

North Dakota's Use of Aerial Inventory for County General Highway Maps

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One of the principal activities of the Statewide Highway Planning Survey since its beginning in the middle thirties has been inventory and mapping. Probably the principal use of inventory data has been for the preparation of county general highway maps. North Dakota prepares these maps (see Fig. 1) in three colors. A number of methods for collecting the inventory data have been developed by the several states.

The North Dakota Highway Planning Survey has instituted an aerial method of collecting a vast majority of the field data. To the best of knowledge, North Dakota was the first state to employ the aerial inventory method. It has been in operation for the past three years and has produced better inventory data at less cost and in less time than the conventional ground inventory methods. During the past three years all 53 counties in the State have been inventoried. These 53 counties cover 70,183 square miles and include about 115,000 miles of roads and streets.

The following subjects will be discussed:

1. The aerial inventory method developed and used in North Dakota and the supporting ground crew activities.
2. The equipment and personnel employed for this operation.
3. Comparative cost data.
4. Proposed future uses of the aerial method.

SYNOPSIS OF INVENTORY OPERATIONS

● THE INVENTORY operations in North Dakota involve essentially a combination of:

1. An office preparation of a work map "loaded" with road and cultural data obtained from aerial photographs.
2. A verification or a revision of the work map based on field observation from the air.
3. The estimating and classifying of certain information (e.g. surface widths and drainage structure sizes and types) from the air.
4. Obtaining structural data, inventory data in incorporated places and certain horizontal control information by a ground crew.

Office Preparation of Work Map

A print of the previous county general highway map at a scale of one mile to one in. serves as a base for the work map. Information such as road identification numbers, map segment numbers and other data which serve to orient the air crew are added to the base map. Data are added to or deleted from the base map by a review of the aerial photographs. The work maps then are cut into segments of convenient size for ease of handling and manipulation in aircraft.

Work Map Check-Off

The work map with the data available from the aerial photographs is then taken in

the aircraft and each road is covered from the air. The roads in North Dakota generally are on the N-S or E-W section lines in the rectangular land grids. The road and cultural data that are observed to be as indicated on the work map are so identified by a check mark on the map. Cultural or other features not shown on the work map but found to be in existence are added by color code to the work map. Features shown incorrectly are corrected and features shown but not existing are crossed out.

Aerial Classification of Surface Widths and Minor Structures

Experience in estimating surface widths from the air has indicated that a satisfactory

