate posts with some kind of identifier to uniquely differentiate the two. Possibly duplicate milepost 112, for example, could be designated 112X. Milepost equations are no longer relevant so equations will be eliminated.

Milepoint

The current Iowa DOT milepoint reference scheme was inaugurated in the early 1980's to correlate accident nodes and mileposts in the base records. Milepoints are not physical markers. Milepoints begin at the county line or beginning of route and proceed south to north or west to east, and reflect distance from the county line or beginning of route. There is no change in the milepoint reference scheme in the proposed reference procedure. A more comprehensive cross reference scheme, discussed later, is the only impact.

Stations

Stations are used in construction (and reconstruction) and are physically indicated on most highways (every five stations or 500 feet) by either a stamp in the pavement (concrete pavement) or a post with placard (A. C.pavements). Stations are often used

as an informal reference scheme, but are not used for reporting by offices such as Maintenance, Materials or Transportation Inventory. There is no change in the way stations are used in the proposed reference procedures.

Milepost/Milepoint/Segmental Cross Reference

The Milepost/Milepoint/Segmental Cross Reference process is essential to the proposed reference procedure. This process will be used exclusively for all differential mileage calculations. The new process will accommodate the milepost and displacement nomenclature and will take milepoint discontinuities into account. See Section V for a description of the implementation methodology.

Spatial

Spatial systems reference information in two or three dimensions and are generally used in all mapping and GIS related activities. The Iowa DOT currently uses four such spatial schemes: Latitude-Longitude, Accident Nodes, Political Subdivisions and X-Y Cartesian Coordinates. The proposed system uses the same scheme, again the difference is in the implementation. Additionally, the proposed system implements Geographic Node/Shape Description and Spatial/Linear/Segmental Cross Reference Processes. Both processes are discussed in the Cross Reference subsection.

Latitude-Longitude

Latitude and Longitude represent a global positioning system and provide absolutely unique positions on the earth's surface. Currently the Iowa DOT references approximately 70% of the bridge structures on the primary road system and all of the airports within the state by Latitude and Longitude. The proposed reference procedure accommodates the use of Latitude-Longitude as a general referencing scheme for any kind of data or position reporting via the Spatial/Linear/Segmental Cross Reference Process. As NAVSTAR GPS portable receivers become more affordable and prevalent, positions along the route can be reported as Latitude-Longitude and programmatically converted to linear or segmental reference for data storage or retrieval.

Accident Nodes

Accident Nodes are currently used to reference accident locations. They are placed at significant locations on all routes within the state. See the Statement of Understanding of Current Conditions for a detailed discussion of Accident Nodes. The proposed reference procedure supports the use of Accident Nodes in the same fashion as does the current system. Additionally, the Spatial/Linear/Segmental Cross Reference Process allows for direct correlation of Accident Nodes with the other reference methods. For example, if an Accident Node is known on the primary road

system, the milepost and displacement of that node can be calculated as can the base record segment, milepoint, X-Y cartesian coordinates and the Latitude-Longitude.

Political (Township, Range and Section)

All land in the State of Iowa is referenced by "Political Township", a system established years ago to subdivide land by the Bureau of Land Management within the Federal government. The proposed reference procedure supports this reference method in the same fashion as the current system. With the advent of a future DOT GIS, the use of the Political reference system can be expanded.

X-Y Coordinates

All mapping performed by Transportation Inventory is based on a customized Lambert mapping projection that covers the entire State. The DNR uses the Universal Transverse Mercater (UTM) system. The new Geographic Node/Shape Description process (discussed later) uses the Transportation Inventory Lambert coordinates as a basis. The Spatial/Linear/Segmental Cross Reference process accommodates the conversion between both X-Y coordinate systems and the linear systems (milepost, milepoint), and segmental systems (base record identification, pavement management identification), and other spatial systems (Latitude-Longitude, Accident Nodes).

Segmental

The most widely used reference scheme within the Iowa DOT is segmental. The segmental reference schemes are record oriented and not necessarily related to geography. Segmental reference schemes include the "control section and aliases" within the base records, accident case numbers within the accident records, maintenance section identification, etc. The proposed reference procedure supports all of the existing segmental reference schemes and adds one additional scheme for pavement management sections. The Spatial/Linear/Segmental Cross Reference process allows for segmentally referenced data to be correlated with linearly or spatially referenced data. For example, if the pavement management section segment identifier is known, the milepost and displacement at the beginning and end of the section can be calculated. Likewise, if a latitude-longitude is known, the nearest pavement management section can be derived.

Cross Reference

The proposed reference procedure supports the current Accident Node Edit/Interface cross reference between the base records and the Accident System. Additionally, the proposed reference procedure features a very powerful cross reference process discussed in the following paragraphs.

Geographic Node/Shape Description

Correlation between the linear, spatial and segmental reference systems requires establishing a complete geographical depiction of each route. This depiction includes selected nodes and shape descriptions between these nodes. These data are maintained in a separate data base which allows for conversion between the spatial, linear and segmental reference methods. Graphic presentations of the highway network are performed using this data base. Adjustments to the geographical depiction when the geographic nodes or node locations are referred are also supported. Since the combination of nodes and shape descriptions define the overall primary and interstate highway network, permit routing and similar network oriented functions can be supported.

Spatial/Linear/Segmental Cross Reference Process

The Spatial/Linear/Segmental Cross Reference Process uses the Geographic Node/Shape Description data base and the Milepost/Milepoint Cross Reference Processes and files to correlate data referenced in these disparate systems. The process consists of a set of conversion utilities that allow the user to convert data from one reference method to another easily and quickly.

Table II-1 shows the locational information that can be derived from various combinations of known information. Specific examples are explained in the following paragraphs.

+ If the county, route, milepost and displacement are known, then the milepoint, X-Y coordinates, pavement management section identifier, base record identifier, latitude-longitude and nearest accident node can be calculated.

+ If the county, route and pavement management section identifier is known, then the beginning and ending mileposts and displacements can be calculated as well as the beginning and ending milepoint values and the segment length. All of the Accident Nodes associated with the length of roadway can be determined. The X-Y coordinates and/or latitude and longitude of the beginning and ending points of the section can be calculated.

+ If an X-Y coordinate (and mapping projection system) is known, then the milepoint and offset can be calculated. All other segmental and linear correlations can be performed from this milepoint. Likewise, conversion to other spatial reference systems (Latitude-Longitude, etc.) can be accomplished.

The above examples are only a portion of the cross references that can be accomplished using the proposed reference procedure. The future DOT GIS will also be able to take advantage of the Geographic Node/Shape Description and cross reference schemes.

Table II - 1

Geographic Location Relationships

County	Route	System	Segmental Identifier	Milepost and Displ.	Milepoint	Lat/Long or X-Y	Accident Node	Offset
X	X	X	X*	Beg. End	Beg. End	Beg. End	2	
Yes	X	X	1	X*	Yes	Yes	2	
X	X	X	1	Yes	X*	Yes	2	
X	X	X	1	Yes	Yes	X*	2	X Optional
X	1	1	1	Yes	Yes	Yes	X*	Yes Optional

Key: X = Known Information
Yes or Note 1 or 2 = Derived Information
1 = Primary and Concurrent Routes
2 = All Nodes Related to Segment
* = Primary Given Value

SECTION III - PROPOSED ROADWAY NETWORK SEGMENTATION

The Iowa Highway System is segmented into discrete sections for various functions, including: reporting of work activities, pavement management, needs analyses, road inventory activities, etc. These segmentations are variable and do not necessarily occur on common boundaries. However, in all cases, the base records are the "finest", most discrete segmentation and all other segmentations are even multiples of base records. In other words, all other segmentations contain a whole number of base records. See the Statement of Understanding of Current Conditions for a detailed discussion of the current road network segmentations.

The only difference between the current segmentations and the proposed segmentations is the guaranteed alignment of pavement management sections and base record segments and the densification of pavement management sections to coincide with changes in pavement type and/or age. As mentioned in the previous section, a pavement management segment identifier has been added to both the base records and the pavement management data sets. The addition of this segment identifier serves to provide seamless correlation between pavement management and base record segments. The proposed roadway network segmentations are discussed in the following paragraphs. Segmentations that are from current conditions are discussed briefly; those that change are discussed in more detail regarding the changes. Again, refer to the Statement of Understanding for more details.

BASE RECORDS

Iowa maintains a 100% inventory of all roads and structures. The inventory data is stored in the base records. There are eight types of base records; four for roads, and four for structures. The indexing method varies slightly between the record types. For pavement management purposes, the road records are the most important. The four road base record types are: Primary, Secondary, Municipal, and Parks and Institutional. Of these, the Primary road base records are used in the existing pavement management processing. The only difference between the current base records and the proposed base records is the addition of a pavement management section identifier on all of the Primary road base records.

PAVEMENT MANAGEMENT (TEST) SECTIONS

Pavement Management sections are the same physically as the Test sections by milepost. They are variable in length and are determined primarily by construction projects. The Office of Materials collects condition data by Pavement Management (Test) sections; for instance, the IJK Ride Meter, Friction, Road Rater and Crack and Patch surveys. Pavement Management sections are defined by milepost and displacement reference. Except for the Interstate highways, Pavement Management sections occur only on the rural primary roads (U. S. numbered, Iowa numbered and unnumbered primaries). For Interstate highways, Pavement Management sections occur on both Rural and Urban portions. There are no Pavement Management sections on ramps and connectors. The identifying key for Pavement Management sections is county, system, route, beginning milepost and displacement, ending milepost and displacement, section identifier, and direction. Pavement Management sections contain a whole number of base records.

MAINTENANCE SECTION

Maintenance sections are used by the Office of Maintenance to identify segments of a route within a maintenance area. They are referenced by milepost and displacement. Maintenance sections are used to report all maintenance activities, except those associated with pavement, shoulder and structure which are reported by specific milepost and displacement.

OTHER SEGMENTATIONS

The other roadway network segmentations are Needs sections, Sufficiency sections, Continuity Control sections and Group Major Intersection (GMI) sections. These segmentations are supported in an identical fashion in the proposed scheme as they are in the existing scheme.

DYNAMIC SEGMENTATION

Although Iowa DOT makes extensive use of predefined essentially fixed segmentation, it will be possible with the proposed reference process to access data stored along a route in a dynamic segmentation manner. Data stored by precise point or precise range limits may be accessed for any set of specified limits. For example, a query scheme could be developed to extract all data of specified types between specified end points. This capability could be augmented with various means of automatically establishing desired end points by:

- specified increment

- increments determined by the data encountered along the route

Data taken by fixed segment could be accessed in this same fashion, but the real benefit will accrue from not having to observe fixed limits for either data acquisition or data access.

SECTION IV - PROPOSED PAVEMENT MANAGEMENT SYSTEM IMPROVEMENTS

BACKGROUND

Iowa DOT has been collecting data for and calculating Present Serviceability Index (PSI) for all of the primary roads for the last 20 years. The Materials Office has been collecting data (non-destructive testing and surveys) for the last ten years. The data collected by Materials is referenced to Pavement Management Sections and is generally stored on the mainframe. However, some data is maintained manually. The seven point matrix system began to be used about seven years ago. The matrix used equal weights for all parameters and did not necessarily represent what was in the field. One of the primary reasons for adopting the Pavement Condition Rating (PCR) scheme was to achieve a better correlation between the computer generated ratings for a section of highway and the true condition as rated by an expert in the field. The matrix solution did not take pavement type into account, so similar ratings between a section of concrete paving and section of asphaltic cement paving did not mean the same thing. This made programming rehabilitation difficult. The new PCR system does take pavement type into account. Three PCR schemes have been developed - PCR-1, PCR-2 and PCR-3.

In 1987, the first PCR was prototyped - PCR-1. PCR-1 used new data only, data not necessarily available on the mainframe. Since then, PCR-2 and PCR-3 have been developed. In all three cases, the coefficients for the equations are derived by running a linear regression process against ratings from the field.

The proposed pavement management improvements are dependent on the proposed reference procedures and segmentations discussed in the prior sections. Of particular interest to pavement management processing is the Milepost/Milepoint Cross Reference, the alignment of Pavement Management Sections with base record segments, and the densification of Pavement Management Sections to include all changes in pavement type and/or age. Three other identified improvements are discussed in the following paragraphs.

DATA AGE AND TIMING CONSIDERATIONS

Ideally, decisions based on pavement condition ratings and similar evaluations should reflect current conditions. Present procedures depend on data that varies in age from one to four years. It is recognized that resource and timing considerations often prevent the achievement of ideal conditions. Since data age varies, it is important to assess the impact of age on the value of the data used in decision making and to take steps to improve the

processes. The specific methodology to improve the processes is discussed in the Section V entitled Design Specifications and Implementation Plan. Another data timing consideration is related to sections of roadway that have been reconstructed between the time pavement condition measurements are taken and PCRs are made. The specific methodology to address this issue is also included in the Section V.

HISTORICAL REFERENCE CONSIDERATIONS

Correlating pavement management data over the years is necessary to predict how certain kinds of pavement structures are performing. The DOT must be able to historically correlate data for the same vicinity and study the changes in values for the various data.

The primary problem with historical data correlation is related to the changes in the highway network over the years. Route designations change, sections of pavement are transferred between systems or abandoned, and new alignments are constructed. The base record archive files do show the state of the network over the years (on a year by year basis). Likewise, IPMS raw data archive files show the state of mainframe related pavement management data since 1983. However, some of the data are not archived in a convenient manner.

Briefly, the correlation methodology involves the following steps:

+ Create a PMS History Reference file for all prior years. This is done in a step-wise manner from the current year to previous years. This process requires manual review.

+ Compile any supplemental data to be incorporated into the PMS History file including data which is not in the archived IPMS raw data files.

