Table 1. VE summary.

Item	Savings ($000s) 1979-1980	1980-1981	1981-1982
Estimated design savings	9,838	11,749	11,241
Construction savings	0	1,178	220
Total	9,838	12,927	11,461

Note: Number of VE studies is as follows: 1979-1980, 12; 1980-1981, 60; 1981-1982, 60.

should be doubled to show the construction cost reduction.

A VE program is not without its problems. There are the usual problems of acceptance of a new program, especially one the purpose of which is to question established ways of thinking and to question the work of designers. This can be overcome by good top management support of the program. Without top-level support a VE program will not succeed. With top-level support it has a fair chance of success. Pennsylvania has been fortunate, because Thomas Larson, Secretary of Transportation, is a strong supporter of VE and is committed to making the program work.

Another serious problem is acceptance of the program by contractors. Many delays have arisen in PennDOT's construction program because of arguments over prices and costs in a contractor's proposal. A contractor's education program is being planned that will describe the steps that a contractor must follow for the submission of a VE proposal. It will emphasize that a contractor's proposal must be complete and must contain justifiable prices. Proposals that are complete and accurate are evaluated quickly. An important point, to which all agencies adhere strictly, is that a VE proposal is not approved until the contract change order has been approved.

Contractors and others have questioned this policy of strict price justification. They claim that the department is saving money anyway, so why should their prices be questioned? The response is simple. We owe it to the taxpayer to save the maximum amount possible. Otherwise contractors could manipulate the prices so that they got a 60 percent or even 75 percent share of the savings.

RECOMMENDATIONS

PennDOT's experience can prove valuable to other agencies that would like to start a VE program. The following recommendations may be useful:

1. Obtain top management support. Without this support, creative ideas will be suppressed, and local staff may lack the incentive to continue with the program.
2. Adopt a multidisciplinary approach. Environmentalists, planners, right-of-way specialists, lawyers, and others will bring a fresh point of view on a problem, whereas designers and engineers may, through old traditions, be restricted in their thinking.
3. Let district or regional personnel perform the studies, but with a central guiding policy and support.

CONCLUSION

VE works. PennDOT has, over the past 2.5 years, saved more than $30 million without reducing performance. A statewide policy has been instituted within the framework of which VE is promoted at the district or regional level. Contractors have been encouraged to join the VE program by adding an incentive clause to construction contracts. VE has even been marketed by using training programs, posters, and pamphlets.

REFERENCE

1. J.J. O'Brien. Value Analysis in Design and Construction. McGraw-Hill, New York, 1976.

Publication of this paper sponsored by Committee on Manpower Management and Productivity.

Pennsylvania's Inventory Reduction Program

PARKER F. WILLIAMS

In October 1981 the Pennsylvania Department of Transportation (PennDOT) launched a statewide inventory reduction program. Results have been dramatic. In September 1982, 1 year after the start of the program, inventories have been reduced by more than $14 million (30 percent). A description of the underlying causes for excessive inventories at PennDOT, specific remedies that have developed to reduce inventories, the results to date, and actions planned for the future are presented. The methodology includes the use of fairly simple inventory management performance indicators such as turnover ratios, zero-use reports, and inventory values per lane mile to highlight excessive inventories and establish priorities for their reduction. PennDOT's program is especially relevant to other states that have computerized systems but can also be useful to those whose automated systems are in the design stage.

The purchase of materials and supplies is the largest cost element in a transportation department's highway and bridge maintenance program next to wages and contract maintenance. The private sector has long recognized that the major potential for controlling these costs lies in inventory management. Because of the astronomical costs of financing inventories at today's interest rates, programs to reduce inventories have been placed high on the priority list of private-sector materials management goals.

Consistent with the efforts in Pennsylvania to apply proven business practices to state government, the Pennsylvania Department of Transportation (PennDOT) has concentrated on applying basic inventory management techniques to reduce inventory costs. Clearly transportation agencies faced with dwindling funding levels that do not match even the most basic maintenance needs must recognize the large cost savings potential in reducing excessive inventories.

NEED FOR INVENTORY REDUCTION

Pennsylvania has the fourth largest state transportation system in the United States: 45,000 miles of highway and 27,000 bridges. Because the three states with larger systems have warm climates, Pennsylvania's system is the most difficult to maintain. Because of declining liquid fuels revenues, the General Assembly appropriated only $439.4 million for Pennsylvania's road and bridge maintenance program in FY 1980-1981, some $46 million less than in 1979-1980. An ambitious highway and bridge maintenance program coupled with this reduction in revenues made it clear that cost efficiencies and productivity improvements would be needed to carry out the program.

Inventory carrying costs are at least 20 to 25 percent per year (1). PennDOT's statewide inventories as of June 1981 totaled $48.1 million (see Figure 1). With a conservative carrying cost of 20 percent (includes storage and financing costs), every $1 million reduction in inventory could save $200,000.

Field visits by top management to county yards, stockpiles, and storerooms confirmed that inventories were excessive compared with operational needs. Clearly PennDOT's Automated Inventory Management System (AIMS), in place since 1975, was not serving its primary inventory management objective. Secretary of Transportation Thomas Larson, aware of the potential cost savings, charged the Bureau of Office Services with the task of determining the causes of high inventories and developing an inventory reduction program to reduce levels without impairing the achievement of maintenance goals.

AIMS

To gain a better understanding of how the PennDOT inventory reduction program was developed, it is first necessary to provide a brief description of the inventory management system. In the late 1960s, PennDOT made a long-term management commitment to automate inventory record keeping, procurement, and materials use functions and began phased institution of the system now known as AIMS. By mid-1975 the system was fully operational in all district offices; since 1975 all central warehouses have been incorporated into the system.

AIMS is an on-line, real-time, remote-data-entry computer system that automates routine clerical procedures for inventory accounting, purchase order preparation, and materials use accounting. AIMS provides managers with automated control mechanisms and ready access to the information needed for decision making.

