MICHIGAN DEPARTMENT
OF
STATE HIGHWAYS AND TRANSPORTATION

A REPORT

OF THE

STUDY COMMITTEE

ON THE

"BENEFITS TO THE STATE OF MICHIGAN

OF A

STATEWIDE COORDINATE SYSTEM"

STATE HIGHWAY COMMISSION

Peter B. Fletcher
Chairman

Carl V. Pellonpaa

Hannes Meyers, Jr.

DIRECTOR

John P. Woodford

Index to Report

I. INTRODUCTION

To meet the long-range commitments of the Michigan Department of State Highways and Transportation (MDSHT) with regard to planning, programming and construction of a total transportation network in conformance with State goals for land use and preservation of the natural environment, it has become apparent that future projects undertaken by the MDSHT must conform to a State coordinate system. Conformance to such a system will permit greater speed and accuracy in performance of surveys and in referencing land titles to a uniform system.

As a result of this apparent need, the Department Executive Committee, on November 12, 1974, authorized formation of a study committee to examine the benefit-cost considerations of future compliance with the Michigan Statewide Coordinate System and to consider methods of financing and implementing the system if it is considered feasible.

A committee to "study the benefits to the State of Michigan of a statewide coordinate system" was established to include representatives of interested State agencies and of industry. The Committee consists of the following:

- John W. Knecht, Jr. Chairman, Administrative Assistant to the Director, MDSHT.
- Casimir Zajac, P. E., Engineer, Road Design, MDSHT.
- M. Tarik Ataman, P. E., Engineer, Route Location, MDSHT.
- Douglas Hooth, R.L.S., P. E., Survey Supervising Engineer, MDSHT.

- Leo Thrall, A.S.P., C.E.T., Supervisor, Photogrammetrics Unit, MDSHT.
- Edward W. Eva, P.E., Engineer, Engineering Systems Development Section, MDSHT.
- Milton E. Dekeyser, P.E., R.L.S., President, Michigan Society of Registered Land Surveyors.
- David Pawlaczyk, R.L.S., Secretary, Giffels-Webster Engineers, Inc.
- Earl F. Burkholder, R.L.S., Project Manager, Commonwealth Associates, Inc.

The following report is furnished on the basis of research and study by the Statewide Coordinate Study Committee. Conclusions and recommendations are the consensus of the Committee, which has concluded that it would be beneficial for the Department and for the State to implement a system of compliance with the Statewide Coordinate System.

II. SUMMARY AND CONCLUSION

The studies and recommendations of the committee are based on a complete review of existing systems and laws and upon meetings with officials of the Federal Government, affected State agencies and members of the Michigan Society of Registered Land Surveyors.

To permit efficient use by all public and private agencies in Michigan, it is important that the system adopted provide a simple but sufficiently precise frame of reference for all forms of land and construction surveys.

The recommended Statewide Coordinate System provides a reference system that will permit rapid storage, retrieval, utilization and interaction between existing and proposed automated data files, but it will be sufficiently simple to permit utilization by users who do not employ sophisticated computers.

When fully implemented, the system would be the basis of all future land surveys in Michigan. Although immediate benefits will be limited, the system's benefits would increase constantly as more surveys are performed in conformance with the State Coordinate System and as the data base expands. This would make initial costs more than worthwhile.

The existing system, as defined by Act 9 of Public Acts of 1964, provides an entirely adequate foundation for the future.

The system meets all existing and projected Federal needs and standards.

The committee, therefore, concluded that the benefits to be derived from the recommended coordinate system will be of major long-range significance to government, industry and the general public.

III. RECOMMENDATIONS

A. That the authority and responsibility for the administration of the coordinate program be the Department of Natural Resources', Office of Geodetic Surveys.

B. That to provide funds needed to administer the program, legislation be enacted to impose a tax of $1.00 on all deeds recorded in Michigan.

C. That the Michigan Department of State Highways and Transportation immediately implement a pilot project for completion of a portion of the State Coordinate System in conjunction with the interstate project on I-69 from Charlotte to Perry. The procedures to be followed are outlined in Federal Highway Administration Transmittal #48 (see attachment). The cost of the project is estimated to be approximately $250,000, requiring 18 to 24 months to complete. Transmittal #48 provides funding for control surveys in the same ratio as the highway construction project, in this case 90% Federal monies and 10% Michigan monies.

D. That the FHWA be requested to increase funds available to MDSHT by 90% of $250,000.

IV. COORDINATE SYSTEMS

A. What are they?

Coordinate Systems provide a method for relating accumulated horizontal control on land surveying information to permanent ground monuments. The monuments have known coordinates or mathematical values that can be related to other points within the same datum, or to other datums when ties exist.

The Michigan Coordinate System is a mathematically designed system of coordinates based upon geodetically* surveyed quadrangle nets that have been established, primarily by the United States Coast and Geodetic Survey (USC&GS), National Geodetic Surveys (N.G.S., formerly USC&GS), during the past 100 years. These nets are defined by permanent "in-the-ground" concrete monuments at numerous locations throughout the State of Michigan and the continental United States.

At present, the concrete monuments established as part of the system lines are approximately 10 to 15 miles apart, with large voids in the existing network. There are many places in the State where the network does not exist. (See attached map). The coordinates utilized in determining geodetic locations are X = Longitude and Y = Latitude.

---

* Geodetic surveys are surveys of high order or precision adjusted to give consideration to the spherical surface of the earth.

B. Effects of a Coordinate System to the State of Michigan

The Michigan State Plane Coordinate System is a tool which can be used in any part of the State of Michigan in which monuments are accessible. A well monumented coordinate system coupled with the availability, capability, and storage capacity of large modern electronic computers, makes it possible to organize and catalogue data in a meaningful and readily accessible manner.

One important common denominator between data files is that of location. It is imperative that capability be provided to locate features both natural and man-made, as well as groupings of demographic data, economic features and patterns of events etc. and so forth on the earth's surface.