+ Using the PMS History Reference files, the IPMS raw data archived files and the supplemental data files create a PMS History file for each prior year. The record keys are converted from fractional mileposts for the prior years to milepost and displacement for the current year.

+ Develop several utility programs which will make access and update of the PMS History files much more convenient.

When these steps have been accomplished, then pavement condition ratings or other analyses can be accomplished. See Section V for a detailed discussion of the correlation methodology.

PCR-3 EQUATIONS AND DATA MIGRATION TO THE MAINFRAME

The DOT has stated that there is a desire to adopt the PCR-3 equations as a standard. In order to accomplish this, all of the data required for PCR-3 equations, as well as the equations themselves, must be converted to the mainframe environment. The following data sets must be converted from the PC or entered from manual files:

+ Structural Rating (New) - PC only
+ Aggregate Age Rating - PC only
+ Percent Life Used - PC only
+ 18 KIP ESAL (Current Year) - 18 KIP ESAL file
+ PSI Rating - PC only
+ Asphalt Age Rating - PC only

Likewise, the HSTA and Construction History files maintained by the Office of Materials will be made compatible with other pavement management data files.

The specific methodology to accomplish this migration is detailed in the section entitled Design Specifications and Implementation Plan.

SECTION V - DESIGN SPECIFICATIONS AND IMPLEMENTATION PLAN

This section describes the tasks required to implement the proposed improvements covered in previous sections of this report and the proposed Implementation Plan. Recommended methodology and algorithms are given where applicable. The proposed Implementation Plan includes Gantt and Pert charts and resource requirements tables.

The proposed reference process and the processes such as Pavement Management which use it involve participation of a number of organizational units. An assigned coordination responsibility is considered essential. This responsibility could be assigned to a current employee or organizational unit. It should include the following functions:

- Understanding the policies, procedures and conventions required for Reference and Pavement Management System.
- Monitoring compliance on the part of all participants to assure success.
- Recommending corrective action where necessary.

REFERENCE SYSTEM IMPROVEMENTS

The proposed reference system states locations in terms of Segmental Identifier, Milepost and Displacement, Milepoint, Spatial Coordinates (X-Y Cartesian Coordinates, Latitude - Longitude), and Accident Nodes. The following subsections describe the implementation requirements.

Milepost and Displacement

Mileposts will serve as reference monuments in the proposed reference process. Coupled with displacement (+/- distance along route) they provide a precise way to state location. It is important to maintain and use them properly.

The tasks required to implement this improvement include:

T1 - Prepare a policy instructing the use of Milepost and Displacement and eliminating use of Fractional Milepost. Within the Implementation Plan, Task T1 is Task ID 001 and is called EST MPOST POLICY.

T2 - Revise the following existing files to replace Fractional Milepost with an alphanumeric field for milepost number and a +/- value for displacement. The alphanumeric field should allow alpha prefix and suffix. This will allow use of optional reference monuments.

+ Crack and Patch
+ Friction
+ IJK Ride
+ Road Rater
+ Construction History File
+ Route/Function Table
+ HSTA
+ Maintenance Milepost Costs
+ IPMS Raw Data
+ 18 KIP ESAL

Within the Implementation Plan, Task T2 is Task ID 002 and is called REV FILES MP/DIS.

T3 - Upgrade the following reference maps to reflect Milepost and Displacement instead of Fractional Milepost.

+ Milepost Maps
+ Test Section by Milepost
+ Maintenance Area Responsibility Maps

It is recommended that CADD procedures be developed for upgrading and maintaining these maps. Within the Implementation Plan, Task T3 is Task ID 003 and is called REV MAPS MP/DIS.

Milepost/Milepoint/Segmental Cross Reference

The proposed cross reference will serve for converting between linear reference methods and/or segmental reference methods. Proper policies and procedures for maintaining milepost marks are also needed for successful use of the cross reference. The tasks required to implement this improvement include:

T4 - Develop Milepost/Milepoint/Segmental Cross Reference. The cross reference is discussed as a separate file for indicating the factors to be included. In actual implementation, it might be incorporated into the Base Record Data Base or some other implementation. It might also be an expansion of the existing MPXREF file. Specifications are as follows:

- Must be on line for use in conversions.

- Must provide milepoint and Base Record Sequence Number for each of the following points for each designated route:

  - o County Line Entry
  - o County Line Exit
  - o All Mileposts
  - o Beginning Concurrent Higher Priority Route
  - o Ending Concurrent Higher Priority Route
  - o Beginning Municipal Gap
  - o Ending Municipal Gap
  - o Any Supplemental Reference Monuments
  - o Applicable Accident Nodes

Within the Implementation Plan, Task T4 is Task ID 004 and is called POST/PT/SEG XREF.

T5 - Cross Reference Update. It will be necessary to establish and maintain procedures for timely update of the cross reference. New reference points should be added as they are identified. The milepoints for moved mileposts should be updated within two weeks*. See Task T6. Within the Implementation Plan, Task T5 is Task ID 005 and is called PPS XREF UPDATE.

* - Suggested value.

T6 - Milepost Policy and Procedures. Since milepost markers are used as reference monuments, they must be maintained properly. New policies and procedures must be established which would include:

- Rename all duplicate milepost numbers by adding a suffix (e.g., the second 112 would become 112X).

- Avoid removal of milepost markers where possible.

- When a milepost marker has been removed, replace it in the same location (within 50 feet*) where possible.

- When a removed milepost marker cannot be replaced in the same location, take one of the following actions:

  a. Replace the milepost mark within 750 feet* of the original location and add a suffix to the marker (e.g., No. 112 would become No. 112A).

  b. Do not replace the milepost marker and do not reuse the number.

- Notify the office responsible for maintaining the Milepost/Milepoint Cross Reference within one week when a milepoint marker is replaced and renamed

Within the Implementation Plan, Task T6 is Task ID 006 and is called MPOST POL & PROC.

* - Suggested values

T7 - Develop Conversion Routine Milepost and Displacement to Milepoint. (See U-7 - Appendix A.) Within the Implementation Plan, Task 7 is Task ID 007 and is called MP/DIS TO MPOINT.

T8 - Develop Conversion Routine Milepoint to Milepost and Displacement. (See U-8 - Appendix A.) Within the Implementation Plan, Task T8 is Task ID 008 and is called MPOINT TO MP/DIS.

T9 - Develop Conversion Routine Other Segments to Base Record Segments. (See U-11 - Appendix A.) Within the Implementation Plan, Task T9 is Task ID 009 and is called OTHER SEG TO BRSEG.

T10 - Develop Conversion Routine Base Record Segmentation to Locational Data. (See U-9 - Appendix A.) Within the Implementation Plan, Task T10 is Task ID 010 and is called BRSEG TO REFDATA.

Geographic Node/Shape Description and Spatial/Linear/Segmental Cross Reference

Correlation between linear and spatial system requires establishing a complete geographic description of each route. The description will include:

- Selected nodes.

- Shape descriptions between nodes.

These data will be maintained separately and used for

- Conversion between linear, spatial, and segmental reference system.

- Graphic presentation of roads and linearly or segmentally based data.

- Adjustment of geographic descriptions when the geographic base or node locations are refined.

- Correlation with Accident Nodes and Base Record segments.

The combination of nodes and shape descriptions will define the overall primary and Interstate highway network. Such definitions would facilitate permit routing and similar network oriented functions.

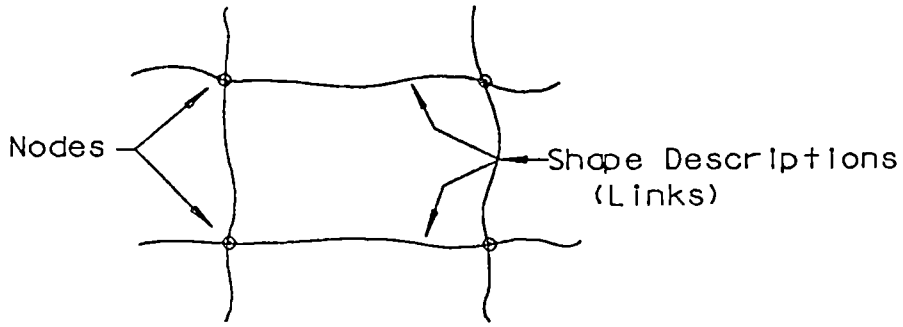
Selected Nodes are key points on routes which can be identified and correlated with the spatial reference system. Node locations should include:

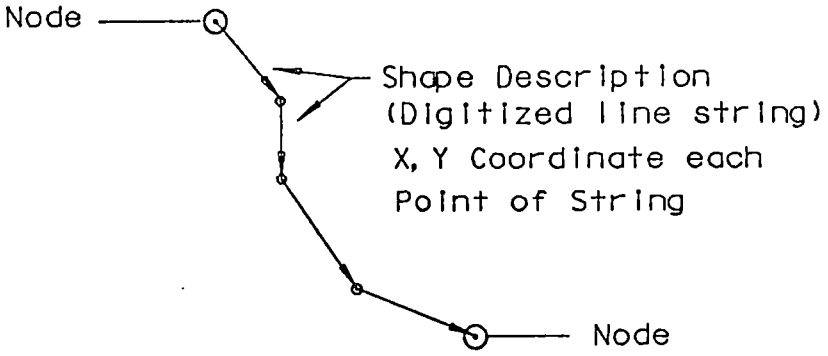
County lines
Route junctions
Other significant physical points

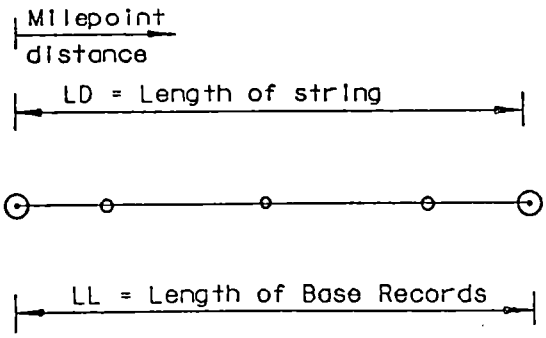
Nodes should be located at existing breaks in base records.

Shape descriptions will consist of line strings between adjacent nodes which represent the route alignment. These will normally be digitized from maps with points expressed in the Transportation Inventory Lambert projection X,Y coordinates. The end points of line strings will provide the X,Y coordinates for nodes originally, but it will be possible to refine X,Y coordinates of nodes in the future. (In most cases, the same shape description will continue to be adequate when node locations are refined.)

Nodes and shapes are depicted in Figure V-1. Digitized shapes should be tested. When the absolute value of (1-SF) exceeds 0.02, the shape description should be reestablished.







Scale Factor, SF = LL/LD

Milepoint distance = SF(String distance)

Figure V-1

The tasks required to implement this improvement include:

T11 - Develop Procedure for Building Shape and Node Files.

Shape and Node data should be captured by digitizing from existing CADD based County maps. It should be possible to "snap" to the selected nodes and digitize the line strings between nodes. Subtasks will include:

- Develop Node Identifier scheme, standards for digitized shapes, methods for handling divided highways, etc.

- Select Nodes

- Develop automated graphic command for digitizing node and shape descriptions. These commands should take advantage of graphic features and any existing attributed data that will reduce keyed input. The DOT has already developed this type of command. These should be reviewed and used if adequate.

- Develop a systematic plan for data capture.

Within the Implementation Plan, Task T11 is Task ID 011 and is called NODES/SHAPE PROC.

T12 - Develop Node File.

This reference information is presented as a file for convenience. Any implementation that provides ready access by conversion utilities, graphic presentation features, and similar functions would be satisfactory. The data elements required for each node include:

- County
- X, Y, Z Coordinates Transportation Inventory Lambert Projection
- X, Y, and Z UORs
- Route
- System
- Milepoint of Node - Each Primary Route
- Adjacent Node Identifier back
- Adjacent Node Identifier forward
- Concurrent Routes and Systems

Within the Implementation Plan, Task 12 is Task ID 012 and is called DEV NODE FILE.

T13 - Develop Shape File.

This reference information is presented as a file for convenience. Any implementation that provides ready access by conversion utilities, graphic presentation features, and similar functions would be satisfactory. The data elements required for each node to node shape description include:

- Beginning Node Identifier
- Ending Node Identifier
- LD (digitized length)
- County
- Route (Primary)
- System (Primary)
- Route (Concurrent)] | Each concurrent
- System (Concurrent)] | route

- X,Y, and Z Coordinates, UORs | Each point of the shape

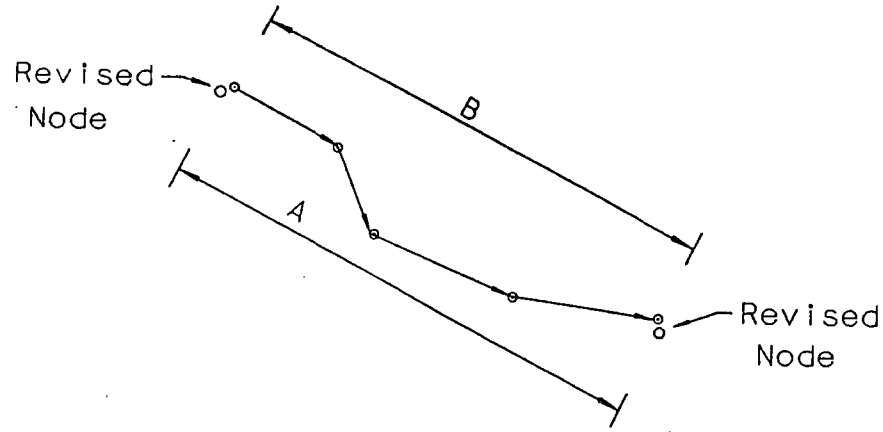
V

Within the Implementation Plan, Task T13 is Task ID 013 and is called DEV SHAPE FILE.

