FRA-76-12
REPORT NO. FRA-OPPD-76-6

SYSTEM REQUIREMENTS AND BENEFITS OF A TERMINAL INFORMATION SYSTEM FOR THE KANSAS CITY RAILROADS

Robert D. Reymond
Kenneth F. Troup

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge MA 02142

AUGUST 1976
FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
Policy and Program Development
Washington DC 20590

Technical Report Documentation Page

1. Report No. FRA-OPPD-76-6	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle SYSTEM REQUIREMENTS AND BENEFITS OF A TERMINAL INFORMATION SYSTEM FOR THE KANSAS CITY RAILROADS		5. Report Date August 1976
		6. Performing Organization Code
7. Author(s) Robert D. Reymond and Kenneth F. Troup		8. Performing Organization Report No. DOT-TSC-FRA-76-12
9. Performing Organization Name and Address U.S. Department of Transportation Transportation Systems Center Kendall Square Cambridge MA 02142		10. Work Unit No. (TRAIS) RR627/R6343
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Railroad Administration Policy and Program Development Washington DC 20590		13. Type of Report and Period Covered Final Report December 1975 to March 1976
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The Kansas City Terminal Railway Company proposed that the Federal Railroad Administration assist in funding the implementation of a Terminal Information and Message Exchange system (TIME), designed to enhance the operations of the twelve railroads in Kansas City. The purpose of this system is to automate the flow of information about cars being interchanged among the railroads in Kansas City. A detailed system requirements and cost/benefit analysis of the proposed system has been conducted by the Transportation Systems Center at the request of the Federal Railroad Administration. The study characterizes current railroad operations in Kansas City and the flow of information about the cars moving into and through the terminal. The costs of some of these operations are developed and the potential benefits of the proposed information system are assessed. A specific example of potential benefits is developed based on reasonable improvement assumptions. Operating costs are developed from experience with a similar system in Chicago. A five to one ratio of the net present value of benefits to the development and implementation costs resulted. The terminal information system is an attractive addition to Kansas City railroad activities and holds promise for improved planning and more efficent terminal operations.

17. Key Words Information Systems Railroad Terminals Railroad Operations Automatic Car Identification		18. Distribution Statement DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 144	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

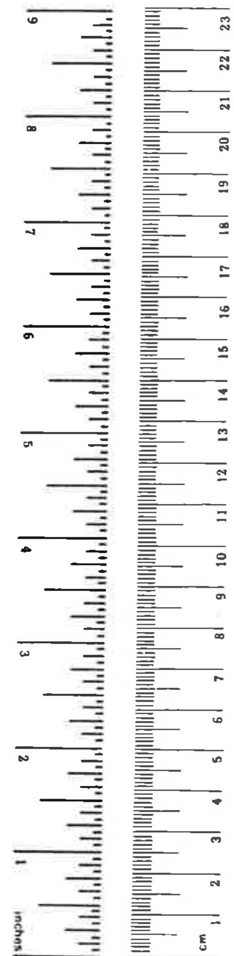
PREFACE

This evaluation of the requirements for a terminal information system in Kansas City was performed by TSC at the request of Mr. Clarence Braddock, Office of Policy and Program Development, Federal Railroad Administration. It was performed as part of TSC's Project Plan Agreement RR-627, Freight Car Management. The authors wish to acknowledge the contributions of the Kansas City Terminal Railway in providing data as required for the study. In particular, Mr. Vernon Coe, Mr. William Apple, and Mr. J. Pat Maher made significant contribution to the study. The following personnel from the railroads in Kansas City also provided valuable information and insight into Kansas City operations: Roy Draper, Sam Livingston, and Mike Collins - Burlington Northern; Otis Burge, John Maple, and Duffy Nunley - KCS/Milwaukee; H. R. Rodgers and Maurice Dunn - Santa Fe; H. J. Lovelady - Frisco; Phil Hare - Union Pacific; H. C. Gruenkemeyer - Missouri Pacific; Tom Mendenhall and Ken Taylor - Katy; Dave Hale and Alan Knox - Rock Island; E. R. Esshom - Chicago and North Western; T. E. Usnick - ICG; and D. E. Harness - N&W. In addition, Larry Brophy of the Chicago Rail Terminal Information System provided valuable operating cost data and whole hearted support to the study. Finally, the authors acknowledge the assistance, contribution, and criticism provided by Dean Smith of ACI Systems Corp.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

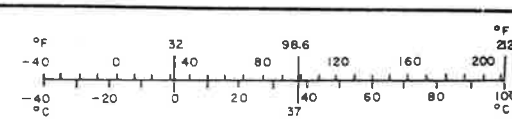


TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF TABLES

1. SUMMARY AND RECOMMENDATIONS

In April 1975, the Kansas City Terminal Railway Company proposed that the Federal Railroad Administration assist in funding development and implementation of a Terminal Information and Message Exchange system (TIME) for the Kansas City gateway. The Transportation Systems Center has evaluated the requirements for such an information system and developed scme of the benefits to the railroads serving the Kansas City gateway. Included in this evaluation is a suggested FRA program approach.

The Kansas City terminal area is the third largest rail center in the United States with twelve railroads operating into or through Kansas City. These railroads jointly own the Kansas City Terminal Railway Company which provides switching and interchange facilities and operates a Central Traffic Control Center for the Kansas City gateway. Four of the railroads operate major hump yards in Kansas City while the other eight have flat yards giving the gateway a yard capacity in excess of 100,000 cars. The railroads interchange some 5000-6000 cars per day and move nearly 10,000 cars from the gateway daily on road trains. Seven of the railroads participate in the operation of twenty-one run through trains which move through Kansas City with only a crew change or mandatory safety inspection.

Train movements in Kansas City are controlled by the Central Traffic Control Center. Train directors communicate directly with trains via on board or wayside radios, set up train routes at the traffic control consoles, and monitor movement of the trains to their exit points from the system. A forty-eight foot control board displays the status of switches and indicates interlocked routes and train locations.

The costs of several aspects of rail operations in Kansas City were determined from operational information obtained from the Kansas City railroads and from rail cost research performed at TSC. Costs of switch engine operations were estimated as a function of switch engine productivity and the number of cars handled. Car detention time was determined for each railroad and terminal detention time was estimated for the various interchange pairs. Costs were expressed as a function of interchange volume. The cost of information errors was computed from data on errors provided by each of the railroads. The cost of clerical labor was determined from information obtained from the railroads on the number of clerical positions. The costs developed in this analysis were then used as the basis for computing potential benefits of the proposed terminal information system.

The flow of waybill information (car identification, origin, destination, routing, contents, etc.) on inbound trains to Kansas City is usually complete, accurate, and automatically received by the respective railroads. On the other hand, the flow of information between railroads on cars in interchange is sporadic and neither timely nor accurate enough to be of any value in yard planning. In general, the railroads must wait for the waybills accompanying the train to be sorted before classification operations can take place. The purpose of the proposed terminal information system is to formalize and automate the exchange of information between railroads on cars involved in interchange. The proposed system would receive advance information (advance consists) on inbound road trains at the same time individual railroads in Kansas City would receive that information. Inbound trains would be scanned by automatic car identification (ACI) scanners prior to the trains' arrival in Kansas City. The information system would then provide a corrected train list to the railroad involved and update the inventory maintained by the system. Railroads would enter train list information on interchange movements into the system at the same time they would normally provide such information to their own central computers. Cars moving in interchange would be scanned by ACI scanners and corrected train lists would automatically be provided to the receiving railroad in advance of the arrival of the interchange train. Outbound road trains would similarly be scanned as they depart Kansas City and the terminal inventory would be adjusted.

Based on discussions with the railroads in Kansas City and on the analysis in this report, TSC identified and developed various quantifiable and non-quantifiable benefits of a terminal information system. These benefits include:

a. An improved management overview of operations in the Kansas City gateway by the Kansas City Terminal Railway.

b. More efficient Traffic Control Center operation with information about the movement of trains currently not controlled by Traffic Control and information on the contents and train length of interchange trains.

c. An inventory of all cars in Kansas City and the ability to access that inventory to provide railroads with information about loaded and empty cars they could expect to receive in interchange.

d. Improved management of the offering and acceptance of cars for interchange. Establishment of a formal procedure for interchange. Verification of the number of cars provided and the actual time of interchange as represented by the latest ACI scan of the train. Automatic receipt of waybill information in advance of the interchange train.

e. Reduction in the number of no bill cars, open records, and cars delivered incorrectly in interchange.

f. Better planning of yard, transfer, and road haul operations. Specifically, the more effective utilization of switch engines used for interchange movements, improved productivity of clerical labor, and a reduction in the average time required to move a car through the Kansas City gateway.

The potential for savings in switch engine expenses, car detention time, clerical labor, and information errors was determined by an analysis of the cost of interchange operations in Kansas City. Relationships of these savings to the volume of traffic were developed. For illustrative purposes, a hypothetical but reasonable example of the savings possible was developed. These annual benefits to the Kansas City terminal were computed for an assumed present volume of 11,000 cars handled in one day.

a.	8% improvement in switch engine productivity (including reduction in overtime by both engine and crew)	$6.5 million
b.	10% reduction in car detention time	$1.5 million
c.	60% reduction in no bills	$ .33 million
d.	60% reduction in open records	$ .04 million
e.	25% reduction in delivery errors	$ .36 million
f.	15% improvement in clerical productivity	$ .41 million
	Total annual benefits	$9.14 million

Operating costs for the proposed terminal information system were estimated from experience with the Chicago Rail Terminal Information System (CRTIS).

a.	Computer operating cost	$ .28 million
b.	ACI operating and maintenance cost	$ .16 million
c.	Communication system lease and operating cost	$ .10 million
	Total annual operating cost	$ .54 million

A present value benefit/cost analysis for a system life of twenty years and the development and implementation cost of $6.35

million as proposed by the Kansas City Terminal Railway was performed.

a.	Net present value of benefits	$34.17 million
b.	Net benefit to development cost ratio	4.99
c.	Net benefit in any given year	$8.60 million

Based on these calculations, the proposed information system appears to be an attractive addition to railroad operations in Kansas City. The calculations above are for the terminal as a whole. Both the benefits and costs are spread non-uniformly among the twelve railroads in Kansas City. Operating cost will be apportioned through an agreement based on traffic volume or some other measure of usage of the system. The actual benefits to any one railroad will depend on its particular Kansas City operations and the extent to which the railroad utilizes the information and system outputs it receives.

2. PRESENT TERMINAL OPERATIONS

2.1 BACKGROUND

The Kansas City Gateway is served by twelve Class I railroads which operate principally in the Western, Southwestern, and Midwestern portions of the United States.

These twelve railroads are:

Union Pacific (UP)
Chicago Rock Island and Pacific (RI)
Atchison, Topeka and Santa Fe (ATSF)
Missouri Pacific (MP)
Chicago and North Western (CNW)
Burlington Northern (BN)
Kansas City Southern (KCS)
Illinois Central Gulf (ICG)
Norfolk and Western (NW)
Chicago Milwaukee St. Paul and Pacific (MILW)
St. Louis - San Francisco (SLSF)
Missouri - Kansas - Texas (MKT)

Together, these roads comprise the proprietorship of the Kansas City Terminal Railway Company (KCT); each road owning 1,833 1/3 shares, $100. par value of the outstanding single class common stock of the KCT. As well as serving as stockholders of the corporation, the proprietors also serve as joint guarantors of first mortgage bonds, promissory notes and other debt instruments of the KCT.

The KCT was incorporated in Missouri in 1906. The original purpose of the KCT under its articles of incorporation was to construct terminals in Kansas City, Kansas and Kansas City, Missouri. In 1910, the KCT expanded its original charter when it absorbed the Kansas City Belt Railway Company and the Union Depot Company. Under this expanded charter, the KCT provides terminal rail facilities, freight switching services to industry and some of the proprietors, and centralized control of train dispatching over its tracks. In addition, it participates in cross town transfers and joint interchange operations. The KCT has historically served as the focus for passenger operations in Kansas City. It operates the Union Station in downtown Kansas City and now provides passenger facilities and services to AMTRAK.

The Kansas City terminal* is the third largest rail center in the United States in terms of cars handled daily. It is a principal center for grain operations both in storage, milling, and processing. As a result, over 40 percent of the annual rail traffic is related to the grain industry. In addition, Kansas City is second only to Detroit in the production of auto parts

*In this report, "terminal area" and "gateway" are used interchangeably to represent the rail facilities of all thirteen railroads in Kansas City as shown in Figure 2-1. The Kansas City Terminal Railway Company is normally referred to as the KCT. The terminals of individual railroads are generally described as "yards." Thus, "The Kansas City Terminal" refers to the gateway.

and finished automobiles. Other major commodities handled are fertilizer, newsprint, steel and limited amounts of coal from the Western coal fields. Kansas City is a major industrial center and the customary raw materials, semifinished and finished products are consigned to or shipped from here. Because of its central location, it is the principal site for single carrier haul to the East, West, and Gulf coasts as well as north to Canada. Kansas City is a termination point on the rail networks of nine of its proprietors and as a result is a major interchange terminal. In addition to local and through train operations conducted by the roads servicing the Kansas City gateway, run through operations are performed between many of the roads. The interchange and train operations will be described in detail in Sections 2.4.1 and 2.4.3.

2.2 KANSAS CITY RAIL TERMINAL SYSTEM

Each railroad outside the context of the gateway exists as a separate transportation network which provides similar services to different regions of the United States. The Kansas City gateway is a node on each one of these networks. The Kansas City Terminal Railway serves to synthesize these nodes into a terminal system by providing the form, continuity and structure between the roads. In this sense, the principal role of the KCT is to serve as a catalyst by integrating the operations of the proprietors in Kansas City into a terminal rail system. By serving as this system catalyst, the KCT has four principal functions:

- to provide up to date facilities and services
- to assist in improving productivity of the proprietors;
- to serve as a focus for common rail activities in the Kansas City Gateway;
- to expedite the movement of trains with minimum delay and congestion through and within the Kansas City terminal;
- to assist in the interchange of cars in an economic, orderly, efficient and systematic manner.

It is within the context of the need and benefits of a terminal information and control system that this study is predicated.

2.3 FACILITIES

Figure 2-1 is a map of the Kansas City terminal area showing the yards, interchange locations, trackage, and other rail facilities owned or operated by 13 roads in the gateway. The trackage facilities of the KCT over which operations are conducted include 153 miles of tracks of which 131 miles are wholly owned. The remaining 22 miles are used through trackage rights or other lease agreements. Included with the trackage facilities is a double decked railroad bridge over the Kansas River at Armourdale. This bridge serves to link the Rock Island and Union Pacific yards with other proprietor yards in Missouri.

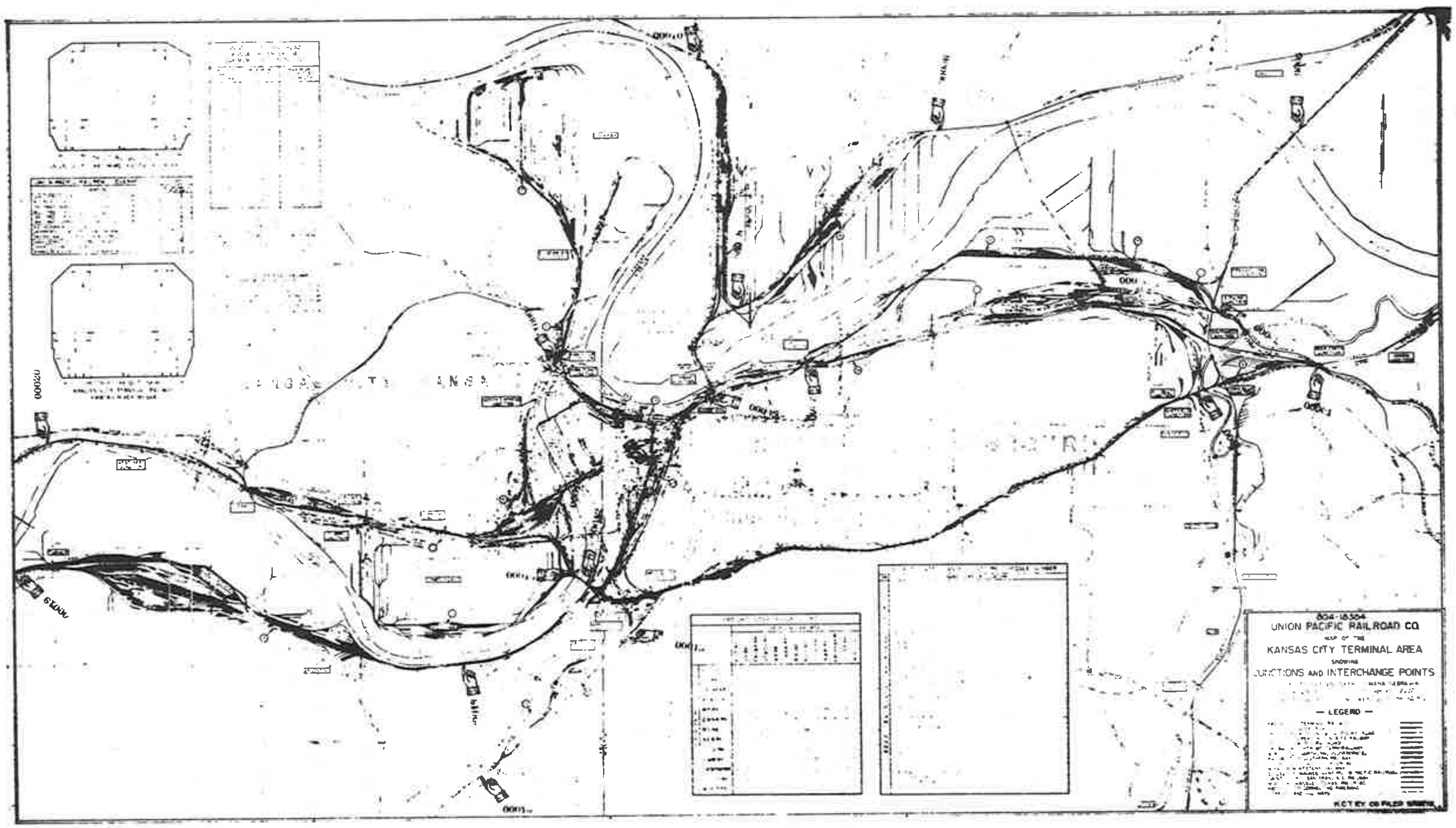


FIGURE 2-1. MAP OF KANSAS CITY TERMINAL AREA

It is also an integral part of the Rock Island's main line freight operations. In addition, main line freight operations are conducted over KCT tracks by the Santa Fe.

There are over fifty classification and support yards shown in Figure 2-1. The major classification and retarder yards are the Santa Fe's Argentine yard, (latest construction was in 1969), the Missouri Pacific's Neff yard (1958-59), the Burlington's North Kansas City Yard (1969) and the Rock Island's Armourdale yard (1949). Smaller principal classification yards at which flat switching operations are performed include the Frisco's Rosedale yard, the MKT's Glen Park Yard and the Knoche yard jointly operated by the KCS and MILW roads. In the aggregate, the theoretical overall yard capacity of the Kansas City gateway is greater than 100,000 cars, including set outs at minor support yards and industry sidings. Capacity in this case is physical space for cars on tracks, based on about 50-100 feet of track per car. However, in actual operations if the total inventory in Kansas City exceeds 50,000 cars at one time, yard movements will become totally congested. The individual yard capacities for each of the roads are shown in Table 2-1.

As can be seen, the ICG and the CNW have extremely small yard capacities which require these roads to move cars with minimal detention time in interchange operations. The CNW yard has an additional constraint inasmuch as access to the yard is

TABLE 2-1. KANSAS CITY TERMINAL YARD CAPACITIES

ROAD	KCT	UP	RI	ATSF	MP	CNW	BN	KCS	ICG	NW	MILW	SLSF	MKT
CAPACITY	1.0	6.0	3.0	10.0	9.0	0.5	4.4	2.8	0.6	2.4	1.0	4.0	1.4

(In thousands of cars)

SOURCE: Kansas City Terminal Railway

via trackage rights over the Missouri Pacific, KCT, and Frisco tracks. In this sense, the CNW yard is an island.

Three of the four hump yards in Kansas City have the capability to control classification operations with computer-based systems, in motion weighing equipment, speed monitoring equipment, and automatic retarders. The Rock Island has manually controlled hump operations. The most sophisticated yard is the Santa Fe's Argentine East which has yard locomotives remotely controlled from the hump tower. The remaining eight major classification yards require flat switching.

The larger yards are generally hump yards while the smaller yards are flat yards. The fact that classification operations in these two types of yards are different however, does not appear to appreciably affect switch engine operations. Figure 2-2 shows that switch engine operations are more closely related to yard size. Data on switch engine usage per trick (terminology for one eight hour shift in railroad yard operations) were obtained from the railroads in Kansas City. These data are displayed in Figure 2-2 as a function of yard capacities obtained from Table 2-1. A least squares fit results in the curve shown. In addition, switching agreements with the KCT are used to assist power-short yards with interchange deliveries. The smaller yards, with limited switch engine power must expedite transfers to avoid excessive yard congestion and excessive switch engine overtime.

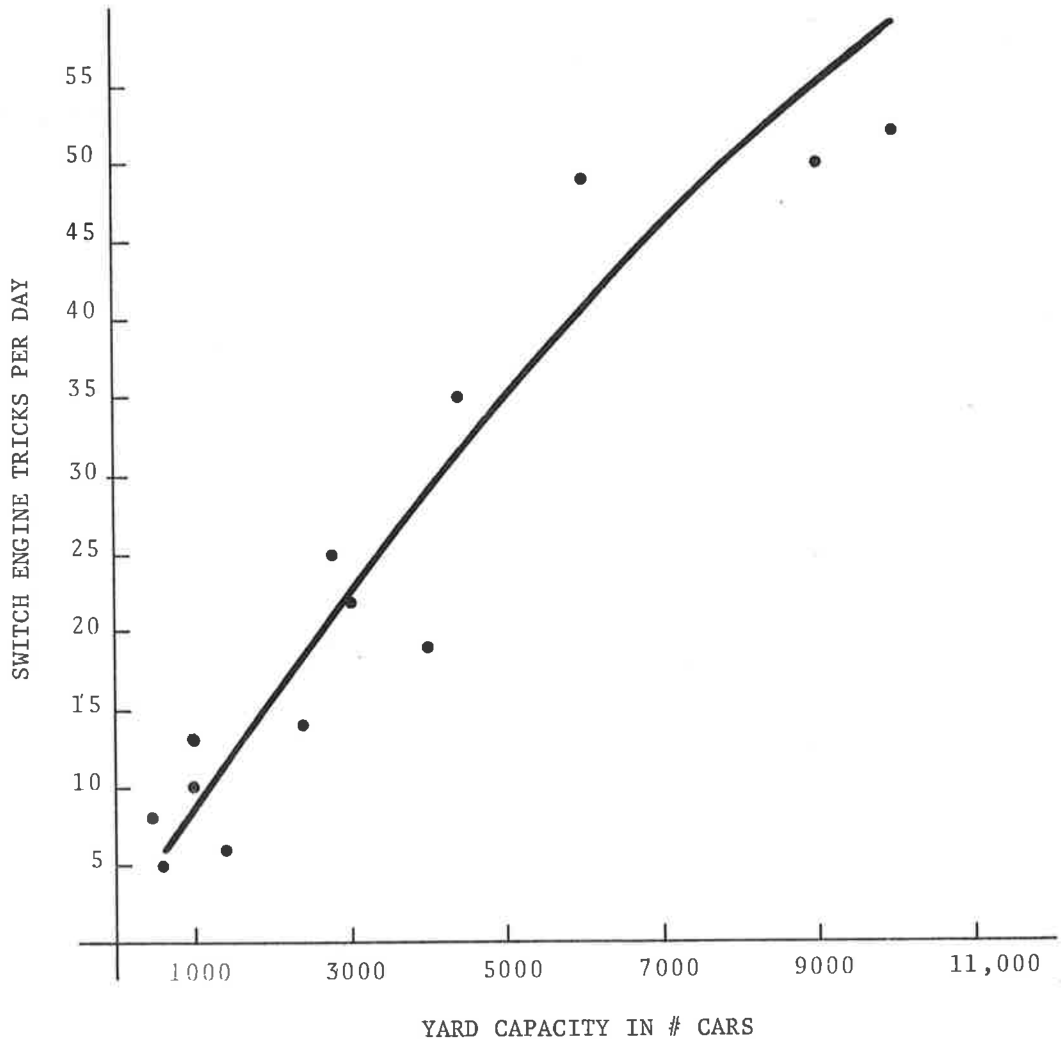


FIGURE 2-2. SWITCH ENGINE USAGE VS YARD SIZE

Hence, limited yard capacity places a premium on advance notification of impending deliveries.