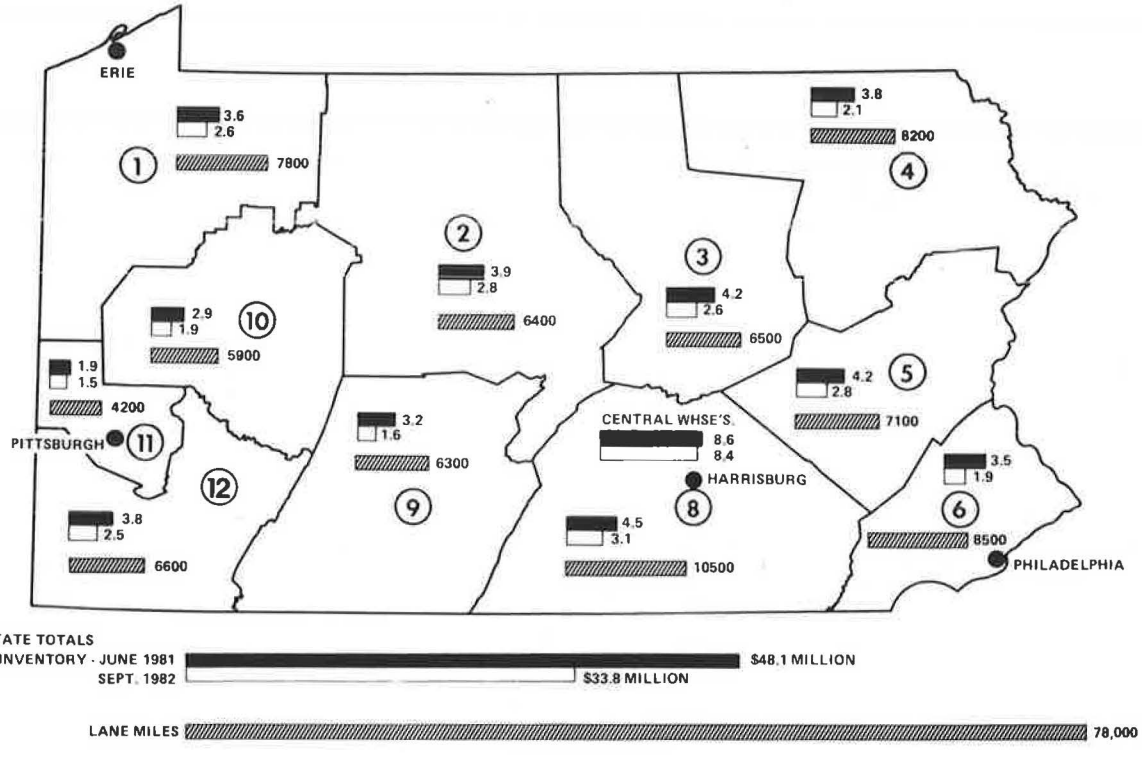
Operating-level managers establish reorder points and reorder quantities. By means of the remote-data-entry terminal located at all district offices and central warehouses, receipts and issues are posted to inventory records; low-stock notices are given; orders are placed; fiscal control over material budgets is maintained; and information on current inventories, open orders, physical inventory adjustments, and historical use is maintained. Summarized reporting is provided at all management levels and data are captured for reporting and analysis.

The director of the Bureau of Office Services as materials manager has overall responsibility for the AIMS system. The Bureau of Maintenance provides guidelines to district materials coordinators on the technical aspects of ordering and using materials.

Each of the engineering districts has an AIMS coordinator who approves or disapproves orders and monitors inventory records, controls, and system performance. Each county maintenance district has a materials coordinator and a storekeeper who oversee AIMS at the operating level.

During FY 1981-1982, AIMS was used to control 14,712 different commodities at 1,053 separate loca-

Figure 1. Inventory reduction and lane miles by engineering district.



tions. The system processed 17,168 orders and 513,409 issue transactions representing $121.6 million in materials charges to the accounting system.

CAUSES OF EXCESSIVE INVENTORIES

After numerous field visits and extensive discussions with responsible individuals, five primary causes of high inventories were identified.

Lack of Management Commitment

The best-designed inventory management system will not work effectively unless managers directly responsible for inventories are committed to, and insist on, accurate and timely input of the order, receipt, issue, transfer, and adjustment transactions critical to the effective operation of the system. Moreover, these managers must also be directly involved with, and take an active interest in, reviewing and analyzing the system's summary reports to be able to monitor and successfully control materials use and inventory levels.

There are three reasons that county-level managers were not motivated to adequately control inventories. First, the AIMS system was primarily designed and established by central office and engineering district staff with less involvement of the county maintenance staff who are responsible for entering transactions and overseeing the system at the operational level. As a result operating-level management did not totally understand the complexities of the system and even viewed it as a threat. Second, it was difficult to get county-level management interested in reducing inventory levels. Many managers did not see the cost savings that resulted from lower inventories, only the possible loss in production if critical materials were not in stock. This has resulted in the tendency to stockpile materials for unforeseeable future needs. Third, top-level management in previous administrations did not place a high priority on inventory management. This lack of management commitment at all levels was the key reason for excessive inventory.

Lack of Quantitative Methods

Quantitative methods were not being extensively used to answer the four questions common to any inventory management system: (a) Which items or group of items should be more closely controlled? (b) How much and which types of items would be needed to meet the production plan (demand)? (c) When must an item be ordered (reorder point)? (d) What quantity must be ordered (order quantity)? The first question can be answered by use of ABC analysis (discussed later), the second by systematic materials requirements planning (MRP), and the third and fourth by mathematical determination of the economic order quantity (EOQ). Although these quantitative techniques are commonly used in the private sector, they were not being used by PennDOT.

Surplus

Excessive inventory always leads to surplus. There is a natural tendency, even in an organization with a well-managed inventory program, to hold on to items even if they can be clearly identified as surplus. Several categories of surplus were identified at PennDOT: usable items overstocked in a particular county maintenance district or statewide, items obsolete in one county but usable in another, items obsolete statewide but having a salable value, salable scrap or wornout items, and junk with little or no value. Surplus was an especially difficult problem for several reasons.

First, without any AIMS exception reports to compare inventory levels and use or to determine whether an item had been used recently, the extent of the surplus problem could not be accurately determined. Second, there were no ongoing central efforts to identify and encourage the transfer of items excessive or obsolete in one county to another county where the items could be used. Third, there was a lack of knowledge of how to dispose of surplus. Fourth, inventory managers had a tendency to retain surplus even if it could be sold, because surplus revenues were not credited back to their budgets. Fifth, planning for the introduction of new materials was inadequate. The quantity, value, and location of material that would be made obsolete by the introduction of improved material were not identified nor were policy guidelines issued that required the use of existing material before new material was ordered. Sixth, not unique to PennDOT, is the obsolescence of equipment repair parts, which occurs as a result of the competitive bidding process. As equipment produced by one manufacturer ages and needs to be replaced, there is always the chance that the low bidder on the new equipment will be a different manufacturer.

Procurement Methods

PennDOT must operate its procurement functions within the policies of the Commonwealth as administered by the Department of General Services. Three basic procurement methods apply: contract purchasing, requisition purchasing, and local purchasing.