T14 - Develop Procedure for Refining Node Coordinates.

The previous discussion relates to the original establishment of the selected nodes and shape descriptions by digitizing. In the future, it may become desirable to refine the coordinates of nodes or make a major revision of the coordinate system. In the latter case, the shape description should be adequate since the roadway alignment has not changed. (Changes in alignment require update of the nodes and shape data.)

The following test should be used to determine if shape data is adequate:



If the absolute value of (1 - A/B) is greater than .01, shape data should be reestablished. If not, the shape data description should be adjusted using the Crandall Method so that its end coordinates correspond with the revised node coordinates. A revised value for SF should also be computed. (See Figure V-1.) The revised shape description coordinates should then be checked to assure that the revised absolute value of (1 - SF) is not greater than 0.02. The shape description should be reestablished in this case.

Other changes in node data such as refined milepoint values should be made whenever they are made in other data records. Within the Implementation Plan, Task T14 is Task ID 014 and is called NODE REFINE PROC.

T15 - Develop Conversion Routine X,Y to Milepoint (and Offset). (See U-21, Appendix A.) Within the Implementation Plan, Task T15 is Task ID 015 and is called XY TO MPNT(OFST).

T16 - Develop Conversion Routines Milepoint (and Offset) to X,Y. (See U-22, Appendix A.) Within the Implementation Plan, Task T16 is Task ID 016 and is called MPNT(OFST) TO XY.

T17 - Develop Conversion Routine X,Y DOT < —— > Lat/Long < —— > X,Y DNR (See U-23, Appendix A.) Within the Implementation Plan, Task T17 is Task ID 017 and is called XYDOT L/L XYDNR.

T18 - Develop Conversion Routine Accident Node to Milepoint. (See U-10 - Appendix A.) Within the Implementation Plan, Task T18 is Task ID 018 and is called ACCNODE TO MPNT.

PAVEMENT MANAGEMENT IMPROVEMENTS

The proposed Pavement Management Improvements are dependent upon the Reference System Improvements discussed above, particularly the Milepost/Milepoint/Segmental Cross Reference features.

During the course of the HLRP project, several improvements were identified. One of these recommendations proposed implementation of a data base environment for pavement management data. Even though a data base version of the pavement management data could be developed at any time, it may be cost effective to inaugurate such a scheme as the new pavement management data structure is being considered. Acceleration of this implementation is not required, but it would facilitate the improvements described below as well as future pavement management functions. See Section VI for more information regarding the data base improvement and an explanation of data base environment concepts.

The following described improvements will enhance the functioning of and the results produced by the Pavement Management process.

Alignment of Sections, Additions of Section Designators and Increased Number of Sections

Base records cover fixed segments of routes for a specific year. Pavement Management Records (test sections) cover similar segments. Base records break at changes of pavement type and other significant data factors. It is considered necessary to align boundaries of each Pavement Management Record with one or more base record boundaries and to correlate the records with a Pavement Management Record designator.

In some cases, there is also a need to subdivide PMS sections so that they will not cover more than one pavement type or age. This subdivision must also align with base record boundaries.

The tasks required to implement this improvement include:

T30 - Develop a scheme for pavement management section designators and add designators to pavement management and base records. Within the Implementation Plan, Task 30 is Task ID 030 and is called PMSEC DESIGNATOR.

T31 - Align Sections - This will require comparison of record boundaries which would be facilitated by prior implementation of the Milepoint/Milepost Cross Reference. The suggested methodology would include these steps:

+ Develop a program to produce an alignment file with the elements shown in Table V-1. The program would build a file for one county at a time for specified systems and routes, but could cycle through other counties. The program steps would include:

  - Access base records to produce one record for each base record boundary in the county, including the end of the last record. The PMS Record fields would be blank for this step.

  - Access the PMS Records to fill in the PMS Record fields for records where PMS boundaries best match. (Error flags where there is improper or no match.)

+ Manually review the alignment file and maps and revise PMS designator by editing where necessary to revise alignment boundaries and/or to subdivide PMS sections so that they will cover more than one pavement type or age.

			Base Record				PMS Records		
County	Route	System	Seq. No.	B/E	Milepoint	Pavement Type	Designator	Beg Milepoint	End Milepoint
				B					
				B					
				B					
				E *					

* End of last base record in the county

Table V-1 - Section Alignment File

+ Produce a second program which will read the alignment file and producing the following:

  - Revise Beg End milepoints for PMS records and compute mileposts and displacement

  - Add PMS designators to base records and PMS records.

Within the Implementation Plan, Task T31 is Task ID 031 and is called ALIGN SECTIONS.

T32 - Modify existing programs that compute PCR 2 ratings and perform other pavement management functions to take advantage of the new reference provisions, PMS section designators, and the data base for base records. These programs fall into two categories:

1. Programs used to compile data for use in computing PCR values.

2. Programs which compute and present PCR-2 data.

The first group should be modified such that revised reference methods are addressed properly. They should be further revised to also compile data from other existing files and supplemental files that may be defined for PCR-3 or other future rating methodology.

The second group of programs for PCR-2 may require minor modifications because of changes to the first group. Migration of PCR-3 programs from PC to mainframe or future PCR equations would use the same approach.

It should be noted that incorporation of PMS data into a data base environment would simplify these and all of the other pavement management processes. Within the Implementation Plan, Task T32 is Task ID 032 and is called RV PCR2PGMS MP/D.

Data Age/Time

Ideally, decisions based on pavement ratings and similar evaluations should reflect current conditions at the time of the decision. Present rating procedures depend upon data which may be one to four years old. Resources and timing considerations prevent the achievement of the ideal condition. An assessment of data age is given in the Statement of Understanding of Current Conditions - Appendix B.

Since data varies in age, it is important to assess the impact of age on the value of data used in decision processes and to take steps to improve the processes. A primary question to ask is "Did the age of available data used in regression analysis have an adverse or misleading effect on development of pavement rating equations?"

Steps that should be considered include the following tasks:

T33 - Evaluate age effect on the data used to derive PCR equations, etc. This might dictate a need for reestablishing equations. Future equation development should consider age factors. Within the Implementation Plan, Task T33 is Task ID 033 and is called EVAL AGE EFFECT.

T34 - Extrapolation of data where feasible (this is currently being done for traffic data). Within the Implementation Plan, Task T34 is Task ID 034 and is called EXTRAPOLATE DATA.

T35 - Discounting of older data where age of data can be shown to reduce validity of data. Within the Implementation Plan, Task T35 is Task ID 035 and is called DISCOUNT DATA.

T36 - Revise procedures to decrease data age where possible and feasible. Within the Implementation Plan, Task T36 is Task ID 036 and is called REV PROC DEC AGE.

T37 - Document age factors and apprise users and decision makers of data age impact. Within the Implementation Plan, Task T37 is Task ID 037 and is called DOC AGE FACTORS.

Another data timing consideration is related to sections that have been reconstructed between the time pavement condition measurements are taken and ratings are made. The recommended steps for addressing this condition include the following tasks:

T38 - Establish a procedure for advising pavement rating personnel when reconstruction occurs. The HSTA file might be used for this purpose. Within the Implementation Plan, Task T38 is Task ID 038 and is called RECONSTRUCT PROC.

T39 - Establish a policy and procedures for making new pavement condition measurements and updating files soon after a reconstruction is completed. Within the Implementation Plan, Task T39 is Task ID 039 and is called DATA AFTER RECON.

Historical Reference Requirements

While pavement condition rating computations are based on the latest data in current year Base Record and Pavement Management records, there are needs to reference the same type of data for prior years. Reasons for needing access to data from previous years include the following:

+ Ad Hoc archival investigation, e.g., search of old records for a certain purpose, could be manual or a special computer program, or both.

+ Bulk data investigation, e.g., prepare a graph of Cracking vs. Age for all records for a certain pavement type for multiple years.

+ Investigations for a single prior year, e.g., compute PCR-3 for the primary system in a single prior year.

+ Multi-year performance evaluation for a specific section of road, e.g., prepare a graph of cracking versus year for a specific PMS section.

It is assumed that prior year IPMS Raw Data file records contain sufficient data from Base Records. Task 42 described below provides means for supplementing the data in these files. It is still necessary to correlate history records between years and with current reference locations. These correlation requirements will involve extensive manual research efforts for the prior years. Some ways to limit this effort include the following:

+ Limit the number of prior years to be included. Older data may be less reliable. The following dates indicate data availability:

  - Base Records - 1970

  - PMS Records - 1983

  - Milepost - 1973

  - Milepoint - 1982

  - ESALs - 1983

+ Choose only certain parts of the highway system.

+ Use selected sample sections by type and system.

+ Eliminate certain data from consideration.

It is recommended that all IPMS raw data records from 1983 forward be incorporated into a new PMS History Data File. The data for this file would be copied from archived prior year files and referenced to the base year locations. This would allow any prior year data to be accessed by current reference limits.

The PMS History Data File will provide greatly improved access to pavement history and provide support for research and any future rating equation development.

It is proposed that the PMS History files use the same format as current PMS data files (see Task T32). Some current data may not be available for prior years. PMS History files will include the following data for each prior year:

+ Year
+ County
+ Route
+ System
+ Beginning Milepost/Displacement - Current
+ Ending Milepost/Displacement - Current
+ Prior Year Data
+ Supplemental Data for Prior Years

The tasks required to provide access to prior year PMS data are discussed in the following paragraphs. All of these tasks are one time tasks to be completed in the current or base year (B). This is the year to which prior years will be referenced. The program developed in Task T46 will then be used for continual update. The programs developed in Tasks T47 and T48 will be used for data access.

T41 - Develop a program to produce PMS history reference files consisting of the following data:

Year	
County	
Route	
System	This data is now
Beg Fractional Milepost	> produced for the
End Fractional Milepost	Test Section by
Length	Milepost Book
Pavement Type	
Direction	
Year Built	
Project Number	
Beg Milepost and Displacement	Base Year
End Milepost and Displacement	Values

PMS History Reference files will contain a record for each prior year PMS record. These files will be used as "work sheets" to facilitate the transfer of current location reference limits (Milepost and Displacement) to prior year records. The current or base year (B) file will be produced first. It will then be used to create the next earlier year. This process will be repeated until all prior year files are complete. Within the Implementation Plan, Task 41 is Task ID 041 and is called DEV HISTREF PGM.

T42 - Compile any supplemental data desired to be incorporated into the PMS History files. This task is optional but it would require compilation of desired data into files with the same keys as prior year PMS data files. These compiled files would then be read in by Task T45. Within the Implementation Plan, Task T42 is Task ID 042 and is called PRIOR YR SUPL FL.

T43 - Produce PMS Reference files using the Task T41 program and correlate with base year milepost and displacements.

The base year (B) file will be produced first with actual milepost/displacement values. The Fractional Milepost segment limits in the base year will be compared (by the program) with those in the next earlier year (B-1). If they match within 0.15 mile*, the milepost/displacement will be transferred to the earlier year file. If they do not match, the milepost/displacement will be left blank.

The PMS History Reference file for year B-1 must then be completed manually before proceeding to year B-2. Transferred milepost/displacement values should be reviewed for validity and corrected by editing if necessary. Blank values must be established by reviewing maps, etc. and entered into the file.

This process will be then repeated for creating files for B-2 by comparing with B-1 files and completing B-2 files.

There will be records which represent PMS sections which have been completely reconstructed in place. These records should be flagged to indicate this condition.

There will also be records which are not on the current system because they have beentransferred off system or abandoned. Within the Implementation Plan, Task T43 is Task ID 043 and is called PRIOR YR HISTREF.

* - Suggested Value.

T44 - Develop a program to build PMS History files. This program will read the archived PMS data records and copy them into the new PMS data format developed under Task T32. It will access the corresponding PMS History Reference File Record and insert the indicated current year beginning and ending

milepost and displacements. If corresponding supplemental files are created by Task T42, these would also be accessed and loaded into the new format files. This process could also eliminate superfluous data from prior records. A second function of the program would be to convert the fractional milepost references to current year milepost and displacement references in the HSTA files. Within the Implementation Plan, Task T44 is Task ID 044 and is called DEV HISTORY PGM.

T45 - Produce PMS History files for each prior year using the Task T44 program and any supplemental data compiled during Task T42. Within the Implementation Plan, Task T45 is Task ID 045 and is called EXE HISTORY PGM.

T46 - Develop a program to be used to update the PMS History files when milepost data changes in the future. When any data regarding a milepost changes, the program would search all records to find any that reference that post in their key. When such records are found, appropriate revisions in the key should be made. A second function of the program would be to convert the fractional milepost references to current year milepost and displacement references in the HSTA files. Within the Implementation Plan, Task T46 is Task ID 046 and is called REV HISTREC KEYS.

T47 - Develop a bulk record search routine for extracting specified data. Within the Implementation Plan, Task T47 is Task ID 047 and is called BULK REC SEARCH.

T48 - Develop a multi-year record search routine. For given milepost and displacement limits, this routine would find all records which fall in the specified range. Within the Implementation Plan, Task T48 is Task ID 048 and is called MULT YR REC SRCH.

Move PCR-3 to Mainframe

Pavement Ratings computations based on PCR-3 equations are currently executed on a personal computer. This approach was taken because of difficulty in correlating pavement management records and base records and because some required data was not available on mainframe storage.

The alignment of pavement management and base records, the pavement segment designators and the new data base implementation of base records will facilitate moving PCR-3 ratings programs to the mainframe. The near term recommendation to implement a data base environment for pavement management records, though not required, would also facilitate this move.