2.4 SYSTEM OPERATIONS

2.4.1 Interchange Operations

Interchange operations are conducted among the thirteen roads which operate in the Kansas City gateway. These operations include regular interchanges, joint interchanges, set outs, cross town transfers, and industry pulls. The average daily interchange traffic for the summer of 1975 was 5853 cars received and 5619 cars delivered. This interchange traffic is shown in detail in Table 2-2 categorized by delivering and receiving road. Principal interchange traffic is generated by the following roads:

- Santa Fe
- Union Pacific
- Missouri Pacific
- Burlington Northern
- Frisco
- Norfolk and Western

TABLE 2-2. INTERCHANGE OF RAIL CARS BETWEEN RAILROADS IN KANSAS CITY TERMINAL ON JULY 23, 1975

Delivering Road	Receiving Road													
	TOTAL	A.T.S.F.	B.N.	U.P.	MOP.	SLSF	CRIP	N.W.	I.C.G.	K.C.S.	MKT	KCT	MILW	CNW
A.T.S.F.	961		195	168	65	79	29	123	32	67	22	9	55	117
B.N.	626	85		97	136	84	42	37	16	50	60	3	9	7
U.P.	901	86	70		154	199	32	192	65	31	66	0	6	0
MOP.	739	77	150	203		54	32	25	11	48	29	10	52	48
SLSF	460	59	62	156	41		27	25	12	11	0	3	35	29
CRIP	281	40	45	20	43	24		13	2	12	16	2	10	54
N.W.	380	75	22	141	35	0	44		7	26	19	0	11	0
C.N.W.*	351	21	15	15	117	47	49	*0	*0	16	30	40	1	
I.C.G.	198	44	5	67	10	6	16	5		13	9	4	12	7
K.C.S.	272	19	15	38	20	13	48	34	12		3	4	40	26
M.K.T.	331	11	23	233	5	3	9	0	5	5		0	5	32
K.C.T.	116	8	9	7	22	3	5	19	3	5	4		3	28
MILW	173	27	0	5	28	19	16	3	0	33	41	1		0
TOTAL	5789	552	611	1150	676	531	349	476	165	317	299	76	239	348

* - Cars from C.N.W. for N&W & I.C.G. are delivered by K.C.T.

These roads account for nearly 70 percent of all car interchanges. Additionally, the major interchange patterns are between the following roads:

Santa Fe { Burlington Northern, Union Pacific, Norfolk and Western }

Burlington Northern and Missouri Pacific

Union Pacific { Missouri Pacific, Frisco, Norfolk and Western }

These interchanges constitute approximately 20 percent of the total terminal interchange traffic while representing only 14 out of the possible 156 interchange combinations.

Current terminal interchange operations are unstructured, often informal, and a function of operating procedures developed between the delivering and receiving roads. An interchange schedule has been established as shown in Table 2-3. However, this schedule is not rigidly adhered to, and is more honored in its breach than its observance. Large cuts of cars are often delivered without regard to the schedule and delivery is a function of per diem considerations rather than orderly traffic flows and yard congestion.

TABLE 2-3. INTERCHANGE SCHEDULE AND RECIPROCAL AGREEMENTS

RECEIVING ROAD

DELIVERING ROAD

	UP	ATSF	MP	BN	KCT	RI	MILW	KCS	MKT	ICG	CNW	NW	SLSF
UP		1,2	1	1	1	2	1	1	1	1/2	2	2	1,2
ATSF	1,2		1	1,2	2	1	3	3	1	1	3	3	1,2
MP	2	1		1,3		2	1,2,3	1,2,3	2	2	1	2	2
BN	1	1,3	1,2		1	1,3	1,2	1,2	1,3	1	1	2	1,2
KCT	1	1	1	1		1	1	1	2	1	1	1	2
RI	1	1	1	2	3		1	1	1	3	3	2	2
MILW	1,3	1,3	1,2,3	1,2	1	1,2		J	1	1	1,2,3	1,2	1,2
KCS	1,3	2	1,2,3	1,2	1	1,2	J		1	1	1,2,3	1,2	1,2
MKT	3		2	1,2	3	3	2	2		3	3	1	2
ICG	3	1	1	1	1,2,3	1	1	1	1		1,2,3	1,2,3	1,2,3
CNW	-		-	-	-				-	-	-	-	-
NW	2,3	2,3	1,2	2	2	1	2	2	2	2			2
SLSF													

1, 2, 3 — SHIFTS

(shaded) — RECIPROCAL AGREEMENT

Offering and acceptance management for interchanges of cars ranges from little or none to reasonably formal procedures between roads. Notification of an impending delivery may be accomplished by a telephone call between yards, the transmission of waybills or switch lists by facsimile machine or through the use of messengers to pick up the waybills from the delivering yard. Often, however, the only advance notification is the appearance at the throat of the yard of the delivering switch engine with its cut of cars.

Reciprocal interchange agreements exist between 37 percent of the roads. The extent of these agreements is shown in Table 2-3. Reciprocal agreements are interchange agreements between two roads whereby one road provides locomotive power for both pick up and delivery. These agreements are generally for ninety days, the end of which time the other road provides transfer service. In addition to conserving power by eliminating "light moves"* and reducing the number of interchange moves, reciprocal agreements provide a semi-structured basis for offering and acceptance management. Within the structure of a reciprocal agreement, the delivering and receiving roads are aware of an impending interchange and are prepared to expedite the movement.

In the Kansas City Terminal, yard configurations mitigate against many reciprocal agreements. Access to the interchange tracks in the Rock Island's Armourdale yard requires excessive

*A light move is an engine moving without cars.

switching moves to accommodate the yard's physical layout. Few roads, therefore, have agreements with the Rock Island. The ICG and the Frisco have similar configuration problems which require this type of "switchback move."

Another interchange situation in Kansas City which impedes the orderly movement and scheduling of cars is a transfer move involving a switching road pulling a car from industry to the billing road. The switching road receives a charge of about $60. per car but does not participate in the division of revenues for the shipment. The billing road is the origination road even though the shipper's siding is serviced by the switching road. The car is frequently pulled without the benefit of waybill or similar documentation. The only information that exists on the car is the shipper's name and the interchange yard to which it is to be delivered. After arrival at the yard, the car is in a "no bill" situation and is assigned to the hold track until waybill information becomes available. This type of situation frequently occurs at night and on weekends when the shipper's traffic office has closed and no personnel are available to prepare the bills. By ordering the car moved in this manner, the shipper avoids demurrage charges or the expense of a delayed shipment while the road is forced to hold the car for the start of the week while awaiting the bill. Although this type of transfer move is fairly common, it is repetitive and certain patterns become established. This repetitive nature permits the roads to anticipate most of these transfers, plan for them, and even send some of them on outbound trains without waybills ("slip billing").

Other movement situations which impact interchange operations are dual deliveries. This type of transfer occurs most frequently among the smaller roads in the Kansas City gateway. It involves multiple interchanges within one delivery move and includes one cut of cars comprising two offerings from the delivering road. Some of the cars are delivered to one receiving road and the balance then delivered to a second yard. Dual deliveries can create congestion and confusion, particularly at a small crowded yard because of additional handling and possible track blockage.

Additional types of transfer moves in the Kansas City terminal include joint interchanges, set outs and interchanges which occur at locations other than the receiving yard's track. A joint interchange move involves a pull of an empty car to industry by one road and the pull from industry of the loaded car by a second road, the latter road usually being the outbound carrier. The interchange occurs at the industry location. This type of transfer move has little effect on yard operations but can cause open records. These types of moves occur most frequently between Armco Steel, the KCT and the KCS or MP; Proctor and Gamble, the KCT and the RI.; and, industries in the North Town Mill area, the BN and the NW.

Interchanges can occur at a location other than the receiving yards track such as a set out on a siding. This is not unlike a joint interchange. Finally, there are interchanges which occur between two roads when the receiving road has leased track inside the delivering road's yard. In this type of situation, these leased tracks serve as storage tracks and the cars remain there for long periods of time. This last type of movement does not impact on terminal operations save for the requirement of maintaining an accurate inventory of car location.

2.4.2 Traffic Control Operations

All movements over the KCT trackage are controlled including through train operations, locals and interchange movements. Current interchange operations are conducted on a semiautomated basis. It is considered semiautomated in the sense that while there is no structured offering and acceptance management for interchanges, there is control over many train movements. The Kansas City Terminal Railway provides the facility for this control by monitoring and directing most interchange and major train movements among the thirteen railroads operating in the terminal area. Control is exercised through a centralized traffic control facility located west of Union Station. The extent of the control exercised over interchange movements is shown in Table 2-4. This table is a matrix of interchange movements conducted wholly or in part over KCT tracks. As can be seen, all but twenty-four moves are monitored and controlled

TABLE 2-4. INTERCHANGE MOVES CONTROLLED BY KCT

RECEIVING ROAD (columns) / DELIVERING ROAD (rows)

DELIVERING ROAD	UP	ATSF	MP	BN	KCT	RI	MILW	KCS	MKT	ICG	CNW	NW	SLSF
UP			▒			▒	▒	▒					
ATSF													
MP	▒			▒			▒	▒				▒	
BN			▒				▒	▒				▒	
KCT													
RI	▒												
MILW			▒										
KCS			▒										
MKT													▒
ICG													
CNW								▒					
NW			▒	▒			▒	▒					
SLSF									▒	▒			

▒ MOVES NOT CONTROLLED BY KCT

81 PERCENT OF INTERCHANGE E TRAFFIC CONTROLLED BY KCT

through the centralized traffic control center. This represents approximately 85 percent of the movement patterns within the terminal. In terms of interchange traffic, 81 percent of the transfers are over KCT tracks or under KCT control.

The traffic control center is designed around two WABCO train control machines, Figure 2-3. A 48 ft. control board displays the status of all switches and signals on the KCT trackage. The traffic control operations are divided into two sectors: east of Union Station and west of Union Station. Two operating consoles provide the means of control over the two sectors.

Each control console is manned by a train director and his assistant. In overall charge is a chief train director or an assistant. The center is manned on a twenty-four hour basis throughout the year. Train routes are set up automatically for each move by pressing control buttons at the points representing positions where the train enters or leaves the KCT tracks. As a train is cleared to enter the system, its route is completely lighted on the board, thus highlighting its moves through the terminal. As a train passes a switch or signal point, the indicator lights turn from white to red thus indicating its progress and locations.

Communications are maintained directly with the trains via on-board two-way radios or through remote wayside terminals located at strategic points on the KCT trackage. In either case,

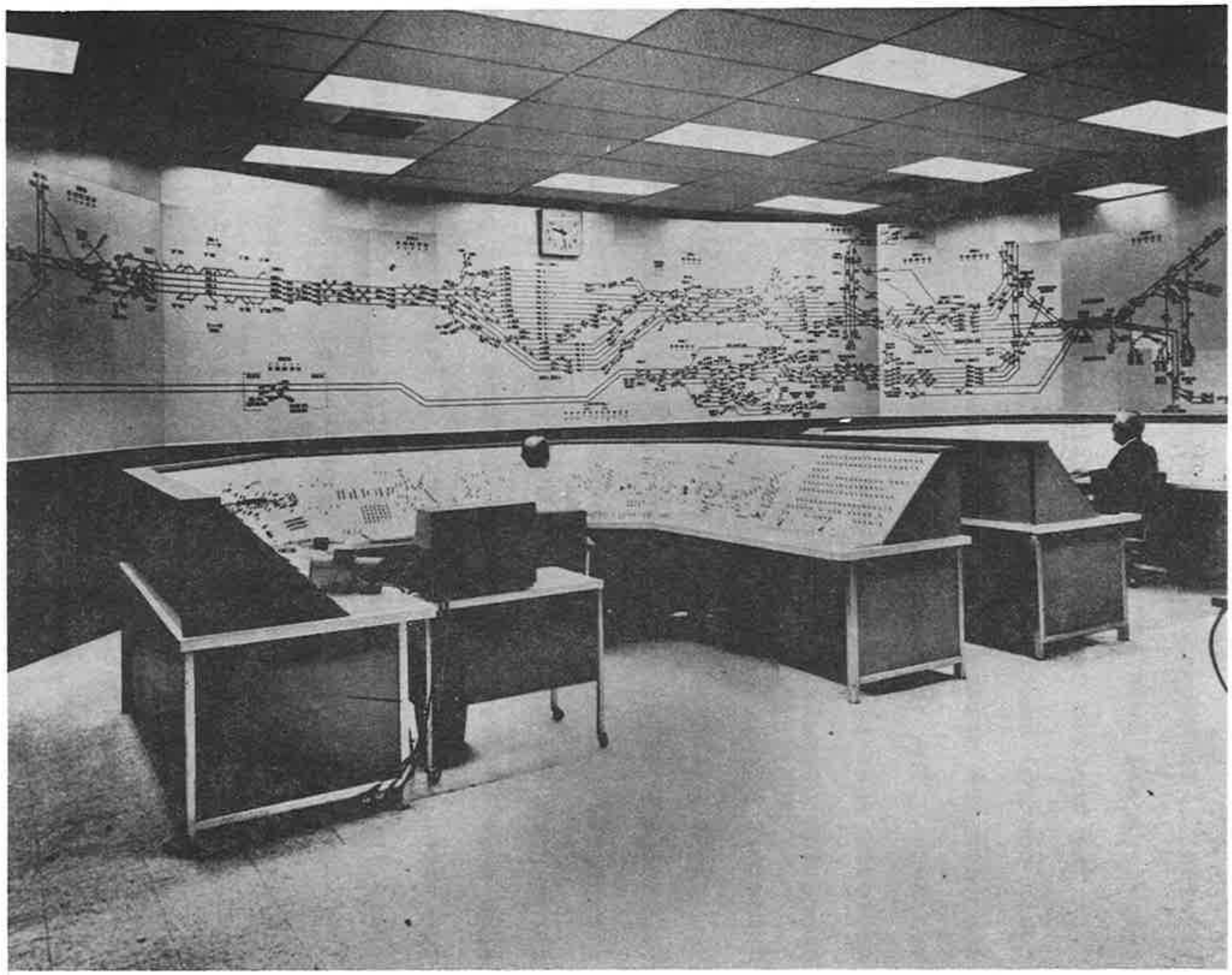


FIGURE 2-3. TRAFFIC CONTROL CENTER

calls come in on talk-back speakers which automatically signify their location by a light at the control desk. Each road has its own type of radio equipment and the Traffic Control Center's equipment is compatible with all. In addition, all of the frequencies used by the roads in the Kansas City terminal area are monitored in the center.

Interchange movements are controlled through the Kansas City Terminal System using the following procedure:

> The delivering road calls the Traffic Control Center and requests permission to enter the system.
>
> The train director acknowledges the call, logs the request and calls the receiving road.
>
> If the receiving road accepts the offering, the train director gives permission to the delivering road to enter the system. The train director also informs the delivering road of the route and destination track in the receiving road's yard. If there is congestion or the route is in use, the delivering road is so informed and permission to enter the system is denied. The road is informed of the expected time of availability.
>
> When the train enters the system, the train director monitors its progress through the interlock on the Traffic Control Center display.

The above sequence is repeated.

A log is maintained of the communications and train moves. Generally, once a train has been cleared through the interlock, it is able to complete its route without stopping or delay.

From the above operating procedures, it can be seen that the Centralized Traffic Control system provides the rudimentary basis for interchange monitoring, message switching, and data base development.

2.4.3 Run Through Trains

Run through agreements between two or more railroads permit the run of a single, jointly operated train between major rail terminals without the necessity of intermediate car interchanges. This type of operation is becoming more and more frequent among major rail carriers and is setting the pattern for future through train operations. Run through operations permit the participating roads to extend rail service beyond their normal operating networks and offer fast freight service between distant points. By definition, run through trains seldom stop except for inspection and refueling. Crew changes are often conducted on the fly while the train is slowly moving through the terminal or yard. Power is supplied by one or both parties to the agreement and trains are often made up with locomotives from two or more roads. Power is not changed during the run of the train, but crews are changed after their normal tour of duty. As a result, crews frequently operate other railroad's locomotives in run through trains.

Run through operations in Kansas City are principally complementary operations between roads whose normal networks terminate in Kansas City. In this manner, rail networks are extended permitting all parties to the run through agreement to offer both extended service and a higher level of service. Kansas City, by virtue of its location in the mid-United States is in a unique position to provide the basis for run through service to the East, West, and Gulf Coast. Of the twelve Class I roads which serve the Kansas City Gateway, nine have operations which terminate in Kansas City. Of the nine roads, seven have run through operations with other Kansas City roads. In addition, two of the roads whose operations continue through Kansas City have run through agreements with terminating roads. Table 2-5 shows the nature of the run through agreements and the extent to which service is extended from the Kansas City gateway.

From Table 2-5 it can be seen that the Union Pacific is the principal participant in run through operations in Kansas City. Its agreements with the MP, NW, ICG and Frisco permit it to extend its operations east to St. Louis, Buffalo, and Roanoke and south to Little Rock, Montgomery, and Birmingham. Conversely, run through westbound service is available to Los Angeles and San

TABLE 2-5. PRINCIPAL RUN THROUGH OPERATIONS IN KANSAS CITY

SOUTHBOUND & EASTBOUND ROADS \ WESTBOUND ROADS	UP	ATSF	BN	MP
NW	LOS ANGELES / BUFFALO	SAN FRANCISCO / BUFFALO		
SLSF	SEATTLE / BIRMINGHAM		SEATTLE / BIRMINGHAM	
ICG	NORTH PLATTE / MONTGOMERY			
MP	LOS ANGELES / LITTLE ROCK ST. LOUIS			
MKT	NORTH PLATTE / DALLAS HOUSTON			

Francisco from the East and South. The Santa Fe and NW agreements provide similar east-west service from San Francisco/Los Angeles to Detroit/Buffalo.

Not shown in this table are run through agreements between Kansas City roads and roads operating outside the Kansas City gateway. For example, the Rock Island is able to offer fast run through service to Los Angeles via a run through agreement with the Southern Pacific. In this agreement, control passes at Tucumcari. Other Kansas City roads have similar agreements extending services east and west.

Although run through agreements provide a faster, more direct and higher level of service, they impose constraints upon the operations of the railroads. These impacts are centered principally on the difficulties in transferring waybill and consist information in a timely manner between the parties to the agreement. These difficulties are particularly pronounced when control of the train passes between the participating roads such as it does in the Kansas City Terminal. Information transfer is usually manual by the conductor of the run through train. In addition, information is also transferred by teletype, facsimile copier, or by messenger between yards. There does not appear to be in most cases an automated information transfer system for accommodating run through train data. Clearly, a timely, formal interface is necessary to link the roads' information systems for data exchange on these operations. Within the context of a

Information on train moves can be categorized into two areas: information about inbound trains - both through trains and locals; and information about trains and cars being delivered and received in interchange. For nearly every through train arriving in Kansas City, the destination yard in Kansas City receives information on the contents, origin, destination, consignor, consignee, and status of each car in the train. Other information can include commodity codes, and subsequent railroads to which the car will be interchanged. These data are contained on a report called an advance consist which provides some or all of the above information listed by car initial and number in approximate train order. The advance consist is usually received in advance of the arrival of the train so that the yard can plan for the receipt, breakup, classification, delivery, and subsequent interchanges of the cars in the train. In the absence of an advance consist, yard operations cannot be planned until all waybills accompanying the train have been sorted and switch lists have been prepared. The advance consist information is the key to any terminal information system which improves planning and operations.

Advance consists on inbound local trains are often non-existent principally because the local station does not have the means of transmitting this information to the receiving yard. The local train may provide pick-up and delivery service to a number of shippers in addition to pulling cars from small unmechanized yards of the railroad along the local route. These stations do not generally have the facilities to provide input to the railroad's information system. The receiving yard in Kansas City, therefore, generally has no prior knowledge of the contents of a local train when it arrives. The waybills carried on the train are the only source of information for subsequent operations planning.

Information on inbound trains in Kansas City is a function of the sophistication of the information systems of the individual railroads. Information can range from current, timely advance consists delivered routinely and consistently to instances of advance consists not having been received for over a week, in the case of one railroad interviewed. The flow of information at the present time in Kansas City is shown in Table 2-6. Advance consists are usually prepared at the central computer of the railroads headquarters from information provided by the originating yard. The information is transmitted over the communications systems of the road which range from teletype to sophisticated microwave data links. Outbound trains from Kansas City are treated in a similar fashion by the individual roads.

While the transmission of advance information on inbound trains to Kansas City is the norm, there is rarely advance

TABLE 2-6. INBOUND DATA FLOW - KANSAS CITY RAILROADS

TYPE OF OPERATION	ORGIN	DESTINATION	TYPE OF MESSAGE	MODE OF TRANSMISSION	DATA QUALITY *
ROAD HAUL	ORIGINATING YARD	RECEIVING YARD	ADVANCE CONSIST	DATA LINK	97%
LOCAL TRAIN	INDUSTRY STATION MINOR YARD	RECEIVING YARD	ADVANCE CONSIST TRAINLIST	DATA LINK NOTHING	25%
INTERCHANGE	DELIVERING YARD	RECEIVING YARD	ADVANCE CONSIST TRAIN LIST	DEX FACSIMILE TELEPHONE MESSENGER NOTHING	25%

*AS REPORTED BY THE RAILROADS

information provided to other roads for interchange moves. The receipt of advance consists by receiving yards in Kansas City does not assure that the same information will be passed on to the next railroad. Information flows on interchange moves are highly informal, and vary not only from road to road, but also from trick to trick within the roads themselves. Often, no advance information at all is given to the interchange road. The information flow for interchange moves is also shown in Table 2-6.

While the railroads provide information on outbound interchange moves on their own central computers, there is no established procedure for providing interchange information to other railroads. Most frequently, information is transmitted via low speed facsimile equipment but even this use is sporadic and varies greatly among the roads. Each railroad in Kansas City was asked about its use of the datafax equipment and the responses were varied and contradictory. One railroad indicated that it neither received nor sent advanced train list information by the system. Yet several railroads indicated that they religiously transmitted advanced lists to all other railroads. Others noted that they occasionally sent lists over the system on the specific request of another road. One railroad even indicated that it drove a truck to the yard of the delivering road in order to acquire information about the contents of the interchange move.

Clearly, in Kansas City as well as in other major gateways, a void exists between the advance consists which are received on inbound trains and the transmission of information about cars being delivered in interchange. This void is a function of the lack of both a formal information exchange structure and a system to assure that such information is developed and exchanged. The basis for such information transfer exists. Each railroad receives information about its own inbound trains. Each railroad prepares switch lists from waybill information, and provides outbound interchange information to its own system. However, none of the information is transmitted to others who need it.

3. CURRENT TERMINAL COSTS

3.1 BACKGROUND

A measure of the efficiency of terminal operations is the cost associated with car handling including interchange and through train operations. In this analysis, cost is used as a principal determinant of elements of terminal system effectiveness and as an index of areas where substantial improvement can be made. Although there are numerous segments of terminal operations which contribute to overall system effectiveness, four activities are identified here as critical and impacting substantially upon total terminal costs. These activities have the additional attribute of being readily quantifiable and having available a reasonably accurate data base. These activities are:

- car detention time
- switch engine use and productivity
- clerical productivity
- information errors

As well as being quantifiable, these activities are identified both for their significance to total railroad operations and as being elements of the terminal operations which could be improved through the use of an information exchange and management system.

While these cost elements are significant, they are not total terminal costs. Interested readers are referenced to TSC's cost research "Description of an Engineered Economic Cost Method for Rail Freight Operations", J. F. Murphy, Sept. 25, 1975, for more complete development of costs. (Reference 1). There may also be some overlap among these four elements in that, for example, car detention time may be increased as a result of clerical labor or information errors. In addition, because of the nature of the calculations, the results are not necessarily comparable, e.g., costs per car, unit costs, total costs. Thus, the costs associated with each activity are discrete and should be considered independent. They are developed primarily for indicating the impact of the present activity and the amount of improvement possible.

In the analysis, the entire terminal was considered as a system and the experience of each particular road and yard was aggregated. In the presentation of the results, no attempt was made to identify particular railroads or yards. However, the data are considered valid and are applicable throughout the terminal. Knowing the operating characteristics of a yard or the performance parameters of a particular railroad, a reasonably accurate picture of that road's performance in terms of costs may be determined from this analysis.

This section does not appraise the efficiency of the Kansas City Terminal. It does analyze the cost of certain elements of terminal operations and presents these costs as areas for potential improvement. Subsequent sections address these elements in terms of the possible benefits and system savings which might accrue.

The costs described in this section are some of the "costs of doing business." How these costs may be reduced is within the purview of the individual railroads; that they may be reduced is the subject of this analysis.