Contract Purchasing

Contracts are established by General Services for major material items regularly purchased by many organizations at locations throughout the state. Some examples of material contracts are those for tires and tubes, motor fuels and lubricants, winter materials, aggregates, bituminous materials, and pipe. Contracts include the free-on-board (FOB) delivered price for every purchasing location. The contracts are loaded into AIMS for automated preparation of a purchase order when a reorder point has been reached. Benefits include fixed prices, usually for 1 year, ease of ordering, and timely receipt of materials in the exact quantity needed. However, because of the extensive and time-consuming process involved in assembling each agency's requirements and bidding, awarding, preparing, and distributing the contract, it was not unusual for the existing contract to lapse before the new contract was available. In the absence of assurances that a new contract would be loaded into AIMS before the existing contract expired, stockpiling before the end of a contract was the rule, especially for critical maintenance materials. An added problem with contracts was the minimum order quantity, which could force excessive inventory if it exceeded immediate needs.

Requisition Purchasing

A purchase requisition must be prepared, either manually or through the AIMS system, for commodities not on contract when the order amount exceeds $1,500. The requisition is processed through the Transportation Procurement Section and goes to General Services for bidding and award, a process that takes an average of 90 days to complete. To gain a better price on noncontract commodities used by maintenance districts throughout the state, the Procurement Section solicits annual requirements

from each maintenance district for a group purchase. The elapsed time between solicitation of needs and delivery of materials is 6 to 9 months. The long lead time coupled with the lack of AIMS reports correlating past use with inventory and the necessity of purchasing the estimated quantities results in excessive inventory levels.

Local Purchasing

Materials not available through contract may be purchased locally by the district office if the order does not exceed $1,500. Because materials purchased locally are readily available and usually used within a short period of time, this procurement method was not a cause of high inventories.

Lack of Inventory Management Performance Indicators

A critical element in any inventory management program is the measurement of the program's success. Without performance indicators, it is difficult to establish and monitor inventory goals and to identify problems that require management attention. With AIMS a variety of useful information was being reported to inventory managers on the system's operation, but the data were not being correlated into exception and performance reports. For example, AIMS reports the quantity and value of inventory by commodity and location and use of each commodity in units and dollars for the current month, year to date, last fiscal year to date, and last fiscal year. The system also provides aggregate totals for commodity groups and all commodities at a particular location, all locations in a county combined, and all counties in an engineering district, and statewide totals. However, a county manager responsible for inventory management could not readily determine through existing AIMS reports the value of county inventory compared with that of other counties, how many months' stock was on hand in relation to use, or which items reflected no use and should be transferred or sold as surplus.

PENNDOT'S INVENTORY REDUCTION PROGRAM

The primary causes of high inventory were identified and presented to top management in May 1981. In October 1981 the Inventory Reduction Program was launched by Secretary Larson. The following discussion describes the specific performance indicators developed to establish inventory reduction goals and what specific remedies were instituted to help achieve those goals. The key cause of high inventories, lack of management commitment, was resolved when the program received top management's endorsement.

Table 1. Zero-use report.