Computer operations are handled more efficiently if location can be expressed in mathematical terms such as coordinates based on the conventional right-handed orthogonal (Cartesian) system. The Cartesian[1] system has been used in mathematical, scientific, and engineering professions for many years.

---

1 Cartesian System Coordinates are a pair of numbers which locate a point by indicating its distance from a fixed pair of lines intersecting one another at right angles, each distance is measured parallel to the other fixed line. (Webster)

Many problems develop when one attempts to relate data of one Cartesian system with that of another one. In order to do so, one must relate the origin and orientations of the two systems. If the systems are well defined, the comparison is a mathematical operation of rotation and translation which is simple on a computer.

Many local coordinate systems have been established with little or no regard for the relationship of their system to state or national systems. These systems are usually unrelated to each other except by their actual physical location which can only be determined by a field survey. The problem is compounded by the fact that our earth is ellipsodal. Attempting to mathematically relate these systems by the use of conventional methods would be a monumental problem. However, once they are tied to the Michigan Coordinate System, they can be related to each other efficiently through the computer.

The U.S. Government has used a system of geographic coordinates to control national mapping activities through the triangulation network, which now covers North America. Geographic coordinates (latitude and longitude) are a global reference system utilizing angular units (degrees, minutes and seconds) rather than length units (feet or meters).

The Federal Government publishes a list (Horizontal Positions or Trig List) of established monuments for use by others. Most surveying is performed using length units rather than angular units and is based on principles of plane Euclidian geometry. Therefore, the state plane coordinate system,(Act 9 of Public Acts of 1964), was developed to provide a mathematical relationship between points on a global reference system (latitude and longitude) and a plane coordinate representation of the same point. Thus, the national triangulation network provides a skeleton framework to which the statewide plane coordinate system can be related.

In projecting from a curved surface to a flat plane a small distortion cannot be avoided, but the resulting individual inaccuracies are so small as to be inconsequential for most uses. Within the state plane system,the angular relationship between objects is preserved and the small inherent lineal distortion is eliminated through proper application of a scale factor. By using the Michigan State Plane Coordinate System, one can share in the advantages of a global reference system and yet have the convenience and efficiency of operating on a Cartesian System. Computer files can then be systematically organized and data can be catalogued by location for manipulation and retrieval for meaningful use by all.

Thus, any project can be given a spatial relationship to the earth's surface. By using the Michigan State Plane Coordinate System a design engineer may accurately determine the location of all features within a project. The coordinate system also provides the ability to locate or reference the project to influencing factors such as sources or power, movement of people, environmental resources, present and projected land use and many other parameters which may have an impact on the project.

The entire State of Michigan is covered by three Lambert Projection Zones; a North Zone, Central Zone, and a South Zone. Projects that are linear such as pipelines, transmission lines, or Interstate and State Highways which cross projection zones or extend into other states can still be related to the total scheme without developing discontinuities in referencing coordinates. This is accomplished by converting to geographic coordinates and back again to the plane coordinates in the next zone through the use of a computer.

Currently, it is only with considerable difficulty, frustration, and clos ly manipulation that projects on separate systems can be accurately related to each other. Even then the product is a "Bastard" system which is severely limited in scope and application. On the other

hand, all information which is referenced to the Michigan State Plane Coordinate System is inherently integrated into a broader, consistent set of data. The Department of State Highways and Transportation can plan, design and build transportation facilities on the same system that the Department of Natural Resources uses to monitor the quality of our environment. Utility compaies can locate and inventory within the State Plane Coordinate System all equipment and service locations as well as their planning, feasibility, and resource allocation studies. City engineers will be able to relate the location of watermains to gas lines, sewer lines, right-of-way lines, or any other feature of interest which has been defined. Furthermore, operating with a common data base, with information on a data file, provides the capability to produce computer generated maps and overlays, drawn to any scale, eliminating expensive drafting. Many agencies in State, county, and local government as well as commercial and private organizations will benefit from using an integrated data base for locating their services and operations.

There are advantages for the surveying profession in using the state plane system. As the surveyor measures the relative positions of objects, and reports on his findings, the value of his information is greatly enhanced if he is able to relate any location to the broader body of data. For example; The size and shape of a building may be

interesting, but with its location defined by coordinates one can tell immediately where it is located with respect to a planned transportation or utility cooridor defined on the same system.

In the surveying profession it is standard practice to return to a common starting or reference point. This is called "closing the survey", and is done to provide a check on the work to insure against errors. In using the state plane coordinates, one can begin at a triangulation station (or similarly defined point) and traverse to another known point miles away, completing the survey without returning to the point of origin. Further, if in so doing one executes the work with proper discipline and adequately marks the traverse points, then points thus defined can become beginning and ending points for those who later survey in the same area.

Another principle essential to surveying is that of monumentation. Since original government surveys marked the location of our section and quarter section corners, in the early 1800's, it has been the responsibility of the surveying profession to perpetuate these locations from available evidence. The importance of the location of section corners cannot be over-emphasized as title to most of the lands throughout Michigan is referenced to the section corners of the U.S. Public Land Survey System.

The change to use of coordinate systems in surveying and aerial mapping becomes greatly simplified through the use of modern computer technology. The storage of data resulting from surveying and mapping activities and the retrieval of pertinent information in usable form is now a reality. Duplication of survey effort and additional costs can be greatly reduced by reproducing stored survey and mapped data on computer driven automatic plotters. These data are available to all persons requiring survey information.

It is significant to note that data, currently being used throughout every subdivision of government, can be tied, by definition, to the coordinate network and then related to other data for analysis purposes.

The need for a point of commonality for referencing information used thorugh all levels of government and industry is paramount. A statewide coordinate system completely meets this need.

