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ABSTRACT

The major objectives of the study were to produce a storage/transportation model which minimized (1) the cost of storage space for book materials, and (2) cost of transportation for book materials. In minimizing these costs, they are considered in relation to the time required to provide service. The data used in the study include land and construction costs, library space usage and transportation data. These data analyzed on an annual cost-per-volume basis enabled a comparison of all of the alternative models on a common denominator. Two versions of the final model are presented. The first presents a solution to the delivery problem at the current rate of transaction between the five member libraries. Of the alternatives studied, United Parcel Service provides the optimum time-cost trade-off in this case. The second version proposes that a high density storage library be built, incorporating a computer-controlled Randtriever system. This configuration solves not only the storage space problem but also enables the utilization of FAUL-operated vehicles, offering the cheapest and fastest delivery service when the loads are high enough. The centralization of these materials-handling services can also support other services which the libraries may wish to consider, e.t., computerized coordinated acquisitions, serials control, status file interrogation and microform services. (Author/AB)

Five Associated University Libraries

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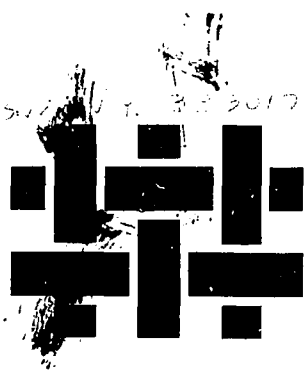

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A FAUL TECHNICAL MEMORANDUM
FTM 70-3

AN ANALYSIS
of
BOOK STORAGE AND
TRANSPORTATION REQUIREMENTS
of
THE FIVE ASSOCIATED UNIVERSITY LIBRARIES

by Tesfaye Dinka
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AUGUST 1970

CONTENTS

INTRODUCTION TO THE SERIES

The purpose of the FAUL Technical Memorandum (FTM) series is to disseminate quickly to librarians and information scientists the objectives, methods, procedures, analyses, conclusions, and recommendations relating to the performance of small projects in applied research. These projects may be imbedded in large long-term efforts, or they may have been undertaken to answer specific questions which bear upon the rational improvement of library procedures and services. Furthermore, such research may have been done wholly within a single library and by its own staff, or by the FAUL Central staff or committees, or by outside specialists under contract.

The material contained within these reports is used by appropriate FAUL staff in planning and decision-making, as well as for preserving an historical public record of the technical interests of the Five Associated University Libraries.

 Comments, corrections, and suggestions for improvement are most welcome.

These memoranda are sent to the ERIC/Clearinghouse on Library and Information Science in Washington, D. C. for announcement in its publications and in ERIC's monthly abstract journal *Research in Education*.

Ron Miller
Coordinator of Library Systems
Five Associated University Libraries

1.0 ABSTRACT

The initial purpose of this study was to analyze the transportation alternatives available for delivery of inter-library loan material between the Five Associated University Libraries. However, the authors became convinced that the five libraries would receive greater benefit if centralized compact storage was also considered as part of the study.

Thus, the major objectives of the study was reformulated to produce a storage/transportation model which minimized:

1) cost of storage space for book materials

2) cost of transportation for book materials

In minimizing these costs they are considered in relation to the time required to provide service.

The data used in the study include land and construction costs, library space usage and transportation data. They are presented in Section 4.0.

In Section 5.0 these data are analyzed on an annual cost-per-volume basis. This procedure enabled the investigators to compare all of the alternative models on a common denominator.

There are two versions of the final model in Section 5.0 - 5.4. The first version presents a solution to the delivery problem at the current rate of transaction between the five member libraries. Of all the alternatives studied, United Parcel Service provides the optimum time-cost trade-off in this case. The second version proposes that a high density storage library be built, incorporating a computer-controlled Randtriever system. This configuration solves not only the storage space problem but also enables the utilization of FAUL-operated vehicles, offering the cheapest and fastest delivery service when the loads are high enough. The centralization of these materials-handling services can also support other services which the libraries may wish to consider, e.g. computerized coordinated acquisitions, serials control, status file interrogation and microform services.

2.0 BACKGROUND

Convinced of the benefits of cooperation among university libraries, Syracuse University, the State University of New York at Buffalo, Cornell University, University of Rochester, and the State University of New York at Binghamton have established the Five Associated University Libraries (FAUL) consortium. "The purpose of the association is to promote and implement cooperative projects which increase the usefulness and availability of library materials and services to the student, faculty, staff and research communities at each member university."[1/] Specifically FAUL hopes to promote cooperation in such areas as "staff pooling, resource sharing, transportation and delivery services, and cooperative experimentation with new technologies."[2/] The present study addresses itself in part to each of the specific organizational objectives as it seeks to examine book delivery systems and centralized storage.