PROG 3584710 — ZERO USAGE REPORT, JULY, 1981 THRU JUNE, 1982 — RUN DATE 06/30/82 PAGE 15 & TIME 20:27

ORG 011

STKPL	COMMODITY CODE	QUANTITY ON HAND	UNIT PRICE	VALUE OF ON HAND	U/M	NOMENCLATURE	DESCIPTION
01	8010-2400-0201	4.0	10.00	$40.00	GAL	PAINT,#4	BLUE GLASS HISTORICAL SIGNS 1 GALLON CAN
01	8010-4000-0206	.0	10.00	$.00	GAL	PAINT,#6	BLACK SEMI-GLOSS SIGN POSTS 1 GALLON CAN
01	8010-4200-0200	80.0	9.50	$760.00	GAL	PAINT,#12	WHITE GLOSS WOOD 5 GALLON CAN
01	8010-5400-0102	21.0	10.00	$210.00	GAL	PAINT,#1ZY	YELLOW ZINC PRIMER STRUCTL TOUCH-UP 1 GALLON CAN
01	8010-5400-0204	5.0	10.00	$50.00	GAL	PAINT,#1ZY	YELLOW ZINC PRIMER STRUCTL TOUCH-UP 5 GALLON CAN
01	8010-5450-0402	3.0	10.00	$30.00	GAL	PAINT,PRIMER	ZINC-DUST ZINC OXIDE PRIMER 1 GALLON CAN
01	8010-6100-0200	.0	6.25	$.00	CAN	PAINT,MRL SP	MINERAL SPIRITS 5 GALLON CAN
01	8010-9900-1070	.0	8.58	$.00	GAL	PAINT, #3	YELLOW ENAMEL, 5 GAL CAN
01	8010-9900-1128	24.0	10.50	$252.00	GAL	PAINT #9	ANTIQ BRONZE MINERL SP ALK RESIN BRIDGE 1 GAL CN
01	5610-4500-0410	.0	4.20	$.00	BAG	CEMENT	OCTOCRETE FAST-SETTING, 50 LB. BAG
01	5350-6000-0500	256.0	2.93	$750.08	BAG	ABRASIVE	SAND BLASTING
01	9545-0100-0050	9.0	29.95	$269.55	EACH	WIRE	BLACK ANNEALED #8 GAUGE, SPEC. FED. QQ-W-461F
01	9545-0100-0104	7.0	30.00	$210.00	EACH	WIRE	BLACK ANNEALED #9 GAUGE, SPEC. FED. QQ-W-461F
01	9545-0100-0250	6.0	30.30	$181.80	EACH	WIRE	BLACK ANNEALED #12 GAUGE, SPEC. FED. QQ-W-461F
01	9545-0100-0352	.0	30.90	$.00	EACH	WIRE	BLACK ANNEALED #14 GAUGE, SPEC. FED. QQ-W-461F
01	9545-0200-0081	.0	32.00	$.00	BAG	TIES	8IN ANNEALED WIRE 14 GAGE 5000 PER BAG
01	9545-0200-0128	.0	21.00	$.00	BAG	TIES	12IN ANNEALED WIRE 14 GAGE 2500 PER BAG
01	9545-0200-0140	.0	23.25	$.00	BAG	TIES	14IN ANNEALED WIRE 14 GAGE 2500 PER BAG
01	7920-5310-0200	23.0	1.21	$27.85	EACH	BRUSH,HANDLE	TAPERED,HARDWOOD,60 IN.,FOR HWY ST. BROOMS
01	7920-5800-0300	1.0	88.80	$88.80	DOZEN	MOP DUST	DUST, SLIP-ON, W/HOLE, 22 IN.FRAME,30 IN.SURFACE
01	7920-5800-0605	1.0	39.96	$39.96	DOZEN	MOP, DUST	REPLACEMENT HEAD FOR 30 IN SURFACE #1130LTR
01	7920-6230-1303	.0	37.59	$.00	EACH	MOP EQUIP	WRINGER,BUCKET-TYPE I CLASS A,STYLE 1,SIZE 1
01	7930-2475-0907	55.0	3.72	$204.60	GAL	DETERGENT	ALKALINE LIQUID DETERGENT FOR BIG RIG STEAM CLNG
01	7930-3400-0400	.0	.18	$.00	EACH	POWDER	SCOURING W/O BLEACH (48/14 OZ CANS PER CASE)
01	8110-2000-0250	.0	11.82	$.00	EACH	COVER, DOME	HOT-DIPED,GALV.,SELF CLOSE DOME COVER,55 GAL CAN
01	8540-3001-0300	.0	21.65	$.00	CASE	TOWELS	PAPER, ROLL, GRADE A, CLASS II
01	2805-0199-0115	28.0	.17	$4.90	EACH	FILTER&COVER	R-10 DUST PRE-FILTER
01	2805-0199-0228	7.0	1.40	$9.80	EACH	FILTER&COVER	R-21 ORGANIC,VAPOR,PAINTING
01	2805-0199-0308	1.0	9.88	$9.88	EACH	RESPIRATOR	SPRAY PAINTING PROTECTION, COMPLETE
01	2805-0199-0330	10.0	2.16	$21.60	EACH	FILTER	R-15 PAINTING PRE-FILTER
01	2805-0199-0400	.0	9.58	$.00	EACH	RESPIRATOR	WELDING PROTECTION, COMPLETE
01	2805-0199-0443	8.0	1.64	$13.12	EACH	CARTRIDGE	R-12 DUST,FUMES,WELDING
01	6505-3758-0100	.0	9.38	$.00	UNIT	IMUNIVY	1CC VIALS 4 TO UNIT
01	6545-1015-0053	1.0	13.48	$13.48	EACH	KIT,FIRSTAID	W/STING-KILL DEPT.OF TRANS FIRST AID 10 UNIT
01	6545-1020-0204	.0	.96	$.00	UNIT	BANDAGE	PLASTIC ADHESIVE 2IN.X3-1/2 IN. 02-09-15
01	7240-4200-1002	9.0	39.15	$352.35	EACH	CAN,DSPNSER	SAFETY DISPENSER 5GAL. RE:EAGLE MODEL U2-51-S
01	8415-5500-1156	50.0	1.54	$77.00	EACH	SUSPENSIONS	ADJ 6 3/4-7 5/8 FOR HARD CAPS NYLON WEB VINYL BD
01	8415-5500-4100	.0	1.20	$.00	EACH	LINER,WINTER	FOR HARD CAPS,SIZE SMALL UP TO 7 1/8
01	8415-7000-0103	3.0	13.90	$41.70	PAIR	GUARD,FOOT	PROTECTIVE,SANKEY (MENDS)_200 ALUM.ALLOY, 5 IN.
01	8415-7000-0409	3.0	13.90	$41.70	PAIR	GUARD,FOOT	PROTECTIVE,SANKEY(MENDS)_200 ALUM.ALY,5-1/2 IN.
01	8340-1000-1508	.0	.38	$.00	SQ FT	TARPAULIN	CLASS 1 VARIOUS SIZES
01	8340-2000-1000	.0	76.00	$.00	EACH	TARPAULIN	STOCKPILE COVER, 24 FT. X 36 FT MT 26
01	8340-2000-2000	.0	101.00	$.00	EACH	TARPAULIN	STOCKPILE COVER, 24 FT. X 48 FT. MT 27
01	8405-6600-0102	6.0	11.46	$68.76	EACH	JACKET	RAIN, SMALL (36-38)
01	8405-6700-0104	1.0	10.00	$10.00	EACH	PANTS	OVERALL, SMALL
01	8405-6700-0308	7.0	10.00	$70.00	EACH	PANTS	OVERALL, LARGE
01	8405-6700-0400	2.0	10.00	$20.00	EACH	PANTS	OVERALL, X/LARGE
01	8405-6800-0106	6.0	2.00	$12.00	EACH	HOOD	RAIN, ONE SIZE FITS ALL

Inventory Management Performance Indicators

Three performance reports were designed: zero-use, inventory turnover, and inventory value versus lane miles.

Zero-Use Report

It was clear that eliminating surplus inventory and junk held the greatest immediate potential for inventory reduction. Thus the first performance report was developed to give inventory managers a tool to assist in identifying those items in inventory that had not been used recently. The report is prepared monthly from AIMS Inventory Master File records and reflects all inventory records for an organization (county maintenance district, engineering district, or central warehouse) against which there have been no issue transactions during the previous 12-month period (Table 1).

When the baseline report was run, the zero-use value totaled $13.9 million, or 29 percent, of the June 30, 1981, total inventory value. This was the first time that the magnitude of excessive and surplus inventories had been quantified. The Inventory Reduction Program set an initial goal to reduce the value of zero-use items 50 percent by June 30, 1982--a goal that would result in a more than $7 million inventory reduction.

Inventory Turnover Report

It was also clear that, for reasons already cited, storekeepers and materials coordinators were setting reorder points and quantities so that they would never be out of stock. As a result, quantities in inventory represented far more than immediate needs plus a safety stock. The problem was that the AIMS system was not reporting a performance measure that has been the most widely used inventory management indicator in the private sector--inventory turnover.

Inventory turnover is the quantitative measurement of the number of times each item in inventory turns over each year. When expressed a little differently, it tells an inventory manager, based on the past 12 months' use, the number of months that the on-hand quantity will last. The turnover rate is used to identify items that may be overstocked or understocked. The inventory turnover report is prepared monthly from AIMS Inventory Master File records and is calculated by comparing total use in units for the previous 12-month period with the average number of units held in inventory for the same period (see Table 2).

Table 2. Inventory turnover report.