C. Development of a Michigan Coordinate System

A plan for establishment of the first state coordinate system was submitted to the U.S. Coast and Geodetic Survey by an engineer of the North Carolina State Highway Department. He sought a method of utilizing geodetic data over an entire state which would involve only principles of plane surveying. This brought about the establishment in 1933 of the North Carolina Coordinate System, by means of which geodetic positions of triangulation stations could be transformed into plane rectangular coordinates on a single grid. Surveys in all parts of the state, so referenced, could be accurately described by their coordinates referenced to the common origin of the grid. The Coast and Geodetic Surveys, engineers, and mathematicians worked out the system.

After the establishment of the coordinate system in North Carolina, a similar system was developed for each state. For some states, a single origin and meridian or reference were sufficient. Other states, because of their large size, were divded into several belts or zones, each zone having its own origin and reference meridian. It is now the practice of the U.S. Coast and Geodetic Survey to compute and publish the adjusted coordinates of the state system, based upon the North American datum of 1927.

At a meeting on September 8, 1936, the Federal Board of Surveys and Maps recommended to its member organizations that, whenever practicable, they adopt the system of plane coordinates. These would be devised for the various states by the Coast and Geodetic Survey. The use of these state systems of plane coordinates as bases for their surveys and maps will not, because of their nature or extent, require the use of some other system of coordinates or method of recording.

A result of the growing use of the State Coordinate System is the formal recognition given the system in a number of state legislatures. Such action has been taken in many states and is pending in others. The following is a list of states with laws establishing State Coordinate Systems:

Alabama	Massachusetts	Oregon
Arizona	Michigan	Pennsylvania
California	Minnesota	Rhode Island
Connecticut	Missouri	South Dakota
Delaware	Nevada	Tennessee
Georgia	New Jersey	Texas
Indiana	New York	Vermont
Louisiana	North Carolina	Virginia
Maine	North Dakota	Washington
Maryland	Ohio	Wisconsin

Individual city and metropolitan surveys:

Washington, D. C.
Philadelphia
New York City
Detroit
Flint
Toronto

In Michigan, since 1964, it has been legally permissable to define the locations of ground positions in terms of the Michigan Coordinate System. At the same time it has not been widely used primarily because of the scarcity of ground monumentation existing throughout the state. The only "in-the-ground" monuments which do exist are those that were established as part of the network established by the U.S. Coast and Geodetic Survey. The large spaces between existing monuments has made it difficult and costly to base engineering projects on the Michigan Coordinate System. The existing system does have one important function; it will serve as the skeleton upon which a usable State Coordinate System can be built and expanded to serve the needs of users in the future.

The location of MDSHT owned property depends upon the existence of properly located public land survey corners. Occasionally, the witnesses and the corner are removed by construction activities in the vicinity. This results in a costly resurvey in order to reestablish the corner in its proper location. If a Michigan State Coordinate System existed where monuments were of sufficient density, the restoration of an obliterated corner would be relatively simple and economical to perform.

Descriptions of state owned land could be prepared using Michigan State Coordinates to define boundaries, thus avoiding the ambiguous and vague wording sometimes found

in land descriptions. Right of way monuments, once established, would have a coordinate value which would make them simple to replace if destroyed. Highway alignment could be shown on plans making use of State Coordinate Grid azimuths in place of the present system of assumed solar or quadrant bearings. The azimuth system will eliminate the need for bearing equations and will relate all abutting project plans and land descriptions when they are based upon the Michigan Coordinate System. Subsequent, resurveys and improvements to trunklines would be expedited when the original construction is based on the same coordinate system.

The Director, National Geodetic Survey (NGS), Captain Leonard S. Baker, has submitted a marked plan and cost estimate whereby the present Michigan Coordinate System can be expanded to a point where it will be useful to many public and private agencies for engineering uses. The plan requires placing additional monuments in all counties except those in the Upper Peninsula, and Emmet, Cheboygan and Presque Isle in the Lower Peninsula. The plan will bring existing control up to an acceptable level of accuracy and density (see attached map). The recommendation for main scheme monuments is based on population per square mile with a close spacing of monuments in the more densely populated counties. Following is a breakdown of the recommendations.

Spacing of Monuments	People Per Square Mi.	No. of Mon. To Be Placed	Cost ($1,000)	No. of Co. Inv.
2-4 miles	101 to 4414	912	4,104	22
4-6 miles	44 to 94	426	1,917	19
6-10 miles	3 to 35	134	603	24

Under the Federal plan the state will pay 50% of the estimated $6,624,000 cost. The above estimate is based on an estimated cost of $4,500 per main scheme monument. NGS also recommends that each main scheme monument have two or three subsidiary monuments established and that traverse monuments be placed at one mile intervals between subsidiary monuments. These later monuments would involve additional expense but presumably could be installed at a later date.

For approximately 30 years prior to passage of Act 9, Public Acts of 1964, the Michigan Coordinate System was based on the Transverse Mercator Map Projection. When legislation was prepared, the Lambert Conformal projection was determined to be most appropriate because no other projection can cover the state with a lesser amount of zones and still conform to the constraints of variation of scale factor from unity not to exceed 1:10,000.

The proposed plan by NGS would provide the basic network from which the remaining Michigan State Plane Coordinate System monuments could be placed. The in-state expertise

required for implementing the last phase of the plan is well within the capabilities of surveyors from both the public and private sectors. This combined expertise should be used for completing the network.

D. Administration of the Program

An organization charged with implementing Geodetic Surveys would have two main purposes. The first purpose would be to provide a source of readily available information concerning the existing U.S. Coast and Geodetic Survey control, within the state, in the form of maps and files of government publications. The second purpose would be to perform surveys in the areas requested by engineers and surveyors in order to increase the number of control markers already established by the NGS.

The authority and responsibility for performing these functions should be placed in a state agency.

House Bill No. 4074 (see attachment), introduced February 1, 1973, proposed adding the administration of the Michigan Coordinate System to the Geological Survey Division (GSD) of the Department of Natural Resources (DNR). It should be pointed out that the bill did not include a provision for funding the organization. Passage of a bill which would include appropriate funding is essential before any long range plan can be developed. It is the consensus and recommendation of the committee that the Department of State Highways and Transportation initiate action leading to the introduction of a bill which would place the authority and responsibility for administration of the Coordinate System Program within the Department of Natural Resources, by creating an Office of Geodetic Surveys.