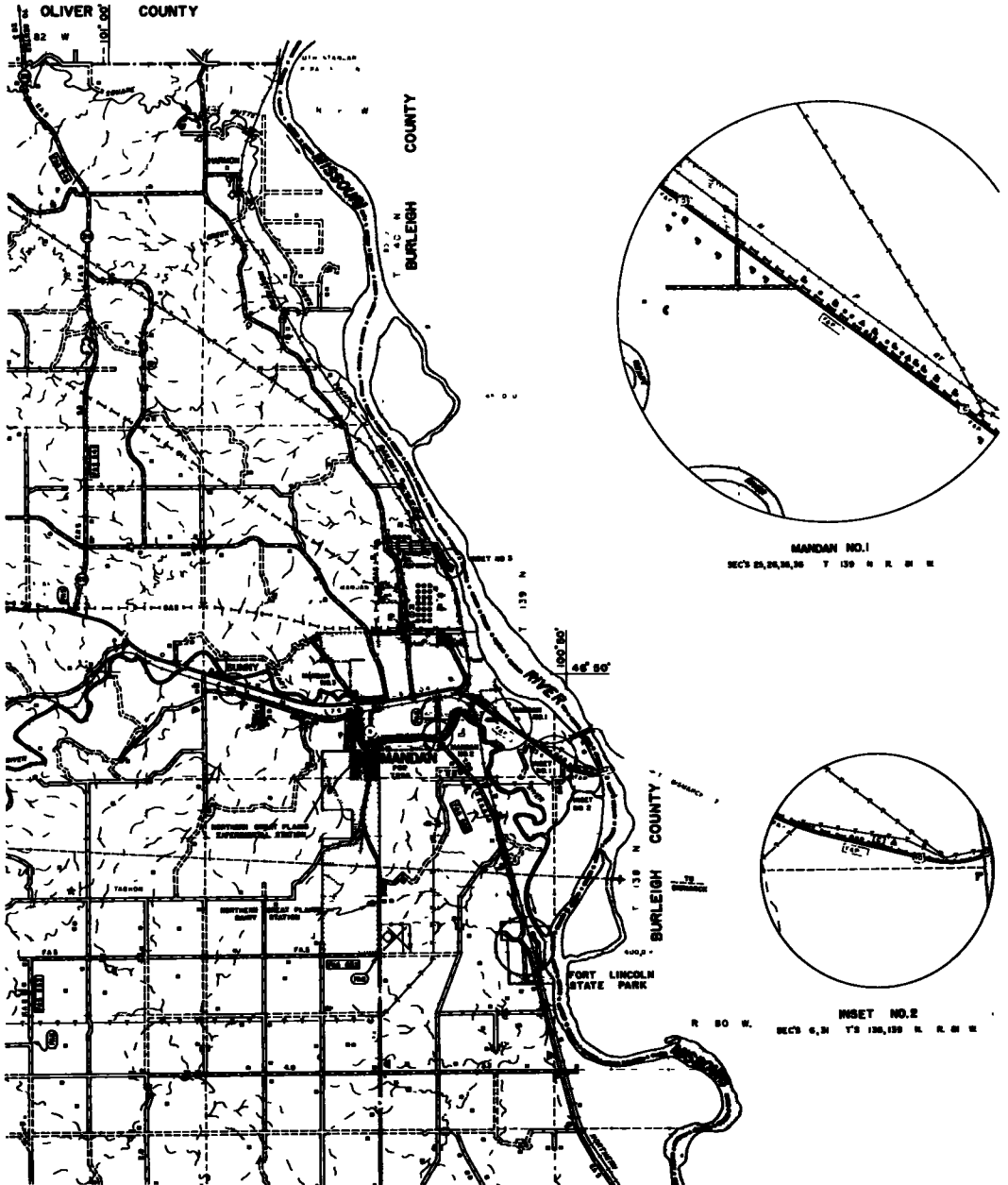


Figure 1.

grouping into surface width classes can be made. Three classes, under 20 ft, 20 to 26 ft, and over 26 ft, are used for the 2-lane roads. Widths from construction plans are available for most all multi-lane roads.

Earth and gravel-surfaced roads under 20 ft are characterized by a single pair of tracks (Fig. 2). The middle class (20 to 26 ft) is characterized by three tracks (Fig. 3) while the wide widths (over 26 ft) in general have two pairs of tracks or four clearly defined wheel tracks (Fig. 4).

There are very few dustless surfaced roads off the Federal-Aid systems in North Dakota. Widths from construction plans are available in the State Highway Department for practically all dustless surfaces.

Minor structures, 10 to 20 ft inclusive are classified according to size and type from the air. Experienced air crew personnel can estimate these types and sizes with a high degree of accuracy.

On the basis of test runs, it was found that experienced air crew personnel can estimate surface width and structure size and type information to better than 95 percent accuracy. This is comparable to ground measurement accuracy for other than dustless surface types.

Ground Crew Activities

The ground crew activities are coordinated with the air crew activities, and they are in effect subservient to the air activities. The aerial inventory is made first; all the data possible of collection are gathered and the balance is left for the ground crew.

In areas where there is inadequate coverage of triangulation stations, the ground crew takes the aerial photographs into the field, locates enough section corners to give adequate horizontal control data for mapping, and pin points the section corner locations on the aerial photographs. It should be noted in passing that the collection of this horizontal control information by the ground crew is a one-time operation. It has been completed following statewide coverage available since 1955.

For structures over 20-ft clear span, the ground crew collects width, length, waterway opening, type, and related data. The gathering of a vast majority of this information has been completed. Future re-inventory operation need be concerned only with the structures built, replaced or

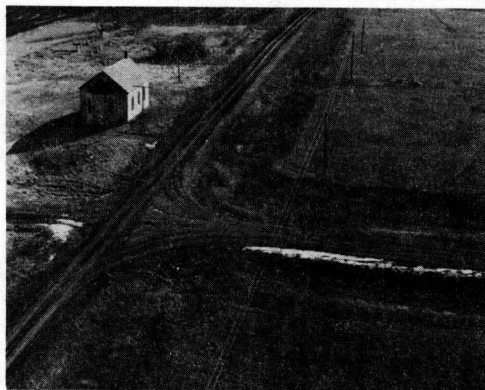


Figure 2.