PROG P3584710 INVENTORY TURNOVER REPORT BY ORG JULY, 1981 THRU JUNE, 1982 RUN DATE 06/30/82 & TIME 20:27 PAGE 7

ORG 011 GROUP 12 SIGN ACCESSORIES

COMMODITY CODE	AVERAGE INVENTORY QTY	AVERAGE INVENTORY VALUE	TOTAL USAGE (UNITS)	INVENTORY TURNOVER (MONTHS)	NOMENCLATURE	DESCRIPTION
0210-2291-0000	272.0	$1,572.62	227.0	14.2	H 2 29 1	CHAN BAR ANCHORS 3FT 6IN 4.0 LB
0210-2300-0000	1,122.0	$1,279.17	810.0	16.5	H 2 30	CHAN BAR STRAP 2.0LB
0210-2320-0000	3.9	$36.36	14.0	3.2	H 2 31	CHANNEL DRIVE CAPS MAN 2.75LB
0210-2360-0000	9.3	$69.69	1.0	111.9	H 2 34	CHANNEL DRIVE CAP 6 FT.
0210-2390-0000	103.0	$1,004.25	222.0	5.5	H 2 38	CHAN BAR BRKWAY 8FT 2.25 LB
0210-4020-0000	3.5	$84.99	5.0	8.4	H 4 2	STEEL BANDIT BAND 3/4IN ROLL
0210-4030-0000	4.9	$75.08	2.0	29.4	H 4 3	BANDIT BUCKLES 3/4IN BOX
0210-6010-0000	10.0	$442.26	24.0	5.0	H 6 1	FRAME PORT SIGN SUPPORT 36IN
0210-9010-0000	85.1	$613.15	59.0	17.2	H 9 1	ORANGE TRAFFIC CONE (28 INCH)
0210-9020-0000	16.6	$26.15	25.0	7.9	H 9 2	REFLECTIVE BAND (28 INCH)
GROUP 12 TOTS	3,791.3	$18,918.40	4,067.0	11.1		
GROUP 13 SIGN RAW MATERIALS						
0210-1170-0000	2.2	$66.16	6.0	4.4	H 1 17	RIVITS CHERRY POP 1000 BOX
GROUP 13 TOTS	2.2	$66.16	6.0	4.4		
GROUP 16 LINE PAINT, BEADS & PROTECTORS						
8010-4320-0101	962.4	$7,158.69	3,026.0	3.7	PAINT,TRAFIC	WHITE TRAFFIC LOW HEAT,RAPID DRY, 55 GAL DRUM
GROUP 16 TOTS	962.4	$7,158.69	3,026.0	3.7		
GROUP 18 FASTENERS						
5305-1520-0012	0.2	$.33	1.0	3.0	SCREW,CAP	ALY STEEL,HEXGN HD,GRADE 5,DIA.1/4,L.1/2 N.C.T.
5305-1520-0056	0.5	$1.06	4.0	1.6	SCREW,CAP	ALY STEEL,HEXGN HD,GR.5,DIA.1/4 L.1 NC
5305-1520-0103	0.2	$.61	2.0	1.4	SCREW,CAP	ALY STEEL,HEXGN HD,GRADE 5,DIA.1/4,L.1/1/2N.C.T.
5305-1520-1104	0.2	$.81	3.0	0.9	SCREW,CAP	ALY STEEL,HEXGN HD,GRADE 5,DIA.5/16,L1-1/2N.C.T.
5305-1520-1206	0.5	$2.75	1.0	6.9	SCREW,CAP	ALY STEEL,HEXGN HD,GRADE 5,DIA.5/16,L.2-1/2N.C.T
5305-1520-1250	2.5	$15.78	1.0	30.9	SCREW,CAP	ALY STEEL,HEXGN HD,GRADE 5,DIA.5/16,L.3 N.C.T
5305-1520-2207	0.0	$.55	3.0	0.2	SCREW,CAP	ALY STEEL,HEXAGN HD,GRADE 5,DIA.3/8,L.2-1/2N.C.T
5305-1520-6109	1.0	$16.15	1.0	12.0	SCREW,CAP	ALY STEEL,HEXAGON HD,GRADE 5,DIA.5/8,L.1-1/2 NCT
5305-1520-6550	0.6	$31.21	1.0	7.9	SCREW,CAP	HEXAGN HD,HIGH CRBN,GRADE 5,DIA.5/8,L.6 NCT
5305-1525-0033	0.5	$1.11	2.0	3.4	SCREW,CAP	HEXAGN HD,HIGH CRBN,GR.5,DIA.1/4 L.1 NF
5305-1525-0204	0.4	$1.63	1.0	4.9	SCREW,CAP	ALY STEEL,HEXAGON HD,GRADE 5,DIA.1/4,L.2-1/2 NFT
5305-1525-1103	0.2	$.64	1.0	3.0	SCREW,CAP	ALY STEEL,HEXAGON HD,GRADE 5,DIA.5/16,L.1-1/2NFT
5305-1525-2057	0.3	$1.28	2.0	1.9	SCREW,CAP	ALY STEEL,HEXAGON HD,GRADE 5,DIA.3/8,L.1 NFT
5306-0510-3150	2.6	$301.77	1.0	31.9	BOLT,CARRAGE	W/O NUT,RND UNSLT HD,SQ NK,GR8,DIA 3/8 L 1-1/2NC
5308-1000-0254	3.3	$.89	1.0	39.9	ROD	THREADED,NC,3FT.LNGTH,CBN.STL,SIZE 1/4,ROD 20
5308-1000-0356	2.7	$1.54	5.0	6.6	ROD	THREADED,NC,3FT.LNGTH,CBN.STL,SIZE 3/8,ROD 16
5308-1000-0403	0.7	$.54	3.0	3.0	ROD	THREADED,NC,3FT.LNGTH,CBN.STL,SIZE 7/16 ROD 14

The formula is X = 12Y/Z, where X is the turnover in months, Y is the average annual inventory, and Z is annual use. For example, a tire that has an average annual inventory of 6 units and an annual use of 12 units has a turnover of 6 months [12(6)/12]. In other words, the normal inventory of this tire is sufficient to last 6 months under typical conditions.

Turnover ratios gain significance when turnover standards or goals are developed. When it is questioned whether an overstocked or understocked condition exists, the turnover rate must be considered in light of the goal and delivery times, minimum purchase requirements, storage capabilities, method of procurement, and actual and anticipated need for the item. When it is determined that there is an excess of an item, the reorder point and quantity should be adjusted and steps should be taken to record the excess quantity as surplus.

The baseline turnover report as of June 30, 1981, identified many commodity groups that had a turnover in excess of 12 months (see Table 3). The Bureaus of Office Services and Highway Maintenance, with the assistance of field inventory managers, developed inventory turnover goals for each major commodity group (except fuels and bulk materials) to be met by June 30, 1982. If these goals were achieved, inventory could be reduced by as much as $4 million. A combined inventory reduction goal of $11 million was set ($7 million zero-use reduction plus $4 million turnover reduction).

Inventory Value Versus Lane Miles

The AIMS system had no indicator by which to compare the relative value of the inventory in one county or engineering district with that in another. Lacking was a common denominator to compare organizations of different sizes. After the correlation coefficient had been tested by using regression analysis (see Figure 2), lane miles was chosen as the common denominator. The graph and tables showing inventory values per lane mile for all counties and districts were included with the Inventory Reduction Program. The indicator can be useful in determining the reasons why inventory value per lane mile is higher (or lower) in one county versus that in another and identifies locations that require a detailed analysis.