It is recommended that the modifications to existing pavement management programs (see Task T32) be done such that PCR-2, PCR-3 and future rating equations can be accomplished with the same set of programs. These programs fall into two categories:

Category 1 - Programs used to compile data for use in computing PCR values

Category 2 - Programs which compute and present PCR data for specific equations

The Category 1 programs are proposed to be modified in Task T32 such that they can access additional data that may be defined in the future. Such data may come from current files or from files to be determined. If this is done, Category 2 programs will be easier to implement.

The tasks required to implement this improvement in concert with Task T32 are as follows:

T50 - Determine data which is needed for PCR-3 ratings which could be accessed from existing files not currently accessed by Category 1 programs. Within the Implementation Plan, Task T50 is Task ID 050 and is called PCR3DATA EXST FL.

T51 - Define and implement supplemental files necessary to provide data from PCR-3 equations which is not available in current mainframe files, such as the following:

+ Structural Rating (New)

+ Aggregate Age Rating

+ Percent Life Used

+ PSI Rating

+ Asphalt Age Rating

within the Implementation Plan, Task T51 is Task ID 051 and is called PCR3DATA SUPL FL.

T52 - Implement compilation of the data defined in Tasks T50 and T51 within the Category 1 programs. Within the Implementation Plan, Task T52 is Task ID 052 and is called ADD EXST/SUPL MF.

T53 - Convert the current PC based PCR-3 programs to mainframe category 2 programs. Within the Implementation Plan, Task T53 is Task ID 053 and is called CNV PCR3EQ to MF.

It should be noted that data base technology would greatly facilitate the above tasks. It should also be noted that the effort to implement any future PCR calculations would parallel these four tasks.

IMPLEMENTATION PLAN

This subsection provides an implementation plan for the tasks detailed in the previous subsections. The Implementation Plan is presented as two summary charts, a proposed resource table, four detailed charts and a supporting appendix (Appendix B). The two summary charts include a summary Gantt (bar) chart and a summary Pert chart. The four detailed charts include a Project Outline, a Pert chart, an abbreviated Gantt chart, and samples of the Task and Resource Details. Appendix B includes a complete set of Task Details, Resource Details and a detailed Gantt chart. The charts are discussed in the following paragraphs.

All of the charts were derived using project management software provided by the Iowa DOT. A complete file of the project model is being provided to the DOT (as a separate submission) to be used in continual project planning. The staffing level, resource requirements, task dependencies, and schedule used in the model were estimated by CWB and should be refined by the Iowa DOT as the project progresses. These refinements can easily be added to the project model.

Figure V-2 is a summary bar chart which shows the major task groups along with the estimated resource requirements and schedule. The dependencies between these major task groups are shown in the summary Pert chart, Figure V-3. The detailed charts discussed in the next paragraph show similar information on a task-by-task basis. Table V-2 shows the proposed staffing requirments for the project.

The Project Outline (Table V-3) lists all of the identified tasks along with such information as estimated task duration, estimated resource requirements (by resource classification) and estimated beginning and ending dates. The projected project milestones are also listed. The Pert Chart (Figure V-3) shows the task dependencies and critical path along with completion dates for all milestones and the total project. The abbreviated Gantt chart (Figure V-4) shows task durations and identifies task float. The sample Task Details (Table V-4) shows full information regarding each task and the sample Resource Details (Table V-5) shows full information regarding each resource. The complete set of Task Details and Resource Details are presented in Appendix B.

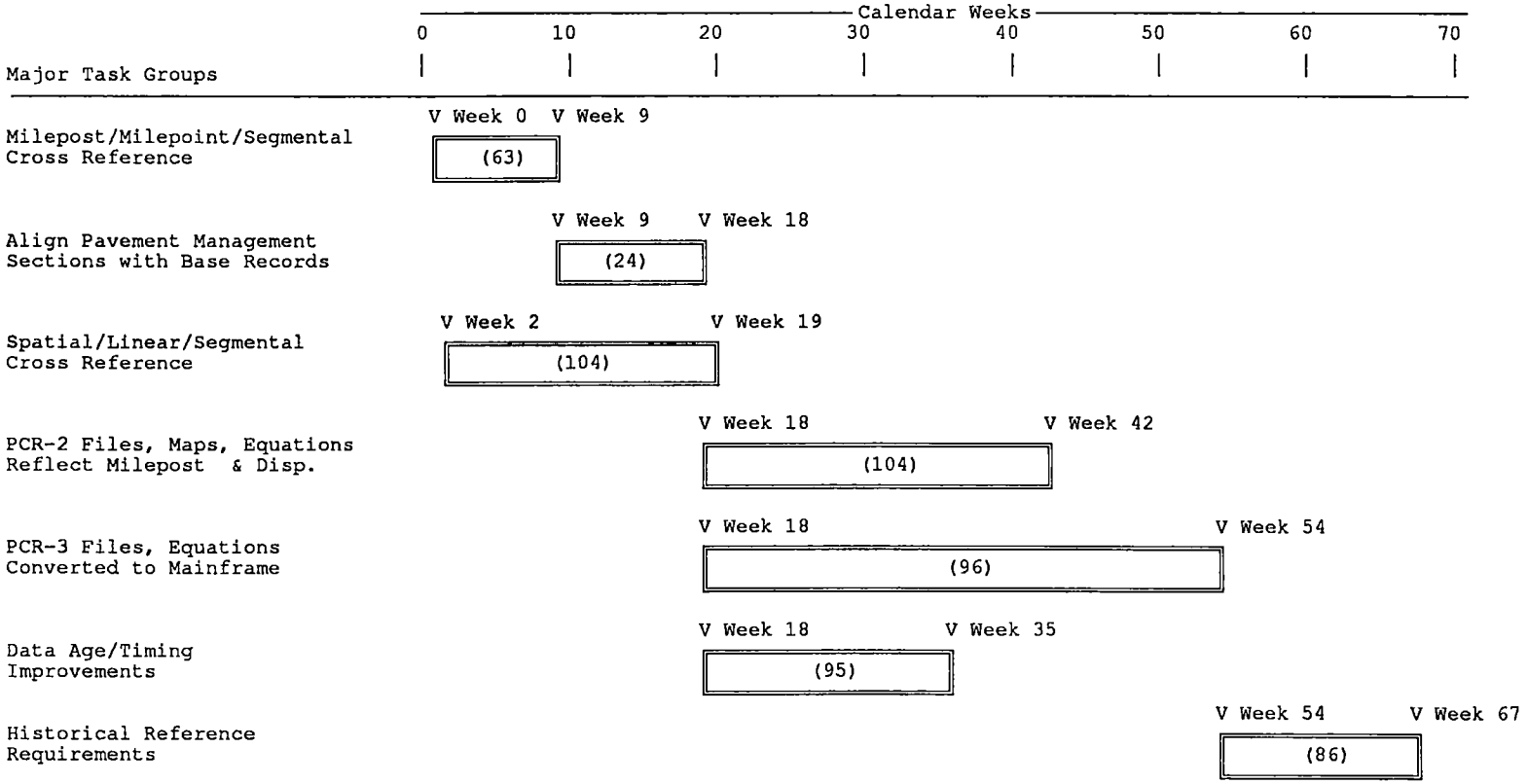
Resource	Quantity	Group
Administrative	2	BIS-1; Other Offices - 1
Clerical	1	BIS
Analyst	2	BIS
Programmer	4	BIS
Professional	2	Other Offices
Technician	2	Other Offices
Digitizer	2	Transportation Inventory

Note:

Other offices include such offices as Materials, Maintenance, Road Design, etc.

Table V - 2

Proposed Staffing Requirements



Notes:

1. Numbers in parentheses are estimated staff weeks, including all resource categories.
2. Numbers adjacent to vertical arrows indicate estimated number of calendar weeks from project start.
3. Estimated total staff weeks for the project, including all resource categories, is 572.

Figure V - 2

Summary Bar Chart

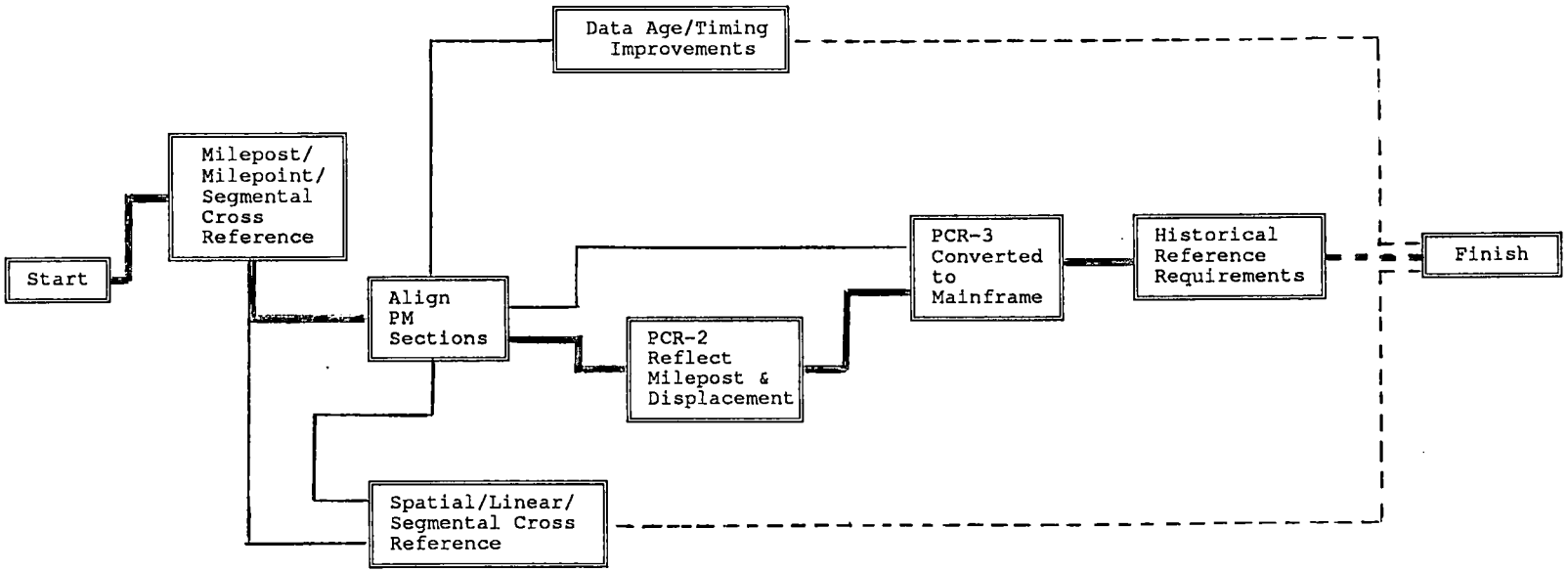
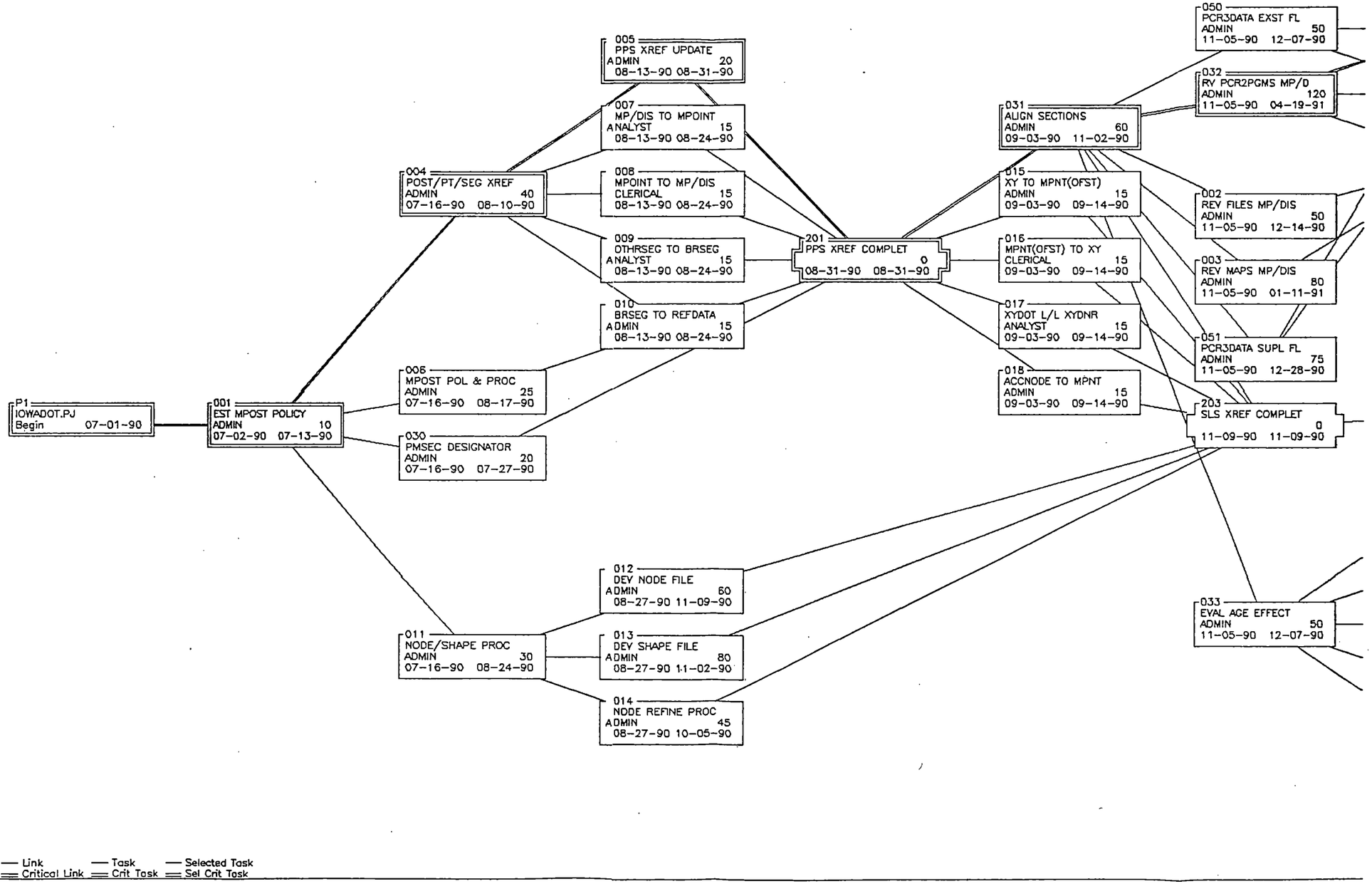