3.2 CAR DETENTION TIME

Car detention time is defined as the length of time a car is held in the yard. In this analysis, car detention time for interchange operations was considered to consist of two phases: The inbound to interchange phase and the interchange to outbound phase. During the inbound-interchange phase the car was switched from an inbound cut, classified, made up with a cut going to a receiving yard or industry and delivered. In the interchange-outbound phase, the car was received from the delivering yard or industry, classified, made up into an outbound train and departed the yard. Thus, while the car was in the Kansas City Gateway, it was handled by two or more roads and its total detention time was a function of the operations of two or more yards. In this analysis, the detention time used was the sum of the experience of two yards.

Table 3-1 is a matrix of car detention times for delivering and receiving road pairs for the Kansas City Terminal. The times

TABLE 3-1. TOTAL CAR DETENTION TIME - HOURS

RECEIVING ROAD

DELIVERING ROAD	KCT	UP	RI	ATSF	MP	CNW	BN	KCS	ICG	NW	MILW	SLSF	MKT
KCT		21	29	45	32	17	21	18	15	20	18	19	28
UP	21		32	48	35	20	24	21	18	23	21	22	31
RI	29	32		56	43	28	32	29	26	31	29	30	39
ATSF	45	48	56		59	44	48	45	42	47	45	46	55
MP	32	35	43	59		31	35	32	29	34	32	33	42
CNW	17	20	28	44	31		20	17	14	19	17	18	27
BN	21	24	32	48	35	20		21	18	23	21	22	31
KCS	18	21	29	45	32	17	21		15	20	J	19	28
ICG	15	18	26	42	29	14	18	15		17	15	16	25
NW	20	23	31	47	34	19	23	20	17		20	21	30
MILW	18	21	29	45	32	17	21	J	15	20		19	28
SLSF	19	22	30	46	33	18	22	19	16	21	19		29
MKT	28	31	39	55	42	27	31	28	25	30	28	29	

J- JOINT AGENCY

were provided by each railroad as its estimate of detention time in its yard both for inbound and outbound traffic. TSC added these individual yard times to create the matrix. These times represent the total time spent in the yard by a car in Kansas City. The policies are a function of both the efficiency of the yard and the operating times for the road. For example, some roads which initiate high speed, through train operations from Kansas City have found it desirable to detain a car for 24 hours or more while making up the train. Experience has shown that the speed and direct routing of the train can greatly compensate for above average detention times. This operating practice is particularly prevalent with Santa Fe scheduled trains.

The annual cost of car detention time for all the yards in Kansas City was determined. In this analysis, a cost of $0.33 per car hour was used. This figure was derived from the annual cost of ownership of a car considering a 10% capital recovery factor and is described in Reference 1, p.37. The annualized cost of car detention is shown in Figure 3-1. In this figure, a series of indifference curves is drawn for car detention time as a function of the number of cars handled per day for various annual costs. For example, if a yard had an average detention time of 4 hours 9 minutes and handled 1000 cars per day, its annual detention time cost would be:

4.15 hours x $.33/hour x 1000 cars x 365 days = $.50 million.

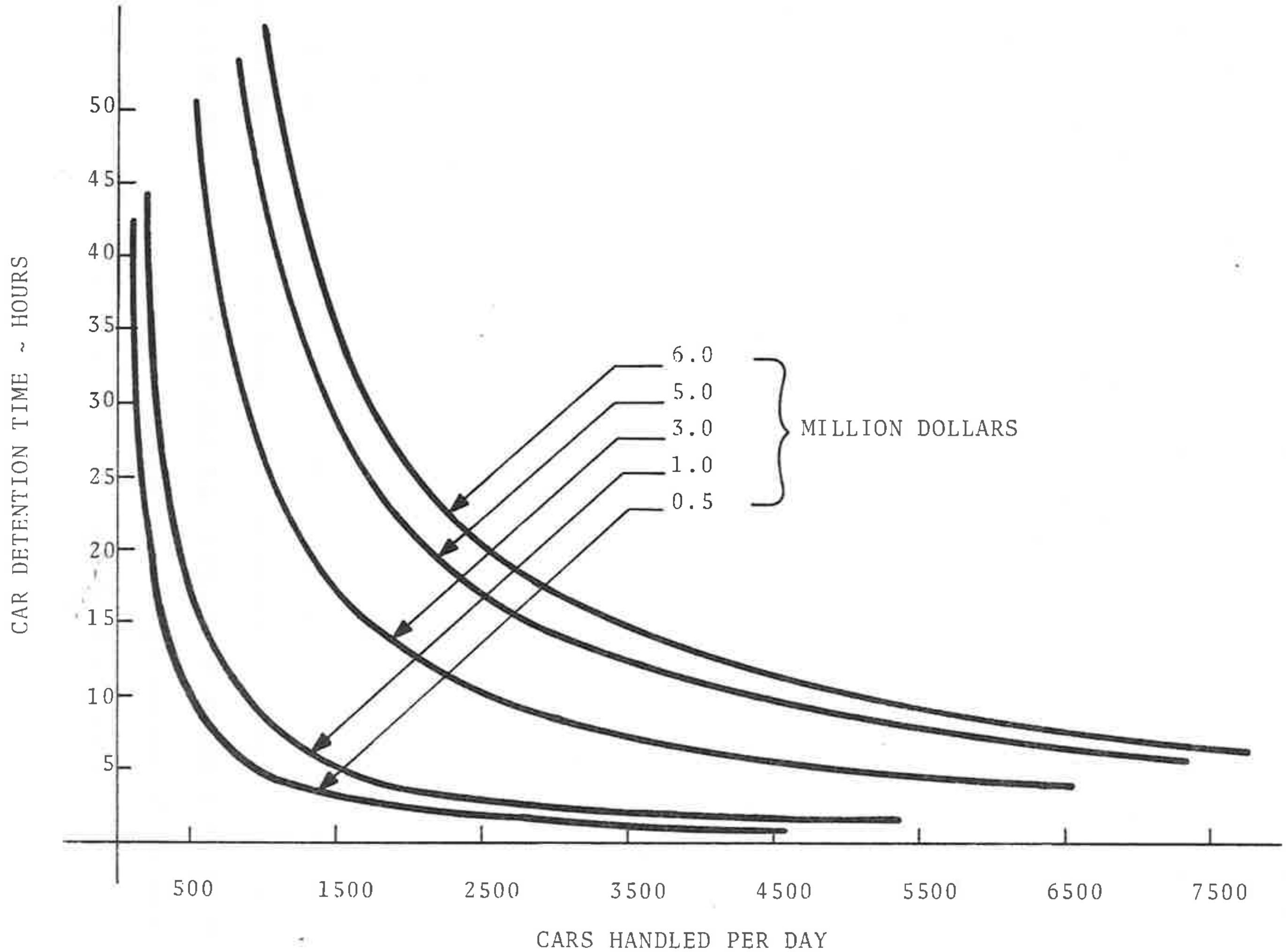


FIGURE 3-1. ANNUAL COST OF CAR DETENTION - KANSAS CITY TERMINAL YARDS

A volume of 500 cars and a detention time of 8 1/2 hours is also on the $.50 million curve. The indifference curves are a convenient way to examine cost as a function of both detention time and the number of cars handled. These curves represent the annual cost of car detention time for the individual yards in Kansas City. Current experience indicates that the average car detention time for an individual yard in Kansas City is 14-15 hours. The detention time ranges from 5 hours for one of the smaller roads to more than 24 hours for a larger road. The cars handled per day is the sum of the deliveries and receipts in interchange.

Figure 3-2 is based on the same detention time calculations for aggregated traffic volumes, average detention times, and annual costs for the entire terminal. Here the range of volume and the cost curves have larger values than in Figure 3-1. The derivation of the two figures is the same. The total interchange volume, counting both cars delivered and received, for Kansas City is about 11,000 cars daily. From Figure 3-2, it can be seen that this results in a detention time cost slightly larger than $18 million. Another way of expressing detention time is that an individual car requires about 29 hours to move through Kansas City in interchange. There are 5000-6000 cars which are delivered in interchange each day.

These curves are shown as representative of the range of the cost of current operations and as indicative of an area wherein

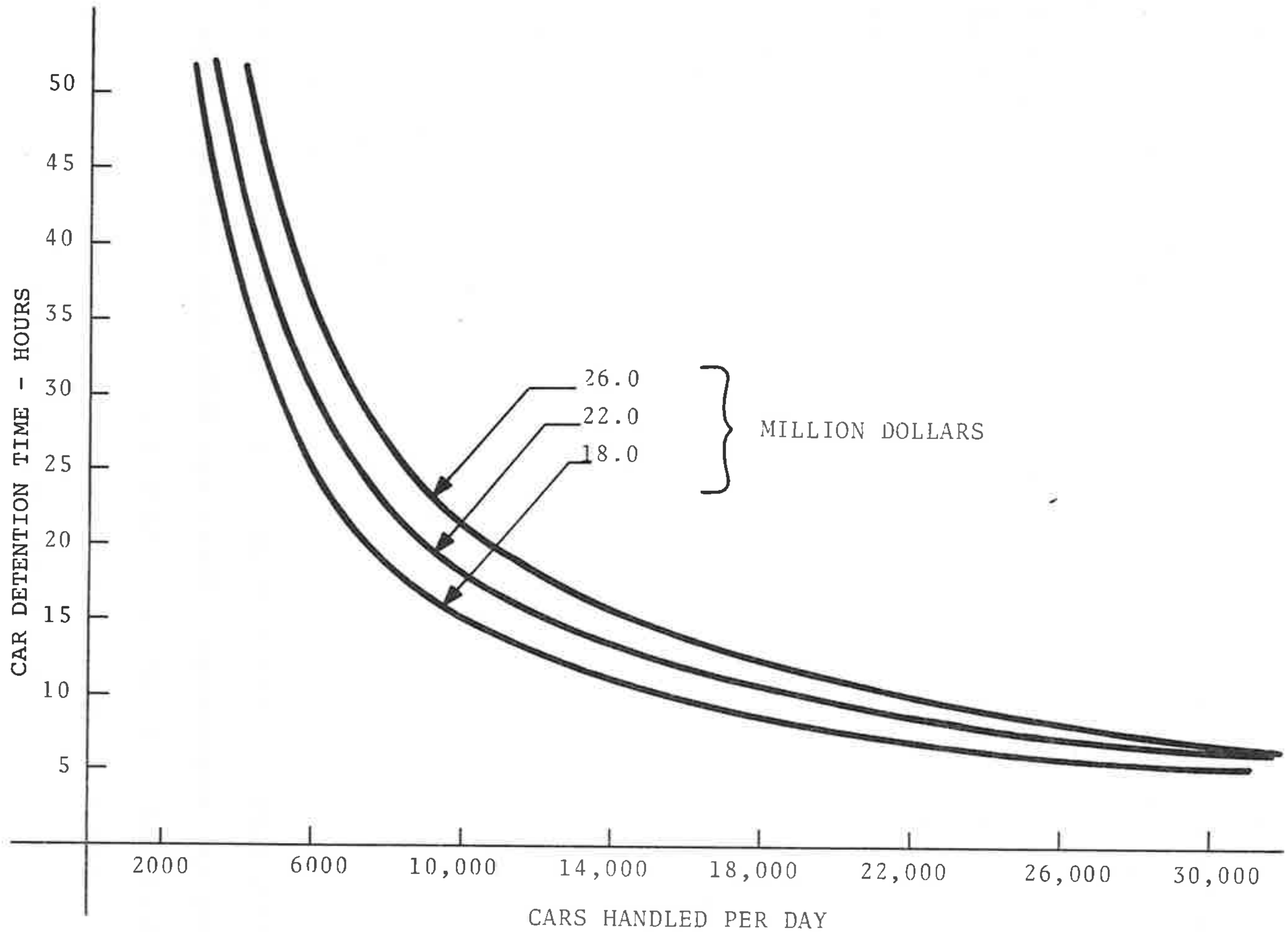


FIGURE 3-2. ANNUAL COST OF CAR DETENTION - AGGREGATED YARDS - KANSAS CITY TERMINAL

savings might be made. The amount of savings and benefits possible were determined from this base and are discussed in Section 5.3.2.

3.3 SWITCH ENGINE USE AND PRODUCTIVITY

A second element of terminal operations analyzed for its cost impact was switch engine use and productivity. Switch engine use was defined as the number of hours per day of straight time and overtime that the switch engines were used. The Kansas City railroads provided information about switch engine tricks worked and overtime applicable to interchange operations. In Figure 3-3, the daily switch engine use in hours (eight times the number of tricks) is expressed as a function of the number of cars handled per day in an individual yard. The curve shown is a least square fit derived from actual utilization data for the thirteen roads as provided to the KCT. As can be seen, there is considerable variation among the roads; however, a distinct trend is apparent. This trend shows that there is an approximate 4.5 to 1 ratio between the number of cars handled per day and hourly switch engine utilization. This translates into a measure of productivity of between 4.4 and 4.7 cars per hour per engine.

From this base, the annualized cost of switch engine utilization was determined for all yards in Kansas City. Current industry experience indicates that switch engine time costs $60 per hour (Reference 1,p.88). The annual costs in millions of dollars are shown in Figures 3-4A and 3-4B as a function of

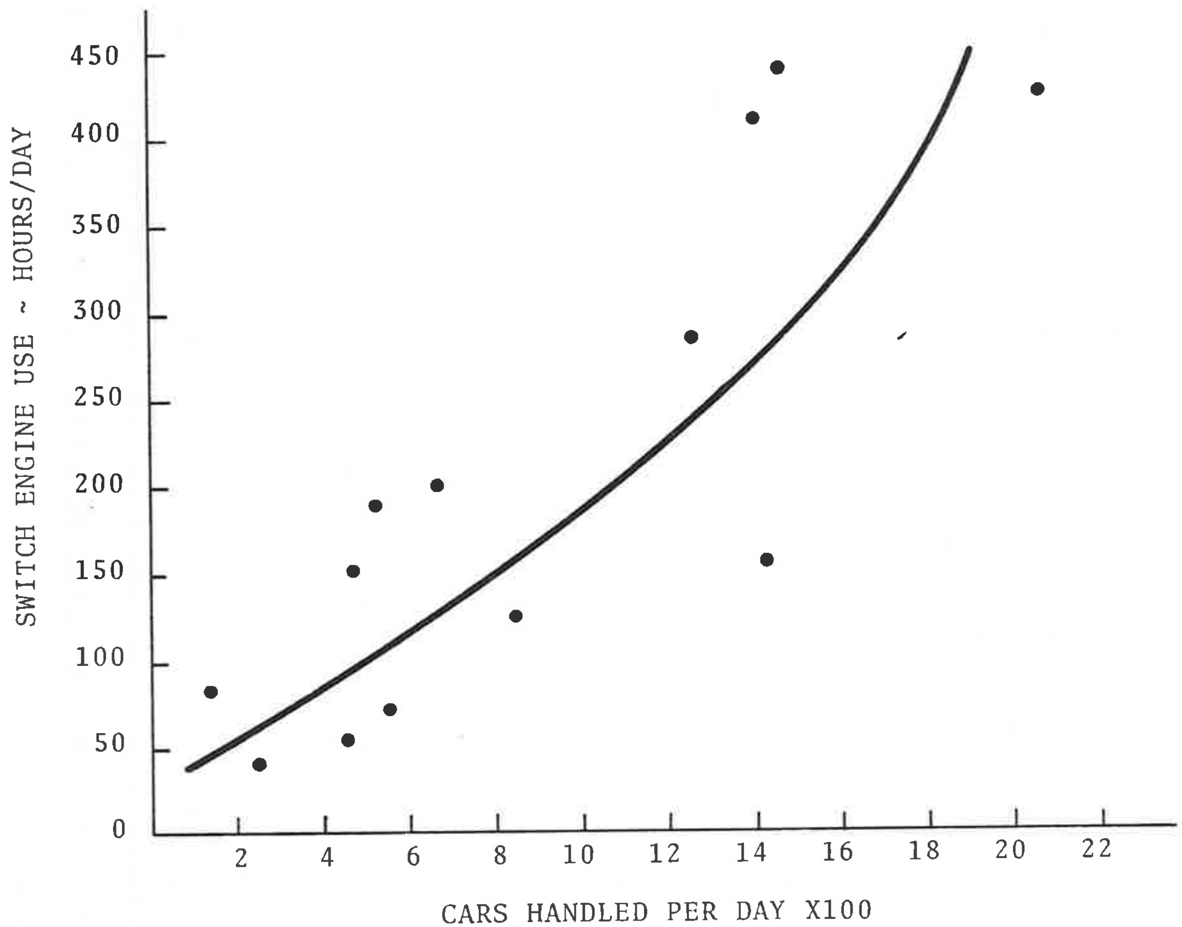


FIGURE 3-3. SWITCH ENGINE USE VS. CARS HANDLED - KANSAS CITY TERMINAL

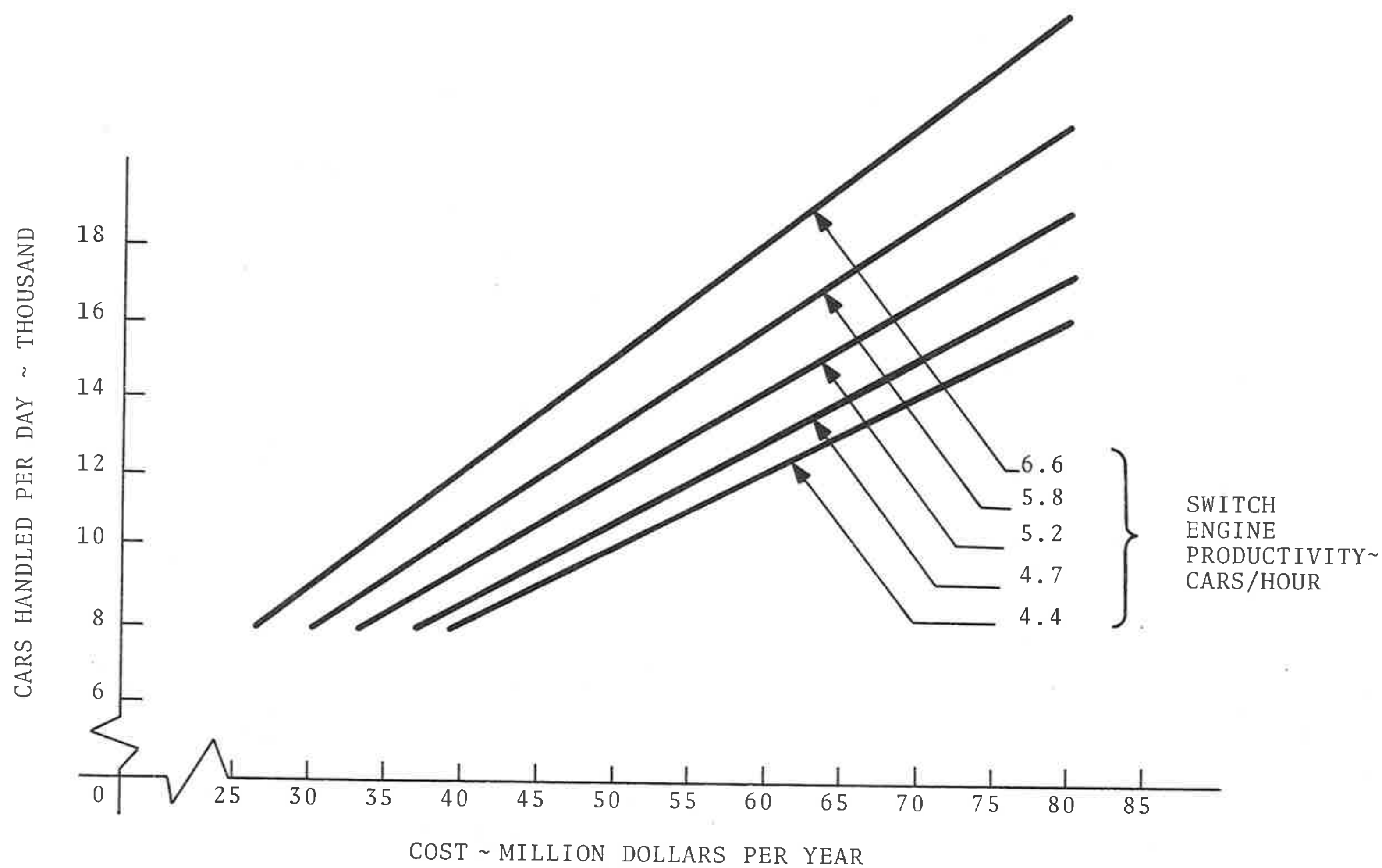


FIGURE 3-4A. SWITCH ENGINE COSTS VS. CARS HANDLED - KANSAS CITY TERMINAL

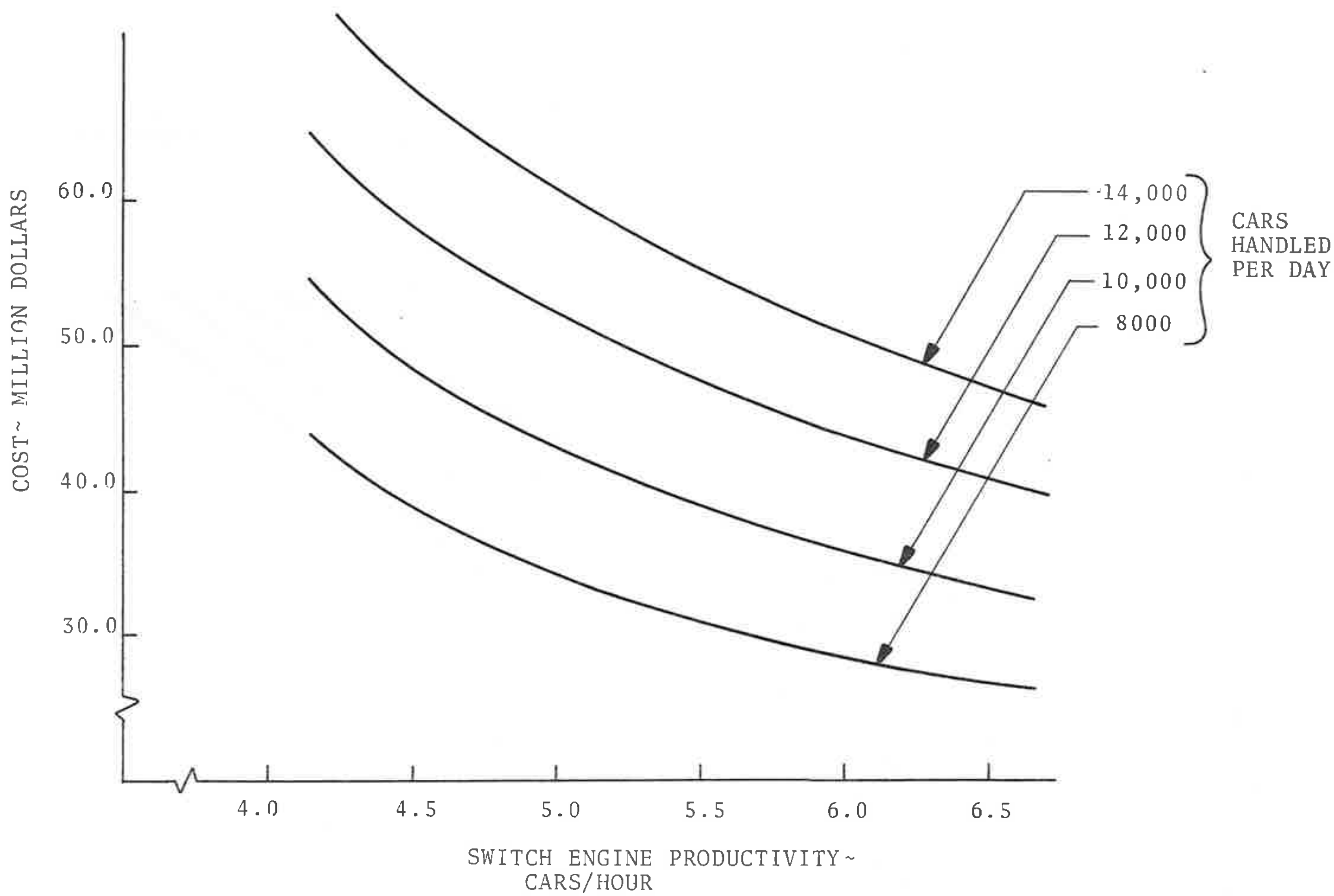


FIGURE 3-4B. SWITCH ENGINE PRODUCTIVITY VS. COST - KANSAS CITY TERMINAL switch engine productivity and numbers of cars handled per day. From these figure, it can be seen that the current costs of switch engine operations in the Kansas City Terminal is $55. million per year based upon interchange traffic of 11,000 cars per day and switch engine productivity of 4.4 cars per hour.

Industry experience has shown that switch engines are approximately 66% productive. Reference 1, p. 86 defines productivity as the percentage of time actually moving cars or delay incurred while in the process of moving cars. Reference 1 lists the productivity as 75%: subsequent analysis by TSC for switch engine operations in East St. Louis resulted in the 66% figure. Revisions of Reference 1 will use 66%. In Reference 2, p. 4-12 ("Indianapolis Terminal Study" Management Sciences, July 1975), productivity was defined as the number of cars switched per hours divided by a standard derived for the operations studied. That productivity was 61%. For the Kansas City analysis, 66% productive time will be assumed.