Table 3. Inventory turnover goals and results.

COMMODITY GROUP	INVENTORY TURNOVER (MONTHS) 6/30/81	INVENTORY TURNOVER GOAL 6/30/82	INVENTORY TURNOVER ACTUAL 6/30/82	INVENTORY TURNOVER ACTUAL 9/30/82
FIELD RELATED				
Signs & Accessories	13	10	14	12
Traffic Line Paint & Beads	15	12	7	7
Pipe	13	11	8	8
Tires & Tubes	8	6	6	5
Tire Chains & Accessories	35	6	16	15
Batteries	6	4	6	6
Automotive Parts	20	12	12	14
Other Equipment Repair Parts	15	6	12	12
Cutting Edges & Shoes	22	15	15	14
Guiderail	37	12	27	24
Lumber	19	12	21	19
Steel & Iron	44	24	26	26
Paint & Brushes	24	12	16	14
Tarpaulins	11	6	12	12
Fasteners	31	12	24	16
Bridge Decking & Inlets	12	10	25	20
Roadside & Landscaping	10	6	11	9
Electrical Supplies	12	6	8	7
Concrete & Cement	7	6	4	4
Safety Supplies	12	9	11	10
GENERAL OFFICE RELATED				
Forms, Publications, Office Supplies	12	10	12	13
Janitorial Supplies	9	6	7	7

Quantitative Methods

It is not enough to issue performance reports that show an inventory manager that a certain percentage of his inventory represents zero-use items or that the turnover ratio for several commodity groups exceeds the goal. Quantitative methods for determining where priorities should be placed, how reorder points and quantities should be set, and how to translate a maintenance program into material requirements are needed. The following three quantitative methods address these problems.

ABC Classification Analysis

ABC analysis is a quantitative technique used to focus attention on and apply effort to items that have the potential for yielding the greatest cost savings (2). ABC analysis stratifies commodities into three classifications based on their value relative to their numbers. Figure 3 is an ABC analysis of PennDOT's commodity groups.

The A items should be controlled the most closely because they are few in number (8 percent) but represent 57 percent of the total inventory value. The A items should be controlled by a computerized inventory system, and an economic order quantity (EOQ) model (discussed later) should be applied to systematically determine optimum reorder points and quantities. The B items represent 39 percent of the total and 31 percent of the value. These items should also be controlled by an automated system but

Figure 2. Lane miles versus inventory value for county maintenance districts.

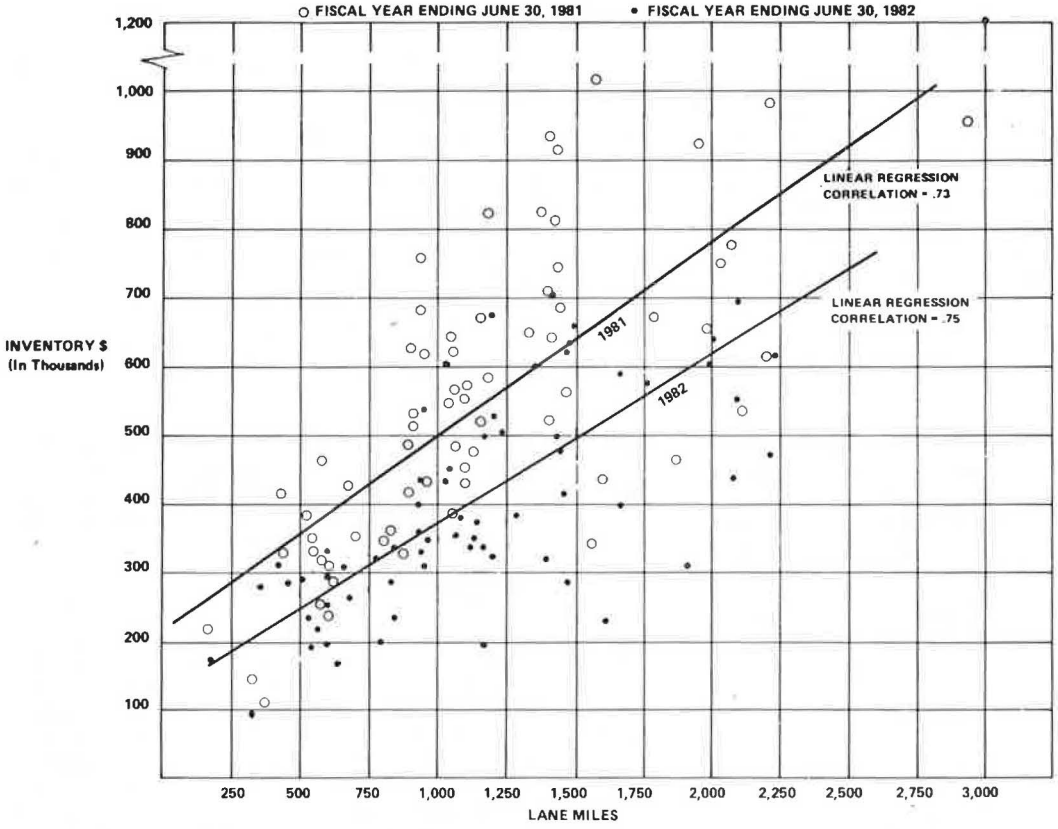
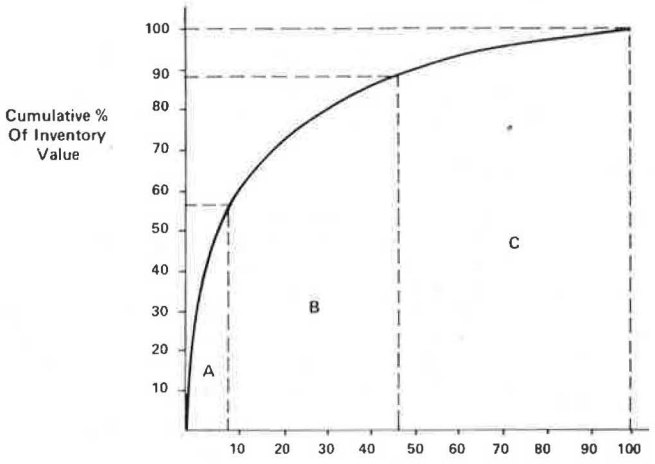


Figure 3. ABC inventory classification.