Figure 3.



Figure 4.

destroyed since the previous inventory. Such structures can be identified readily by the air crew. Many structures are built on one of the Federal-Aid systems and plans are available for them.

The air crew has inventoried the unincorporated compacts working from photographic copy enlargements of the aerial photographs by the check-off method in the less congested compacts. In a few of the larger unincorporated compacts, especially those over 500 population, some assistance from the ground crew has been required.

AERIAL EQUIPMENT, PERSONNEL AND OPERATION

The aerial inventory is accomplished in a Cessna 170B four-place all-metal aircraft equipped with all-weather instruments including a directional gyro compass (Figs. 5 and 6). The aircraft is leased from a privately owned corporation exclusively for the inventory operation. The rental rate is \$12.00 per hour without pilot; there is no minimum guarantee. The purchase price new of an airplane of this general type so equipped would be in the order of \$10,000 to \$15,000.

The State has full control of all operations and maintenance. The State orders whatever repairs or maintenance is deemed necessary, whether it be a new motor or a small screw, and the corporation pays the bill.

There is strict adherence to the CAA safety regulations both in maintenance and in flight. The corporation carries insurance covering the airplane, and liability and property damage covering all State or Federal personnel that may be in the craft. No other commercial activities are covered by the insurance.

The air crew consists of two, a pilot and recorder. The State employs a pilot on an annual salary, which includes an increment for flight activities. He is assigned office duties during the winter months and when he is not in the field. There are a large number of individuals holding commercial pilot licenses which qualify them for this type of work. The Road Inventory Manager, is a licensed commercial pilot and forms the nucleus of a standby crew. The recorder is one of the regular draftsmen in the Inventory and Mapping Section. Several draftsmen have been trained for recorder duties.

The flight time required by the aircraft to reach 75 percent of the counties in North Dakota from the State Capitol in Bismarck does not exceed one hour (Fig. 7). The air activities have headquartered out of Bismarck to save subsistence and quarters allowances and to be able to use the air crew in the office during inclement weather. Further, up to about one-half hour of flight time each way can be used profitably for paper work, keeping records of operations, costs, arranging maps, and so forth.

In working the outlying counties the State collects inventory data in intermediate counties enroute both ways. By the time the outlying counties are completed, a good portion of the aerial inventory in the intermediate counties has been completed. By proper planning in scheduling the counties for inventory in any given year, little time

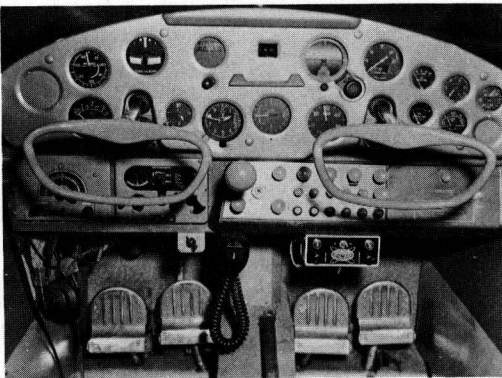


Figure 5.



Figure 6.

is lost in "dead heading." In rough terrain, such as the badlands, high level reconnaissance at 2,000 to 5,000 ft above the ground is necessary for orientation.

After completion of the high level reconnaissance, the flight altitude is reduced to 500 to 1,000 ft above the ground for detailed road information.

In flat or gently rolling terrain the high level reconnaissance is employed only in the more congested areas. In rural areas the section lines ordinarily are well defined and there is a road or trail on most of them. Orientation presents no special problem in such areas and the inventory data can be collected by low level flights. These flights generally are at an altitude of 200 to 500 ft above the ground. The air speed is about 80 mph at the low level.

These low level flights require CAA and North Dakota low flight waivers. At the low flight altitudes county wide runs are made covering one section line at a time. Depending on the wind direction on a given day, either N-S or E-W section lines are flown.