3.0 THE GENERAL PROBLEM

In this study the authors attempt to investigate and compare various storage and transportation methods so as to optimize the usage of the library facilities of all five institutions. Taking into consideration the future expansion and space requirements of the five libraries, the objectives of our model are to minimize the library space needed to house materials, to minimize delivery and operating costs as functions of expended time.

1/ *FAUL HANDBOOK*, May 1970, p. 2.
2/ *Ibid.*, p. 2.

4.0 DATA

Most of the data needed for the study were available either from the office of the Coordinator of Library Systems, FAUL, based in Syracuse, pertinent literature or from various reports done by or for the five member universities. Data about land and constructions costs, rates for leasing and purchasing vans, the time expended in processing interlibrary loan requests and vehicle maintenance costs were gathered by means of interviews and observations conducted in Syracuse. In a changing economy, cost figures change rapidly.

4.1 Land and Construction Cost Data

ITEM	COST
On-campus Land Cost	$5/sq. ft.
Off-Campus Land Cost	$2/sq. ft.
Conventional Library Construction Cost	$35/sq. ft.
High Density Storage Construction Cost	$20/sq. ft.

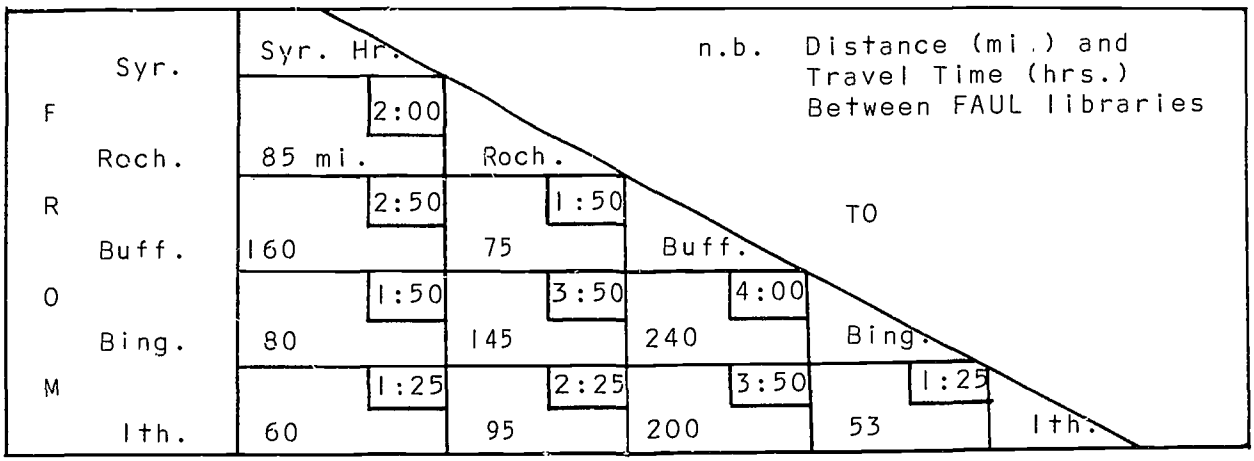
*4.2 Library Space Data**

Conventional	15 Vols/sq. ft.
High Density	
(a) Yale System	64 Vols/sq. ft.[3/]
(b) Randtriever System	147 Vols/sq. ft.
Interest Rate on Capital	15% per annum
Assumed Life of Structure	20 years

* Source: Mr. James Lattore, Space Planning Director, Syracuse University

3/ *Ellsworth*, p. 18.

4.3 Transportation Distance and Travel Times Between FAUL Libraries



4.4 Delivery Cost Data, U. S. Mail[4/]

Weight	Rate
FOURTH CLASS PARCEL POST	
1-2 lbs.	$0.60
Less than 5 lbs.	$0.75
Less than 10 lbs.	$1.05
Less than 20 lbs.	$1.55
Less than 50 lbs.	$2.75
BOOK RATE	
First lb. or fraction of a lb.	$0.12
Each additional lb.	$0.06
LIBRARY RATE	
First lb. or fraction of a lb.	$0.05
Each additional lb.	$0.02

INSURANCE FEES	
Liability	Fee
$0.01 to $15.00	$0.20
$15.01 to $50.00	$0.30
$50.01 to $100.00	$0.40
$100.01 to $150.00	$0.50
$150.01 to $200.00	$0.60
Liability for insured mail limited to	$200.00

4/ *Domestic Postage Rates and Fees*, Post Office Dept., Publication 3, December 1969. Recent action taken by Congress concerning mail rate increases may cause an upward revision in all categories of mail charges. See recent issues of *The Washington Newsletter* (ALA, 110 Maryland Avenue, N. E., Washington, D. C. 20002).