Personnel with the DNR have indicated acceptance of this course of action, providing the necessary funding is appropriated by the Legislature. As an alternative to establishing the administrative authority for the Coordinate System in the DNR we propose that the MDSHT be given the appropriate authority and funds for the administration of the program through legislative action.

The rationale for this course of action is that the Department currently has a large fund of expertise to meet the requirements of a long range program.

The MDSHT in performing normal activities required within the Department carries out more surveying, throughout Michigan, than any other agency.

The need for coordinate type data including planimetric, topography, maps, census data etc., used in the planning and constructing of transportation facilities no doubt qualifies the Department as one of the largest data users in the state.

The administration of the Michigan Coordinate System program, requires the development of a highly professional organization equipped with the proper instruments and accessories to produce the required accuracies under the Act.

The National Geodetic Survey is most anxious to engage in a program of Geodetic Control Surveying within the State of Michigan.

Gilbert Mitchell of NGS, in a meeting held in Lansing, stated that NGS is willing to help institute a control program in Michigan. There are presently two methods which could be employed to accomplish this:

A.) NGS will provide an advisor and equipment, for training purposes of personnel in all facets of control surveying for period of one year. The state would be obligated to furnish 1/2 the cost of this individual, (approximately$15,000) and provide office space and secretarial service.

B.) A force of approximately 40 people could be put to work in Michigan, as early as the spring of 1976, to work 6 months of the year setting control monuments in the state. The DNR would provide their own people and equipment to work along with the NGS personnel to set the local second order stations while the towers were still in place.

An alternative to the methods described would be to develop a program using resources from the private sector.

The Professional Land Surveyors using their technical expertise and equipment resources can make a major contribution toward completing the system. Using their

knowledge and drawing from the pool of non-technical unemployed, a large work force could be mobilized to produce an immediate impact upon unemployment as well as the immediate benefits to be derived from the system.

A program of this nature could create 400-500 new jobs for the life of the project. Additional monies from the general fund would be needed to support the project.

Supportive of the cooperative program with DNR is a program developed through the Federal Highway Administration for control surveys in conjunction with transportation facilities.

Transmittal #48, as addendum to the Federal Highway Administration, (FHWA), Federal-aid Highway Program Manual defines procedures for performing control surveys as part of highway construction and states that the ratio of federal participation will be that authorized for the class of funds applicable to the Federal-aid system involved. In other words, control work along the interstate system would be on a 90% - 10% federal-aid basis,while work along primary and secondary federal-aid roads would be on a 70% - 30% basis. In addition, NGS will supply one-half of the state's share of the cost of the control surveys. (copy of Transmittal #48 is attached to this report).

Transmittal #48 describes the only existing methods of implementing a monumentation program utilizing federal

funds. It should be emphasized that funding for other than Interstate Highways would come from the yearly approptionment. However, the cost, to the state, of a control survey program will be far exceeded by the future benefits both public and private.

As previously discussed, a joint or cooperative long range program between NGS, the State of Michigan, private surveying and engineering firms is the ideal method of completing the network.

An analysis of field and office operations indicate the need for DNR, Office of Geodetic Surveys, to establish at least initially, a professional staff of eleven (11); supporting technical staff of ten (10); clerical staff of one.

The field crews working with NGS crews would then place the subsidiary stations and one mile stations, that are required, utilizing thirty meter towers of NGS.

NGS normally places one main scheme station per man per month. The forecasted time required for completing the main schemes stations is then six plus years. The forecast for completing the remainder of the network is projected to be ten plus years.

The MDSHT could make a major impact on the time required to complete the system by developing a plan for placing monuments in conjunction with planned transportation facilities.

V. FISCAL EFFECT

A. Cost

The development of a cooperative program between National Geodetic Surveys (NGS) and Office of Geodetic Surveys of the Department of Natural Resources involves combining professional expertise of both organizations into an integrated work unit.

The NGS crew consists of 20 men equipped with the latest in theodolites, long distance measuring devices, and self erecting towers.

The Geodetic Survey crews should include 6 men each, 3 crews with a supporting office staff of 4 people as well as comparable equipment.

NGS Cost

Twenty (20) men @ $22,000/year (including living costs) = $440,000.

DNR Cost

The Office of Geodetic Surveys staff would incur the same annual operating cost of $440,000.

Therefore, in a contributing program the State of Michigan would be required to support financially 50% of the NGS cost or $220,000.

In support of this program, the Michigan Department of State Highways and Transportation (MDSHT) in conjunction with the annual transportation facility construction

program could perform similar activities. The MDSHT work would be performed under the direction of NGS following the guidelines of Federal Highway Administration (FHWA) Policy and Procedural Memorandum (PPM) #48 (attached). The added cost for performing the monumentation work to a minimum of second order accuracy would be an added cost to the MDSHT. The additional cost should be credited to the MDSHT account from GENERAL FUNDS. The added cost for first and second order monumentation and increased survey accuracy would be approximately $1,000 per mile.

The annual estimated amount for additional surveying work to be performed on the Federal-aid Primary and Secondary System, Interstate System and other transportation facilities is based upon 70 miles of new construction per year. Considering federal participation in the program, it is estimated the MDSHT would incur added cost in the amount of approximately $20,000 per year for this type of a program.

The MDSHT could under the same FHWA program develop an annual program for monumenting the completed portion of the transportation system. The cost for this work would be dependent upon the availability of field crews and Federal Highway monies. The projected fiscal effect to the State of Michigan is forecasted to be approximately $50,000 per year, for the initial six plus years. Approximately

$440,000 per year for the following five to six years and then reducing to approximately $300,000 per year to maintain supporting staff.

B. Financing the Program

2. State Monies

a. Available Michigan Department of State Highways and Transportation Monies.