Occasional circling and reruns are necessary if features are not clearly identifiable on the first run. This may be necessary to ascertain whether a dwelling unit in a grove of trees is occupied or vacant. Further, at the low altitude clusters of houses sometimes go by too fast relative to the observer. If the culture is quite dense, it may be necessary to climb to a higher altitude to get a good view.

COMPARATIVE COST DATA

As shown in Table 1 and Figure 8, the average county in North Dakota contains 1,324 square miles. During 1955, the last year the ground inventory method was used the inventory operations in an average county cost \$6,103.64 or \$4.61 per square mile. The cost in previous years approximated this amount.

In 1956, the first year of the aerial inventory, this average cost was \$2,118.40 per county or \$1.60 per square mile. In 1957 this unit cost was reduced to \$1,880.08 per average county or \$1.42 per square mile while in 1958 it was further reduced to \$1,681.48 per average county or \$1.27 per square mile.

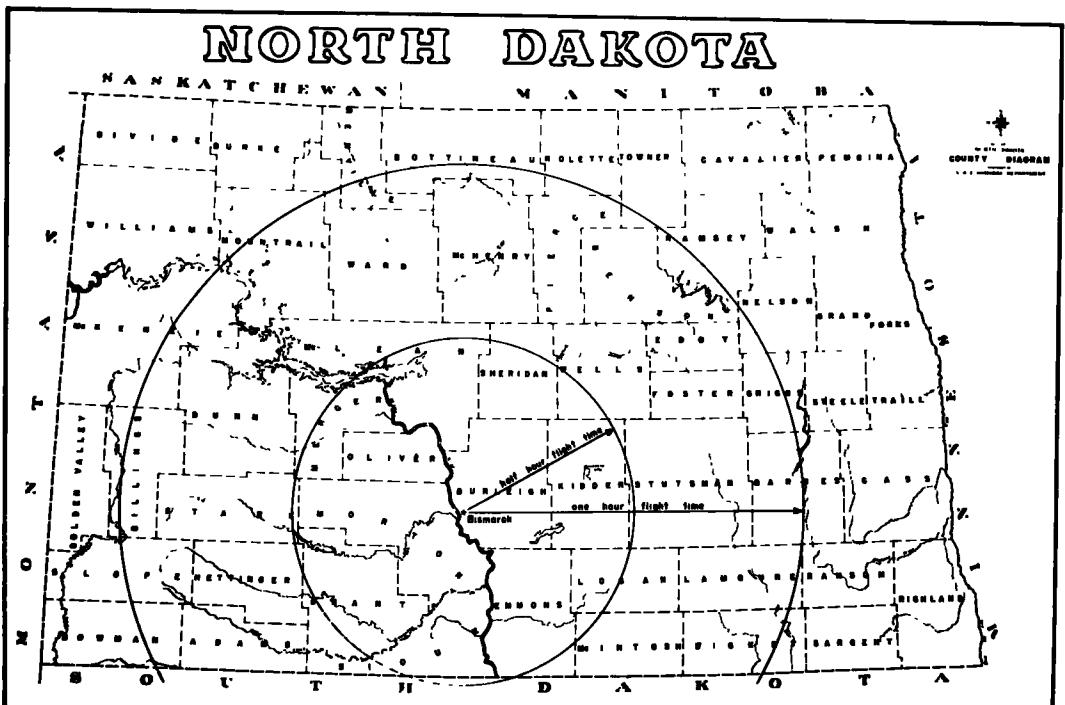


Figure 7.

TABLE I,
COMPARATIVE AVERAGE PER COUNTY AND PER SQUARE
MILE INVENTORY COSTS, 1955 TO 1958, BASED ON AN
AVERAGE OF 1324 SQUARE MILES PER COUNTY.