4.41 Delivery Cost Data, United Parcel Service (UPS)[5/]

Weight	Rate
1 lb. or less	$0.50
5 lbs. or less	$0.68
10 lbs. or less	$0.90
20 lbs. or less	$1.35
50 lbs. or less	$2.70
Weight and size limits:	
Max. wt. per pkg.	50 lbs.
Max wt. of all pkgs. from one shipper to another	100 lbs.
Max. size of pkg. lgth & grth.	108 inches

5/ *UPS Rates for Shippers in New York (etc.).* Effective August 3, 1970.

INSURANCE (UPS)

If the value of item shipped is less than $100 the insurance fee is included in the rate. For each additional $100 or fraction thereof per package a charge of $0.25 applies.

PICKUP SERVICE (UPS)

For an additional charge of two dollars per week per institution a daily pickup service is provided. The two dollar fee does not apply to state institutions, in this case SUNY-Buffalo and SUNY-Binghamton. The following data, compiled by FAUL Central over a 22-week period, shows the total shipment and the corresponding payment (including the pickup cost) made to UPS:

Period of Observation	Total Wt. Delivered	Total Cost
22 weeks	3693 lbs.	$763.97

Average cost per pound (UPS) - $0.207

*4.42 Delivery Cost Data, Greyhound Package Express**

Destination Weight	Ithaca	Buffalo	Rochester	Binghamton
0 - 2 lbs.	$1.55	$1.75	$1.55	$1.55
2 - 10 lbs.	1.75	2.30	1.85	1.75
10 - 20 lbs.	1.95	2.55	2.15	1.95
40 - 50 lbs.	2.65	3.75	3.00	2.65

INSURANCE (Greyhound)

The above rates include insurance up to $50 per shipment weighing 100 lbs. or less. When the declared value exceeds

* These data apply only to the case where shipment is made from Syracuse to the other four libraries.

$50 per shipment, an insurance fee of $0.25 is applied for each additional $100 or fraction thereof. The packages are delivered from one Greyhound terminal to another within 24 hours. Therefore, it is necessary that each institution provide additional pickup service to and from the terminal.

4.43 Delivery Cost Data, FAUL-Operated Vehicles

LEASED VAN ON A TWO-YEAR CONTRACT BASIS:	
Rental cost	$150/month
Mileage charge (above 50,000 miles)	$0.02/mile
Maintenance	$800/year
Operator's wages	$9,000/year
Insurance for vehicle	$250/year
Total per vehicle per year	$12,850
PURCHASED VAN:	
Purchase cost & special book racks (tax exempt)	$3,000
Maintenance	$800/year
Operator's wages	$9,000/year
Insurance for vehicle	$250/year
Total per vehicle per year	$13,050

4.5 Pertinent Statistics About The FAUL Libraries

1. Approximate Current Holdings

Institution	Monograph Vols. (est.)	Serial Subscriptions* (est.)
SUNY-Binghamton	400,000	9,000
Cornell	3,800,000	52,900
Syracuse	1,400,000	23,380
Rochester	1,200,000	12,000
SUNY-Buffalo	1,200,000	17,424
TOTAL	8,000,000	114,704

2. Transactions (General and reserve room circulation, interlibrary loan)

Total transactions over twelve month period	5,750,000
Average transactions per day (359 workdays)	16,000

* Data supplied to Coordinator's office by FAUL Public Service Librarians and from the FAUL Joint Serials Control System Project staff.

5.0 DATA ANALYSIS

Although the study began with an initial objective of defining and analyzing the transportation problem and investigating the optimal solution for it, a closer study of FAUL operations revealed that there is an interrelation between the storage of library materials and transportation requirements. The seriousness of the storage space problem is described in the next section. The following analysis compares alternative solutions to the storage and transportation problems:

5.1 Comparison of Storage Systems Costs[6/]

		Annual Cost/ sq. ft.
5.11	Conventional	
	Land----------$5/sq. ft. (at 15% interest)	$0.75
	Construction--$35/sq. ft. (ammortized at 15%, 20 years.)----------	$5.25
	Repairs-------2% of construction cost-------	$0.70
	Current Maintenance----------	$0.60
	Shelving------$3.50/sq. ft. (ammortized at 15%, 20 yrs.)---------	$0.525
	TOTAL----	$7.825
	Annual cost per volume = $\frac{\$7.825}{15}$ = $0.5212	
5.12	Yale system	
	Land----------$2/sq. ft. (at 15% interest)	$0.30
	Construction----$20/sq. ft. (ammortized at 15%, 20 yrs.)----------	$3.00
	Repair fund-----2% of construction cost------	$0.40
	Current Maintenance----------	$0.30
	Transfer, selection and change of records-----	$1.98
	Shelving--------$6/sq. ft. (ammortized at 15%, 20 yrs.)----------	$0.90
	TOTAL----	$6.88
	Annual cost per volume = $\frac{\$6.88}{60}$ = $0.115	

6/ Estimates of volumes per square foot, maintenance cost, and transfer costs are from R. B. Downs, *University Library Statistics*, R. E. Ellsworth, *The Economics of Book Storage*, and H. H. Fussler and J. L. Simon, *Patterns in the Use of Books in Large Research Libraries*.

5.13 Randtriever system

		10 Annual Cost/ sq. ft.
Land	$2/sq. ft. (at 15% interest)	$0.30
Repairs	2% of construction cost	$0.40
Construction cost) Shelving)	$157/sq. ft. (ammor. at 15%, 20 yrs.)	$24.30
Current Maintenance		$0.30
Transfer, selection and change of records		$6.39
Annual rent of computer		$1.32
	TOTAL	$33.01
Annual cost per volume = $\frac{\$33.01}{147}$ = $0.225		

As is clear from the above calculations, the high density storage systems range from about one-fifth to two-fifths of the cost of conventional library storage. In other words, use of the Yale system should result in savings of about 80% of the conventional library, while Randtriever should realize 60% savings.

5.2 Alternate Methods of Interlibrary Transportation

Under the present system, an average package shipped weighs about 5 pounds. If FAUL operated a central compact storage library, the weight of a package could go as high as 50 pounds or more. In the following table, the per pound rates for a package of 5 pounds and for one of 50 pounds are compared for the three U. S. mail alternatives that can be used for mailing library material.

5.21 U. S. Mail

Pkg. Wt.	Cost/Item	Fourth class Parcel post	Book rate	Library rate
5 lbs.	Rate	$\frac{.75}{5}$ = $0.15/lb.	$\frac{12+4(.06)}{5}$ = $0.07/lb.	.05+4(.02) = $0.026/lb.
	Insurance	$0.08/lb.	$0.08/lb.	$0.08/lb.
	Packaging	$0.05/lb.	$0.05/lb.	$0.05/lb.
	TOTAL	$0.28/lb.	$0.20/lb.	$0.156/lb.
50 lbs.	Rate	2.75/50 = $0.055/lb.	$0.06/lb.	$0.02/lb.
	Insurance	$0.012/lb.	$0.012/lb.	$0.012/lb.
	Packaging	$0.05/lb.	$0.05/lb.	$0.05/lb.
	TOTAL	$0.117/lb.	$0.122/lb.	$0.082/lb.

5.22 *United Parcel Service*

Statistical data gathered by FAUL indicates that, on the average, 167 pounds of library material was delivered weekly through UPS among the five member libraries. The amount paid to UPS for a daily pickup service for all five libraries is an additional $6 per week. When this is added to the regular UPS rates, we will have the following unit cost estimates for a 5 pound and a 50 pound package:

ITEM	5 lb. package	50 lb. package
UPS rate	$.68/5 - $0.136/lb.	$2.70/50 - $0.054/lb.
Pickup cost	$0.06/lb.	$0.03/lb.
Packaging	$0.05/lb.	$0.05/lb.
Insurance		$0.025/lb.
TOTAL	$0.246/lb.	$0.159/lb.

A calculation of the actual per pound rate from the total weight of material delivered and the total payments made gives us a rate of $0.207 per pound. The discrepancy is due to the fact that (a) actual average package size was less than 5 pounds, (b) no accurate estimates of packaging cost have been made by FAUL, and (c) no insurance fee is paid which implies that the total value the libraries put on each package is almost always $100 or less.

5.23 *Greyhound Package Express*

The rate in this case is not a constant figure. If, for instance, Syracuse is the mailing center, four different rates for delivery to the other four libraries apply. To put these data on the same basis for comparison as the other systems, a median rate for each of the two package sizes can be taken as follows:

ITEM	10 lb. package	50 lb. package
Delivery rate	$0.185/lb.	$0.06/lb.
Pickup service	$0.060/lb.	$0.04/lb.
Packaging	$0.050/lb.	$0.05/lb.
Insurance	$0.025/lb.	$0.03/lb.
TOTAL	$0.320/lb.	$0.18/lb.