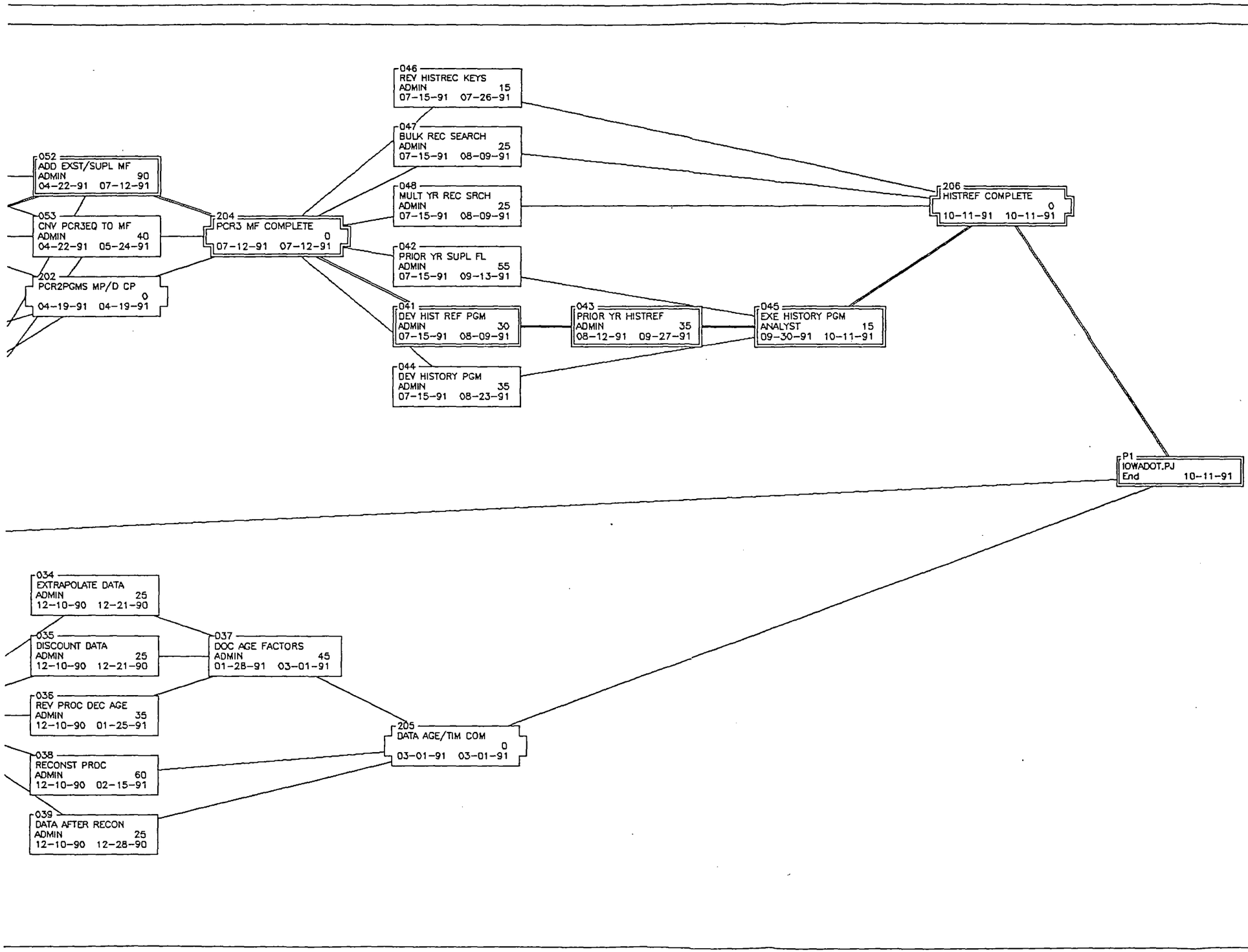
Figure V - 3

Summary Pert Chart

Pert Chart, Figure V - 3, follows


P1
IOWADOT.PJ
Begin 07-01-90
001
EST MPOST POLICY
ADMIN 10
07-02-90 07-13-90
004
POST/PT/SEG XREF
ADMIN 40
07-16-90 08-10-90
005
PPS XREF UPDATE
ADMIN 20
08-13-90 08-31-90
006
MPOST POL & PROC
ADMIN 25
07-16-90 08-17-90
007
MP/DIS TO MPOINT
ANALYST 15
08-13-90 08-24-90
008
MPOINT TO MP/DIS
CLERICAL 15
08-13-90 08-24-90
009
OTHRSEG TO BRSEG
ANALYST 15
08-13-90 08-24-90
010
BRSEG TO REFDATA
ADMIN 15
08-13-90 08-24-90
030
PMSEC DESIGNATOR
ADMIN 20
07-16-90 07-27-90
011
NODE/SHAPE PROC
ADMIN 30
07-16-90 08-24-90
012
DEV NODE FILE
ADMIN 60
08-27-90 11-09-90
013
DEV SHAPE FILE
ADMIN 80
08-27-90 11-02-90
014
NODE REFINE PROC
ADMIN 45
08-27-90 10-05-90
201
PPS XREF COMPLET
0
08-31-90 08-31-90
031
ALIGN SECTIONS
ADMIN 60
09-03-90 11-02-90
015
XY TO MPNT(OFST)
ADMIN 15
09-03-90 09-14-90
016
MPNT(OFST) TO XY
CLERICAL 15
09-03-90 09-14-90
017
XYDOT L/L XYDNR
ANALYST 15
09-03-90 09-14-90
018
ACCNODE TO MPNT
ADMIN 15
09-03-90 09-14-90
050
PCR3DATA EXST FL
ADMIN 50
11-05-90 12-07-90
032
RV PCR2PGMS MP/D
ADMIN 120
11-05-90 04-19-91
002
REV FILES MP/DIS
ADMIN 50
11-05-90 12-14-90
003
REV MAPS MP/DIS
ADMIN 80
11-05-90 01-11-91
051
PCR3DATA SUPL FL
ADMIN 75
11-05-90 12-28-90
203
SLS XREF COMPLET
0
11-09-90 11-09-90
033
EVAL AGE EFFECT
ADMIN 50
11-05-90 12-07-90
FS— SS—— – FF—— — Link — Task — Selected Task
FS═ SS═══ = FF═ ═ Critical Link ═ Crit Task ═ Sel Crit Task

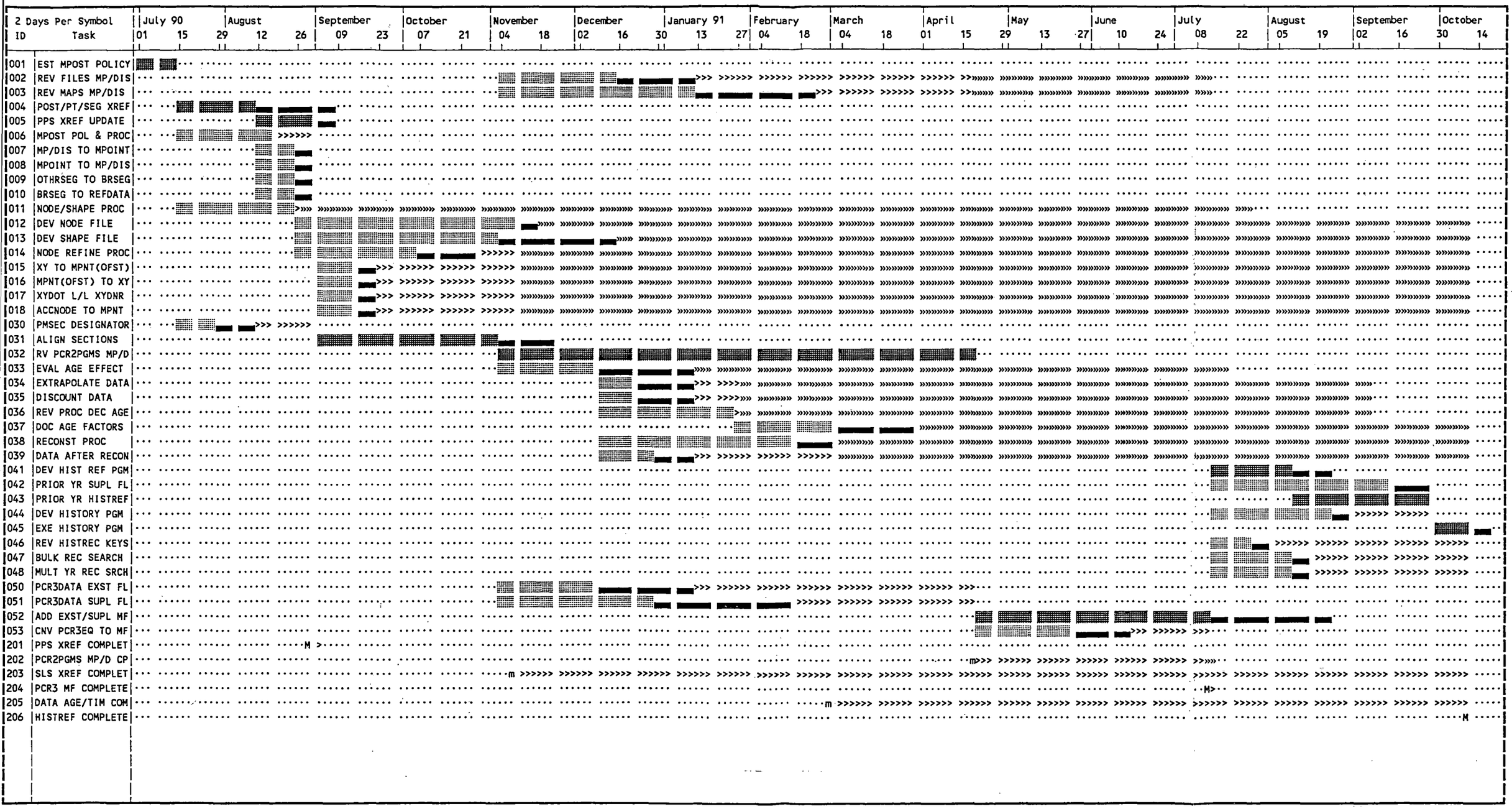
Project: IOWADOT.PJ
06-26-90



Abbreviated Gantt Chart, Figure V - 4, follows

Task Gantt
06-25-90 6:03p

Project: IOWADOT.PJ
Revision: 15



Non Critical m Milestone »»» Float/Delay Finish Delay ___ Interrupt
Critical M Critical MS >>> Free Float Unassigned

Project Outline, Table V - 3, follows

Outline
06-25-90 5:24p

Project: IOWADOT.PJ
Revision: 15

Heading/Task Resource	Task ID	Dur	Total Hours	Schd Start	Schd Finish	Un	Early Start	Early Finish	Late Start	Late Finish
IOWADOT.PJ	P1	335	22880	07-02-90<	10-11-91		07-01-90<	10-11-91	07-02-90	10-11-91
EST MPOST POLICY	001	10	160	07-02-90	07-13-90		07-01-90	07-13-90	07-02-90	07-13-90
ADMIN	001	10	40	07-02-90	07-06-90	1				
CLERICAL	001	10	40	07-02-90	07-06-90	1				
PROFESSION	001	10	80	07-02-90	07-13-90	1				
PPS XREF UPDATE	005	20	360	08-13-90	08-31-90		08-10-90	08-31-90	08-13-90	08-31-90
ADMIN	005	20	40	08-13-90	08-17-90	1				
CLERICAL	005	20	40	08-13-90	08-17-90	1				
ANALYST	005	20	80	08-13-90	08-24-90	1				
PROGRAMER	005	20	120	08-13-90	08-31-90	1				
TECH	005	20	80	08-13-90	08-24-90	1				
MPOST POL & PROC	006	25	480	07-16-90	08-17-90		07-13-90	08-17-90	07-30-90	08-31-90
ADMIN	006	25	40	07-16-90	07-20-90	1				
CLERICAL	006	25	80	07-16-90	07-27-90	1				
PROFESSION	006	25	200	07-16-90	08-17-90	1				
TECH	006	25	160	07-16-90	08-10-90	1				
PMSEC DESIGNATOR	030	20	240	07-16-90	07-27-90		07-13-90	07-27-90	08-20-90	08-31-90
ADMIN	030	20	40	07-16-90	07-20-90	1				
ANALYST	030	20	80	07-16-90	07-27-90	1				
PROGRAMER	030	20	80	07-16-90	07-27-90	1				
PROFESSION	030	20	40	07-16-90	07-20-90	1				
NODE/SHAPE PROC	011	30	640	07-16-90	08-24-90		07-13-90	08-24-90	06-17-91	07-26-91
ADMIN	011	30	80	07-16-90	07-27-90	1				
CLERICAL	011	30	40	07-16-90	07-20-90	1				
ANALYST	011	30	120	07-16-90	08-03-90	1				
PROGRAMER	011	30	240	07-16-90	08-24-90	1				
PROFESSION	011	30	40	07-16-90	07-20-90	1				
TECH	011	30	80	07-16-90	07-27-90	1				
DIGITIZER	011	30	40	07-16-90	07-20-90	1				
POST/PT/SEG XREF	004	40	640	07-16-90	08-10-90		07-13-90	08-10-90	07-16-90	08-10-90
ADMIN	004	40	80	07-16-90	07-27-90	1				
CLERICAL	004	40	40	07-16-90	07-20-90	1				
ANALYST	004	40	160	07-16-90	08-10-90	1				
PROGRAMER	004	40	240	07-16-90	08-03-90	2				
PROFESSION	004	40	40	07-16-90	07-20-90	1				
TECH	004	40	80	07-16-90	07-27-90	1				
MP/DIS TO MPOINT	007	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
ANALYST	007	15	40	08-13-90	08-17-90	1				
ADMIN	007	15	40	08-13-90	08-17-90	1				
PROGRAMER	007	15	80	08-13-90	08-24-90	1				
MPOINT TO MP/DIS	008	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
CLERICAL	008	15	40	08-13-90	08-17-90	1				
ANALYST	008	15	40	08-13-90	08-17-90	1				
PROFESSION	008	15	80	08-13-90	08-24-90	1				
OTHRSEG TO BRSEG	009	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
ANALYST	009	15	40	08-13-90	08-17-90	1				
PROGRAMER	009	15	80	08-13-90	08-24-90	1				
TECH	009	15	40	08-13-90	08-17-90	1				
PPS XREF COMPLET	201	0	0	08-31-90	08-31-90		08-31-90	08-31-90	09-03-90	09-03-90
BRSEG TO REFDATA	010	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
ADMIN	010	15	40	08-13-90	08-17-90	1				
ANALYST	010	15	40	08-13-90	08-17-90	1				