It was noted that Figure 3-3 showed an average engine productivity in Kansas City of 4.4 cars per hour. It is assumed that 66% productivity is equivalent to 4.4 cars per hour. Thus, changes in the cost (i.e. benefits) due to increased productivity can be determined for percentage improvements. Note in Figures 3 A and 3-4B that an improvement in productivity from 4.4 cars to 4.9 cars represents an improvement of 10% to 72.6% productivity, and a savings of about $6. million annually for 11,000 cars handled. These figures are used to derive the switch engine benefits in Section 5.3.1.

The Kansas City railroads provided estimates of switch engine overtime in interchange movements, which for the terminal amounts to about 130 hours per day or about 5.3% of present switch engine usage. The annual cost of this overtime is about $3. million. It can be argued that an increase in productivity by switch engines would tend to reduce the amount of overtime. This argument is taken into account in developing the benefits in Section 5.3.1.

Figure 3-5 shows the cost of non-productive time. For 66% productivity, there are about 800 hours of nonproductive time in Kansas City which is a cost of nearly $18 million. It can be seen that this is a significant cost impact. The benefits of switch engine productivity improvement are developed from this cost information.

3.4 CLERICAL PRODUCTIVITY

The impact of clerical operations upon the cost of doing business in Kansas City is a function of the number of personnel employed in clerical positions, and the productivity of the personnel. In this analysis, productivity is defined as the number of cars handled per day per person. The individual operations of each clerical position were not analyzed; rather all the positions of all the roads were aggregated to arrive at an overall measure of performance in the Kansas City terminal.

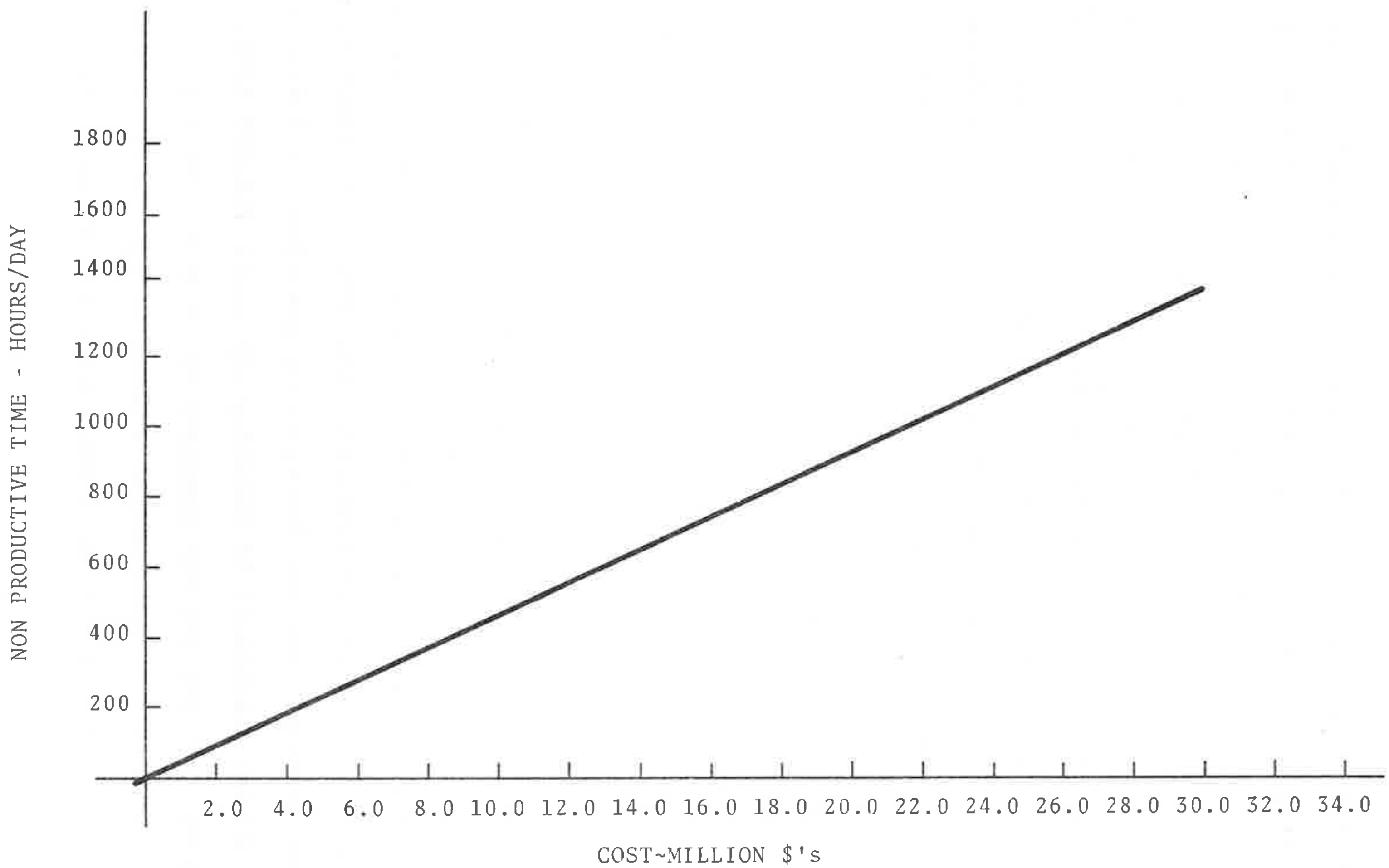


FIGURE 3-5. COST OF NON-PRODUCTIVE SWITCH ENGINE TIME - ANNUALIZED BASIS

Table 3-3 shows clerical force levels on each road for several job categories taken from railroad figures provided for the summer 1975. Since clerical productivity impacted not only on the interchange operations but also on through traffic, the number of cars handled per person was assumed to be the sum of these two activities. In the determination of cost, a figure of $8.40 per hour was used. This figure includes time not worked due to sick time, vacation and holidays. It represents an average figure for Kansas City operations in August 1975 and tracks well with figures derived from Reference 3, ("Use of ACI on the Burlington Northern"), p. 180 and Reference 4, ("Economic Evaluation of ACI" Grand Trunk Railroad) p. 15 increased through 1975 by 1% a month per the labor contract provisions.

Clerical productivity was determined as a function of clerical cost per car. From Table 3-2, the total clerical cost for Kansas City was taken (i.e., $8.395 million or $23,000. per day). It was assumed that the clerical cost was fixed at $23,000 per day regardless of the volume of traffic handled. From information provided by the KCT, the total traffic volume was calculated to be 28,827 (inbound, outbound, interchange received and delivered). For the 549 clerical positions in Table 3-3, this volume represents 53 cars/day per clerk (28,827÷549). The clerical cost per car was computed to be $0.80 per car ($23,000÷28,827). This became a point on the curve in Figure 3-6 as well as present operating experience for Kansas City.

TABLE 3-2. CLERICAL LABOR REPORTED FOR KANSAS CITY

	ATSF	BN	CNW	ICG	KCS	KCT	MILW	MKT	MP	NW	RI	SLSF	UP	TOTAL
Super-visory	4	2	1	1	1	1		1	1	4	3	1	8	28
Agency	31	44	5	7	16	4	7	2		21		8	56	201
IBM	8	12		4	1			2	12	6	6	2	14	67
Train	37	17	8	5	23	9	11	5	10	6	7	14	13	165
PICL	6												9	15
Misc	6	3	3		2	1				3	1		7	26
Car Record							2						10	12
Inter-change	1					2			3					6
Car Correlator											7			7
Guard Extra Board													22	22
Total No.	93	78	17	17	43	17	20	10	26	40	24	25	139	549
Annual Cost (thous)	$1468	1245	271	271	688	271	319	160	415	638	383	399	1867	$8395

NUMBER OF POSITIONS PER RAILROAD AT SALARY OF $15,785 PER YEAR
DATA SUBMITTED BY THE RAILROADS

Addition points were plotted by assuming changes in clerical productivity (the number of cars per clerk per day), computing the number of cars handled (549 clerks x cars per day), and then dividing that traffic volume into $23,000. For example, 40 cars per clerk per day gives 21,960 cars handled (40 x 549) and a cost of $1.05 per car ($23,000÷21,960). Figure 3-6 represents the average cost per car at various levels of clerical productivity for all Kansas City railroads.

It is possible that an information system can impact upon these costs. Reference 2, p. 3-5 indicates that clerical productivity averages 61.6 percent for the railroad industry. This represent the amount of time actually working and is measured in cars per person. Assuming that this figure is valid for Kansas City and that productivity could be measured and increased through improved information exchange, this curve could be used to show the effect of such an increase. For example, if productivity could be improved to 60 cars per person (a 13% increase), clerical costs would be reduced to $0.70 per car. This example is shown as indicative of the type of improvements possible; the possible savings generated by such improvements are discussed later.

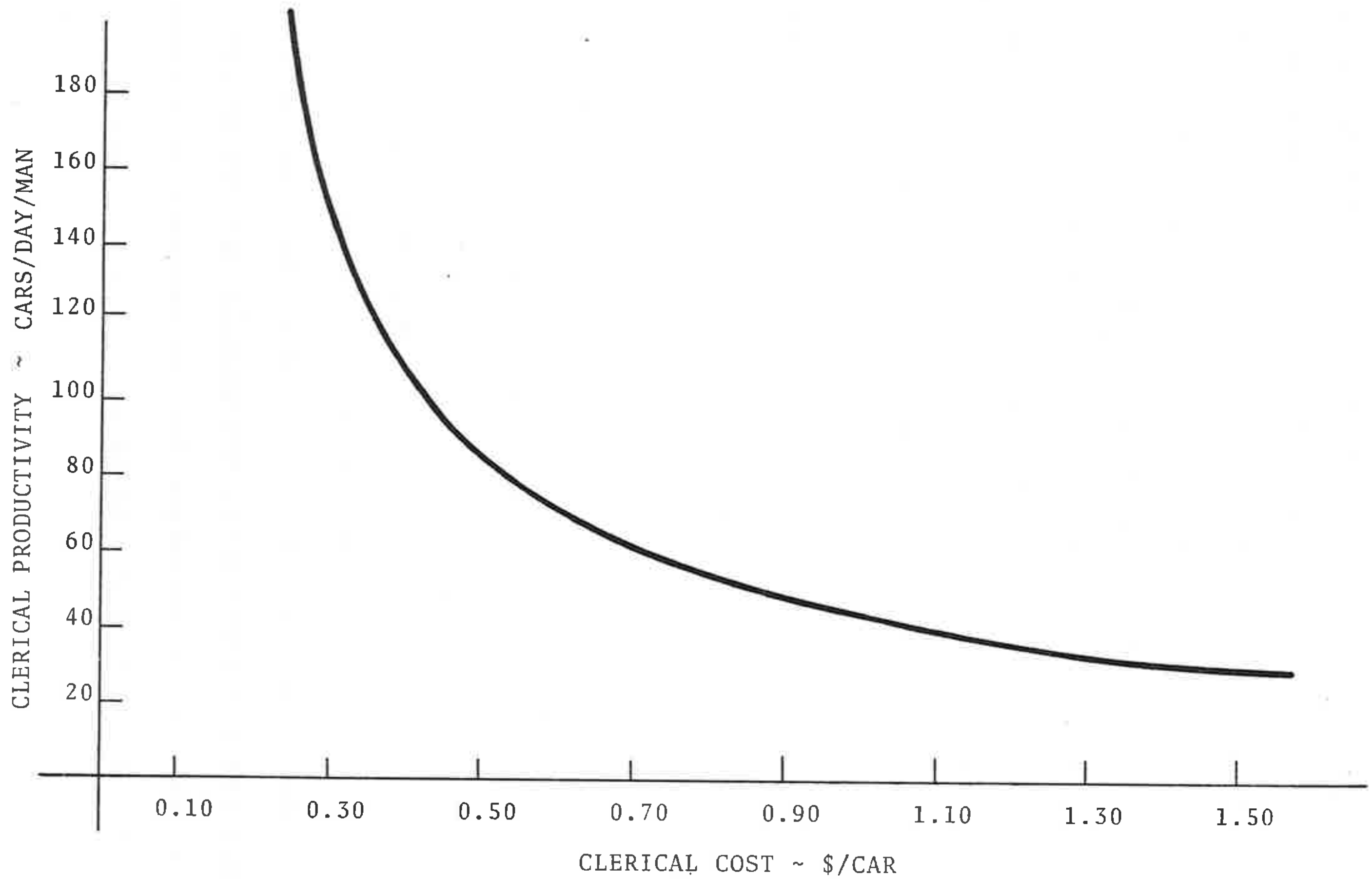


FIGURE 3-6. CLERICAL PRODUCTIVITY VS. COST - AGGREGATED ROADS - KANSAS CITY

3.5 INFORMATION ERRORS

Cars are occasionally mishandled in yards as a result of incorrect or missing information. Cars often arrive at terminals without any information concerning their destinations, contents, etc. Such cars must be held until the railroad determines the destinations for the cars and can take appropriate action. Incorrect information can result in misclassification of a car; if undetected, delivery in error to a subsequent yard or, worse yet, to an interchange point may occur. This section addresses the cost of these errors in Kansas City.

Thirteen principal information errors were identified by TSC and are shown in Table 3-3. The railroads in Kansas City provided information concerning the extent of information errors they experience. Data from all of the railroads are shown in Table 3-4 which list the number of cars placed on the hold track waiting for information, the number of cars incorrectly received and delivered in interchange, and the number of open records per day. The cost bases for this section are taken from References 1, 3, and 4.

No bill cars are those cars received for which neither a waybill nor consist-type information exists. In virtually all no bill cases, the car must be placed on the hold track and indefinitely delayed until the waybill arrives at the terminal, or at least the destination for the shipment is determined. For cars to be interchanged in Kansas City, this means a delay of at

TABLE 3-3. PRINCIPAL INFORMATION ERROR AND IMPACTS

INFORMATION ERROR	EFFECT ON OPERATIONS	IMPACT ON RAILROAD
No Bill Car	Detain car, search for bill	Delay of car on hold track
Overbill	Search for car	Car exists somewhere else as a no bill, delay results
Incorrect Car Initial No.	Detain car, determine correct initialed number	Causes two open records until error is corrected
Wrong Train Order	None	None
Wrong Origin	None	Accounting
Wrong Destination	Delivery to wrong terminal Misclassification in yard	Detain and reroute car additional switching to reclass
Wrong Routing	Delivery to wrong intermediate yard	Detain and reroute car
Wrong Consignor	None	Accounting
Wrong Consignee	Wrong delivery	Additional delay, switching, road haul, and processing
Error in Contents	Little or none	None except for hazardous materials
Error in Charges	None	Accounting
Error in Interchange	Delivery to wrong road	Additional delay, fines

TABLE 3-4. INFORMATION ERRORS IN KANSAS CITY

RR	Total Inbound Cars	Open Records	(%) (Of Inbound Cars)	Hold Track (Cars)	(%)	RR Errors Inbound (Cars)	Intechge Errors in (Cars)	Total Errors in (Cars)	(%)
ATSF	2971	7	(0.24)	25	(0.84)	-	17	17	(0.57)
BN	1211	90	(7.43)	40	(3.3)	2	8	10	(0.82)
CNW	555	5	(0.9)	6	(1.08)	-	6	6	(1.08)
ICG	359	1	(0.28)	5	(1.39)	-	2	2	(0.56)
KCS	573	20	(3.49)	7	(1.22)	1	2	3	(0.53)
MILW	455	7	(1.54)	4	(0.88)	1	1	2	(0.44)
MKT	442	20	(4.5)	2	(0.45)	-	2	2	(0.44)
MP	2492	60	(2.41)	55	(2.21)	-	5	5	(0.20)
NW	1328	-	-	16	(1.2)	1	3	4	(0.30)
RI	1032	-	-	5	(0.48)	10	1	11	(1.06)
SLSF	1542	3	(0.19)	15	(0.97)	-	7	7	(0.45)
UP	1966	2	(0.10)	35	(1.78)	10	25	35	(1.78)
KCT	72	2	(2.78)	1	(1.39)	-	3	3	(4.17)
TOTAL	14998	217	(1.45)	216	(1.44)	25	82	107	(0.71)

Based on daily average information obtained from railroads.

least 24 hours even if the waybill is located quickly. The Kansas City railroads reported an average of 1.29% of the cars received each day go to the hold track to await information. The cost per car of this activity is $12.42; $4.50 in additional switching cost and $7.92 in detention time. Figure 3-7 shows the range of cost to the entire terminal for no bills as a function of car activity.

Open records are clerical problems which result from incorrect or missing information. Special effort must be expended in order to close these records or obtain the necessary car movement information. The railroads reported 1.45% open records as a percentage of cars received. The cost of open records are developed from Reference 4, p. 15 as follows:

> Two-thirds of the records are corrected using the central computer of the railroad at a computer time cost of $2.64.
>
> One-third of the records require clerical effort to trace the records to other locations on the railroad in order to locate the information. The clerical cost plus computer cost to close these records is $6.86.

Figure 3-8 shows the range of costs for open records.

The most costly problem resulting from information errors is incorrect deliveries. The railroads reported about 0.71% of the cars received each day are in error. About 3/4 of these cars are incorrect interchanges. (It should be noted that railroads are

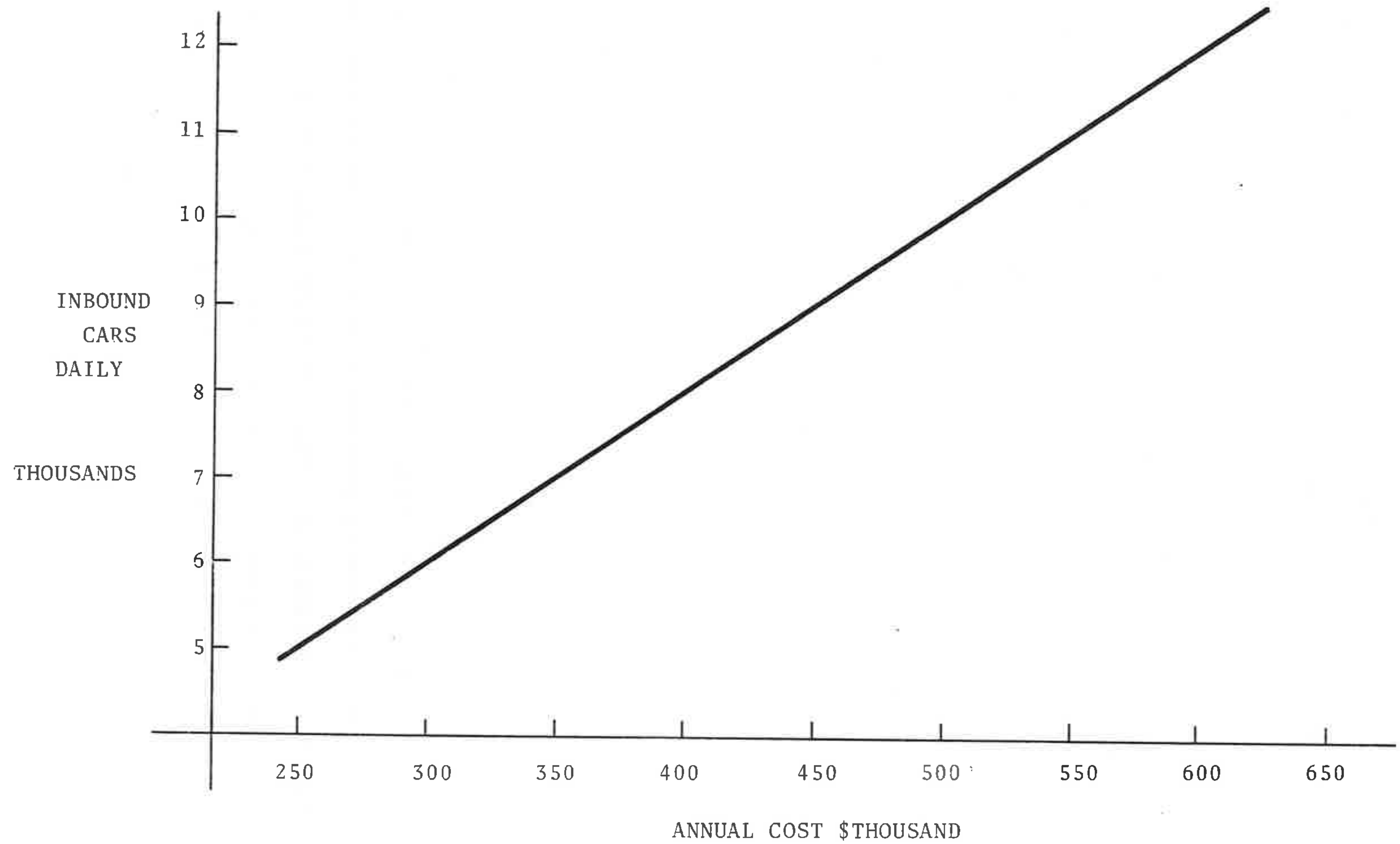


FIGURE 3-7. COST OF NO BILLS

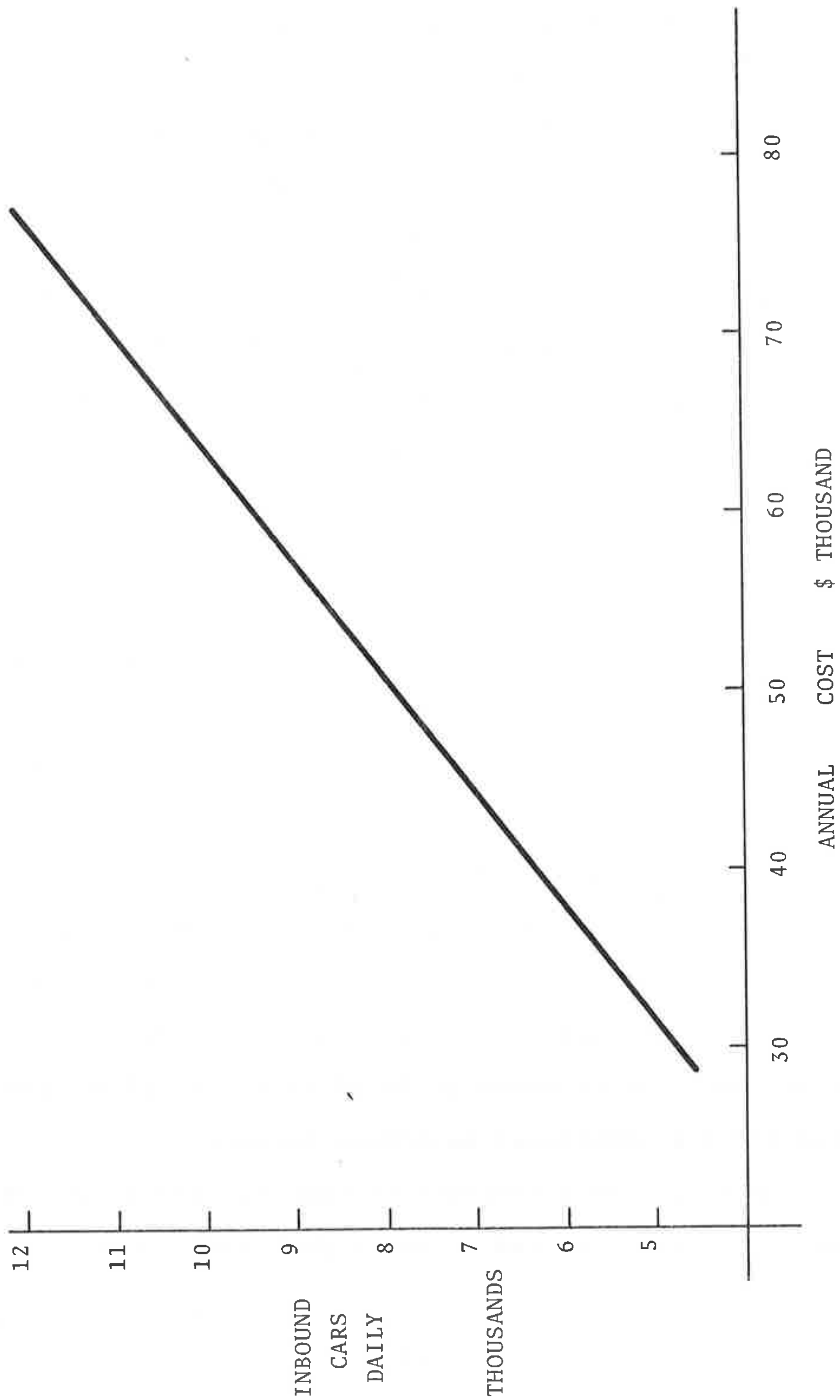


FIGURE 3-8. COST OF OPEN RECORDS

far more likely to report receiving errors from others than from their own railroad.) Effort is required on the part of the railroads to correct the errors and the car encounters significant delay. In addition, there are penalties and holding fees assessed on railroads who deliver incorrect cars in interchange. An estimated two days of delay occurs after an error has been discovered. The car delivered in error would be placed on the hold track until the correct destination or the last origination point is determined. If the car is to be returned to that last origin, it must be moved from the hold track and classified with other cars going to that location. It then must wait for the next train. Once returned to the point of error, the car must be reclassified for the proper destination and placed on the next available train. The variation in these times is obviously dependent on the train scheduling between the two points and the speed with which the correct information about the car is obtained. For incorrect deliveries in Kansas City, a two-day delay costing $7.92 x 2 or $15.84 seems quite reasonable.