Act 51 of Public Act 1951 restricts the use of the gasoline tax to highway purposes, however, monumentation within the corridors of highway facilities is an integral part of the design and planning process. Highway funds used to monument the entire highway system should then play a significant role in completing the system.

It is estimated a program of this nature would account for approximately 10,000 monuments of the needed 50,000 monuments.

b. Department of Natural Resources (DNR) Monies.

The DNR currently has a mapping program but has neither the authority nor the funds to support a coordinate monumentation program.

The State Mapping Advisory Committee, created in 1966 by Section 16 of House Bill 4044, recommended that the State participate in the cooperative program for 7.5 minute quadrangle mapping by USGS. The legislature has appropriated a yearly allocation of $50,000 of MDSHT funds as the State share in the program.

c. It will be necessary to provide monies from the GENERAL FUND to financially support a program for monumentating the remainder of the state.

In order to eliminate the negative affect of the program on the General Fund, legislation proposing $1.00 tax on all deeds registered in Michigan is recommended. The $1.00 tax will produce between $500,000 to $750,000 annually, enough to administer the program. A continuing program for funding is not only essential but, mandatory.

C. Cost Benefits

The coordinate study committee examined present survey procedures and compared them with methods that would be used with a completely monumented system compatible with existing state statutes.

Three areas of survey costs and savings were the basis for the cost benefit analysis:

1. Land surveys being performed by surveyors in the private sectors to set or re-set property boundaries.

2. Engineeering surveys performed in connection with planning, design and construction of physical projects.

3. Functions related to using, recording, checking and approving documents, plans, legal descriptions, creating maps etc., resultant from the previous two types of surveys.

There are approximately 500 Registered Land Surveyors in private practice in Michigan at the present time. In performing property surveys approximately 58% of their time involves locating corners. Approximately 750,000 deeds are recorded each year. Approximately 200,000 of these transactions require a property survey that includes locating corners. The cost savings resulting from a completed system would evolve from the man hours saved in locating corners. It is estimated 50% of these hours would be saved.

Charges for property surveys are based upon costs for men and equipment. Therefore, the following analysis is developed:

1. Average cost per property survey is approximately $100.00.

   $100.00 x 200,000 x (58% x 50%) = 5,800,000

2. Engineering Surveys

   A. Department of State Highways and Transportation Field Surveys, 5%-10% of Annual Expenditures (1,500,000) = 150,000

   B. Private Engineering Surveys in Michigan estimated 10,000,000 = 4,000,000

3. Related Functions = 1,000,000

TOTAL 10,950,000

Cost/Benefit Analysis (In Millions)

	Years 1-6	Years 7-12	Year 13	Year 14
Cost	$3,9	$2.6	$ 0.3	$ 0.3
Benefits			$10.95	$10.95
Accured Benefits	($3.9)	($6.5)	$4.15	$14.8

Act No. 9
Public Acts of 1964
Approved by Governor
March 20, 1964

Enacted

STATE OF MICHIGAN
72ND LEGISLATURE
REGULAR SESSION OF 1964

Introduced by Reps. Bursley, Gordon, Rasmussen, Mrs. Hager, Davis, Cobb and Tisdale

ENROLLED HOUSE BILL No. 203

AN ACT to describe, define and officially adopt a system of coordinates for designating the position of points on the surface of the earth within this state.

The People of the State of Michigan enact:

Sec. 1. (1) The system of plane coordinates which has been established by the United States coast and geodetic survey for defining and stating the positions or locations of points on the surface of the earth within this state is hereafter to be known and designated as the Michigan coordinate system.

(2) For the purpose of the use of this system the state is divided into a north zone, a central zone and a south zone.

(3) The area now included in the following counties constitutes the north zone: Gogebic, Ontonagon, Houghton, Keweenaw, Baraga, Iron, Marquette, Dickinson, Menominee, Alger, Delta, Schoolcraft, Luce, Chippewa and Mackinac.

(4) The area now included in the following counties constitutes the central zone: Emmet, Cheboygan, Presque Isle, Charlevoix, Leelanau, Antrim, Otsego, Montmorency, Alpena, Benzie, Grand Traverse, Kalkaska, Crawford, Oscoda, Alcona, Manistee, Wexford, Missaukee, Roscommon, Ogemaw, Iosco, Mason, Lake, Osceola, Clare, Gladwin and Arenac.

(5) The area now included in the following counties constitutes the south zone: Oceana, Newaygo, Mecosta, Isabella, Midland, Bay, Huron, Muskegon, Montcalm, Gratiot, Saginaw, Tuscola, Sanilac, Ottawa, Kent, Ionia, Clinton, Shiawassee, Genesee, Lapeer, St. Clair, Allegan, Barry, Eaton, Ingham, Livingston, Oakland, Macomb, Van Buren, Kalamazoo, Calhoun, Jackson, Washtenaw, Wayne, Berrien, Cass, St. Joseph, Branch, Hillsdale, Lenawee and Monroe.

Sec. 2. (1) As established for use in the north zone, the Michigan coordinate system shall be named, and in any land description in which it is used it shall be designated the Michigan coordinate system, north zone.

(2) As established for use in the central zone, the Michigan coordinate system shall be named, and in any land description in which it is used it shall be designated the Michigan coordinate system, central zone.

(3) As established for use in the south zone, the Michigan coordinate system shall be

(4)

named, and in any land description in which it is used it shall be designated the Michigan coordinate system, south zone.

Sec. 3. The plane coordinates of a point on the earth's surface, to be used in expressing the position or location of such point in the appropriate zone of this system, shall consist of 2 distances, expressed in American survey feet and decimals thereof. One of these distances, to be known as the "x-coordinate", shall give the position in an east and west direction; the other, to be known as the "y-coordinate", shall give the position in a north and south direction. These coordinates shall be made to depend upon and conform to the coordinates, on the Michigan coordinate system, of the triangulation and traverse stations of the United States coast and geodetic survey within this state, as those coordinates have been determined by the survey.