Outline
06-25-90 5:24p

Across: 1 Down: 2
Project: IOWADOT.PJ
Revision: 15

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Heading/Task	Resource	Task ID	Dur	Total Hours	Schd Start	Schd Finish	Un	Early Start	Early Finish	Late Start	Late Finish
	PROGRAMER	010	15	80	08-13-90	08-24-90	1				
DEV NODE FILE		012	60	800	08-27-90	11-09-90		08-24-90	11-09-90	07-29-91	10-11-91
	ADMIN	012	60	80	08-27-90	09-07-90	1				
	CLERICAL	012	60	40	08-27-90	08-31-90	1				
	ANALYST	012	60	80	08-27-90	09-07-90	1				
	PROGRAMER	012	60	80	08-27-90	09-07-90	1				
	PROFESSION	012	60	40	08-27-90	08-31-90	1				
	TECH	012	60	40	08-27-90	08-31-90	1				
	DIGITIZER	012	60	440	08-27-90	11-09-90	1				
DEV SHAPE FILE		013	80	1440	08-27-90	11-02-90		08-24-90	11-02-90	08-05-91	10-11-91
	ADMIN	013	80	120	08-27-90	09-14-90	1				
	CLERICAL	013	80	80	08-27-90	09-07-90	1				
	ANALYST	013	80	160	08-27-90	09-21-90	1				
	PROGRAMER	013	80	80	08-27-90	09-07-90	1				
	PROFESSION	013	80	80	08-27-90	09-07-90	1				
	TECH	013	80	120	08-27-90	09-14-90	1				
	DIGITIZER	013	80	800	08-27-90	11-02-90	2				
NODE REFINE PROC		014	45	640	08-27-90	10-05-90		08-24-90	10-05-90	09-02-91	10-11-91
	ADMIN	014	45	80	08-27-90	09-07-90	1				
	CLERICAL	014	45	40	08-27-90	08-31-90	1				
	ANALYST	014	45	120	08-27-90	09-14-90	1				
	PROGRAMER	014	45	240	08-27-90	10-05-90	1				
	PROFESSION	014	45	40	08-27-90	08-31-90	1				
	TECH	014	45	80	08-27-90	09-07-90	1				
	DIGITIZER	014	45	40	08-27-90	08-31-90	1				
SLS XREF COMPLET		203	0	0	11-09-90	11-09-90		11-09-90	11-09-90	10-11-91	10-11-91
ALIGN SECTIONS		031	60	960	09-03-90	11-02-90		08-31-90	11-02-90	09-03-90	11-02-90
	ADMIN	031	60	80	09-03-90	09-14-90	1				
	CLERICAL	031	60	40	09-03-90	09-07-90	1				
	ANALYST	031	60	120	09-03-90	09-21-90	1				
	PROGRAMER	031	60	200	09-03-90	10-05-90	1				
	PROFESSION	031	60	160	09-03-90	09-28-90	1				
	TECH	031	60	360	09-03-90	11-02-90	1				
XY TO MPNT(OFST)		015	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
	ADMIN	015	15	40	09-03-90	09-07-90	1				
	ANALYST	015	15	40	09-03-90	09-07-90	1				
	PROGRAMER	015	15	80	09-03-90	09-14-90	1				
MPNT(OFST) TO XY		016	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
	CLERICAL	016	15	40	09-03-90	09-07-90	1				
	ANALYST	016	15	40	09-03-90	09-07-90	1				
	PROGRAMER	016	15	80	09-03-90	09-14-90	1				
XYDOT L/L XYDNR		017	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
	ANALYST	017	15	40	09-03-90	09-07-90	1				
	PROGRAMER	017	15	80	09-03-90	09-14-90	1				
	TECH	017	15	40	09-03-90	09-07-90	1				
ACCNODE TO MPNT		018	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
	ADMIN	018	15	40	09-03-90	09-07-90	1				
	ANALYST	018	15	40	09-03-90	09-07-90	1				
	PROGRAMER	018	15	80	09-03-90	09-14-90	1				
PCR3DATA EXST FL		050	50	640	11-05-90	12-07-90		11-02-90	12-07-90	03-18-91	04-19-91
	ADMIN	050	50	80	11-05-90	11-16-90	1				
	ANALYST	050	50	120	11-05-90	11-23-90	1				

Heading/Task	Resource	Task ID	Dur	Total Hours	Schd Start	Schd Finish	Un	Early Start	Early Finish	Late Start	Late Finish
	PROGRAMER	050	50	200	11-05-90	12-07-90	1				
	PROFESSION	050	50	160	11-05-90	11-30-90	1				
	TECH	050	50	80	11-05-90	11-16-90	1				
PCR3DATA SUPL	FL	051	75	1120	11-05-90	12-28-90		11-02-90	12-28-90	02-25-91	04-19-91
	ADMIN	051	75	120	11-05-90	11-23-90	1				
	CLERICAL	051	75	40	11-05-90	11-09-90	1				
	ANALYST	051	75	200	11-05-90	12-07-90	1				
	PROGRAMER	051	75	320	11-05-90	12-28-90	1				
	PROFESSION	051	75	200	11-05-90	12-07-90	1				
	TECH	051	75	240	11-05-90	12-14-90	1				
RV PCR2PGMS MP/D		032	120	1920	11-05-90	04-19-91		11-02-90	04-19-91	11-05-90	04-19-91
	ADMIN	032	120	200	11-05-90	12-07-90	1				
	CLERICAL	032	120	40	11-05-90	11-09-90	1				
	ANALYST	032	120	480	11-05-90	01-25-91	1				
	PROGRAMER	032	120	960	11-05-90	04-19-91	1				
	PROFESSION	032	120	120	11-05-90	11-23-90	1				
	TECH	032	120	120	11-05-90	11-23-90	1				
REV FILES MP/DIS		002	50	800	11-05-90	12-14-90		11-02-90	12-14-90	06-03-91	07-12-91
	ADMIN	002	50	80	11-05-90	11-16-90	1				
	CLERICAL	002	50	80	11-05-90	11-16-90	1				
	ANALYST	002	50	240	11-05-90	12-14-90	1				
	PROGRAMER	002	50	240	11-05-90	12-14-90	1				
	PROFESSION	002	50	160	11-05-90	11-30-90	1				
REV MAPS MP/DIS		003	80	1440	11-05-90	01-11-91		11-02-90	01-11-91	05-06-91	07-12-91
	ADMIN	003	80	120	11-05-90	11-14-90	2				
	CLERICAL	003	80	80	11-05-90	11-16-90	1				
	ANALYST	003	80	160	11-05-90	11-30-90	1				
	PROGRAMER	003	80	80	11-05-90	11-16-90	1				
	PROFESSION	003	80	80	11-05-90	11-16-90	1				
	TECH	003	80	120	11-05-90	11-23-90	1				
	DIGITIZER	003	80	800	11-05-90	01-11-91	2				
EVAL AGE EFFECT		033	50	640	11-05-90	12-07-90		11-02-90	12-07-90	06-17-91	07-19-91
	ADMIN	033	50	40	11-05-90	11-09-90	1				
	CLERICAL	033	50	40	11-05-90	11-09-90	1				
	ANALYST	033	50	120	11-05-90	11-23-90	1				
	PROGRAMER	033	50	200	11-05-90	12-07-90	1				
	PROFESSION	033	50	160	11-05-90	11-30-90	1				
	TECH	033	50	80	11-05-90	11-16-90	1				
ADD EXST/SUPL MF		052	90	1440	04-22-91	07-12-91		04-19-91	07-12-91	04-22-91	07-12-91
	ADMIN	052	90	160	04-22-91	05-17-91	1				
	CLERICAL	052	90	80	04-22-91	05-03-91	1				
	ANALYST	052	90	240	04-22-91	05-31-91	1				
	PROGRAMER	052	90	480	04-22-91	07-12-91	1				
	PROFESSION	052	90	240	04-22-91	05-31-91	1				
	TECH	052	90	240	04-22-91	05-31-91	1				
CNV PCR3EQ TO MF		053	40	640	04-22-91	05-24-91		04-19-91	05-24-91	06-10-91	07-12-91
	ADMIN	053	40	40	04-22-91	04-26-91	1				
	CLERICAL	053	40	40	04-22-91	04-26-91	1				
	ANALYST	053	40	120	04-22-91	05-10-91	1				
	PROGRAMER	053	40	200	04-22-91	05-24-91	1				
	PROFESSION	053	40	160	04-22-91	05-17-91	1				
	TECH	053	40	80	04-22-91	05-03-91	1				

Heading/Task	Resource	Task ID	Dur	Total Hours	Schd Start	Schd Finish	Un	Early Start	Early Finish	Late Start	Late Finish
PCR2PGMS MP/D	CP	202	0	0	04-19-91	04-19-91		04-19-91	04-19-91	07-15-91	07-15-91
PCR3 MF COMPLETE		204	0	0	07-12-91	07-12-91		07-12-91	07-12-91	07-15-91	07-15-91
EXTRAPOLATE DATA		034	25	320	12-10-90	12-21-90		12-07-90	12-21-90	08-26-91	09-06-91
	ADMIN	034	25	40	12-10-90	12-14-90	1				
	CLERICAL	034	25	40	12-10-90	12-14-90	1				
	ANALYST	034	25	80	12-10-90	12-21-90	1				
	PROGRAMER	034	25	80	12-10-90	12-21-90	1				
	PROFESSION	034	25	80	12-10-90	12-21-90	1				
DISCOUNT DATA		035	25	320	12-10-90	12-21-90		12-07-90	12-21-90	08-26-91	09-06-91
	ADMIN	035	25	40	12-10-90	12-14-90	1				
	ANALYST	035	25	80	12-10-90	12-21-90	1				
	PROGRAMER	035	25	80	12-10-90	12-21-90	1				
	PROFESSION	035	25	80	12-10-90	12-21-90	1				
	TECH	035	25	40	12-10-90	12-14-90	1				
REV PROC DEC AGE		036	35	640	12-10-90	01-25-91		12-07-90	01-25-91	07-22-91	09-06-91
	ADMIN	036	35	40	12-10-90	12-14-90	1				
	CLERICAL	036	35	40	12-10-90	12-14-90	1				
	PROFESSION	036	35	280	12-10-90	01-25-91	1				
	TECH	036	35	280	12-10-90	01-25-91	1				
RECONST PROC		038	60	920	12-10-90	02-15-91		12-07-90	02-15-91	08-05-91	10-11-91
	ADMIN	038	60	80	12-10-90	12-21-90	1				
	CLERICAL	038	60	40	12-10-90	12-14-90	1				
	ANALYST	038	60	240	12-10-90	01-18-91	1				
	PROGRAMER	038	60	400	12-10-90	02-15-91	1				
	PROFESSION	038	60	80	12-10-90	12-21-90	1				
	TECH	038	60	80	12-10-90	12-21-90	1				
DATA AFTER RECON		039	25	320	12-10-90	12-28-90		12-07-90	12-28-90	09-23-91	10-11-91
	ADMIN	039	25	40	12-10-90	12-14-90	1				
	CLERICAL	039	25	120	12-10-90	12-28-90	1				
	PROFESSION	039	25	120	12-10-90	12-28-90	1				
	TECH	039	25	40	12-10-90	12-14-90	1				
DOC AGE FACTORS		037	45	640	01-28-91	03-01-91		01-25-91	03-01-91	09-09-91	10-11-91
	ADMIN	037	45	80	01-28-91	02-08-91	1				
	CLERICAL	037	45	160	01-28-91	02-22-91	1				
	PROFESSION	037	45	200	01-28-91	03-01-91	1				
	TECH	037	45	200	01-28-91	03-01-91	1				
DATA AGE/TIM COM		205	0	0	03-01-91	03-01-91		03-01-91	03-01-91	10-11-91	10-11-91
REV HISTREC KEYS		046	15	160	07-15-91	07-26-91		07-12-91	07-26-91	09-30-91	10-11-91
	ADMIN	046	15	40	07-15-91	07-19-91	1				
	ANALYST	046	15	40	07-15-91	07-19-91	1				
	PROGRAMER	046	15	80	07-15-91	07-26-91	1				
BULK REC SEARCH		047	25	320	07-15-91	08-09-91		07-12-91	08-09-91	09-16-91	10-11-91
	ADMIN	047	25	40	07-15-91	07-19-91	1				
	ANALYST	047	25	80	07-15-91	07-26-91	1				
	PROGRAMER	047	25	160	07-15-91	08-09-91	1				
	PROFESSION	047	25	40	07-15-91	07-19-91	1				
MULT YR REC SRCH		048	25	320	07-15-91	08-09-91		07-12-91	08-09-91	09-16-91	10-11-91
	ADMIN	048	25	40	07-15-91	07-19-91	1				
	ANALYST	048	25	80	07-15-91	07-26-91	1				
	PROGRAMER	048	25	160	07-15-91	08-09-91	1				
	PROFESSION	048	25	40	07-15-91	07-19-91	1				
PRIOR YR SUPL FL		042	55	960	07-15-91	09-13-91		07-12-91	09-13-91	07-29-91	09-27-91