Additional switching costs are incurred by both railroads in holding the car, sending it back to the point of error, and then sending it out to the correct destination. A conservative estimate of three switch moves at $4.50 or $13.50 seems quite reasonable for the additional switching incurred.

Additional line haul movement is required and to the extent line haul costs are allocated to individual cars a cost for this activity could be estimated. It is assumed here, however, that most of the errors are in interchange and that their magnitude would not really affect line haul costs.

The railroad which returns the car it received in error is entitled to a $5.00 per day holding charge and is not liable for per diem on the car provided disposition is requested within twenty-four hours. In addition, a setback charge of $25.00 (per Car Service Rule 7) can be assessed on the delivering railroad if the car delivered is a no bill. For this analysis, the cost of a car delivered in error in terms of penalty payments is estimated to be $25.00.

This makes the total estimated cost of delivery errors to be:

extra delay	$15.84
additional switching	$13.50
setback charge	$25.00
Total	$54.34 per car

Figure 3-9 shows the range of cost for delivery errors in Kansas City.

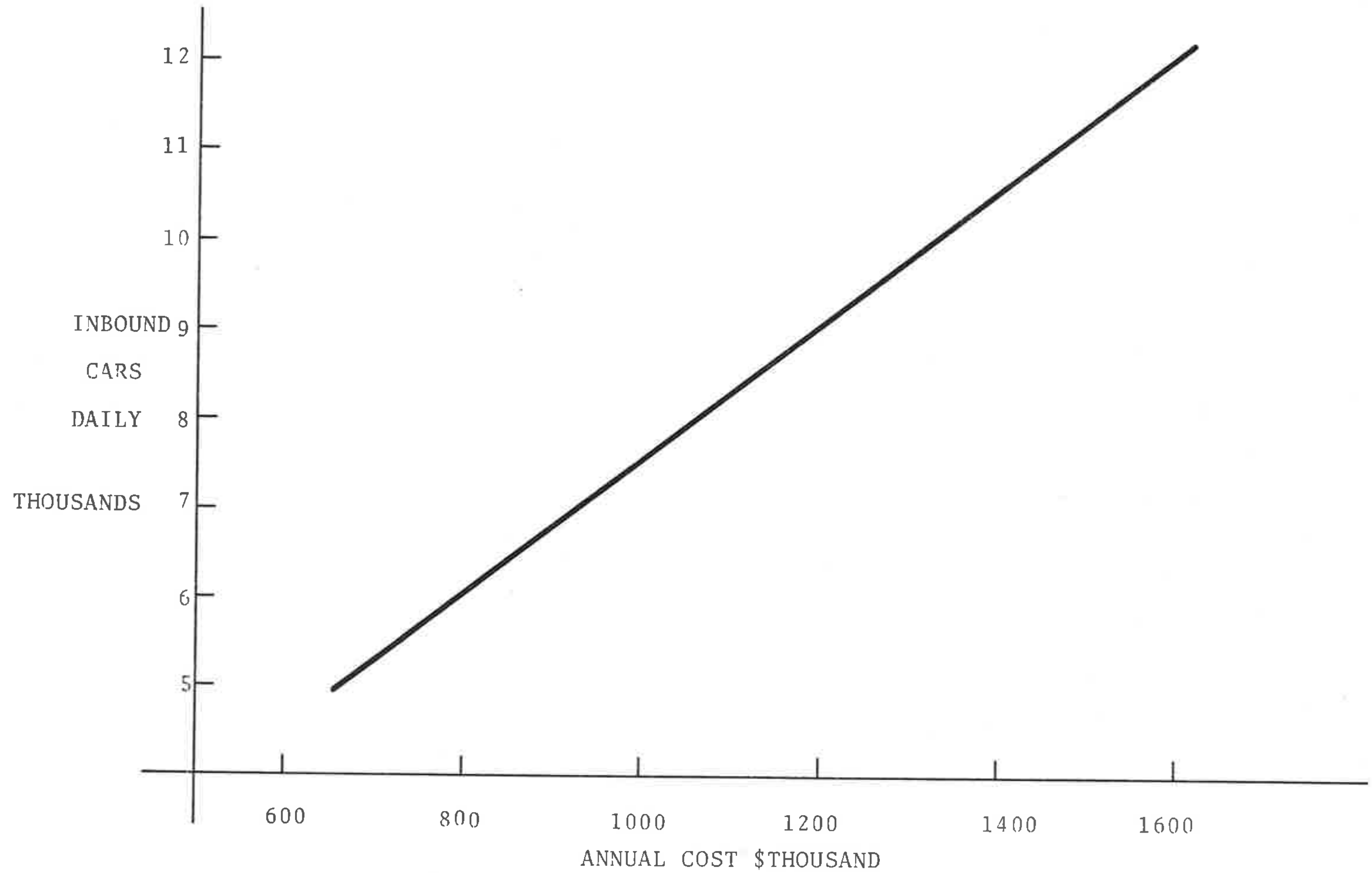


FIGURE 3-9. COST OF DELIVERY ERRORS

4. PROPOSED TERMINAL INFORMATION SYSTEM

4.1 SYSTEM PROPOSAL

In April 1975, the Kansas City Terminal Railway Company proposed that the Federal Railroad Administration assist in funding development and implementation of a Terminal Information and Message Exchange system (TIME) for the Kansas City gateway (Reference 5 - "A Proposal for the Implementation of a Terminal Information Message Exchange System at Kansas City, Missouri"). The purpose of the proposed system is to formalize and automate the exchange of information between railroads on cars involved in interchange. The proposed system would receive advance information (advance consists) on inbound road trains at the same time individual railroads in Kansas City would receive that information. Inbound trains would be scanned by automatic car identification scanners prior to the trains' arrival in Kansas City. The information system would then provide a corrected train list to the railroad involved and update the inventory maintained by the system. Railroads would enter train list information on interchange movements into the system at the same time they would normally provide such information to their own central computers. Cars moving in interchange would be scanned by ACI scanners and corrected train lists would automatically be provided to the receiving railroad in advance of the arrival of the interchange train. Outbound road trains would similarly be scanned as they depart Kansas City and the terminal inventory would be adjusted.

The system concept proposed is based in part on the Chicago Rail Terminal Information System which monitors interchange movement in Chicago and allows information exchange among the railroads. The system for Kansas City would improve on the Chicago System by automating railroad data input and increasing the coverage of the system through its ACI scanners to virtually all movements into and out of Kansas City. A central computer would be located on the property of the KCT and would communicate with all twelve roads operating in Kansas City. Forty-four ACI scanners were identified in the proposal. Software would be developed to allow message switching in the format of each railroad, maintenance of an inventory of cars in the terminal, and preparation of output reports for use by the railroads in Kansas City.

4.2 INFORMATION FLOW

The key input to the proposed information system is train consist and car waybill information on all trains en route to Kansas City. Figure 4-1 represents the flow of information to provide the input to the information system. The advance consist information would be automatically sent to the terminal information system in Kansas City at the same time a consist would normally be sent from a railroad's main computer to the terminal office of that railroad in Kansas City. Thus, no

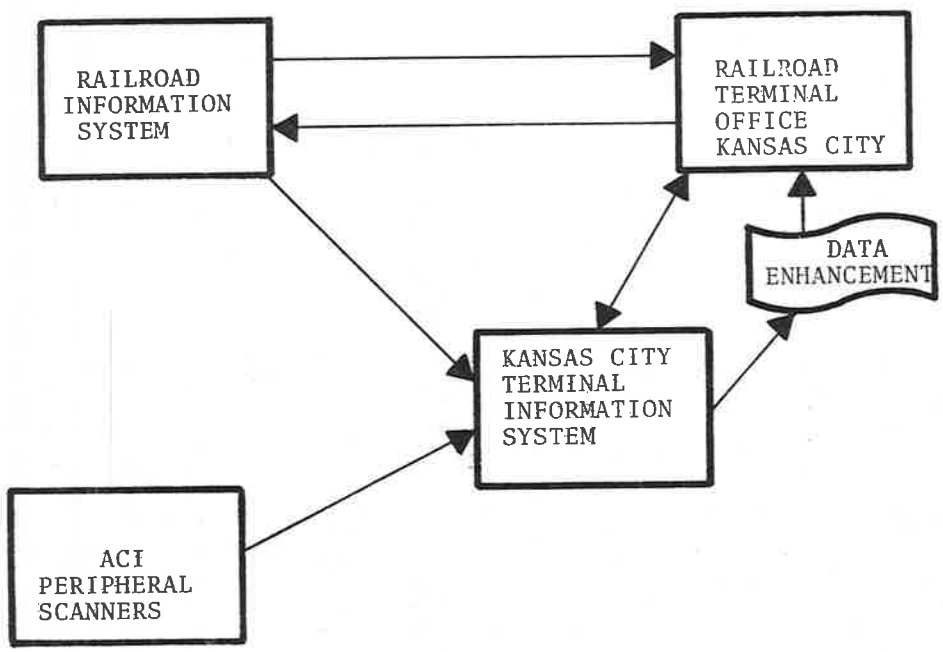


FIGURE 4-1. KANSAS CITY TERMINAL INFORMATION - ADVANCE CONSIST INFORMATION FLOW

additional clerical or computer processing effort would be required of the railroad's main computer to provide the required input to the terminal information system. All trains en route to Kansas City would be scanned prior to their arrival at their Kansas City yards by one of the ACI scanners. The ACI data would be fed directly to the terminal information system where they would be merged with the appropriate train consist through a matching procedure called data enhancement. Errors or non-readable ACI labels from the scanning data are corrected where possible with the advance consist data, resulting in a final train list more accurate than either the ACI scan list or the advance consist. This enhanced train list would be automatically provided to the Kansas City office of the appropriate railroad. The Kansas City office would then be able to provide updated train list information to the railroad's main computer. The enhanced consist and the time of physical scanning of the train by an ACI scanner become key information bases for the terminal information system.

Figure 4-2 shows the information flow involved in the actual interchange of cars between two railroads in Kansas City. It is this flow of information that is the primary purpose of the proposed terminal information system. As described in Section 2.4.4, the present flow of information between interchanging railroads is sporadic and not usually timely. This system would provide advance information on all interchange moves

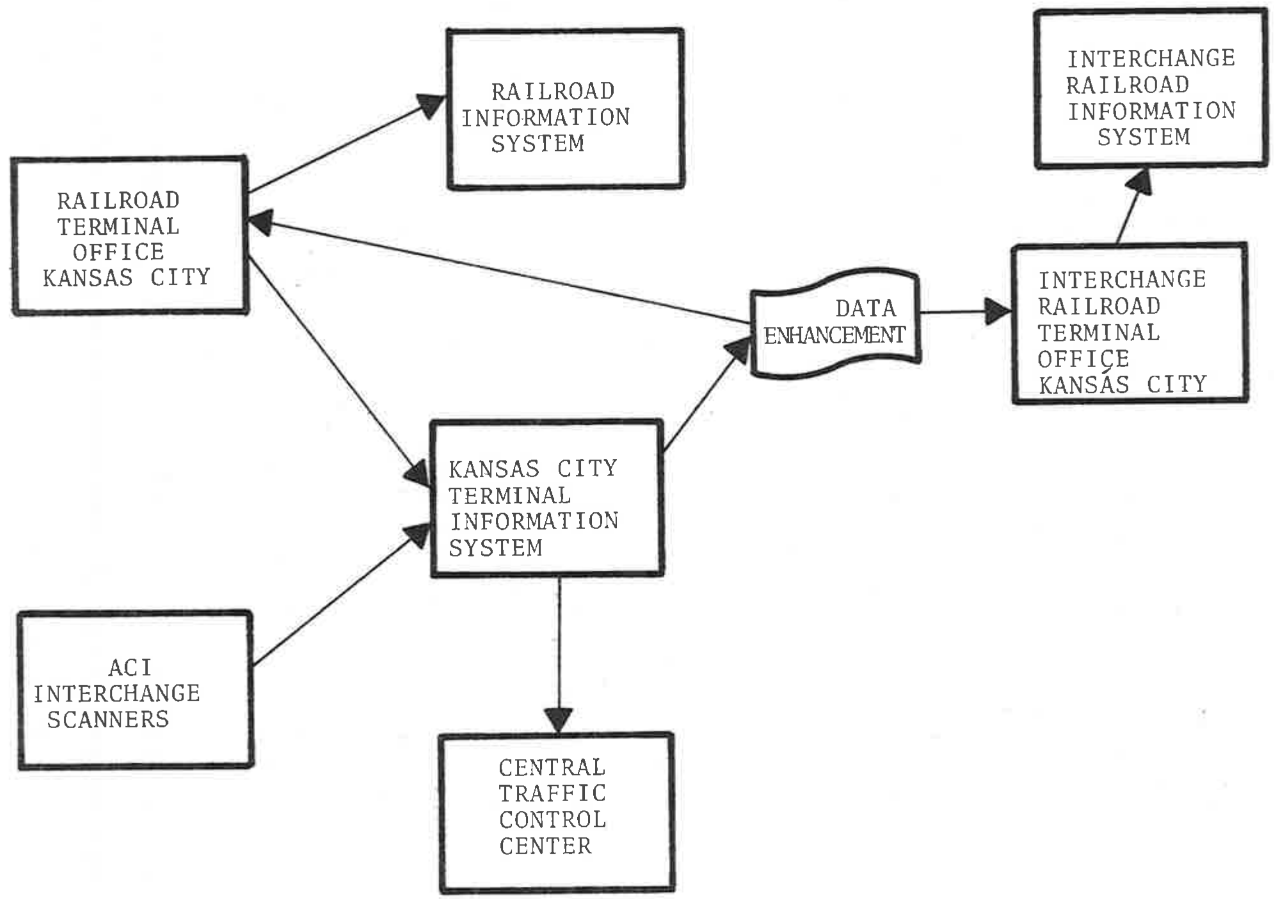


FIGURE 4-2. KANSAS CITY TERMINAL INFORMATION SYSTEM - CAR INTERCHANGE INFORMATION FLOW

automatically. When a railroad originates an interchange train for another Kansas City railroad, it should provide the consist information to its main railroad computer system, so that the cars being interchanged can be removed from that railroad's inventory and so that proper interchange agreements can be executed. Most railroads provide such information, but the input does not necessarily occur at the time the train departs. The terminal information system would automatically receive the train list information at the same time the yard office provides the information to its headquarters. Here again, no additional clerical effort or computer processing would be required on the part of the railroad to input the terminal information system. This is a particularly important facet of the Kansas City system as a result of the experience of the CRTIS system in Chicago. CRTIS required clerical input of train consist information from the yard office in order for the system to provide the interchange information. At this writing, CRTIS is not receiving many of the inputs in the time required.

After an interchange train departs its yard, it would be scanned by one of the ACI scanners. An enhanced train list would be produced as with inbound train lists. This list would then be automatically transmitted to the receiving railroad in advance of the arrival of the train at the receiving yard. (The time is a function of the distance between the delivering and receiving railroads, but is typically 45 minutes). The system would also provide the movement information to the Central Traffic Control Center of the Kansas City Terminal Railway. An enhanced list would be returned to the delivering road for updating of its information. The receiving railroad would provide the information on the train to its headquarters computer to update the railroad's inventory. The receiving yard would have information about a train before its arrival and thus would have the ability to plan the switching and classification operations, train scheduling, etc., in order to reduce delays, improve yard efficiency, and speed cars to their destinations.

The Central Traffic Control Center would have an additonal, more accurate input of train origination information, and would have additional knowledge about the length of the train, tonnage, and the types of commodities being carried. The effectiveness of the Traffic Control operations can therefore be improved with the information provided by the proposed terminal information system.

It should be noted here that the information transfer would take place in the format of each of the participating railroads. This further eliminates the necessity of reprogramming, or reformatting on the part of individual roads. All of the format conversion takes place within the terminal information system. While this increases the complexity and cost of the information system, it keeps individual railroad impact to a minimum and enhances the prospects of carrier involvement and acceptance of the system.

Figure 4-3 represents a typical advance consist and the type of information that will be required to initialize the information system for the Kansas City terminal. The terminal information system will have the ability to sort and aggregate that information in any way. The railroads will ultimately determine data availability, i.e., there may be some information which one railroad would not want any other railroad to have access to. The system would be designed to provide these safeguards.

The primary function of the terminal information system as noted above is the automatic transmission of interchange data among the Kansas City railroads. Both the accuracy and timeliness of the information would be improved. In addition, the system will maintain a current inventory for the Kansas City terminal by combining all of the advanced consist data from all of the railroads. The system would have records by railroad of all the cars in Kansas City and the time they arrived there. The functions of the system in the future would be dictated by the railroads involved. The system has the capability to support almost any kind of operational improvement that might be contemplated for the Kansas City terminal. If nothing else, it provides timely, accurate, and advanced information about anticipated interchange activities, automatically with little clerical effort on the part of the railroad. It is then up to

NW Calumet Yd to RI So. Chicago
Engine NW 002704

car initial and number		car type	weight	consignee	destination	status	STCC (commodity code)	interchange railroad
NW	002704	Eng						
NW	002508	Eng						
NW	219149	B	010	TARSTORES	FRIDLEYMN	L	37512	RI
UTLX	030372	T	000	T619NORTH	EMORRISIL	E	29121	RI
UTLX	030425	T	000	T619NORTH	EMORRISIL	E	29121	RI
UTLX	030498	T	000	T619NORTH	EMORRISIL	E	29121	RI
NW	600936	B	050	MERPRINTI	DESMOINIA	L	27211	RI
NW	603590	B	050	MERPRINTI	DESMOINIA	L	27211	RI
RI	036065	B	000	A230AGTRI	DAVENPOIA	E	20421	RI
BN	232037	B	010	FURWAREHO	MINNEAPMN	L	25999	RI
SP	508366	F	000	F211AGT	CHICAGOIL	E	24996	RI
RI	012145	C	000	L151AGT	UTICA IL	E	14413	RI
CABOOSE								
END								

Total 10 cars plus 2 engines and caboose

Explanation: NW 219149 - loaded box car wieghing 10 tons loaded with bicycles going to Tara Stores via the Rock Island

UTLX three empty tank cars which normally carry liquified gas. Being delivered to East Morris, Illinois to station T619North for loading.

NW600936 and 603590 - loaded box cars weighing 50 tons each. Loaded with magazines going to a printing company in Des Moines, Iowa via the Rock Island.

BN 232037 - Loaded box car weighing 10 tons filled with restaurant furniture for a furniture warehouse in Minneapolis.

SP 508366 - Empty flat car which carries particle board. To be delivered to freight agent F211 in Chicago on the Rock Island.

RI 012145 - empty covered hopper which last carried sand. Being delivered to agent in Utica, Illinois.

FIGURE 4-3. TYPICAL ADVANCE CONSIST

the individual railroads to determine how they will utilize the information and what the benefits of the system will be.

5. SYSTEM BENEFITS

5.1 BACKGROUND

The proposal submitted to FRA by the Kansas City Terminal Railway for the terminal information system did not deal with the benefits of the proposed system, except that it identified several uses which would improve the operations of the various railroads. No effort was made to quantify any benefits or to indicate the significance of the use of the information by the railroads. A major part of this study, therefore, deals with the benefits to be gained by implementation of an information system. Subsequent to submittal of the proposal, KCT and its contractor ACI Systems Corp. (ACIS) developed, in conjunction with each railroad, data concerning the resources applied by railroads in conducting the operations in Kansas City. ACI Systems then prepared some information which gave expected costs and benefits of the system. During the TSC visit to Kansas City in December 1975, the data obtained from the railroads by ACIS were verified and supplemented through interviews with each of the terminal superintendents. This section will deal with the analysis of benefits performed by TSC. The analysis indicates the areas most susceptible to improvement and contains an indication of the significance of various levels of improvement by building on the cost of operations data developed in Section 3. It also includes an enumeration of some of the expected and potential uses of the system. It must be emphasized that any benefit to be derived from the system is dependent on the use of the information by the railroads. The actual magnitude of benefits can only be determined by the railroads as they begin to use the system. This analysis indicates potential areas of improvement and application of the system. Based on operating costs developed in Section 3, this section develops the range of benefits possible and presents a reasonable example of improvement for which savings are computed in order to determine net system benefit.

5.2 UNQUANTIFIED BENEFITS

5.2.1 Management Overview

One of the most important capabilities of the terminal information system is its ability to merge all consist records together in order to form an inventory of the entire Kansas City terminal. Several purposes are served by this capability. First, it gives the Kansas City Terminal Railway (KCT) for the first time an overall picture of activity in the terminal. This facilitates the coordinating and management services provided by the KCT. As noted earlier, it gives the Traffic Control Center an additional input of information on the departure and arrival of trains, and also provides for the first time information on trains which are currently not covered by the Traffic Control system. As noted, Traffic Control would have information about the contents of trains in order to improve routing and scheduling of hazardous materials, and would also know the number of cars in a consist which could be useful in predicting block clearances.

5.2.2 Inventory Capability

The inventory capability, when combined with the ability to make inquiries to the system, provides the KCT and all of the individual railroads with important new sources of information about individual cars or groups of cars in the area. A railroad, for example, could inquire of the information system about all cars in Kansas City expected to be delivered to that railroad. The system would have the ability to determine the number of cars and list them by origin, destination, contents, etc. Such information would be of obvious benefit to yard operators in planning their locomotive, crew, and clerk activities. The car distribution function on an individual railroad would be improved by the knowledge of the railroad's empty equipment present in Kansas City (or en route to Kansas City on other railroads). Similarly, a shipper served by the KCT or one of the other railroads could inquire of a railroad about the status of or the location of a particular car. The system would be able to provide this information, probably via CLM (Car Location Message). While the shipper would not have direct access to the system, it would be easy for the railroad serving him to obtain the information desired. The railroad is able to offer an improvement in service through this feature.

5.2.3 Interchange Management and Verification

The terminal information system would offer the railroads vastly improved management and verification of interchange of cars. Presently, railroads offer cars to others in non-uniform ways as described in Section 2.4.4. The delivering railroad's record of arrival time at the interchange point is accepted as the time of interchange and per diem payments are negotiated. Disputes of the arrival time are not uncommon and are usually resolved through arbitration between the railroads. At best, significant time elapses before per diem is settled. At worst, a railroad is charged for cars it did not have. The ability of the ACI scanners to record the time of passing a train and to identify each car in the train provides an unbiased, accurate verification of the interchange of a car. It is reasonable to foresee the institution of an automatic certification of interchange by the terminal information system and the issuance of appropriate documents for settling per diem payments far earlier than is the case today.

Perhaps even more important to the railroads is the management of the offering procedure during peak periods when yards are full. If a railroad offers cars which the receiving railroad cannot accept, the cars become the responsibility of the receiving road for per diem purposes even though the cars remain outside their yard. The receiving railroad has no way to determine whether the offering road actually has the cars to deliver at the time of the offering. Several of the roads interviewed noted that other railroads sometimes offered cars that were en route to Kansas City but had not yet arrived, or offered cars that had just arrived but that would normally not be ready for interchange until the next train (usually during the next shift or the next day depending on the road's interchange schedule). The inventory capability of the system would verify the offerings of the other by inquiring of all cars to be delivered and their time of arrival in Kansas City. Cars en route would not be in the data base at this point and would therefore not be included. The system could determine whether cars that had just arrived would be ready for interchange. The benefit of this interchange management is in the smoother operation of the Kansas City gateway. For individual railroads, the benefit is one of assuring that the other railroads actually have the cars they offer and of avoiding unnecessary per diem payments. In a "system benefit" calculation, these per diem savings would "wash" in that savings to one Kansas City railroad would be a cost to another. Still, the overall management and verification of interchange and the formalization of the offering and acceptance procedure is a benefit to the more efficient operation of the terminal area.

5.2.4 Mishandled Cars

A system which will automatically provide consist and waybill information about all cars moving through Kansas City, will allow the railroads to classify and move cars that they have been unable to move because of missing waybill information. The terminal information system also allows railroads to catch mistakes they might make in misrouting, misclassifying, and incorrectly interchanging cars. As noted, these improvements could only be made by the railroads. The system itself will not prevent mistakes or generate the waybill to accompany the car. But the information will exist which if properly applied by the railroads, can significantly reduce or eliminate these sorts of problems. Costs of information errors were developed in Section 3.5. Potential savings attributable to the terminal information system are described in Section 5.3.3. below.