CLASS	GROUP	Cumulative % of Items in Inventory: Percentage of Total Commodities	Cumulative % of Items in Inventory: Percentage of Total Inventory Value
A	Traffic Paint/Beads; Pipe; Bituminous Mat's; Aggregates; Winter Mat's; Petroleum Products; Cutting Edges; Engines; Guiderail; Tarpaulins; Bridge Decking; Roadside/Landscaping Mat's.	8%	57%
B	Signs/Accessories; Tires/Tubes/Chains; Batteries; Hand Tools; Lumber Steel/Iron; Paint/Brushes; Misc. Mat's.	39%	31%
C	Equipment Repair Parts; Office/Janitorial/Safety Supplies; Forms/Pubs/Maps; Fasteners	53%	12%
		100%	100%

less closely than the A items through use of the optimum order quantity portion of the model alone. The C items represent 53 percent of the total but only 12 percent of the dollar value. These items need to be further classified into two groups: (a) items to be controlled on an automated system because of operational problems in the event that the items are out of stock (e.g., equipment parts) and (b) items requiring no automated controls (e.g., office supplies and forms). C items should be controlled by subjectively determined order quantities.

Inventory managers at PennDOT have been encouraged to prepare an ABC analysis on the inventory they control. The primary usefulness of this technique thus far has been to focus attention on A items, which should be first-priority items when the zero-use and inventory turnover reports are used to identify and reduce inventory.

EOQ Model

All inventory reorder points and quantities on the AIMS system are currently set subjectively. Subjective determination does not assure minimum inventory costs. Private-sector enterprises, particularly manufacturers, have successfully used the EOQ model as an inventory device for some time. Basically the EOQ model, given annual demand, cost of placing an order, cost of carrying a unit in inventory 1 year, cost of being out of stock 1 unit, lead time between the date on which the order is placed and the date on which the order is received, and average demand over the lead time, will first determine the optimal order quantity and then determine the optimal order point to balance inventory costs against the risk that the item will be out of stock to minimize inventory costs.

In a report prepared by an Office Services business intern in summer 1981, many of the problems in applying the EOQ model were described. For example, one of the biggest problems in applying the model, particularly to a department of transportation in a cold-weather state, is determining the effect of seasonality of maintenance activities and the unpredictability of winter activity on demand for materials. Simplified EOQ models are currently being investigated (3).

Materials Requirements Planning

Materials requirements planning (MRP) is another quantitative method that has been extensively used by the private sector to manage inventories but has not been so used by PennDOT. MRP is the process of translating a maintenance plan into detailed materials requirements. MRP is a relatively new (late 1960s) solution to an old problem: availability of the material needed for production without excess inventories (1).

The computerized Highway Maintenance Management System (HMMS) used by PennDOT to define, among other things, the effort and resources required to perform a maintenance activity is scheduled for redesign. One of the goals of the redesign will be to integrate the maintenance programming on HMMS with materials use and inventory on AIMS, a step toward MRP.

Surplus

Armed with the new zero-use report, inventory managers made efforts to reduce surplus-dominated inventory reduction activities in the initial phases of the program. Office Services released a procedure memorandum that brought inventory managers up to date on the various methods available to dispose of surplus. They were made aware of the Department of General Services' surplus contracts for tire casings, batteries, steel drums, waste motor oil, and scrap material and how to use them. Office Services also negotiated with local authorities for advertising and selling surplus or damaged snow fence, posts, and guiderail wire. Transfer procedures were explained and AIMS coordinators were encouraged to advertise surplus items statewide over the department's computer network. A new inquiry through AIMS was developed so that any division could determine for any commodity its quantity and location anywhere in the state. Procedures for transferring surplus to the Surplus Property Division of General Services for public advertising and sale were also explained. Due to the sheer volume of surplus identified at inventory locations throughout the state, the Surplus Property Division did not have sufficient storage facilities or staff to handle it efficiently. The lead time between identification of surplus and approval for transportation to Harrisburg and sale of the surplus quickly became unacceptably long. The alternative of holding regional auctions with General Services was investigated. Two public auctions were held in the central and southwestern parts of the state. More than $1.5 million in surplus (book value on AIMS) was sold or transferred to other state agencies from these auctions. Because proceeds from the public auctions were low, the department developed another alternative by offering surplus to local government at 50 percent of the book value.

Four local sales open only to municipalities have been held thus far; more are being scheduled. As an incentive to dispose of surplus, revenues from the sales are credited back to the organization declaring the surplus.

Other efforts made to help remedy the causes of surplus are better planning for the introduction of new materials so that existing materials are used up before new materials are ordered and the introduction of life-cycle cost analysis to determine the low bidder on equipment purchases.

Procurement Methods

PennDOT has worked closely with the Department of General Services in eliminating material contract lapses. An extension clause has been added to contracts that should eliminate any future problems with lapses. Stockpiling before the end of a contract has been eliminated. Authority to purchase contract items locally when contract minimums exceed immediate needs has been granted. Now that contract problems have been resolved, commodities that have statewide use but have been purchased through the requisition process are being placed on contract. Even though there is a long lead time between submission of requirements and issuance of the contract, the terms of the contract do not require a county to purchase the estimated quantity. Moreover a county can order from the contract as needed rather than receiving a year's supply at one time.

Management Commitment

In addition to the top management commitment given to the development and institution of the inventory reduction program, managers at all levels are held accountable for achieving the reduction goals. The deputy secretary for administration, who has top management responsibility for the program, conducts periodic inventory control visits to determine progress and identify necessary improvements. As an incentive to achieve the inventory reduction goals, inventory management has been added as a new category to the annual Maintenance Awards Program.

INVENTORY REDUCTION PROGRAM RESULTS

By June 1982, 9 months after the program had been launched, statewide inventories had been reduced $11.9 million (25 percent), from a level of $48.1 million in June 1981 to $36.2 million in June 1982 (see Figure 4). The overall reduction goal of $11 million had been exceeded. By September 1982, further reductions of $2.4 million had been achieved, bringing the total reduction to $14.3 million (30 percent). Inventory reduction by engineering district was shown in Figure 1, and the reduction by commodity group is shown in Table 4.

Figure 4. Inventory reduction: June 1981 versus September 1982.