Sec. 4. When any tract of land to be defined by a single description extends from 1 into another of the above coordinate zones, the positions of all points on its boundaries may be referred to either of the 2 zones, the zone which is used being specifically named in the description.

Sec. 5. (1) For the purposes of more precisely defining the Michigan coordinate system the following definition by the United States coast and geodetic survey is adopted:

(a) The Michigan coordinate system, north zone, is a Lambert conformal projection of the Clarke spheroid of 1866, magnified in linear dimension by a factor of 1.0000382, having standard parallels at north latitudes 45 degrees 29 minutes and 47 degrees 5 minutes, along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 87 degrees zero minutes west of Greenwich and the parallel 44 degrees 47 minutes north latitude. This origin is given the coordinates: $x = 2{,}000{,}000$ feet and $y = 0$ feet.

(b) The Michigan coordinate system, central zone, is a Lambert conformal projection of the Clarke spheroid of 1866, magnified in linear dimension by a factor of 1.0000382, having standard parallels at north latitude 44 degrees 11 minutes and 45 degrees 42 minutes, along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 84 degrees 20 minutes west of Greenwich and the parallel 43 degrees 19 minutes north latitude. This origin is given the coordinates: $x = 2{,}000{,}000$ feet and $y = 0$ feet.

(c) The Michigan coordinate system, south zone, is a Lambert conformal projection of the Clarke spheroid of 1866, magnified in linear dimension by a factor of 1.0000382, having standard parallels at north latitude 42 degrees 6 minutes and 43 degrees 40 minutes along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 84 degrees 20 minutes west of Greenwich and the parallel 41 degrees 30 minutes north latitude. This origin is given the coordinates: $x = 2{,}000{,}000$ feet and $y = 0$ feet.

(2) The position of the Michigan coordinate system shall be as marked on the ground by triangulation or traverse stations established in conformity with standards adopted by the United States coast and geodetic survey for first-order and second-order geodetic control surveys, whose geodetic positions have been rigidly adjusted on the North American datum of 1927, and whose coordinates have been computed on the system herein defined. Any such station may be used for establishing a survey connection with the Michigan coordinate system.

Sec. 6. No coordinates based on the Michigan coordinate system, purporting to define the position of a point on a land boundary, shall be presented to be recorded in any public land records or deed records unless such point is within ½ mile of a triangulation or traverse station established in conformity with the standards prescribed in section 5 of this act.

Sec. 7. The use of the term Michigan coordinate system on any map, report of survey, or other document, shall be limited to coordinates based on the Michigan coordinate system as defined in this act.

Sec. 8. Wherever coordinates based on the Michigan coordinate system are used to describe any tract of land which in the same document is also described by reference to any subdivision, line, or corner of the United States public land surveys, or to any subdivision plat duly recorded in accordance with Act No. 172 of the Public Acts of 1929, as amended, being sections 560.1 to 560.80 of the Compiled Laws of 1948, the description by coordinates shall be construed as supplemental to the basic description of such subdivision, line, or corner contained in the official plats and field notes filed of record, and in the event of any

conflict the description by reference to the subdivision, line, or corner of the United States public land surveys, or recorded subdivision plat, shall prevail over the description by coordinates.

Sec. 9. Nothing contained in this act shall require any purchaser or mortgagee to rely on a description, which depends exclusively upon the Michigan coordinate system.

Clerk of the House of Representatives.

Secretary of the Senate.

Approved

Governor.

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

FEDERAL-AID HIGHWAY PROGRAM MANUAL

VOLUME	6	ENGINEERING AND TRAFFIC OPERATIONS
CHAPTER	3	PRECONSTRUCTION PROCEDURES
SECTION	2	PROGRAM AND PROJECT PROCEDURES
SUBSECTION	1	GEODETIC SURVEYS AND STATION MARKERS

Transmittal 48
August 5, 1974
HNG-11

Par.

1. PURPOSE

* *The purpose of this directive is to prescribe procedures for conducting geodetic control surveys when participation with Federal-aid highway funds in the cost thereof is proposed and to encourage interagency cooperation in setting station markers, surveying to measure their position, and preserving the control so established.*

2. AUTHORITY

Section 101(a), Title 23, United States Code, defines the term "construction" to include the establishment of temporary and permanent geodetic markers in accordance with specifications of the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce. Section 315, Title 23, United States Code and 49 CFR 1.48 authorize the issuance of regulations to implement these projects.

3. BACKGROUND

a. The National Ocean Survey (NOS), a component of NOAA, has the responsibility for establishing a network of basic control surveys and station markers of sufficient accuracy and permanence to provide the rigid framework needed by engineering, cadastral and cartographic agencies. Adequately monumented second-order geodetic

* Regulatory material is italicized.

surveys are needed to provide the necessary horizontal and vertical control for the aerial and ground surveys and mapping activities required in the development and operation of modern highways.

b. The Office of Management and Budget has delegated to the Department of Commerce, the leadership in insuring that Federal funds for high-order surveying are expended in such a manner that they contribute to the completion of the National Geodetic Control Networks and are not performed as single purpose surveys. This responsibility has been further delegated to NOS and its subcomponent the National Geodetic Survey.

4. POLICY

a. *Geodetic surveys along Federal-aid highway system routes may be programmed as Federal-aid highway projects.* It shall be the policy of the Federal Highway Administration (FHWA) to encourage the use of the procedures described herein to establish permanent survey control of second-order accuracy, or better, whenever feasible or practicable for highway development.

b. *All geodetic survey work performed as a Federal-aid highway project will conform to NOS specifications. The NOS will, as the representative of FHWA, be responsible for the inspection and verification of the work to ascertain that the specifications for the work have been met. Final project acceptance by FHWA will be predicated on a finding of acceptability by NOS.* Geodetic surveys may be performed by NOS forces or by qualified crews assigned by the State highway department. A State highway department should feel free to do the work with its own forces but if it does not have personnel on its staff qualified to undertake the work, it may employ either qualified private firms or NOS if that agency's services can be secured.

c. Geodetic station marker projects may be established to aid in the development of any Federal-aid route. Extensive projects covering routes that will result in a pattern of closed geometric figures are encouraged. This is especially desirable as a means of increasing the reliability of the survey where few existing markers are available for checking the accuracy of surveys.

d. Modern surveying instruments and methods provide a means of establishing a considerable number of geodetic station markers on adjacent routes by developing auxiliary control stations. Consideration, therefore, should be given to establishing some geodetic station markers to serve as control points on routes nearby or connecting to the Federal-aid routes covered by geodetic survey projects when this can be done as an incidental to the main project with little additional cost.