Heading/Task	Resource	Task ID	Dur	Total Hours	Schd Start	Schd Finish	Un	Early Start	Early Finish	Late Start	Late Finish
	ADMIN	042	55	80	07-15-91	07-26-91	1				
	CLERICAL	042	55	40	07-15-91	07-19-91	1				
	ANALYST	042	55	120	07-15-91	08-02-91	1				
	PROGRAMER	042	55	360	07-15-91	09-13-91	1				
	PROFESSION	042	55	160	07-15-91	08-09-91	1				
	TECH	042	55	200	07-15-91	08-16-91	1				
DEV HIST REF PGM		041	30	320	07-15-91	08-09-91		07-12-91	08-09-91	07-15-91	08-09-91
	ADMIN	041	30	40	07-15-91	07-19-91	1				
	ANALYST	041	30	80	07-15-91	07-26-91	1				
	PROGRAMER	041	30	160	07-15-91	08-09-91	1				
	PROFESSION	041	30	40	07-15-91	07-19-91	1				
PRIOR YR HISTREF		043	35	720	08-12-91	09-27-91		08-09-91	09-27-91	08-12-91	09-27-91
	ADMIN	043	35	80	08-12-91	08-23-91	1				
	CLERICAL	043	35	40	08-12-91	08-16-91	1				
	ANALYST	043	35	80	08-12-91	08-23-91	1				
	PROGRAMER	043	35	120	08-12-91	08-30-91	1				
	PROFESSION	043	35	120	08-12-91	08-30-91	1				
	TECH	043	35	280	08-12-91	09-27-91	1				
DEV HISTORY PGM		044	35	480	07-15-91	08-23-91		07-12-91	08-23-91	08-19-91	09-27-91
	ADMIN	044	35	40	07-15-91	07-19-91	1				
	ANALYST	044	35	160	07-15-91	08-09-91	1				
	PROGRAMER	044	35	240	07-15-91	08-23-91	1				
	PROFESSION	044	35	40	07-15-91	07-19-91	1				
EXE HISTORY PGM		045	15	160	09-30-91	10-11-91		09-27-91	10-11-91	09-30-91	10-11-91
	ANALYST	045	15	40	09-30-91	10-04-91	1				
	PROGRAMER	045	15	40	09-30-91	10-04-91	1				
	TECH	045	15	80	09-30-91	10-11-91	1				
HISTREF COMPLETE		206	0	0	10-11-91	10-11-91		10-11-91	10-11-91	10-11-91	10-11-91

Outline
06-25-90 6:11p

Project: IOWADOT.PJ
Revision: 15

Task Name	Task ID	Dur	Total Hours	Schd Start	Schd Finish	Un	Early Start	Early Finish	Late Start	Late Finish
EST MPOST POLICY	001	10	160	07-02-90	07-13-90		07-01-90	07-13-90	07-02-90	07-13-90
REV FILES MP/DIS	002	50	800	11-05-90	12-14-90		11-02-90	12-14-90	06-03-91	07-12-91
REV MAPS MP/DIS	003	80	1440	11-05-90	01-11-91		11-02-90	01-11-91	05-06-91	07-12-91
POST/PT/SEG XREF	004	40	640	07-16-90	08-10-90		07-13-90	08-10-90	07-16-90	08-10-90
PPS XREF UPDATE	005	20	360	08-13-90	08-31-90		08-10-90	08-31-90	08-13-90	08-31-90
MPOST POL & PROC	006	25	480	07-16-90	08-17-90		07-13-90	08-17-90	07-30-90	08-31-90
MP/DIS TO MPOINT	007	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
MPOINT TO MP/DIS	008	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
OTHRSEG TO BRSEG	009	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
BRSEG TO REFDATA	010	15	160	08-13-90	08-24-90		08-10-90	08-24-90	08-20-90	08-31-90
NODE/SHAPE PROC	011	30	640	07-16-90	08-24-90		07-13-90	08-24-90	06-17-91	07-26-91
DEV NODE FILE	012	60	800	08-27-90	11-09-90		08-24-90	11-09-90	07-29-91	10-11-91
DEV SHAPE FILE	013	80	1440	08-27-90	11-02-90		08-24-90	11-02-90	08-05-91	10-11-91
NODE REFINE PROC	014	45	640	08-27-90	10-05-90		08-24-90	10-05-90	09-02-91	10-11-91
XY TO MPNT(OFST)	015	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
MPNT(OFST) TO XY	016	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
XYDOT L/L XYDNR	017	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
ACCNODE TO MPNT	018	15	160	09-03-90	09-14-90		08-31-90	09-14-90	09-30-91	10-11-91
PMSEC DESIGNATOR	030	20	240	07-16-90	07-27-90		07-13-90	07-27-90	08-20-90	08-31-90
ALIGN SECTIONS	031	60	960	09-03-90	11-02-90		08-31-90	11-02-90	09-03-90	11-02-90
RV PCR2PGMS MP/D	032	120	1920	11-05-90	04-19-91		11-02-90	04-19-91	11-05-90	04-19-91
EVAL AGE EFFECT	033	50	640	11-05-90	12-07-90		11-02-90	12-07-90	06-17-91	07-19-91
EXTRAPOLATE DATA	034	25	320	12-10-90	12-21-90		12-07-90	12-21-90	08-26-91	09-06-91
DISCOUNT DATA	035	25	320	12-10-90	12-21-90		12-07-90	12-21-90	08-26-91	09-06-91
REV PROC DEC AGE	036	35	640	12-10-90	01-25-91		12-07-90	01-25-91	07-22-91	09-06-91
DOC AGE FACTORS	037	45	640	01-28-91	03-01-91		01-25-91	03-01-91	09-09-91	10-11-91
RECONST PROC	038	60	920	12-10-90	02-15-91		12-07-90	02-15-91	08-05-91	10-11-91
DATA AFTER RECON	039	25	320	12-10-90	12-28-90		12-07-90	12-28-90	09-23-91	10-11-91
DEV HIST REF PGM	041	30	320	07-15-91	08-09-91		07-12-91	08-09-91	07-15-91	08-09-91
PRIOR YR SUPL FL	042	55	960	07-15-91	09-13-91		07-12-91	09-13-91	07-29-91	09-27-91
PRIOR YR HISTREF	043	35	720	08-12-91	09-27-91		08-09-91	09-27-91	08-12-91	09-27-91
DEV HISTORY PGM	044	35	480	07-15-91	08-23-91		07-12-91	08-23-91	08-19-91	09-27-91
EXE HISTORY PGM	045	15	160	09-30-91	10-11-91		09-27-91	10-11-91	09-30-91	10-11-91
REV HISTREC KEYS	046	15	160	07-15-91	07-26-91		07-12-91	07-26-91	09-30-91	10-11-91
BULK REC SEARCH	047	25	320	07-15-91	08-09-91		07-12-91	08-09-91	09-16-91	10-11-91
MULT YR REC SRCH	048	25	320	07-15-91	08-09-91		07-12-91	08-09-91	09-16-91	10-11-91
PCR3DATA EXST FL	050	50	640	11-05-90	12-07-90		11-02-90	12-07-90	03-18-91	04-19-91
PCR3DATA SUPL FL	051	75	1120	11-05-90	12-28-90		11-02-90	12-28-90	02-25-91	04-19-91
ADD EXST/SUPL MF	052	90	1440	04-22-91	07-12-91		04-19-91	07-12-91	04-22-91	07-12-91
CNV PCR3EQ TO MF	053	40	640	04-22-91	05-24-91		04-19-91	05-24-91	06-10-91	07-12-91
PPS XREF COMPLET	201	0	0	08-31-90	08-31-90		08-31-90	08-31-90	09-03-90	09-03-90
PCR2PGMS MP/D CP	202	0	0	04-19-91	04-19-91		04-19-91	04-19-91	07-15-91	07-15-91
SLS XREF COMPLET	203	0	0	11-09-90	11-09-90		11-09-90	11-09-90	10-11-91	10-11-91
PCR3 MF COMPLETE	204	0	0	07-12-91	07-12-91		07-12-91	07-12-91	07-15-91	07-15-91
DATA AGE/TIM COM	205	0	0	03-01-91	03-01-91		03-01-91	03-01-91	10-11-91	10-11-91
HISTREF COMPLETE	206	0	0	10-11-91	10-11-91		10-11-91	10-11-91	10-11-91	10-11-91

Sample Task Details, Table V - 4, follows

Task Details
06-25-90 5:26p

Project: IOWADOT.PJ
Revision: 15

ID: 001
Name:EST MPOST POLICY

		Start	Finish	Totals
Duration: 10	Actual Dur: 0	Erly:07-01-90	07-13-90	Var: 4000.00
Strt Del: 0	Finish Del: 0	Late:07-02-90	07-13-90	Fix: 0.00
Float: 0	Free Float: 0	Schd:07-02-90	07-13-90	Tot: 4000.00
Pct Comp: 0	BCWP: 0.00	Actl:		Act: 0.00
Type:ASAP		Plan:		Plc: 0.00
WBS:01.01.00.00.0001	Acct: 0	Scheduled/Crit.	Priority: 1	Hrs: 160
		Dev:0.00		Plh: 0 Ovr: 0

Resource	Hrs	Allc	Un	Predecessors	Successors		Lag
ADMIN	40	dayd	1		004 POST/PT/SEG XREF	FS	0h
CLERICAL	40	dayd	1		006 MPOST POL & PROC	FS	0h
PROFESSION	80	dayd	1		030 PMSEC DESIGNATOR	FS	0h
					011 NODE/SHAPE PROC	FS	0h

Task Details
06-25-90 5:30p

Project: IOWADOT.PJ
Revision: 15

ID: 030
Name: PMSEC DESIGNATOR

		Start	Finish	Totals
Duration:	20 Actual Dur: 0	Erly: 07-13-90	07-27-90	Var: 6000.00
Strt Del:	0 Finish Del: -10	Late: 08-20-90	08-31-90	Fix: 0.00
Float:	25 Free Float: 25	Schd: 07-16-90	07-27-90	Tot: 6000.00
Pct Comp:	0 BCWP: 0.00	Actl:		Act: 0.00
Type:	ASAP	Plan:		Plc: 0.00
WBS:	01.04.00.00.0030 Acct: 0	Scheduled	Priority:	Hrs: 240
		Dev: 0.00		Plh: 0 Ovr: 160

Resource	Hrs	Allc	Un	Predecessors			Successors			Lag
ADMIN	40	dayd	1	001	EST MPOST POLICY	FS	201	PPS XREF COMPLET	FS	0h
ANALYST	80	dayd	1							
PROGRAMER	80	dayd	1							
PROFESSION	40	dayd	1							

Task Details
06-25-90 5:30p

Project: IOWADOT.PJ
Revision: 15

ID: 033
Name: EVAL AGE EFFECT

		Start	Finish	Totals
Duration: 50	Actual Dur: 0	Erly: 11-02-90	12-07-90	Var: 16000.00
Strt Del: 0	Finish Del: -25	Late: 06-17-91	07-19-91	Fix: 0.00
Float: 160	Free Float: 0	Schd: 11-05-90	12-07-90	Tot: 16000.00
Pct Comp: 0	BCWP: 0.00	Actl:		Act: 0.00
Type: ASAP		Plan:		Plc: 0.00
WBS: 01.26.00.00.0033	Acct: 0	Scheduled	Priority:	Hrs: 640
		Dev: 0.00		Plh: 0 Ovr: 400

Resource	Hrs	Allc	Un
ADMIN	40	dayd	1
CLERICAL	40	dayd	1
ANALYST	120	dayd	1
PROGRAMER	200	dayd	1
PROFESSION	160	dayd	1
TECH	80	dayd	1

Predecessors			Successors			Lag
031	ALIGN SECTIONS	FS	034	EXTRAPOLATE DATA	FS	0h
			035	DISCOUNT DATA	FS	0h
			036	REV PROC DEC AGE	FS	0h
			038	RECONST PROC	FS	0h
			039	DATA AFTER RECON	FS	0h

Sample Resource Details, Table V - 5, follows

Resource Details
06-26-90 12:38p

Project: IOWADOT.PJ
Revision: 15

Rsrc Name:ADMIN	ADMIN RESOURCE		
Work Code:1 Accrue:Strt	Defaults		Totals
Total Overscheduled: 920 Rate Mult:1.00	Hours: 40		Var: 59000.00
Calendar Variance: 0 No. Units: 2	Fixed: 0.00		Fix: 0.00
Workday: Sun Mon Tue Wed Thu Fri Sat	Rate: 25.00		Tot: 59000.00
Start: 8:00a 0 8 8 8 8 8 0	Standard Day: 8		Act: 0.00
	Allocation: dayd		Hrs:2360