5.2.5 Improved Operations Planning

The primary objective of the terminal information system as noted before is to provide accurate information on the movement of cars in advance of their arrival so that railroad yard operations can be adequately planned. It goes without saying that this benefit is possible only to the extent the railroads actually do plan their operations better and that resource reductions or improvements in resource utilization occur. The majority of the discussion which follows will deal with this problem.

Each railroad yard in Kansas City has a certain number of locomotives, crews, yard personnel, and clerical forces whose jobs are to receive, classify, make up, and move cars to and from industries, interchange with other roads, and on their own inbound and outbound trains. Section 3 above dealt with these resources and their costs to Kansas City operations. Several railroads in Kansas City, notably the Santa Fe and the Burlington Northern, have sophisticated systems providing information to yard personnel for the conduct of operations within the yard. Other railroads have and require less detailed systems. Virtually all roads, as has been noted, receive information on their own trains destined for Kansas City. The need and the benefit to be derived from the information system proposed is to provide each railroad with good information about the traffic coming from other railroads. If properly applied by the railroads, the information should help the yard more efficiently utilize its locomotives and crews by knowing in advance the level of activity it will have on a given day; by knowing that a cut of forty-five cars will arrive in interchange within the next two hours; by knowing that six cars could make the next outbound connection if that train were held for fifteen minutes; by knowing that certain other railroads are unable to receive cars for the next three hours. If each railroad adjusts its operations based on the improved information about the other railroads' activities, the total detention time for cars in

Kansas City should decrease. For individual railroads this may mean per diem reductions. For the terminal as a whole and for the industry, this means a better utilization of its cars and a potential profitable use for a car in lieu of the yard detention time. For the shipper, this means better service both by receiving his shipments earlier and more reliably, and by increasing the prospects of receiving empty equipment when needed. These are significant benefits which justify the proposed Federal involvement in the program. But individual railroads perceive the benefits differently and it is these benefits that become important in the railroad's decision to support the system. No attempt has been made to specifically quantify benefits to individual roads. Sections 5.3.1 and 5.3.2 below develop the range of cost savings possible for individual roads and for the terminal. The amount of savings depends on the railroad involved but can be computed for any amount of improvement.

5.2.6 Perceived Railroad Uses and Benefits

The material below is taken from interviews made by TSC with railroad superintendents in December 1975. Most of the carriers found advance information of train order, waybill information, etc., to be useful. Several did not think the terminal information system as proposed would give enough advance warning in order for planning to take place. This is a subject which should be addressed in the initial design phase of the program by assessing the location of ACI scanners with respect to the various yards and the average travel times between points in the terminal. Other carriers saw a particular usefulness in the load or empty status of cars to be received, especially through the inquiry capability already discussed. At least one railroad noted the ability to better allocate locomotives with accurate tonnage information, and the ability to cancel trains that are not needed in order to save a crew stop-over point which involves extra pay. The system would provide the type of information to plan operations to make these improvements. Several roads thought that the detention time through the terminal could be improved, but no one offered good measures of that time or costs attributable to it. Most of the railroads with at least one exception thought that advance information about what others had for them and advance information on the offering of cars in interchange would be useful. Several of the roads also noted the importance of the verification of interchange and offering management. Two railroads saw no benefit to advanced information in interchange traffic. The data would not be useful to one of these roads because of the dated nature of its Kansas City yard facilities and its experiences with CRTIS. The other road has little interchange traffic and a preponderence of run through trains, but acknowledged that other larger roads in Kansas City might benefit from the system.

5.3 QUANTITATIVE BENEFITS

It was noted earlier that it is extremely difficult to quantify such benefits as reduction in detention time, improved utilization, etc. This discussion will deal with four potential benefits of the information system. For each, the cost of the present practice or operation has already been estimated in Section 3 and data will be developed which indicates the sensitivity of the cost to various levels of improvement, i.e., how much savings could result if the railroads were able to improve by a certain amount. The assumption as stated before is that the benefits can only accrue to the extent the railroads actually use and apply the information. For illustrative purposes, a reasonable improvement example is developed for computing net system benefit.

5.3.1 Switch Engine Savings

The KCT compiled information on switch engine usage for each railroad in Kansas City. Both straight time for three shift operation and the amount of overtime were determined. The costs of switch engine operation, overtime, and non-productive switch engine time were developed in Section 3.3. The cost basis for these calculations was taken from other TSC work being conducted for FRA.

It can be argued that advance information on traffic to be received in interchange and better management of the interchange procedure in Kansas City could result in better management and allocation of switch engines. It is also reasonable to assume that the productivity of engine usage could be improved by the improved operations. In Figure 3-4, the costs of switch engine operation were displayed as a function of productivity measured in cars switched per hour. Figures 3-4A and 3-4B were used to derive Figure 5-1 and Figure 5-2 which display potential switch engine savings from productivity improvement. These two figures are indifference curves displaying the switch engine savings in two different ways; they display the same data, however. Both figures relate productivity and savings to the number of cars handled per day. Figure 5-1 displays indifference curves in dollars of savings. Figure 5-2 displays several levels of productivity improvement in the indifference curves.

Section 3.3 noted that overtime in Kansas City represented 5.3% of switch engine usage. Thus, in Figure 5-1, overtime reduction represents a 5% productivity improvement. This seems to be reasonable in that one would expect less overtime if jobs were performed more efficiently during straight time. In terms of cars handled, this overtime reduction represents an increase from 4.4 to 4.7 cars per hour. The savings would be in the order of $3. million for present Kansas City operations as shown in Figure 5-2. A 10% increase in productivity represents 4.9 cars per hour and about $8. million in savings.

These seemingly small improvements yield major savings in terms of engine productivity. Whether railroads could actually

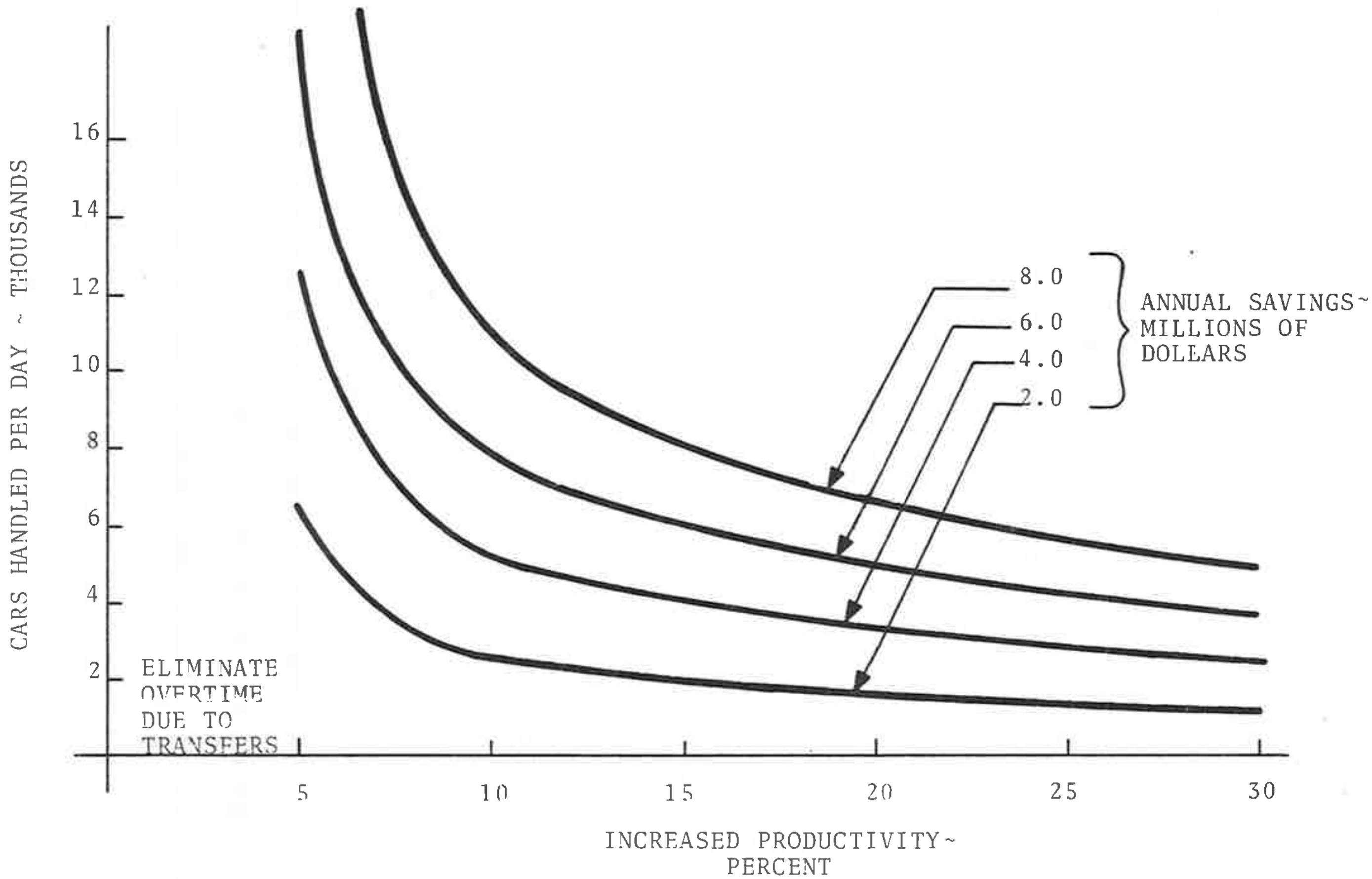


FIGURE 5-1. SWITCH ENGINE SAVINGS DUE TO INCREASED PRODUCTIVITY - CONSTANT DOLLARS

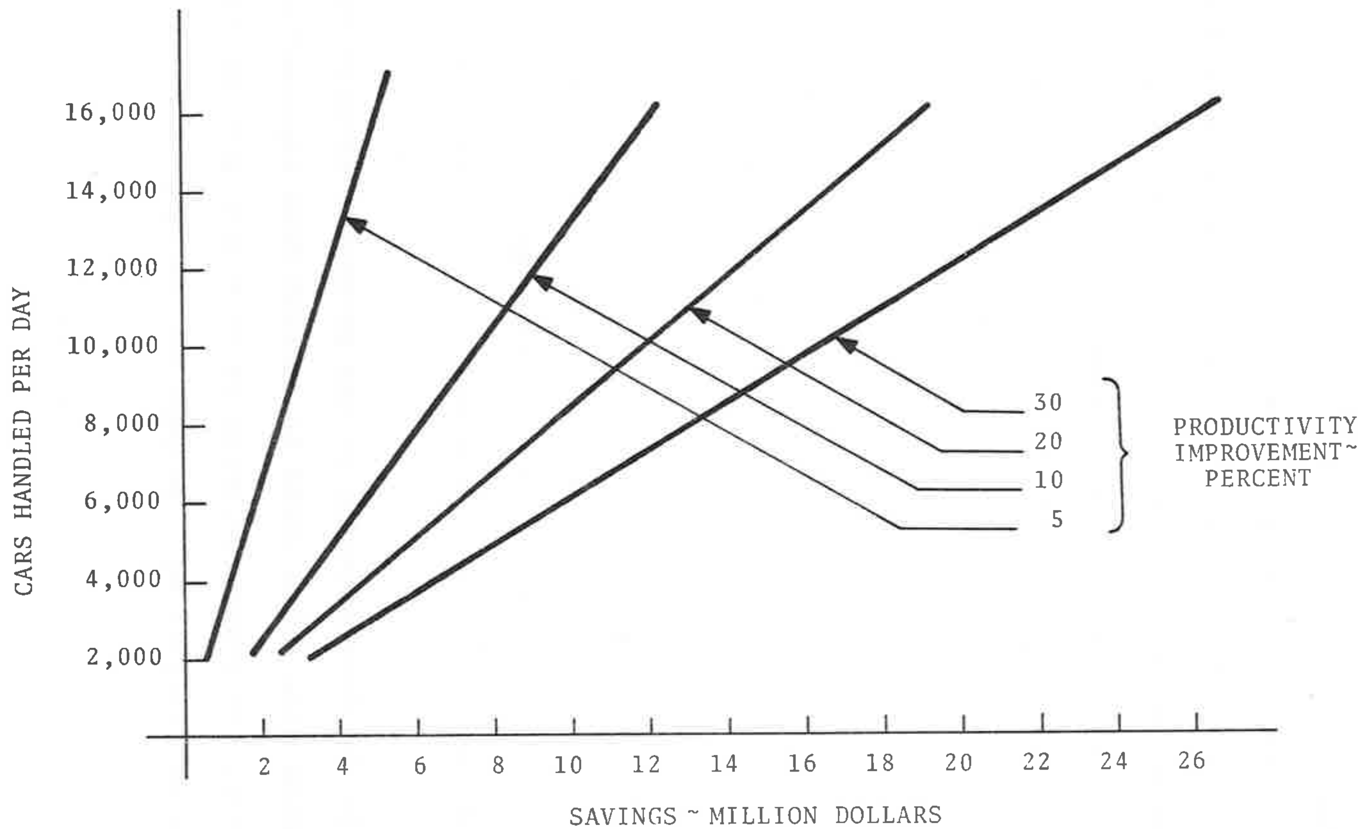


FIGURE 5-2. SWITCH ENGINE SAVINGS DUE TO IMPROVED PRODUCTIVITY

reduce the number of switch engines in the near term as a result of this system is a debatable issue. But the ability to meet increased traffic levels easily and to improve the efficiency of present operation should result in some savings of overtime and fuel/operating cost.

5.3.2 Terminal Detention Time

Car detention time is the most frequently used measure of potential improvement in yard and terminal operations. In Chicago, for example, a reduction in average terminal detention time of two hours was the most readily identifiable goal of the Chicago Rail Terminal Information System. In this analysis, car detention time was examined as an area wherein potential benefits might accrue. As noted earlier, detention time is a function of the time the car is held in each yard of the interchange pair. However, some interchanges which affect detention time are not included because they take place at locations other than the receiving yards' interchange tracks. These would include joint interchanges, set outs, and interchanges on leased tracks. A simplifying assumption has been made which treats all cars interchanged as being a component of the yard pair's detention time.

In the determination of the potential savings in car detention time which could be derived from improved information transfer, the characteristics of each yard and the railroad's operating policies with respect to that yard were examined. It is assumed that the number of interchange trains which each railroad originated, while somewhat flexible, was essentially restricted to one per shift with a few roads having more if the traffic volume dictated. Thus, reductions in individual yard detention times by whatever means did not necessarily result in a like reduction in detention time for the terminal. Individual cars would probably not experience reductions of two or three hours in detention time because even if they were classified expeditiously, they must wait until the next scheduled interchange train which may be several hours away. Also, receipt, inspection, classification, and formation of trains does take a finite amount of time. Hence, the total cost of detention time for Kansas City was not equal to the potential benefit. Secondly, it was assumed that no yard could reduce the detention time for a car in interchange to less than eight hours. Some railroads by necessity already move cars through their yards in less than eight hours. For these, no benefit was derived from reductions in detention time. In one case, the yard of the railroad has internal management needs for information which far exceed the types of information the system proposed here would provide. Doubtless the system could help reduce the detention time, but improved yard management generally would have a far greater net benefit to that railroad.

Unfortunately, benefits from detention time reductions are complicated by several other factors which contribute to the time. Time saved by causing interchanges to occur faster for individual cars, does not necessarily assure a reduction in aggregated detention time for the terminal. The operating policies of the individual railroads with respect to the number of outbound trains they originate from Kansas City and the way in which they schedule these trains have a marked affect on detention time. For example, the Santa Fe's detention time was found to be from 24 to 48 hours, the longest of all the roads in Kansas City. However, the Santa Fe's operating policies call for high speed through trains from Kansas City to one destination, and slower speed trains which pick up and set out en route to a destination. Thus a car may be detained in the Santa Fe yard for 24 hours in order to be put on a high speed train which will result in the car arriving at destination sooner than it would have if the Santa Fe had put it in a slow speed train the previous day. In this instance, there would be no overall benefit from a reduction of as much as 24 hours in detention time.

Using these assumptions about minimum detention time and individual operating policies, aggregate annual savings in dollars for reduced car detention time were determined for the yards in Kansas City. Reduction was expressed as a percentage of present detention time, and savings were derived from Figure 3-2. The results are shown in Figure 5-3 for a total delivery and receipt interchange volume of 11,000 cars per day. Two cases are

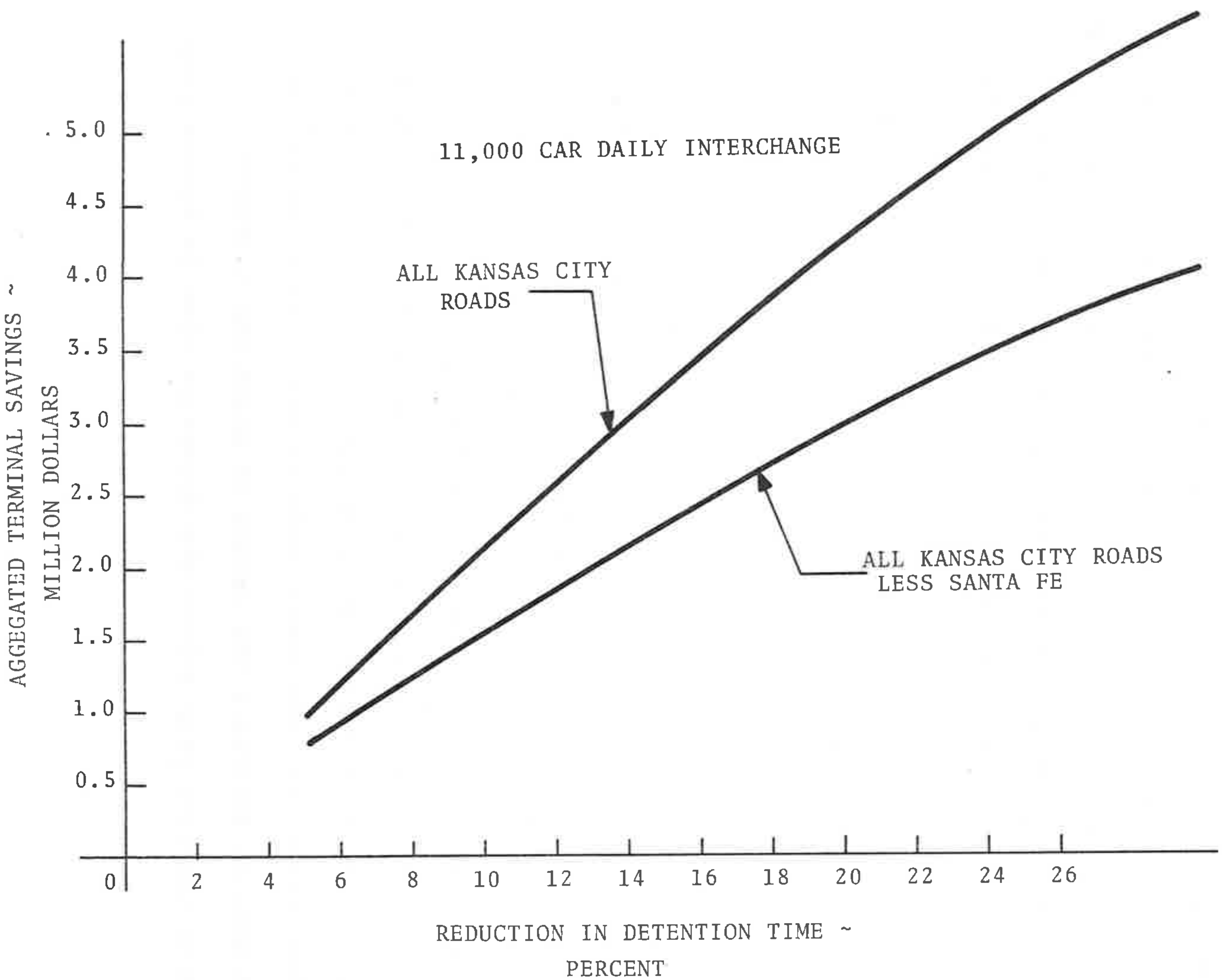


FIGURE 5-3. ANNUAL SAVINGS DUE TO REDUCED CAR DETENTION TIME

shown: all of the Kansas City railroads and all of the Kansas City railroads less the Santa Fe. The latter case was used because of the operating strategies employed by that road. Assuming, for example, that detention time can be reduced by 10% (a three hour reduction for an individual car), annual savings in car detention time of $1.5 to 2.2 million might be realized. The curves can be used to project other levels of improvement. It should be emphasized that these savings are for the terminal as a whole. It should not be inferred that these savings would be evenly spread among the individual railroads for the reasons noted above. For individual railroads, detention time must be viewed on an interchange pair basis keeping in mind realistic classification times and railroad operating policies.

In summary, terminal detention time, a major benefit to the system if reductions can be made, is both difficult to measure and difficult to ascribe to the information system being proposed. This section has indicated the magnitude of the detention presently both in hours and in dollars, and has attempted to characterize the operations among the different railroads so that determination of potential improvements on various inter-railroad moves could be made. It is up to the railroads to determine the extent to which the system's information will help reduce the detention time in Kansas City.

5.3.3 Reduction in Information Errors

Section 3.5 developed costs of three information related problems: no bill cars, open records, and delivery errors. The extent of these errors in Kansas City was estimated from information provided by the railroads. These estimates were for 1.44% no bill cars, 1.45% open records, and 0.71% delivery errors as a function of inbound traffic. The costs noted for these errors are not trivial. The issue becomes one of determining how much reduction in this error and the attendant cost can be achieved, and how much of the reduction would be attributable to the terminal information system. The benefits can only be achieved if the railroads use the information system.

The terminal information system should be useful to the railroads in reducing the number of no bill cars, providing of course that the railroad's central computer has some information concerning the destination and routing of the car. Current industry practice dictating that waybills physically accompany cars would seem to limit the amount of delay reduction possible on no bills. Even if information as to the destination of the car were obtained, the car theoretically at least could not depart until the waybill was actually located and sent to the yard. In reality, railroads frequently move cars with knowledge of the destination; hence overbills (waybills present without a car) are not uncommon. It does seem reasonable that the number of cars on hold tracks waiting for information would reduce with the terminal information system, and that the delay incurred by no bill cars could also be reduced. Figure 5-4 notes the savings possible for various levels of improvement in no bill cars, as a function of the number of inbound cars per day. The curves were derived from the cost of no bill cars shown in Figure 3-7. The cost for a given level of inbound traffic was taken from Figure 3-7 (for example, 7,000 cars cost $350,000). Percentage reductions of 40%, 60%, and 80% were computed (e.g. 7,000 cars yielded $140K, $210K, and $280K respectively). Computations at one other point yields the curves shown in Figure 5-4. For the present level of activity in Kansas City, about 11,000 cars per day, the annual benefit could be expected to be in the order of $330 thousand.