5. INITIATION OF PROJECTS

All geodetic survey projects shall be coordinated by the FHWA Division Engineer, the State highway department and NOS. Any State highway or transportation department desiring to initiate a project for the establishment of geodetic station markers, either as a planning survey project or as a Federal-aid construction project, should first write to the Director, National Geodetic Survey, Rockville, Maryland 20852. He will arrange for his representative to meet with representatives of the State and the FHWA Division Engineer to discuss the proposed project. At this meeting a decision should be reached on such things as (1) the means by which the survey project will be accomplished; (2) the spacing between markers, (3) whether the State will furnish aerial photographs on which the location of markers will be indicated; (4) the approximate schedule to be followed; and, (5) the approximate cost of the project, which shall include all station markers, their setting and surveying, and the computations and adjustments of the survey. The agreement between the State and NOS resulting from this meeting should be made a part of the project record. The NOS will be custodians of and the distributing agency for the survey data.

6. STANDARDS

a. *Highway purposes may best be served by the establishment of station markers for horizontal control along Federal-aid highway routes at spacings of 3 to 8 kilometers (about 2 to 5 miles) and station markers for vertical control at spacings no closer than 1 kilometer.*

b. *Projects should be of sufficient scope to permit efficient use of field parties. Projects should extend at least*

30 kilometers. Projects may be coordinated with adjoining States to attain greater efficiency.

c. *Where geodetic station markers cannot be established initially at points readily accessible from the Federal-aid route, or where unavoidable circumstances result in their being established within construction limits, supplemental projects may later be approved to set and survey markers at satisfactory permanent points, preferably within the right-of-way but at points where their use does not introduce traffic hazards.*

d. In the execution of surveys for establishing geodetic station markers, it may be necessary to establish temporary intermediate geodetic stations. If these intermediate stations have a potential value for extending or checking other future highway surveys or would be of benefit to other survey agencies, they should be preserved by setting permanent station markers, where needed, and preserving the necessary data.

PROGRAMING

a. Federal-aid construction projects for the establishment of geodetic station markers should be programmed in the same manner as other Federal-aid projects. Projects in each State shall be identified by a separate numbering system in chronological order beginning with number one. A separate symbol designation of GM will be used, followed by the letter indicating the class of funds, such as GMI, GMF, and so forth. The ratio of Federal participation will be that authorized for the class of funds applicable to the Federal-aid system involved.

b. Projects for the establishment of geodetic station markers may be included in HPR work programs provided that regular necessary planning activities can be maintained otherwise. On such work programs, geodetic station marker projects will be included as separate items.

PRESERVATION

a. Any loss or destruction of permanent monuments necessitates additional expenditure of public funds and deprives engineers of much valuable data until they are replaced.

b. It is recognized that some station markers may be in such locations or placed in such a manner as to interfere with future highway construction or maintenance. When such situations occur, advice should be forwarded to the Director, National Geodetic Survey, Rockville, Maryland 20852, telephone 301-496-8600, who will take corrective measures or arrange with other agencies for this service. Surveying and mapping agencies have given assurance that they will, to the best of their ability, relocate the monuments with their own forces. When this cannot be accomplished readily, they would appreciate cooperation of State highway officials or contractors to insure that the basic data is preserved until such time as the new monuments can be established.

HOUSE BILL No. 4074

February 1, 1973, Introduced by Rep. Smit and referred to the Committee on Conservation and Recreation.

A bill to amend Act No. 9 of the Public Acts of 1964, entitled

"An act to describe, define and officially adopt a system of coordinates for designating the position of points on the surface of the earth within this state,"

being sections 54.231 to 54.239 of the Compiled Laws of 1970, by adding sections 10 and 11.

THE PEOPLE OF THE STATE OF MICHIGAN ENACT:

Section 1. Act No. 9 of the Public Acts of 1964, being sections 54.231 to 54.239 of the Compiled Laws of 1970, is amended by adding sections 10 and 11 to read as follows:

SEC. 10. THE ADMINISTRATIVE AGENCY OF THE MICHIGAN COORDINATE SYSTEM SHALL BE THE GEOLOGICAL SURVEY DIVISION OF THE DEPARTMENT OF NATURAL RESOURCES, AND IT SHALL HAVE THE FOLLOWING ADDITIONAL POWERS AND DUTIES:

(A) TO COORDINATE, PREPARE, AND ADMINISTER A GEODETIC CONTROL PROGRAM THROUGHOUT THE STATE.

(B) TO CREATE AN ADVISORY COUNCIL OF REPRESENTATIVES OF AFFECTED STATE AGENCIES, STATE ENGINEERING, SURVEYING AND PLANNING SOCIETIES, AND LOCAL GOVERNING AND PLANNING GROUPS. THE ADVISORY COUNCIL SHALL RENDER SUCH SERVICE AS THE GEOLOGICAL SURVEY DIVISION OF THE DEPARTMENT OF NATURAL RESOURCES REQUIRES IN CARRYING OUT THE PROVISIONS OF THIS ACT.

(C) TO UTILIZE SERVICES OF THE UNITED STATES COAST AND GEODETIC SURVEY AND THE UNITED STATES GEOLOGICAL SURVEY ON A MATCHING FUND BASIS.

(D) TO PREPARE AND ADMINISTER A GENERAL TOPOGRAPHIC MAPPING PROGRAM THROUGHOUT THE STATE.