5.24 *FAUL-Operated Vehicles*

There are two possible ways whereby the FAUL organization can operate its own delivery system: one way is to rent vans and the other is to buy them. A decision as to which alternative to adopt should be based on an analysis of the costs and convenience of each. An annual cost comparison of the two approaches is given below:

Cost Item	Rent	Buy
Rental cost ($150/mo. + $0.02/mi. above 50,000) = (150 x12) + (0.02 x20,000)	$2,200	---
Annual cost of buying ($3,000 ammortized at 15%, 2 yrs.)	---	$1,845
Gasoline	$2,210	$2,210
Oil	$ 221	$ 221
Maintenance	$ 800	$ 800
Operator's wages	$9,000	$9,000
Insurance for car	$ 250	$ 250
Total annual cost	$14,681	$14,326

Clearly, it is cheaper to buy the vehicle rather than lease it. Since the vehicle will be equipped with special racks there will be no packaging cost other than placing books in open re-usable bins. The annual cost can be used to compute the cost per pound of material delivered.

ITEM	Pres. Sys.(uncen.) (167 lbs/wk)	Proposed Sys.(cen.) (800 bks. - 1600lbs/da.
Number of vehicles needed	1	2
Delivery cost	$\frac{14,326}{167x52}$ = $1.50/lb.	$\frac{14,326x2}{1600x5x52}$ = $0.07/lb.
Insurance (for books)	$0.0125/lb.	$0.0125/lb.
	$1.5125/lb.	$0.0825/lb.

Insurance premium is estimated as "one per thousand", and the value of 1 pound of library material at $12.50.

6.0 OPTIMUM STORAGE/TRANSPORTATION

6.1 The Book Storage Problem

It has been established by experts in the library field that an average research library doubles its collection every sixteen years.[7] The available data for the Five Associated University Libraries supports this conclusion. The analysis of the data indicates that acquisitions of all five libraries range between 450,000 and 500,000 volumes per year. At this rate the total number of acquisitions will amount to about 8 million in the next sixteen years, which means that, unless some intervention or change is made, total holdings will double since current holdings are 8 million now.

All of the libraries in the FAUL system now have, or will have soon, a storage problem. To take one instance, a study of the Cornell library system concluded that two of their libraries were out of space, and the third (Olin) would soon be full head of estimates. The study adds that "a reasonable projection of acquisitions shows that within only six years of the time a new library could be completed (about 1975) enough books would be acquired to fill a library as large as Olin".[8]

The library space crisis that more or less prevails at each university could be solved by one of the following ways:

1. Build more conventional library buildings on campus.
2. Store the less often used books in a high density storage facility off-campus.

Studies of library usage over a long period have shown that a relatively low percentage of the books in a collection meet a substantial proportion of requests. The

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7/ Ellsworth, p. 24.
8/ J. H. Brown, et. al., p. 1.

pattern is as follows:[9/]

20% of collections account for 80% of demand
50% " " " " 93% " "
75% " " " " 95-97% " "

Thus one-fourth of the total holdings are responsible for only 3 to 5% of requests. Assuming the same usage patterns will continue in the future, removing the lowest (in terms of usage) 25% from the conventional library to a compact storage area would only mean a relatively longer waiting period in meeting about 5% of all demand, in return for considerable savings in space and storage costs. In the absence of reliable use data per title, careful procedures should be worked out for selecting the 25%. Several methods are outlined below.

As of 1970, the total holdings at the five member libraries are about 8 million volumes. This means that a minimum of 2 million volumes could be sent gradually to high density storage without any significant reduction in service to the clientel of the libraries.

By high density storage we mean a system where an effort is made to contain as many volumes per square foot as possible. Space savings are accomplished by such means as narrow aisles, not leaving any space between groups of books, shelving higher than the usual 7 1/2 feet characteristic of a conventional library, grouping books according to size rather than subject matter, and by stacking books on fore-edges. All these measures increase the number of books stored per square foot of library space. Whereas the conventional type of shelving only averages about 15 books per square foot, high density systems can store up to 60 books per square foot using regular shelves (Yale system) and almost 150 books per square foot using special shelving and accessing devices (Randtriever). However, compact storage results in reduced accessibility for browsing and some delay in getting books to the library user.

9/ Fussler and Simon, p. 143. See also Brown, op. cit., p.22.