The terminal information system should reduce the number of open records which need to be closed by the railroads. Figure 5-5 shows the possible savings for several levels of reduction in open records. This figure was derived from the cost of open records in Figure 3-8. The curves were derived as a percentage reduction on these cost figures, as described above for no bill reductions. Again, it is up to the railroads to actually determine the amount of improvement possible. One would expect that the overall improvement in quality of data on cars in Kansas City would eliminate many of the data gaps which cause open records, or at least would reduce the number which need to be closed via tracers. The costs of open records (if the data

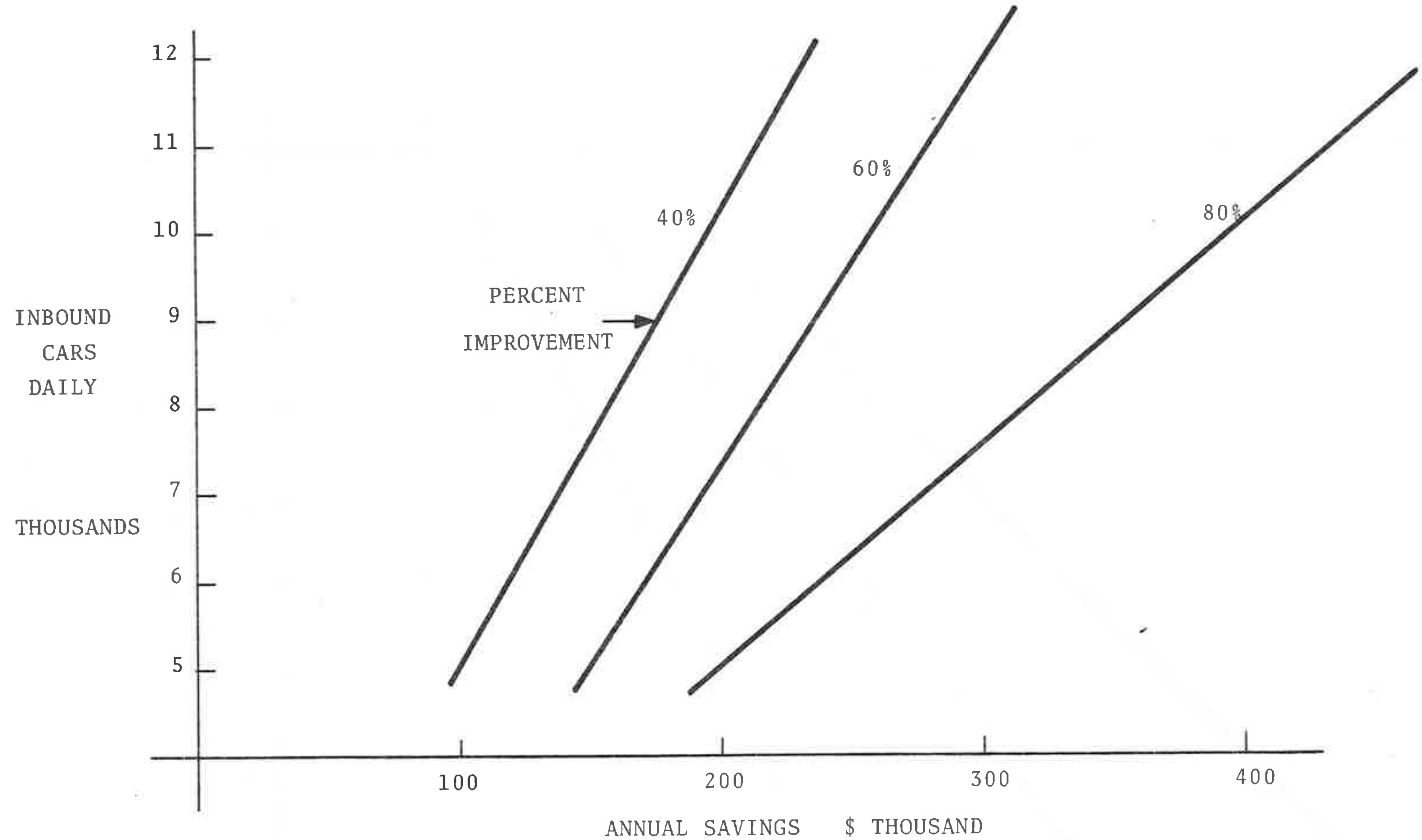


FIGURE 5-4. POTENTIAL NO BILL REDUCTION

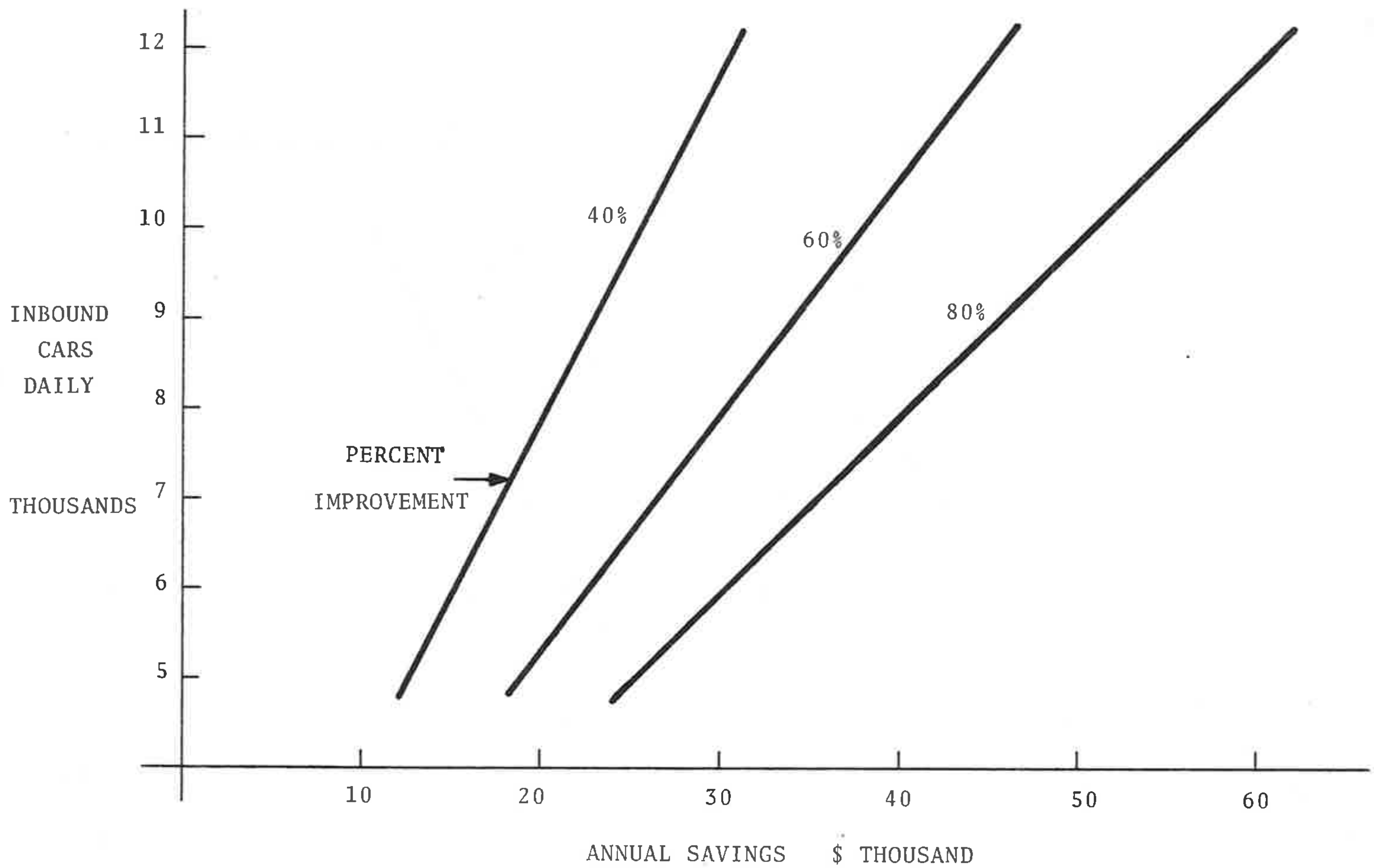


FIGURE 5-5. POTENTIAL OPEN RECORD REDUCTION

provided by the railroads can be considered accurate) is small compared to other benefits. Still, for inbound terminal activity of 11,000 cars per day, the expected benefits would be in the order of $40,000 per year if, for example, open records could be reduced by 60%.

The largest potential benefit in the information error reduction area is that of reduction in the number of incorrect deliveries of cars in interchange. Determining the number of such errors is somewhat difficult. Railroads, quite naturally, do not like to admit such errors, particularly if they reflect on the quality of the road's own information system. Figures provided by the Kansas City railroads do give some indication of the extent of delivery errors (Table 3-4). The railroads reported receiving 82 cars in error per day from other roads, but they admitted delivering only 41 interchange errors. Figure 3-9 was derived from the 82 cars per day figure, and although 0.55% of the received traffic might be considered conservative, these errors resulted in costs to the railroads in the order of $1.2 million as derived in Section 3.5. This is an unnecessary cost in which it would be reasonable to expect substantial reductions. The terminal information system would provide what amounts to a triple check on delivery errors where only one manual check point exists today. The receiving road, the terminal information system operations personnel, and the delivering road will all have the ability to detect potential interchange errors before they occur. Only the delivering road now has the ability to detect such errors, and then only when it performs a physical outbound check. Figure 5-6 shows the range of benefits possible in reducing interchange errors. This figure was derived from the cost of delivery errors developed in Section 3.5 and shown in Figure 3-9. An addition indifference curve for lower potential savings was included. Because delivery errors are often truly mistakes, less improvement would probably occur. Several of the Kansas City railroads noted that while the other information errors could be substantially reduced, delivery error reduction was more limited. It must be noted that the range of benefits assumes the railroad-provided number of errors to be correct. If the number is indeed conservative, the benefits could be substantially higher. For the present traffic volume of 11,000, the benefits of reducing these errors would be in the order of $300 thousand annually even if only 25% of the errors are eliminated.

5.3.4 Clerical Force Utilization

The classic savings attributable to automatic car identification systems in the past has been the reduction in clerks who check the car initial (e.g., ATSF) and car number of cars in trains. While some railroads have actually documented such improvements, generally speaking clerical reductions seem reasonable, but often do not take place when information systems are installed. This is particularly true where the individual

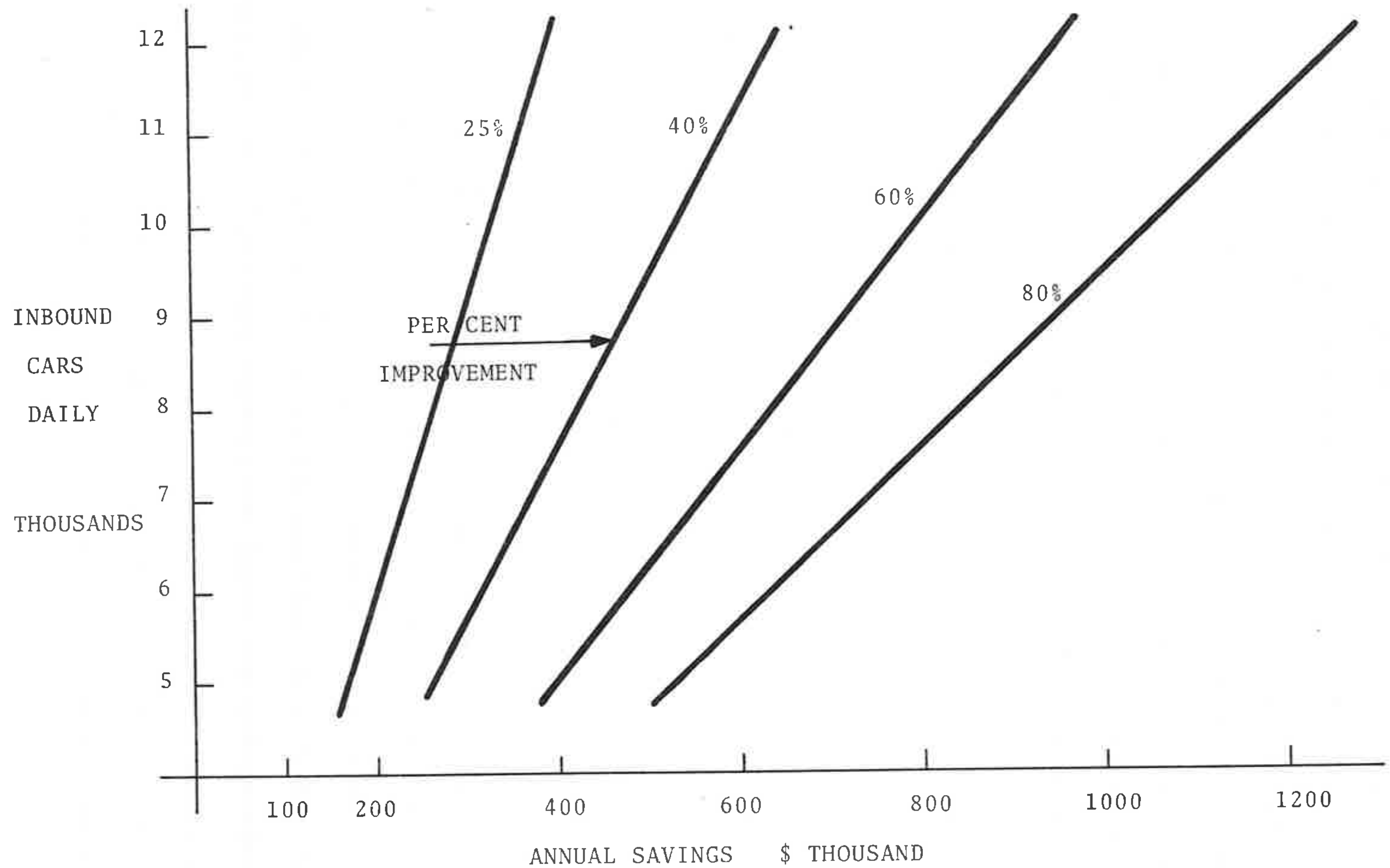


FIGURE 5-6. REDUCTION IN DELIVERY ERRORS

checking cars has other duties as well. One railroad in Kansas City noted that its cars are checked by the personnel who perform the mandatory physical checks of seals on freight cars. Removing the initial and number checking job would not remove the clerk and would therefore probably not result in a savings in that area to that railroad. It does seem reasonable, however, to talk about improvement in the utilization of clerical forces as a result of an information system with ACI as one of its inputs. Whether a railroad chooses to identify this as a benefit, however, would depend on its own operation. Its labor agreements may prevent any reductions in the clerical force and may even restrict the changing of functions.

Several detailed terminal studies were performed during 1974-75 for the United States Railway Association dealing with potential improvements on the Penn Central. These provide insight into labor utilization generally, clerical labor particularly, and provide indication of possible roles for information systems similar to the one proposed for Kansas City (References 2 and 6). The Hines Study found, as noted above, that no clerical savings resulted from the use of information systems on the railroad (Reference 6, p. 157-161 "Labor Productivity and Local Management Control in the Philadelphia and Cincinnati Terminals of the Penn Central" R. L. Hines, July 1975). This was in large part an indictment of the design of the system. Hines noted the importance of developing the information needs and requirements from the terminal level up to the system organization rather than the other way around. Much of the information available through the Penn Central's system was unusable by local operating personnel.

The Management Science Study which dealt more with labor utilization noted that clerical labor utilization could be improved by the training of management in short interval scheduling (Reference 2, p.6-1 to 6-19). It found inefficiencies in the jobs performed, over-specialization of jobs, a disparity among individuals in terms of work load, and an overall clerical labor productivity of 61.6%. (Reference 2, p. 3-5) Planning and scheduling of jobs was judged to be inadequate and often nonexistent. The functions and objectives of the proposed information system for Kansas City address many of these problems. The system is intended to provide the kind of information which could be used to better schedule labor resources. As noted, this has been difficult historically. Perhaps a real benefit of the system is providing a basis for standardizing many of the operations and jobs now performed in a reactive or haphazard way by the railroads. It is the feeling of the authors that reductions in this clerical force will not generally occur as a result of the proposed information system. Penn Central experience as noted in the two USRA reports indicates this as well. Individual railroads can draw their own conclusions as to the possibility of reduction in the number of clerks.

It is quite reasonable, however, to expect the job content and productivity of much of the clerical labor force to increase. Management Science indicated an expected improvement of as much as 25% from the present 61.6% productivity (Reference 2, p. 3-22). Figure 3-6 displayed the cost per car of clerical labor and Section 3.4 noted the relationship of clerical productivity to cost. Figure 5-7 shows the per car savings possible from various levels of productivity improvement. The curve is derived directly from Figure 3-6. For example, a 10% increase in productivity from 60% to 66% gives a reduction in per car clerical cost of $.06 from $.72 to $.66. This point appears on the curve of Figure 5-7. By multiplying the per car savings by yearly traffic volume, Figure 5-8 was derived. Three indifference curves for varying levels of volume are shown. As noted in Section 3.4, current volume is about 28,800 cars. This means that a 10% improvement in clerical productivity would result in a savings of about $630 thousand per year. (The cost savings assumes that an additional productive hour is worth an hour of pay). The major productivity gains would be expected to occur in the Train, PICL (Perpetual Inventory Car Location), Car Record, Interchange, and Car Correlator positions. These positions represent 205 clerks or $3.27 Million per year (from Table 3-3). If one assumes productivity increases in the IBM

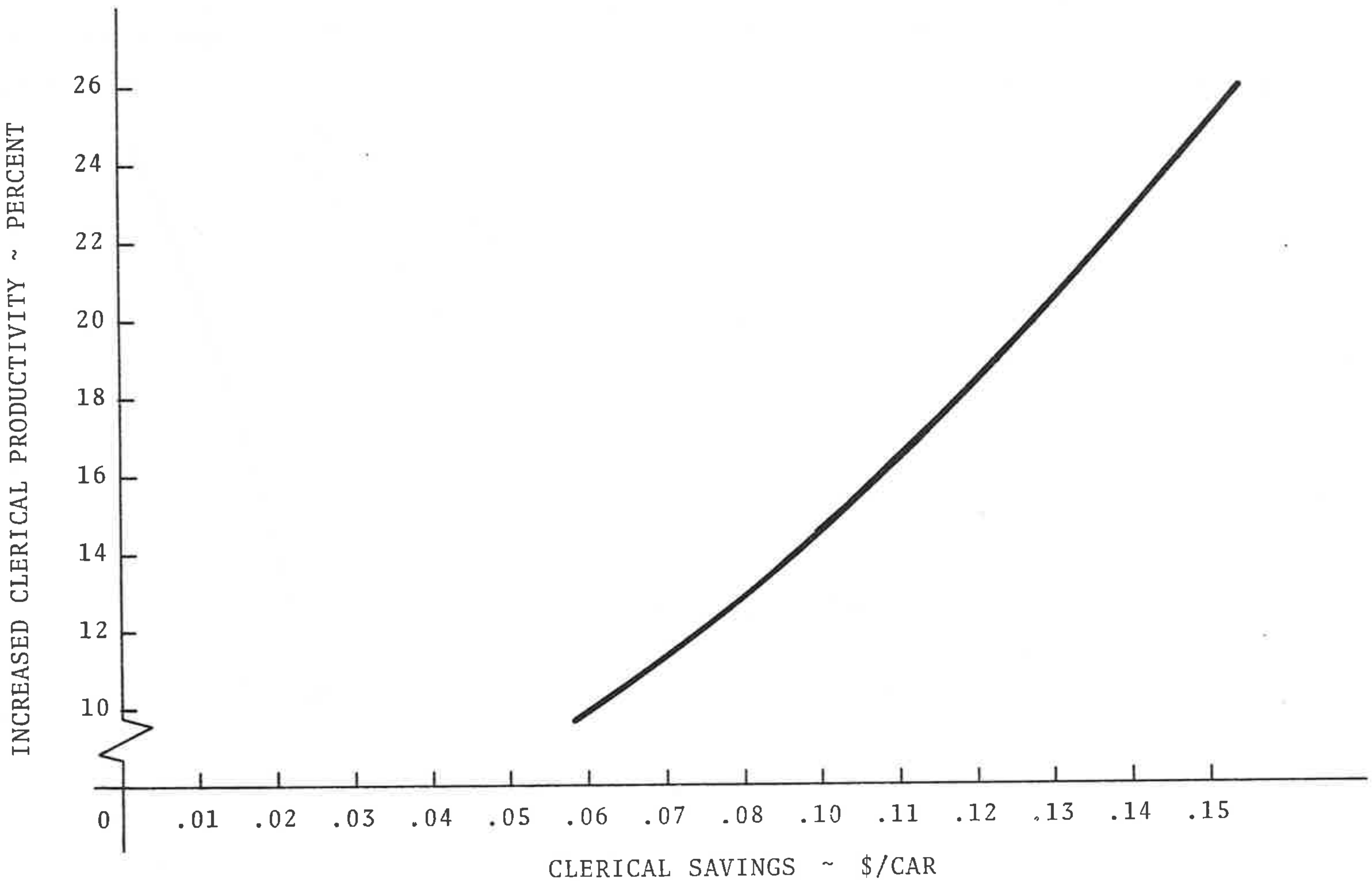


FIGURE 5-7. INCREASED CLERICAL PRODUCTIVITY VS. CLERICAL SAVINGS

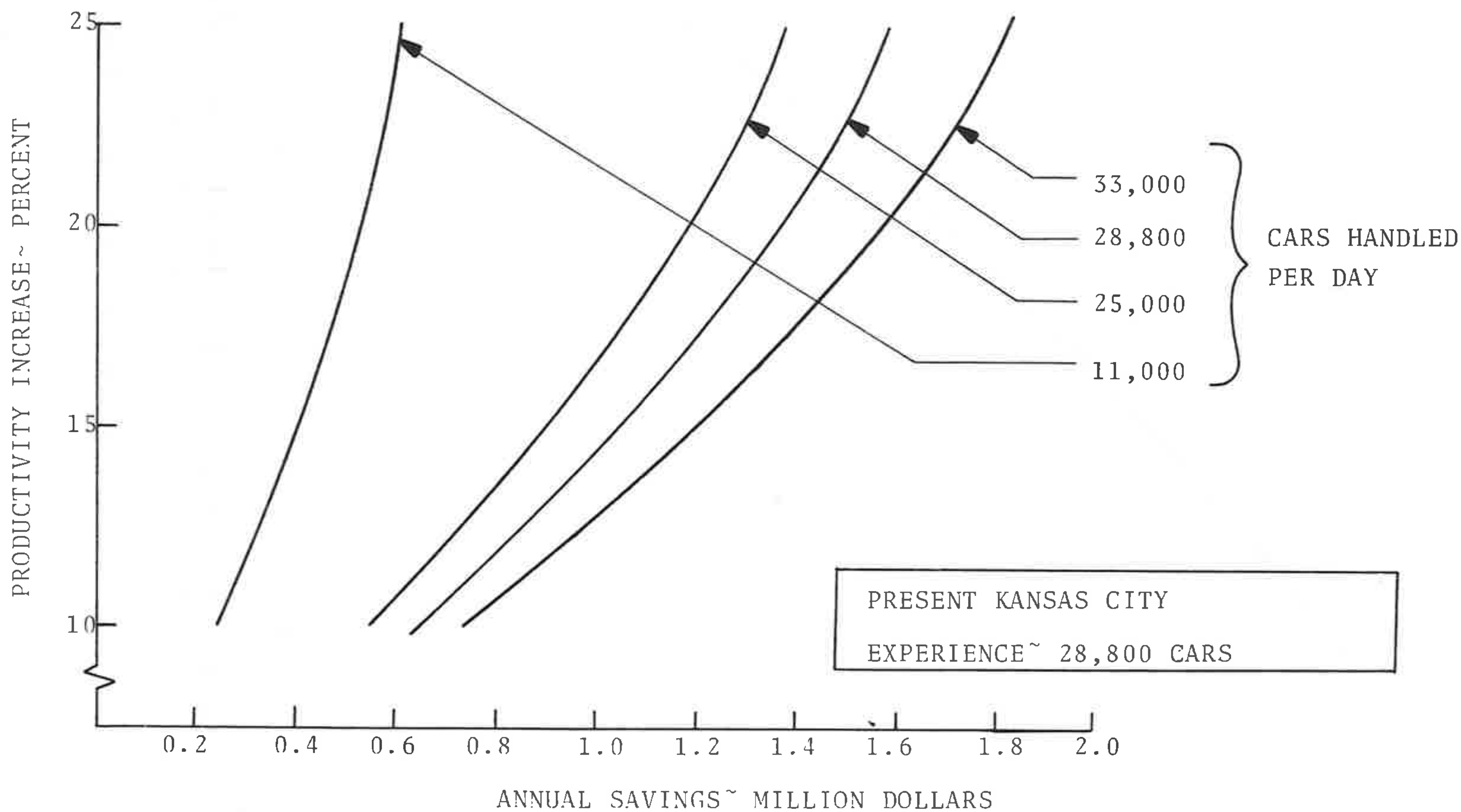


FIGURE 5-8. ANNUAL CLERICAL SAVINGS DUE TO INCREASED PRODUCTIVITY

clerks and agency personnel as well, the number involved is 473 clerks and the total cost is $7.55 M. It is expected that the increases for agency personnel might be less than for the aforementioned positions. Agency jobs involve interface with customers and would not be so affected by the information system as some of the other positions which involve the preparation of switch lists, etc. Determining car status and location for a shipper would be far easier by virtue of the inquiry capability of the system, but generally one would not expect so significant productivity gains as with the other clerks.

The system will require some additional clerical labor at some locations to provide timely input to the system. In addition, some additional labor will be required at the central computer office. In both cases, this means an expansion of duties rather than addition of personnel. For this reason, the IBM clerk position, while it may increase its productivity may also increase its duties and thus not derive specific benefit from the system. For the sake of simplicity, it was assumed in deriving Figure 5-7 and 5-8 that productivity increases uniformly in the clerical force without regard to the specific position. This may overstate the potential of clerical savings somewhat.