YEAR	PER COUNTY			PER SQUARE MILE			UNIT COST DATA ADJUSTED TO 1955 COSTS, 1955=100	
	AERIAL INVENTORY	GROUND INVENTORY	TOTAL	AERIAL INVENTORY	GROUND INVENTORY	TOTAL	PER COUNTY	PER SQ MILE
1955	\$ —	\$ 6103.64	\$ 6103.64	\$ —	\$ 4.61	\$ 4.61	\$ 6103.64	\$ 4.61
1956	1165.12	953.28	2118.40	0.88	0.72	1.60	1991.30	1.50
1957	966.52	913.56	1880.08	0.73	0.69	1.42	1748.47	1.32
1958	807.64	873.84	1681.48	0.61	0.66	1.27	1563.78	1.18

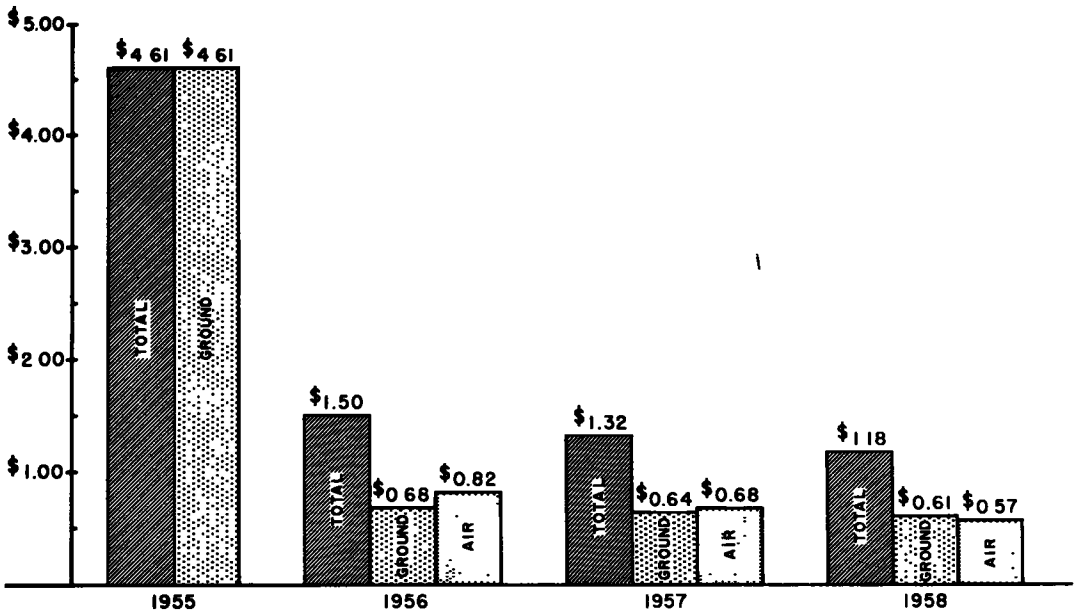


Figure 8.

It is the opinion of the State that the field inventory costs will be reduced further during subsequent reinventory operation.

FUTURE PLANS

It is planned that the reinventory operations will be continued on a 3-year cycle basis. The 3-year cycle is considered a practical one for efficient inventory and mapping operations, and the extensive use made of the maps makes this 3-year period desirable.

Every effort is being made to transfer ground crew activities to the air crew. In the past the ground crew has inventoried all incorporated places primarily to obtain official corporate limit information. New methods of obtaining reliable corporate limit information by other than a direct visit are under consideration. Also under consideration is the purchase of a camera and appropriate enlarging, developing, and reproduction equipment to permit direct photographing of areas having relatively heavy cultural development. It now appears that within a short time all incorporated places under 500 population, which represents about 70 percent of all incorporated places in North Dakota, will be inventoried by aerial inventory methods without assistance from a ground field crew.

It is expected that before long the ground crew activities will be limited to:

1. City street information in cities over 500 population.
2. The measurement and typing of structures.

SUMMARY AND CONCLUSIONS

1. North Dakota is, in general a prairie state. Its terrain varies from flat to rolling with some rough badlands areas. This type of terrain and the sparsely settled areas are ideal for aerial inventory operations. It is believed that the aerial methods would work well in a large portion of the U.S.

2. The aerial inventory methods in North Dakota have produced better inventory data in much less time and at much less cost than the conventional methods. The average inventory costs by the aerial methods are approximately 25 percent of the conventional method costs.

3. In North Dakota where there is a snow cover during three to five months of most years, a 3-year inventory cycle permits an optimum balance between the inventory and mapping operations for a permanent crew. Under this method of operation each county general highway map is current every three years.

4. Three years experience with the aerial inventory methods have convinced us of its merits.

North Dakota only has scratched the surface in the use of aerial methods for inventory. Further experience undoubtedly will produce many refinements and improvements.