The advantage of compact storage is in that it permits high savings in storage cost. As was shown in the data analysis section, it costs about $0.52 per volume per year to expand a conventional library, whereas it costs only $0.115 per volume per year in the Yale System and about $0.225 per volume per year in the Randtriever system.

It is fairly apparent then, that it is less costly to build and use high density storage than to expand conventional storage facilities continuously. In theory, there are at least two possible configurations of high density storage in FAUL:

1) install high density storage facilities at each of the five institutions as needed, or
2) acquire a single central high density store to serve all five libraries.

Having compact storage at each of the five universities will increase the transportation cost within each institution and between the institutions because more network nodes are added. It will also result in delayed service to the library user. In addition, because of economies of scale the initial construction cost, the cost of installing utilities and the average cost of handling and administration would be higher as compared to a single central store. This contention is supported by many studies. To quote just one of them: "There are sound reasons for believing that institutional cooperative storage programs, and perhaps other cooperative enterprises, would result in storage costs...well below those for a local storage facility".[10/]

6.12 Selecting Books for Central Storage

As mentioned above, the determination of the optimum location for the central store is closely related to transportation problems and the type of materials located within the store. Irrespective of the location, there is the question of which books should be housed and serviced by

10/ Fussler, op. cit., pp. 133-134.

a central storage library. In principle, the books to be sent to storage are those which are least used. There are various ways of identifying and selecting the least frequently used books. Some of the variables in determining the use of library material are:

1) date of publication (or date of acquisition)
2) language of publication
3) amount of prior use.

Each of the variables can be used as a predictor by itself or in combination with other variables--using multiple regression analysis.

It has been established that the amount of prior use of an item is a good predictor of future use. "Past use, where sufficient data is available, was found to be the single predictor of the future use of a book."[11/] If statistical data of past use is not easily available an alternative way of selection is to remove all books that did not circulate within a given historical period. This can be done simply by examining the last date of checkout of a book. Both of the above methods do not take in-library use into consideration, unless strictly closed stack access pertains. A third approach is to remove a predetermined percentage of books to storage using the publication date as the criterion of selection. The cut-off dates for different subject areas might be determined in consultation with the appropriate academic department. A particular problem arises here, however, with subject areas which are historically oriented. Perhaps a mix of the three approaches could be attempted.

Using one or more of the above methods of selection at least 25% of the total holdings should be removed to storage. The actual procedure of selection, with "past use" as the criterion, would be as follows:

1) Take a large enough sample (to provide the desired confidence limit) from each subject category.

11/ *Ibid.*, p. 15.

2) Determine the past use and check the impact on demand when 25% of the books are removed.
3) Select titles to be stored, change records and transport to central storage.*

6.2 The Book Transportation Problem

The principal delivery systems suitable for inter-library loan are:

1) U. S. Mail
2) United Parcel Service
3) Greyhound Package Express
4) FAUL-operated vehicles

Helicopter service was cursorily costed and rejected, as annual expense for one year was estimated at $56,000 for 480 air hours. A brief description of the advantages and shortcomings of each alternative accepted deeper analysis is given below.

U. S. Mail

Three types of service is provided by U. S. mail among which "Library Rate" is the cheapest. However, U. S. Mail has the longest and least predictable delivery time. Time taken within the postal system will, on the average, be about 5 days. There will be further delay when the package arrives at a university mail room where the mail is sorted and then sent to the library. In addition to the delay in delivery, the system requires special packaging, and since the maximum insurance coverage is $200 it is risky to send valuable material such as those in rare book and manuscript collections through this unpredictable service.

* For the faint-hearted, the selected books could be retained locally for a short while in a closed stack area in order to simulate centralized storage. Other physical indicators, such as color-coded book cards could be used as an even earlier step.

United Parcel Service

At present, inter-library loan material deliveries among FAUL members are done through seven contracts by United Parcel Service. The requests are processed and library material packed at the library mail center, from where it is picked up by UPS daily. On the average, delivery time is currently about 2.5 days. This system also requires packaging. The daily pickup service is a special arrangement and it costs $6 per week for all five to have this service, or an average of 85.7 cents per contract. The advantage of UPS is in that pickup is daily and is provided by the carrier, not the libraries, billing is centralized therefore monitorable by the FAUL central office, and delivery time is predictable.

Greyhound Package Express

Greyhound has a faster service than the above alternatives, but it has one more inconvenience in that daily pickup service, to and from the bus terminal, has to be provided by the libraries. Again, this service requires special packaging.