5.4 SUMMARY OF BENEFITS

The following type of benefits have been identified in Section 5.2 and 5.3 for the proposed Kansas City terminal information system

1. Management overview by KCT Railway (Section 5.2.1)
   (Benefit to terminal)

2. More efficient traffic control operation (Section 5.2.1)
   (Benefit to terminal)

3. Inventory of cars in Kansas City (Section 5.2.2)
   (Benefit to terminal and individual railroads)

4 Car inquiry capability - individual cars or groups of cars (Section 5.2.2)
   (Benefit to individual railroads and shippers)

5 Improved interchange management (Section 5.2.3)

   A. Offering and acceptance procedure
   B. Verification of number of cars for interchange
   C. Certification of time of interchange
   (Benefit to individual railroads)

6. Reduction in excess or erroneous car handling (Section 5.2.4 and Section 5.3.3)

   A. Open records
   B. No bill/over bill
   C. Delivery errors
   (Benefit to individual railroads)

7 Better operations planning (Section 5.2.5)

   A. Switch engine utilization (Section 5.3.1)
   B. Car detention time (Section 5.3.2)
   C. Clerical labor utilization (Section 5.3.5)

   (Benefit to individual railroads)

5.5 SYSTEM BENEFIT EXAMPLE

Most of the benefits described above are at present not quantifiable. For those that are quantifiable, the estimated present cost was developed in Section 3 and potential ranges of improvement have been developed in Section 5.3. In order to compare the costs and benefits of the system, a hypothetical but reasonable improvement example will be described here and the benefits in dollars will be calculated. It must be understood that this is an example of what seems to be possible for the terminal as a whole, based mostly on data provided by the railroads in Kansas City. No significance should be placed on the amount of improvement assumed for the example. The benefits to individual railroads may vary considerably. In some cases, no benefits may actually occur; in others, greater improvement may be possible. In addition, use of the terminal information system by the railroads may result in actual savings not presently identified. Additionally, better data about current railroad experience or the cost estimating procedures could change the results. In particular, railroads may be able to identify real dollar benefits from the benefit areas not quantified in this report.

For this example, the daily inbound volume of cars in Kansas City is assumed to be 11,000. This is consistent with present Kansas City volume. All switch engine overtime is eliminated because of the ability to better schedule the use of engines.

The normal operational productivity is assumed to improve slightly as well resulting, from Figure 5-1, in a productivity improvement of 8%. This gives an estimated savings of $6.5 million per year.

Car detention time for the terminal is assumed for this example to improve by 10%. This results in a reduction of the average time through Kansas City from 30 hours to 27 hours. It should be noted that Figure 5-3 represents a road by road assessment of present detention time, car movements, and operating policies. Using the lower savings curve without consideration of the Santa Fe for the reasons cited in Section 5.3.2 results in a detention time savings of $1.5 million per year.

Error reductions of 60% were assumed to be reasonable for no bills and open records. A 25% reduction was assumed for delivery errors. From Figures 5-4, 5-5, 5-6, this results in the following savings for the hypothetical example:

No bill cars	$329 K
Open Record	$ 42 K
Delivery Errors	$365 K per year.

All of these savings, as with the others in the example, assume traffic volumes of 11,000 car per day.

Productivity of the clerical force is assumed to improve by 15% by the automatic input of some information, the timely and accurate receipt of most data, and better operations planning which can result from the use of the terminal information system. From Figure 5-7, the clerical savings is noted to be $0.103 per car. This gives a $413K savings per year. Since clerical labor is involved for all cars handled, the assumed savings here is probably understated. Figures 5-7 and 5-8 were derived using present volumes of 28,000 cars. For this hypothetical example, the volume of 11,000 was used for simplicity and consistency with the other benefits.

In summary, the results of the benefit calculations for this example are:

8% switch engine productivity improvement	$6.5 million
10% car detention time reduction	$1.5 million
60% error reduction in no bills	.33 million
60% reduction in open records	.04 million
25% reduction in delivery errors	.36 million
15% clerical productivity improvement	.41 million
Total annual benefits with 11,000 cars per day	$9.14 million

It must again be emphasized that this is an example of the savings possible if the railroads effectively utilize a terminal information system. The curves derived in Section 5 can be used to compute other examples of potential savings if the railroads were to effect different levels of improvement.

6. RAILROAD IMPACTS

6.1 RAILROAD INPUT REQUIREMENTS

6.1.1 Inbound Advance Consist

It has been noted in Section 4.2 that the proposed terminal information system was designed as much as possible to minimize impact and clerical effort on the part of the railroads' central computer operations and Kansas City yard personnel. The primary inputs required from the railroads are advance consists on every inbound train to Kansas City, as well as similar consist information on interchange movements between the railroads. Information provided by all of the railroads indicated that all receive advance consists on their own through trains from major terminals to Kansas City. One railroad did note during the TSC interviews that it had not received a consist in a week. It is reasonable to assume in any case that providing advance consist input to the information system will not be a problem for trains destined for Kansas City. And as noted, the system will automatically receive the consist at the same time the consist is sent to the railroad's Kansas City offices.

For local trains (commonly called "way trains"), the advance consist input may be more complicated. These trains provide pick up and delivery service to small non-mechanized yards or industries along routes as much as 100 miles in length from Kansas City. Waybill information about the contents of these types of trains is not usually reported accurately and timely to the railroad's central computer, and would therefore not be available to the terminal information system until the train arrives in Kansas City. The method used by the railroads to provide waybill input from these outlying areas on the railroad varies from carrier to carrier. The Missouri Pacific is moving toward a system in which virtually every manned station has a CRT terminal which can communicate with the central computer. The Milwaukee, with only a teletype link with its computer from Kansas City, has manual communications means at its small terminals. The sacrifice is primarily in the timeliness of the data input. It is not uncommon for a local train to service a small yard or siding and depart with the train information being provided to the central computer one to several hours later. Depending on the length of the input delay, the train may already have reached Kansas City. If a consist is received on such a train, it may well not include cars picked up at shippers since the last station, and may show cars in the consist which were delivered en route to Kansas City. It is for this reason that the railroads indicated a 25% accuracy for local train consists. Of course, this is one of the key functions and advantages of the ACI scanners. These scanners would provide an accurate train order list before the train arrives. Unless waybill information exists on the cars, however, the list is of no use in classification. Thus the advance consist waybill information is critical to success of the Kansas City information system.

6.1.2 Computer Interface

It was proposed in Reference 5 that each railroad's central computer provide the consist inputs to Kansas City automatically. This will involve some sort of interface mechanism or programmable switch which will address the Kansas City information system whenever advance consists are sent to the railroad's office in Kansas City. Modification to software will also be necessary in order to address the Kansas City system. While this is probably not a major cost compared with the system as a whole or with the benefits to be derived from the system, it is nonetheless a direct cost and effort to the data processing personnel of the railroad. Task Force #3 of the AAR Car Utilization Program found considerable opposition to proposed modification to the Car Location Message system on the railroads because of the software modification needed to provide Car Location Messages to more than one addressee. Although the impact of automatic consist input for each railroad is probably not significant, it must be presented to the railroads as an impact early in the program.

6.1.3 Interchange Consists

The other major impact on the railroads will be in the communication of train list and waybill information to the information system upon the departure of interchange trains within the Kansas City terminal. It was noted earlier that the interchange operations presently conducted in Kansas City are largely unscheduled and loosely controlled. If waybill information in train order is to precede a train in interchange with another railroad, the waybill data on cars to be interchanged will have to be promptly input to the information system. As with the receipt of consists on inbound trains, the system would be designed to receive waybill information on interchange moves at the same time that the Kansas City yard provides the movement information to its own central computer operation. Where this procedure currently takes place before the train actually moves, there will be no adverse impact on clerical forces. If, however, input of interchange information takes place at the convenience of the local clerical personnel at times varying from fifteen minutes to several hours, the impact on that railroad will be major in its data reporting requirements. For a long interchange move from Neff Yard of the MoPac east of Kansas City to Argentine in Kansas, a delay of fifteen to twenty minutes might not interfere with proper operation of the system. But for moves requiring only a short time to complete (such as the MOPAC to KCS/Milwaukee), information transmission before or at the time of departure of the interchange train is crucial. The time of input of interchange information by each railroad in Kansas City is not known. One can assume from interview results concerning the extent of use of facsimile that such information exchange is haphazard and untimely. Special effort will be required during the design phase of the program to determine the timeliness of this data input and the effort that will be required to make the necessary input to the proposed information system.

It can be seen then that even though the system is being designed to minimize impact and additional effort on the part of the railroad's clerical forces, there are definitely additional input requirements by the railroads which are essential to system success. Every effort needs to be made during the design phase of the program to thoroughly review these requirements with the railroads and to design the system as much as possible to accommodate operating procedures.

6.2 SYSTEM COSTS

Aside from the input requirements above, the individual railroads are impacted by the system in its development, implementation, and operating costs. This is particularly true since the railroads are equal owners and all contribute to the operation of the Kansas City Terminal Railway. Any operating costs of the new terminal information system would be reflected in higher terminal operating costs for each of the railroads.

This section addresses the estimated costs for the proposed terminal information system.

6.2.1 System Development and Implementation Costs

In work it performed for the KCT, ACI Systems Corp. (ACIS) developed estimates for the hardware, software, and development costs. Those estimates are reproduced in Table 6-1 with the caveat that they are dependent on the computer and scanner configurations chosen during the design phase. The costs provided by ACIS seem to be the correct order of magnitude for the type of hardware and software required for this type of information system. It is these costs which the Kansas City Terminal Railway proposes to be funded in whole or in part by FRA.

TABLE 6-1

DEVELOPMENT AND IMPLEMENTATION COSTS

Hardware - computers, scanners, communications, interface devices, I/O terminals	$2.78 Million
Software - message handling, input/output, data processing, report preparation	$2.28 Million
System Development - design study, management, system integration, system assessment	$1.29 Million
Total Development and Implementation	$6.35 Million

6.2.2 System Operating Costs

Unlike the development and implementation costs which are one time and for which Federal assistance is desired, the operating costs of the system would be borne by the railroads in Kansas City through the KCT in some sort of funding arrangement based on traffic or interchange volume. It is these recurring costs which are especially important to roads like the Rock Island that are bankrupt. It seems reasonable to represent these costs as a worst case by those experienced in the similar computer-based operation in Chicago. The Chicago Rail Terminal Information System (CRTIS) provided TSC with actual data on computer, ACI, and communication system operating costs in Chicago. Since Chicago's system covers a larger area with higher data volumes from more railroads and more scanners, it would be expected that the Kansas City system would not exceed the operating cost of the Chicago system. For the computer costs, Chicago data are used to represent expected Kansas City cost. For ACI operating costs, the Kansas City figures were adjusted for the difference in the number of sites and scanners to be used (44 at 17 sites versus 109 at 40 sites for Chicago). For communication costs, a cost per data line was computed from the Chicago data, and assumptions were made by TSC with respect to the number of lines required to interface scanner sites and railroads to the terminal information system. Since the communications requirements for Kansas City are not known at this time, this cost may be very different when the system is operational. It appears to be the right order of magnitude, however.

6.2.2.1 Computer Costs

The development costs above assume purchase of a computer system by the KCT. This would of course be more beneficial to the railroads if FRA is paying a share of the cost. If FRA does not participate, leasing of computers (directly from the manufacturer) may be more financially attractive and includes all maintenance. Under the purchase option, operating costs are:

	(In Thousands)
Computer Operations (Labor and utilities)	- $116.9 per year
Computer Maintenance (Labor and parts)	- $ 49.3 per year
I/O Device maintenance	- $ 1.5 per year
Computer Peripherals (Lease and maintenance)	- $ 49.1 per year
Software Maintenance (Labor)	- $ 55.2 per year
Computer Supplies (Disc rental, paper, etc.)	- $ 9.4 per year
TOTAL Annual Computer System Costs	- $281.4 per year

6.2.2.2 Automatic Car Identification Costs

As proposed by the KCT, the information system would use 44 automatic car identification scanners at twenty different sites in the Kansas City area. The cost of these scanners was estimated to be $721. thousand of the $2.78 million hardware cost for the system. A reasonable estimate for scanner maintenance (provided by the manufacturer, ACI Systems, as well as several railroads) is 1.5% of the purchase price per month. For the 44 Kansas City scanners proposed, this would be $10,815 per month or $129,780. per year for parts and labor. Chicago Rail Terminal Information System experience with its scanners show comparable figures - $9086 labor per month plus $2700 parts for a total of $11,786 per month or 1.63% of the purchase price. The yearly total would be $141,432. This figure from Chicago will be used in this analysis.

The other ACI-related cost is that of electrical and telephone service to the huts which house the computer control devices for the scanners. For Kansas City's twenty sites, based on Chicago experience, utilities would cost $11,969. per year. Assuming that one telephone would be included at each site, Kansas City's telephone service to the ACI sites, again based on Chicago experience, would be $3,746. per year. This gives a total utility cost for the ACI sites of $15,715.

Total ACI costs for system operation are therefore:

Scanner maintenance	$141,432. per year
Site utilities	$ 15,715. per year
TOTAL ACI operating costs	$157,147. per year

6.2.2.3 Communications Costs

Neither the background work and proposal by the KCT nor this analysis addressed the issue of communications requirements. It is quite clear that the communications requirements for automated input and output to and from a central computer facility are large. What is not clear is the extent to which the existing communications systems of the twelve railroads could be used without additional cost to meet this requirement. This determination is an important element of the design study for the system. It would appear that, as a minimum, communications facilities will be required for input of the ACI data from the twenty sites to the KCT computer center. The KCT will also require some terminal devices for communications with the various railroads. The extent of each railroad's communications system will determine whether additional modems and data lines will be required. The Chicago experience provides one estimate which can be used to assess the minimum cost until better information is available. For ACI data input, ten data lines and the necessary data modems, the monthly lease is $3,770. or $45,240. per year. Additional data lines would be required for railroad input of interchange data to the terminal information system. Assuming one line per railroad, the monthly cost for twelve data lines and necessary modems would be $4,524. or $54,288. per year. The total communications cost would thus be $99,528.

6.2.2.4 Operating Cost Summary

The total operating cost from the previous sections then is:

Computer Costs	$281.4 K
ACI Costs	$157.1 K
Communications	$ 99.5 K
TOTAL	$538.0 K

6.3 Benefit/Cost Analysis

The results of the benefit calculations in Section 5.5 can now be combined with the cost data developed in Section 6.3 to produce net benefit and benefit/cost ratio calculations. From Section 5.5, the benefits computed for the example are:

Annual System Benefits

8% switch engine productivity improvement	$6.5 million
10% car detention time reduction	$1.5 million
60% reduction in no bills	$ .33 million
60% reduction in open records	$ .04 million
25% reduction in delivery errors	$ .36 million
15% clerical productivity improvement	$ .41 million
Total annual benefit	$9.14 million

For this analysis, we assume a twenty year project life. Because of the development and implementation phase, it is assumed that no benefits accrue during the first five years.

While this in fact may not be true, it does conservatively state the benefits. The present value of the benefits of $9.14 million per year from the sixth to the twentieth year of the project was then calculated using a 10% discount rate.

<u>Present value of benefits $43.16 million</u>

From Section 6.2, the expected system operating costs are:

Annual System Operating Costs

Computer operating cost	$ .28 million
ACI operating and maintenance cost	$ .16 million
Communications systems lease and operating Cost	$ .10 million
Total Annual Cost	$ .54 million

Again, the twenty year life is assumed and the present value of the system cost was determined for years one through twenty at a 10% discount rate.

<u>Present value of cost $4.60 million</u>

As noted in Section 6.2, the development and implementation cost for the project is $6.35 million to be expended in the first three to five years of the project. In addition, a $500 thousand cost for a one year design phase is assumed. For the sake of simplicity and to present a worst case, it is assumed for this analysis that the entire design phase and development cost is expended in the beginning of the program and is borne entirely by the railroads. In other words, the present value of the design and development cost is $6.35 million plus $.50 million or $6.85 million.

Net benefits of the terminal information system development thus are:

present value of benefits - present value of costs - development cost

$45.62 - $4.60 - $6.85 = $34.17 million net benefit

For benefit to cost ratio, the net benefit above is divided by the development cost to give:

$34.17 / $6.85 = 4.99

Another way of viewing the benefits of the system is that the net benefit in any given year after the system is operational is:

$9.14 - $0.54 = $8.60 million

7. RECOMMENDED PROGRAM*

7.1 APPROACH

The foregoing discussion indicates the economic and operational feasibility of the information system concept proposed by the Kansas City Terminal Railway for improving interchange operations in Kansas City. The section on benefits shows that the operations of the railroads in Kansas City will be improved by implementation of the information system with commensurate savings in time and dollars. There is, however, one caveat - the railroads must use the system and the information it provides. Hence, the importance of railroad involvement cannot be overemphasized. Each of the thirteen railroads must be involved from its inception and participate in the design phase of the program.

The system concept work on ACI scanners and the computer hardware and software configuration has been completed. Now the system will require a major analysis and formulation of the detailed design and system specifications in conjunction with the railroads. The proposal describes automatic input of data from railroad central computers to a computer in Kansas City. The hardware, software, and railroad institutional considerations of such data input need to be addressed in the design phase.

---

*The suggested program indicated in the following section assumes a degree of federal participation both through financial assistance and technical advice.

It is clear that strong management of the design, development, and implementation phases is essential to success of the program. The management of such a program should be experienced in the acquisition of large, computer-based information systems including system integration and evaluation. If federal funds are to be applied to the project, the KCT is the logical contracting vehicle. In addition, it is in the best interest of both the KCT and the Federal government that an organization with available technical resources monitor and review the system design activities, coordinate with the railroads, and conduct the project evaluation. Finally, it is the KCT which must actually procure the hardware and software of the information system.

Three major phases are recommended for this program.

Phase I - System Design Study

Phase II - System Implementation

Phase III - System Operation and Evaluation

Each is described below. Appropriately, the Phase I design study is described in more detail than the other two phases.

7.2 PHASED PROGRAM

7.2.1 Phase I - System Design Study

This detailed system design study would be initiated after the railroads in Kansas City approve the project and FRA authorizes initial funding and a commitment for future funding of the project. The result of the study would be detailed design specifications for the Terminal Information and Message Exchange system for Kansas City. The FRA should select an organization to monitor and review this design study. A suggested project organization chart is shown in Figure 7-1. The design study would build upon the hardware and software design concepts included in the April 1975 proposal. System inputs and outputs should be defined in detail. Any additional information about operations in Kansas City which is considered necessary in order to successfully design and evaluate a terminal information system should be acquired.

The methods and techniques of consist, train list, and waybill information input by the railroads should be defined in detail. This includes design specifications of the automatic input device to be used to obtain data from each of the railroads' central computers. An advisory committee of railroad personnel should assist in the design review and negotiation with each railroad. Detailed design specifications for the hardware systems - computers, peripherial devices, ACI scanners, and communications devices - should be prepared including site location definition for scanners, computer terminals, communications equipment, and computer interface devices.

Specifications for software systems should also be prepared. Software developed in previous FRA projects, i.e., CRTIS, KCS-Shreveport, Grand Trunk, and Missouri Pacific should be reviewed for applicability and transferability to the Kansas City system.

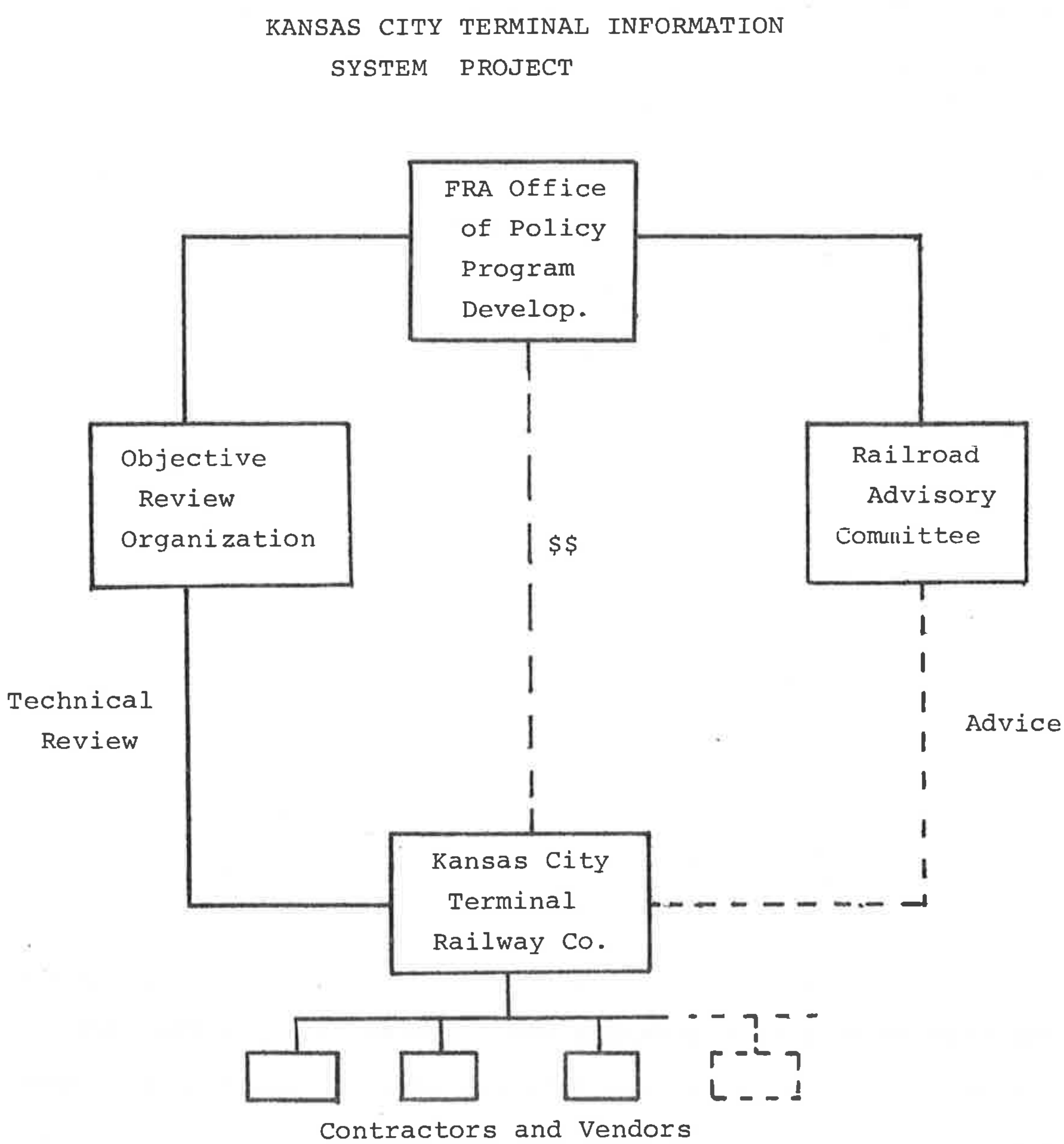


FIGURE 7-1. SUGGESTED PROGRAM ORGANIZATION

A system operations document should be prepared in conjunction with development of system level specifications. Report generation software and interface control routines should be specified in detail. FRA or its representative and the railroad advisory committee would review the detailed specifications. Suitable test and validation procedures would be prepared and approved by FRA.

This design phase should be completed as soon as possible after project approval, if possible within one year, and should be performed so that all parties to the project have a detailed understanding of and concurrence in the design and projected performance of the terminal information system. This is particularly critical to assure railroad participation in the system operation. The estimated cost of the Phase I activity is $500 thousand.

7.2.2 Phase II - Implementation

After successful completion of the design phase and development of detailed specificattions, the implementation of the system would commence. This would involve procurement of the necessary hardware by the Kansas City Terminal Railway; installation, check out, and test or validation of the system; and programming of the system software by a contractor selected by the KCT. Evaluation plans and test procedures would be developed and carried out as appropriate in order to verify proper operation of the system. The railroad advisory committee would be involved at all levels appropriate to assure carrier involvement in and use of the terminal information system. The implementation phase would take place over a one to three year period following the approval of the design phase.

7.2.3 Phase III - Operation and Evaluation

Once the system is in full operation, it is important to assess the use of the system by the railroads and to measure any improvement in terminal operations, including benefits identified in this report. Such system evaluation would demonstrate to the Federal government and the railroads the wise expenditure of funds for the system. It would also allow future expansion of system capabilities for use in other terminal areas such as New Orleans, St. Louis, or Detroit. The evaluation would also be useful for improving the procedures involved in estimating benefits of railroad improvement projects. It would also provide feedback in order to make any modifications required for the Kansas City system. A two year evaluation program would be conducted after the system is fully implemented.

7.3 RAILROAD ADVISORY COMMITEE

It is recommended that a committee of personnel from the various railroads in Kansas City be established at the inception of the Phase I design study to work with FRA or its representative, the KCT, and the contractors selected to perform the design studies. The committee would provide assistance in reviewing system functions, in identifying railroad inputs and outputs, and in acting as the key interface with the railroads in Kansas City. The committee should consist of representation both from Kansas City personnel and headquarters personnel from the various railroads. The personnel should include operating, management information systems, and agency representation. Participation would be contributed by the various railroads from the railroad portion of funding for the project. This committee would assure railroad involvement and cooperation during the project and would enhance participation and use of the information system by the railroads. In addition, the success of the FRA program would be enhanced.