(E) TO PROVIDE EXPERT CONSULTING AND ADVISORY SERVICES TO MUNICIPALITIES AND PLANNING DISTRICTS FOR SEPARATE LARGE SCALE MAPS. THE SERVICES SHALL INCLUDE BUT NOT BE LIMITED TO SPECIFICATIONS FOR FORMAT, CONTENT, SCALE, CONTOUR INTERVAL, AND ACCURACY.

(F) TO PROMULGATE RULES FOR CONTRACTING FOR LARGE SCALE MAPS AND TO ESTABLISH STANDARDS FOR INSPECTION, ACCEPTANCE, OR REJECTION OF THE MAPS.

(G) TO MAKE OR CAUSE TO BE MADE SURVEYS, COMPUTATIONS, AND FIELD MONUMENTATIONS NECESSARY TO FURTHER OR COMPLETE THE MICHIGAN COORDINATE SYSTEM.

(H) TO ENTER INTO CONTRACTS OR COOPERATIVE AGREEMENTS WITH OTHER STATE OR FEDERAL AGENCIES IN PROMOTING THE MICHIGAN COORDINATE SYSTEM.

(I) TO ACCEPT GIFTS, GRANTS, BEQUESTS, OR DEVISES FOR THE PURPOSE OF CARRYING OUT THE PROVISIONS OF THIS ACT.

(J) TO COORDINATE, ORGANIZE, AND DIRECT FEDERAL OR OTHER ASSISTANCE WHICH MAY BE OFFERED TO FURTHER THE PROVISIONS OF THIS ACT.

(K) TO COOPERATE WITH ANY INDIVIDUAL, FIRM, COMPANY, AND PUBLIC OR PRIVATE AGENCY IN CARRYING OUT THE PROVISIONS OF THIS ACT.

(L) TO PROMULGATE RULES AND ESTABLISH SPECIFICATIONS FOR THE ESTABLISHMENT AND USE OF THE MICHIGAN COORDINATE SYSTEM CONSISTENT WITH THE PRACTICES

AND STANDARDS OF THE UNITED STATES COAST AND GEODETIC SURVEY, AND ACT NO. 288 OF THE PUBLIC ACTS OF 1967, AS AMENDED, BEING SECTIONS 560.101 TO 560.293 OF THE MICHIGAN COMPILED LAWS.

(M) TO PREPARE TO ASSUME CONTROL OVER TOWNSHIP PLATS AND FIELD NOTES NOW IN THE LANDS DIVISION OF THE DEPARTMENT OF NATURAL RESOURCES.

SEC. 11. (1) THE GEOGRAPHICAL SURVEY DIVISION OF THE DEPARTMENT OF NATURAL RESOURCES SHALL PROVIDE FOR A REPOSITOR OF ALL MAPS, CHARTS, SURVEYS, NOTES, PHOTOGRAPHS, OR OTHER MATTERS RELATING TO THE LAND, AIR, OR WATER OF THIS STATE INCLUDING BUT NOT LIMITED TO:

(A) UNITED STATES GEOLOGICAL SURVEY MAPS OF TOPOGRAPHIC QUADRANGLES, BOTH PRELIMINARY AND FINAL PRINTS, AND ANY OTHER GEOLOGICAL MAP.

(B) MAPS RELATING TO FOREST SERVICE OR SOIL CONSERVATION.

(C) NAVIGATIONAL CHARTS AS PREPARED BY: UNITED STATES LAKE SURVEY; UNITED STATES AIR FORCE; AND THE UNITED STATES GEOLOGICAL SURVEY.

(D) COMPILED MAPS OF THE ARMY MAP SERVICE AND UNITED STATES GEOLOGICAL SURVEY.

(E) PUBLISHED MAPS OF STATE DEPARTMENTS AND AGENCIES.

(F) UNITED STATES PUBLIC LAND SURVEYS OF TOWNSHIP PLATS AND FIELD NOTES.

(G) SUBDIVISION MAPS AND SURVEYS.

(H) MAPS OF CITIES, VILLAGES, TOWNSHIPS, AND COUNTIES.

(I) HISTORICAL MAPS.

(J) SURVEY MAPS AND RECOVERY SECTION CORNER NOTES.

(K) AERIAL PHOTOGRAPHS AND NEGATIVES.

(2) THE GEOLOGICAL SURVEY DIVISION SHALL PROVIDE FOR THE INDEXING, FILING, CATALOGING, REPRODUCTION, SALE, AND ACCESS OF ALL MATTERS PROVIDED FOR IN SUBSECTION (1).

STATE OF MICHIGAN
(NORTHERN SECTION)
TRIANGULATION DIAGRAM
U.S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
COAST AND GEODETIC SURVEY
WASHINGTON, D.C.
February 1968

HORIZONTAL CONTROL

Note: Data may be requested by quadrangle, county, or other unit. Since publication of data in quadrangle units may not be complete for this State, requests for information by quadrangle number will be supplied with data in whatever form is available.

Information may be obtained from the Coast and Geodetic Survey, Environmental Science Services Administration, Rockville, Maryland 20852

For names of additional triangulation stations along the St. Mary's River see Nos. 866 to 1041 in key to numbered stations.

Completed Recon

Completed Recon

U.S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
COAST AND GEODETIC SURVEY
WASHINGTON, D.C.

TRIANGULATION DIAGRAM
STATE OF MICHIGAN
(SOUTHERN SECTION)
November 1969

HORIZONTAL CONTROL

Note: Data may be requested by quadrangle, county, or other unit. Since publication of data in quadrangle units may not be complete for this State, requests for information by quadrangle number will be supplied with data in whatever form is available.

Information may be obtained from the Coast and Geodetic Survey, Environmental Science Services Administration, Rockville, Maryland 20852

SOUTHERN MICHIGAN

KEY

(7) people (per square mile)

32 stations (recommend)

spacing: 2 – 4 miles

4 – 6

6 – 10

— TCT (completed)

Team

10/24/74