ID	T a s k	Dur	Hrs	Allc	Un	Ovr	Actl	Pr	Start	Finish
002	REV FILES MP/DIS	50	80	dayd	1	0	0	50	11-05-90	11-16-90
003	REV MAPS MP/DIS	80	120	dayd	2	56	0	50	11-05-90	11-14-90
004	POST/PT/SEG XREF	40	80	dayd	1	0	0	50	07-16-90	07-27-90
005	PPS XREF UPDATE	20	40	dayd	1	0	0	50	08-13-90	08-17-90
006	MPOST POL & PROC	25	40	dayd	1	0	0	50	07-16-90	07-20-90
007	MP/DIS TO MPOINT	15	40	dayd	1	0	0	50	08-13-90	08-17-90
012	DEV NODE FILE	60	80	dayd	1	0	0	50	08-27-90	09-07-90
011	NODE/SHAPE PROC	30	80	dayd	1	40	0	50	07-16-90	07-27-90
013	DEV SHAPE FILE	80	120	dayd	1	0	0	50	08-27-90	09-14-90
014	NODE REFINE PROC	45	80	dayd	1	80	0	50	08-27-90	09-07-90
015	XY TO MPNT(OFST)	15	40	dayd	1	40	0	50	09-03-90	09-07-90
018	ACCNODE TO MPNT	15	40	dayd	1	40	0	50	09-03-90	09-07-90
030	PMSEC DESIGNATOR	20	40	dayd	1	40	0	50	07-16-90	07-20-90
031	ALIGN SECTIONS	60	80	dayd	1	40	0	50	09-03-90	09-14-90
032	RV PCR2PGMS MP/D	120	200	dayd	1	64	0	50	11-05-90	12-07-90
041	DEV HIST REF PGM	30	40	dayd	1	0	0	50	07-15-91	07-19-91
042	PRIOR YR SUPL FL	55	80	dayd	1	0	0	50	07-15-91	07-26-91
043	PRIOR YR HISTREF	35	80	dayd	1	0	0	50	08-12-91	08-23-91
044	DEV HISTORY PGM	35	40	dayd	1	40	0	50	07-15-91	07-19-91
046	REV HISTREC KEYS	15	40	dayd	1	40	0	50	07-15-91	07-19-91
047	BULK REC SEARCH	25	40	dayd	1	40	0	50	07-15-91	07-19-91
048	MULT YR REC SRCH	25	40	dayd	1	40	0	50	07-15-91	07-19-91
033	EVAL AGE EFFECT	50	40	dayd	1	40	0	50	11-05-90	11-09-90
034	EXTRAPOLATE DATA	25	40	dayd	1	0	0	50	12-10-90	12-14-90
035	DISCOUNT DATA	25	40	dayd	1	0	0	50	12-10-90	12-14-90
036	REV PROC DEC AGE	35	40	dayd	1	40	0	50	12-10-90	12-14-90
037	DOC AGE FACTORS	45	80	dayd	1	0	0	50	01-28-91	02-08-91
038	RECONST PROC	60	80	dayd	1	40	0	50	12-10-90	12-21-90
039	DATA AFTER RECON	25	40	dayd	1	40	0	50	12-10-90	12-14-90
050	PCR3DATA EXST FL	50	80	dayd	1	80	0	50	11-05-90	11-16-90
051	PCR3DATA SUPL FL	75	120	dayd	1	80	0	50	11-05-90	11-23-90
052	ADD EXST/SUPL MF	90	160	dayd	1	0	0	50	04-22-91	05-17-91
053	CNV PCR3EQ TO MF	40	40	dayd	1	0	0	50	04-22-91	04-26-91
010	BRSEG TO REFDATA	15	40	dayd	1	40	0	50	08-13-90	08-17-90
001	EST MPOST POLICY	10	40	dayd	1	0	0	1	07-02-90	07-06-90

Resource Details
06-26-90 12:38p

Project: IOWADOT.PJ
Revision: 15

Rsrc Name:ANALYST

Work Code:3 Accrue:Strt
Total Overscheduled: 1600 Rate Mult:1.00
Calendar Variance: 0 No. Units: 2
Workday: Sun Mon Tue Wed Thu Fri Sat
Start: 8:00a 0 8 8 8 8 8 0

Defaults
Hours: 40
Fixed: 0.00
Rate: 25.00
Standard Day: 8
Allocation: dayd

Totals
Var: 100000.00
Fix: 0.00
Tot: 100000.00
Act: 0.00
Hrs:4000

ID	T a s k	Dur	Hrs	Allc	Un	Ovr	Actl	Pr	Start	Finish
002	REV FILES MP/DIS	50	240	dayd	1	0	0	50	11-05-90	12-14-90
003	REV MAPS MP/DIS	80	160	dayd	1	0	0	50	11-05-90	11-30-90
004	POST/PT/SEG XREF	40	160	dayd	1	0	0	50	07-16-90	08-10-90
005	PPS XREF UPDATE	20	80	dayd	1	0	0	50	08-13-90	08-24-90
007	MP/DIS TO MPOINT	15	40	dayd	1	0	0	50	08-13-90	08-17-90
008	MPOINT TO MP/DIS	15	40	dayd	1	40	0	50	08-13-90	08-17-90
009	OTHRSEG TO BRSEG	15	40	dayd	1	40	0	50	08-13-90	08-17-90
012	DEV NODE FILE	60	80	dayd	1	0	0	50	08-27-90	09-07-90
011	NODE/SHAPE PROC	30	120	dayd	1	0	0	50	07-16-90	08-03-90
013	DEV SHAPE FILE	80	160	dayd	1	0	0	50	08-27-90	09-21-90
014	NODE REFINE PROC	45	120	dayd	1	80	0	50	08-27-90	09-14-90
015	XY TO MPNT(OFST)	15	40	dayd	1	40	0	50	09-03-90	09-07-90
016	MPNT(OFST) TO XY	15	40	dayd	1	40	0	50	09-03-90	09-07-90
017	XYDOT L/L XYDNR	15	40	dayd	1	40	0	50	09-03-90	09-07-90
018	ACCNODE TO MPNT	15	40	dayd	1	40	0	50	09-03-90	09-07-90
030	PMSEC DESIGNATOR	20	80	dayd	1	80	0	50	07-16-90	07-27-90
031	ALIGN SECTIONS	60	120	dayd	1	80	0	50	09-03-90	09-21-90
032	RV PCR2PGMS MP/D	120	480	dayd	1	160	0	50	11-05-90	01-25-91
041	DEV HIST REF PGM	30	80	dayd	1	0	0	50	07-15-91	07-26-91
042	PRIOR YR SUPL FL	55	120	dayd	1	0	0	50	07-15-91	08-02-91
043	PRIOR YR HISTREF	35	80	dayd	1	0	0	50	08-12-91	08-23-91
044	DEV HISTORY PGM	35	160	dayd	1	80	0	50	07-15-91	08-09-91
045	EXE HISTORY PGM	15	40	dayd	1	0	0	50	09-30-91	10-04-91
046	REV HISTREC KEYS	15	40	dayd	1	40	0	50	07-15-91	07-19-91
047	BULK REC SEARCH	25	80	dayd	1	80	0	50	07-15-91	07-26-91
048	MULT YR REC SRCH	25	80	dayd	1	80	0	50	07-15-91	07-26-91
033	EVAL AGE EFFECT	50	120	dayd	1	120	0	50	11-05-90	11-23-90
034	EXTRAPOLATE DATA	25	80	dayd	1	40	0	50	12-10-90	12-21-90
035	DISCOUNT DATA	25	80	dayd	1	80	0	50	12-10-90	12-21-90
038	RECONST PROC	60	240	dayd	1	80	0	50	12-10-90	01-18-91
050	PCR3DATA EXST FL	50	120	dayd	1	120	0	50	11-05-90	11-23-90
051	PCR3DATA SUPL FL	75	200	dayd	1	200	0	50	11-05-90	12-07-90
052	ADD EXST/SUPL MF	90	240	dayd	1	0	0	50	04-22-91	05-31-91
053	CNV PCR3EQ TO MF	40	120	dayd	1	0	0	50	04-22-91	05-10-91
010	BRSEG TO REFDATA	15	40	dayd	1	40	0	50	08-13-90	08-17-90

SECTION VI - ADDITIONAL RECOMMENDED IMPROVEMENTS

The preceding sections of this Report describe the improvements considered to be within the scope of the HLRP project. These are Recommendations 1 through 8,10, 11, 12 and 18, as specified in the Final Recommendations document. The Design Specifications and Implementation Plan address these improvements.

During the course of the HLRP project, several other improvements were identified and presented to the DOT for consideration as a part of the Final Recommendations. These additional recommended improvements are discussed in the remainder of this section.

REFERENCE SYSTEM

Two additional improvements were identified regarding the proposed reference system - a reference system instructional document and monument extensions. Both of these improvements are discussed in the following paragraphs.

Reference System Instructional Document

Recommendation Number Fifteen identified the need for the DOT to prepare, distribute and maintain an instructional document, explaining the proposed reference system. An instructional document explaining the proposed reference system would be a beneficial tool for DOT personnel. Such a document should describe the accuracy, both relative and absolute, of the linear and spatial reference systems. It should discuss the impact of horizontal versus odometer measured distances. It should show the user how to use the reference systems and which system would be most relevant for a specific purpose.

Implementation of an instructional document could be a parallel process to other activities and should be made available as the proposed reference system is brought on line. Once completed, the document must be diligently maintained and updated to reflect current conditions. As the future DOT GIS is developed, the document could serve as a basis for a GIS instructional document.

Monument Extensions

Recommendation Number Seventeen proposed establishing additional monuments along the routes. These monuments could be physical features such as bridges, culverts, county line markers, or other existing features. These features would be handled in the same fashion as mileposts in that reference would be a plus or minus displacement from the feature. The feature identification would have to be clearly marked on the feature and exist in the Milepost/Milepoint Cross Reference scheme. These monuments could be added on, on an as-required basis.

PAVEMENT MANAGEMENT

Three additional improvements were identified regarding the Pavement Management System. These three improvements are discussed in the following paragraphs.

Data Base Version of Pavement Management Data

Recommendation Number Fourteen proposed that the DOT implement a data base system for pavement management data. A single file or a group of files can be considered a data base, but references in this report to converting to a data base mean placing data in a data base environment. In this case, data base manager software controls data definition, storage, and access. Instead of rigidly defining files and file access processes, the data and its attributes are defined to the data base software and data accesses take advantage of query language and utilities by the software.

The new data base implementation of the base records appears to be well conceived and should add considerable flexibility to base record related activities. The DOT should consider implementing a similar data base for pavement management data. In essence, the IPMS Raw Data File, as augmented with PCR-3 related data, should be converted to the data base.

Since the DOT has already designed the base record data base implementation, designing one for pavement management data should be straight forward. The implementation of a segment identifier on pavement management sections and on the base records should allow for seamless correlation between base records and pavement management sections.

Even though a data base version of the pavement management data could be developed at any time, it may be cost effective to inaugurate such a scheme as the new pavement management data structure is being considered. If the DOT opts for early implementation, the Design Specifications and Implementation Plan would have to be modified to reflect this replacement. Other aspects of the proposed reference procedure would be unaffected.

Dynamic Pavement Management Segmentation

Recommendation Number Sixteen identified the possible implementation of dynamic (programmatic) subdivision of pavement management sections. It is possible that the segmentation could be dynamically altered, depending on the data encountered. Using such a scheme, the Pavement Management (Test) Sections would remain the same, but certain calculations would be done on shorter segments, then the results aggregated back to the longer segments.

Implementing this recommendation would require that significant system analysis and programming effort be expanded. The effort may be worthwhile, however, in that data could be gathered independently, not constrained to arbitrary boundaries.

It should be noted that this recommendation relates to dynamic subdivision of existing pavement management segments. It should not be confused with the currently used "dynamic segmentation" terminology, which is inherent in the Highway Location Reference Process being proposed for Iowa DOT. The proposed process will accommodate future segmentation as desired, regardless of how any roadway related data is referenced.

Automatic Truck Weight and Classification

Recommendation Number Thirteen identified the need to hasten implementation of the automatic truck weight and classification system. We recognize that research on adequate systems is just now being completed. However, early implementation of such a system offers needed benefits.

Additional Recommendation

The need for unified functions and procedures for reporting construction and maintenance costs referenced according to the proposed reference system was identified late in the project. This would involve revisions to accounting procedures as well as coordination with the proposed reference methodology.

FUTURE DOT GEOGRAPHIC INFORMATION SYSTEM

Recommendation Numbers Nine and Nineteen identified the need for a Geographic Information System (GIS) within the Iowa DOT. Recommendation Number Nine discussed the GIS definition and Recommendation Number Nineteen the implementation. The proposed Highway Location Reference Procedure will support the development of a DOT GIS.

Implementation of a DOT GIS involves several steps. First, a Strategic Plan must be developed, then, GIS software and hardware need to be procured, data needs to be converted and applications need to be developed.

The Strategic Plan should identify the long range goals and objectives of the DOT, discuss the current environment, define user requirements, application requirements and system requirements. It should address the organization and management structure, data base development issues, and financial issues as well as system maintenance issues. The Strategic Plan becomes a recipe for GIS development.

The DOT needs to proceed with Strategic Plan development in the near term to reap the benefits of a GIS as soon as possible. A GIS Task Force should be appointed, made up of a cross section of DOT personnel, to serve as a catalyst in the process. Once the Strategic Plan is developed and a software and hardware solution is selected, work should commence on developing the GIS.