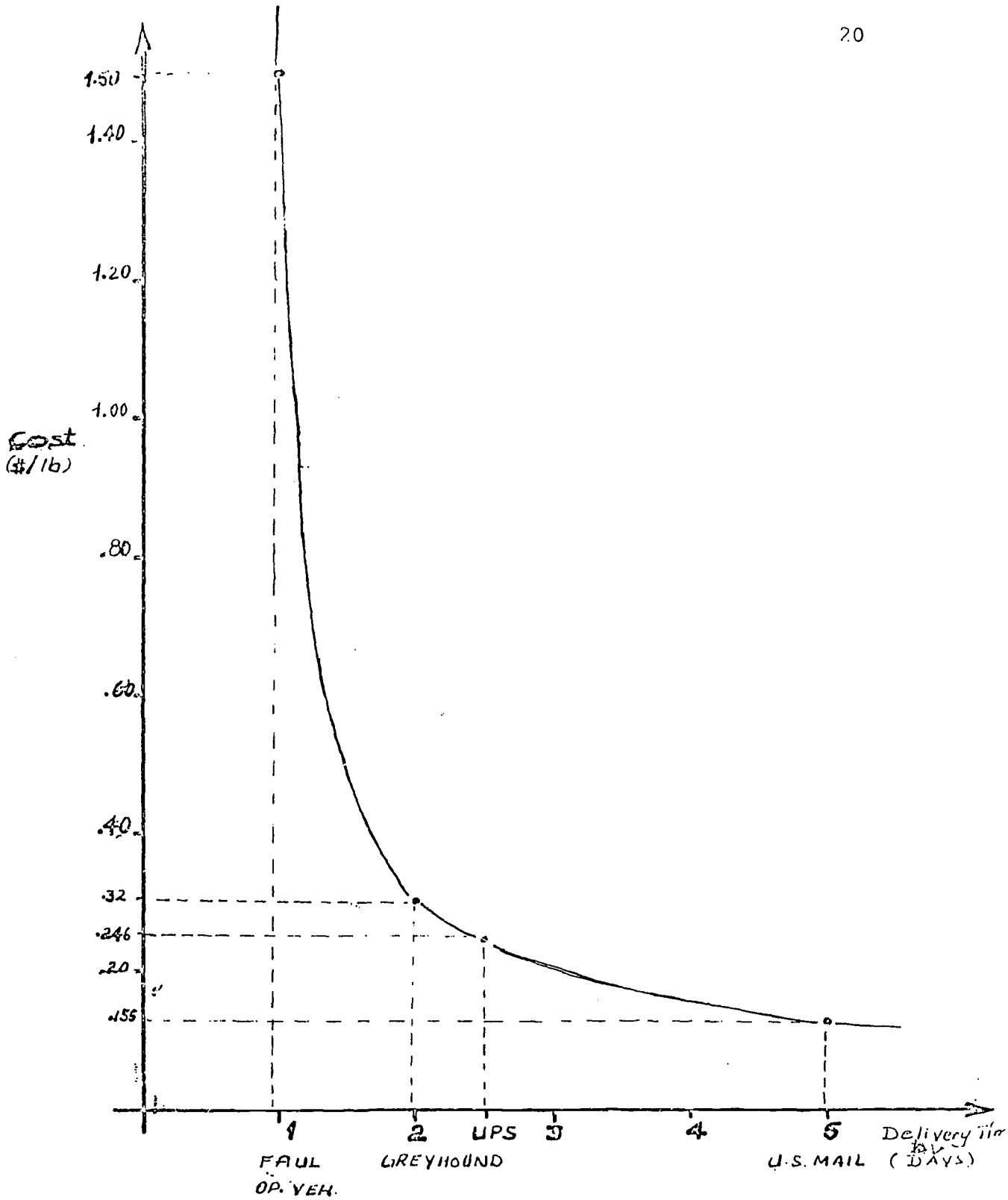
FAUL-Operated Vehicles

The fastest service of all could be attained if FAUL operated its own delivery system. Vehicles can be leased or bought, but as was shown in the Data Analysis section (5.24), the annualized operating cost would be somewhat cheaper if the vehicles were bought. At the current level of activity, this alternative has the highest cost. The vehicles can be equipped with special racks which dramatically reduces packaging cost and time. Since delivery would be made directly to the several points on a campus in addition to the library itself, on-campus as well as intra-FAUL delays are minimized.