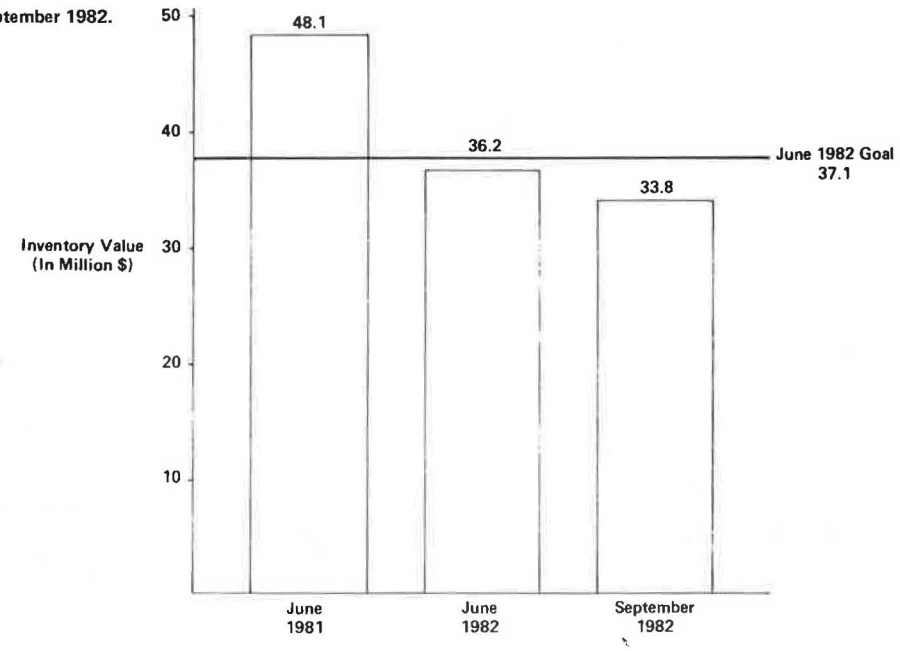
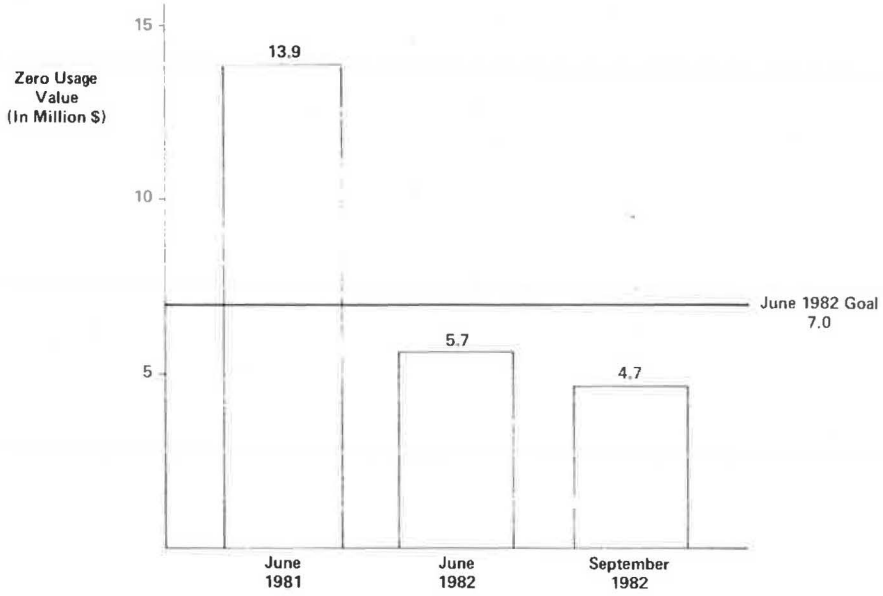


Table 4. Inventory reduction by commodity group: June 1981 versus September 1982.

Group	Inventory Value In Millions			Change	
	June 1981	June 1982	Sept. 1982	$	%
Signs & Accessories	$ 9.3	$ 6.8	$ 6.6	– 2.7	–29
Traffic Paint & Beads	4.2	4.2	3.7	– .5	–12
Pipe	2.4	2.2	1.3	– 1.1	–46
Bituminous Materials	2.0	1.7	1.7	– .3	–15
Aggregates	3.9	3.5	2.5	– 1.4	–36
Winter Materials	5.7	2.5	3.3	– 2.4	–42
Motor Fuels	1.0	1.0	1.0	–	–
Other Fuels, Anti-Freeze, Detergents	.4	.4	.4	–	–
Motor Oils & Lubricants	.5	.4	.4	– .1	–20
Tires, Tubes, Tire Chains	1.9	1.3	1.3	– .6	–32
Batteries	.2	.2	.2	–	–
Engine and Engine Parts	.6	.3	.3	– .3	–50
Automotive & Equipment Parts	.8	.7	.7	– .1	–13
Hand Tools	1.3	.5	.4	– .9	–69
Cutting Edges & Shoes	2.6	1.5	1.4	– 1.2	–46
Lumber	.3	.2	.2	– .1	–33
Guiderail	3.1	2.3	2.2	– .9	–29
Steel & Iron	.9	.4	.4	– .5	–56
Paints & Brushes	.8	.5	.4	– .4	–50
Tarpaulins	.2	.1	.1	– .1	–50
Fasteners	.7	.5	.3	– .4	–57
Bridge Decking & Inlets	.3	.3	.3	–	–
Roadside & Landscaping Materials	.8	.8	.4	– .4	–50
Forms, Pubs, Maps	2.4	2.6	3.1	+ .7	+29
Office, Janitorial, Safety Supplies	1.2	.9	.8	– .4	–33
Other Materials	.6	.4	.4	– .2	–33
	$48.1	$36.2	$33.8	$–14.3	–30%

Figure 5. Reduction of zero-use value: June 1981 versus September 1982.



The value of zero-use items was reduced 59 percent ($8.2 million), from a level of $13.9 million in June 1981 to $5.7 million in June 1982 (see Figure 5). The reduction goal of 50 percent ($7 million) had been exceeded. By September 1982, further reductions had brought the zero-use value down to $4.7 million.

By June 1982, the inventory turnover rate on 17 of 22 commodity groups had improved from the 1981 level. However, only five of the established turnover goals had been met (see Table 3). The turnover rate on several A commodities (e.g., cutting edges, pipe, and guiderail) and B commodities (e.g., steel and iron and tires and tubes) improved dramatically, whereas the turnover rate on several C commodities (e.g., equipment parts and forms, publications, and office supplies) showed less improvement or increased slightly. The turnover calculation reflects only quantities and not value. If the higher relative value of A and B items compared with that of C items (see Figure 3) and the dramatic reduction in several A and B commodities is considered, this may explain why total inventory was reduced by $3.7 million due to turnover rate improvements, an amount that almost met the $4 million goal.

APPLICATION TO OTHER DEPARTMENTS OF TRANSPORTATION

A survey conducted by the Texas State Department of Highways and Public Transportation in fall 1981 revealed that of the 39 state departments of transportation that responded, 22 have state-of-the-art computerized inventory management systems, 3 have old or outdated systems, and 14 have no system at all (unpublished survey). It is suggested that many aspects of Pennsylvania's inventory reduction program can be applied to those states with computerized systems and that those states in the process of designing automated systems can benefit from the quantitative methods and performance indicators adapted by PennDOT.

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