6.3 *The Combined Model*

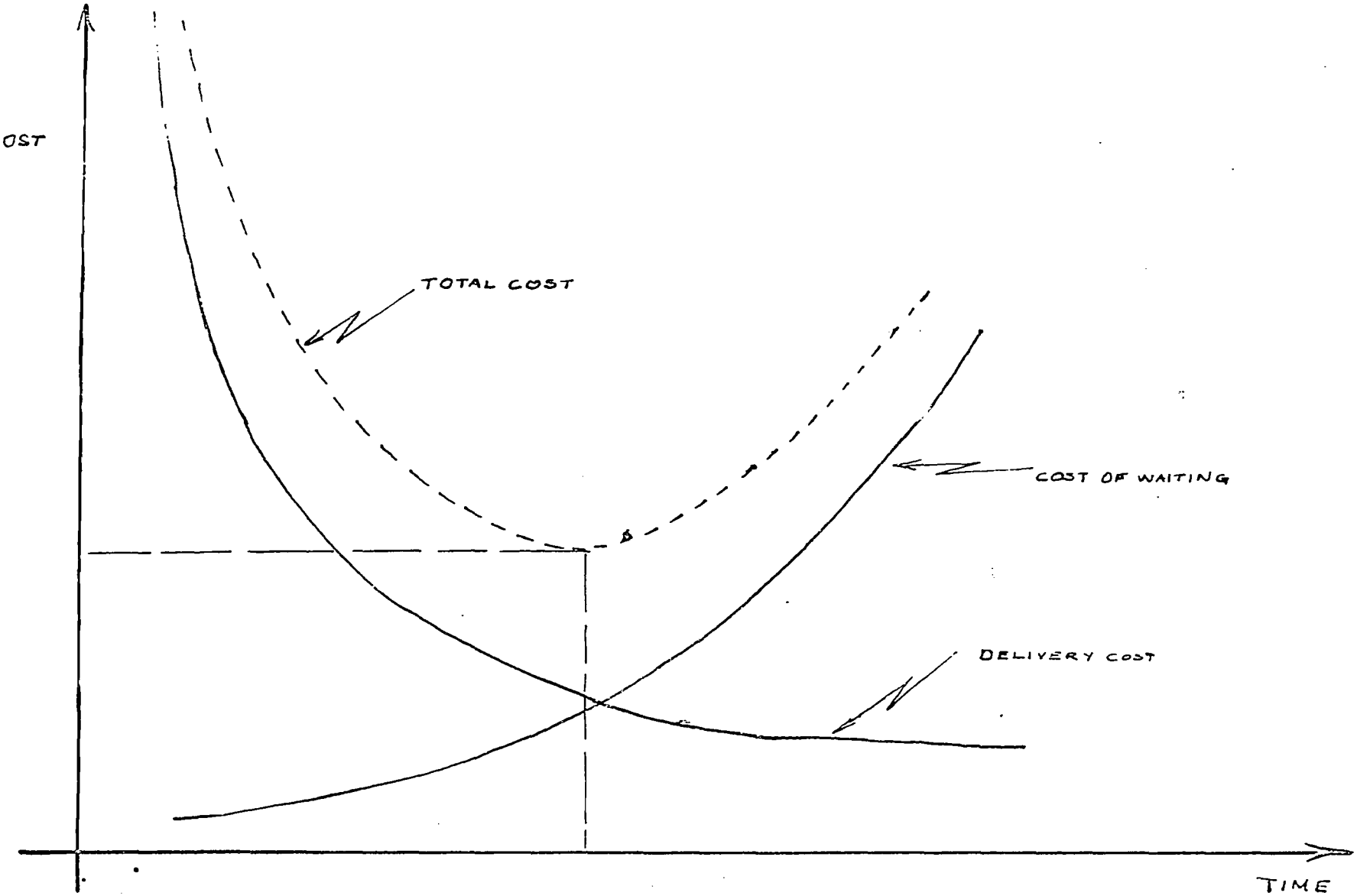
If a high volume of transactions takes place and the distribution is done through a central location, the FAUL-operated vehicles provide the most economical delivery system with respect to both time and cost. At present, the transactions among the five institutions averages about 167 pounds of library material per week. The size of a package is about 5 pounds. On the basis of these factors, the cost (per pound) of delivery is calculated for each alternative. The cost per pound varies from $0.156 for U. S. Mail to $1.50 for FAUL-operated vehicles. However, U. S. Mail takes at least 5 days to deliver material from one library to another. By operating its own vehicles, FAUL can have the same day delivery or next day delivery at the latest. The relation between delivery time and cost per pound is shown graphically in Figure 1. Under the present system FAUL will be forced to make a time-cost trade-off as shown in Figure 2. The optimum trade-off appears to be UPS where the cost is $0.246 per pound and average delivery time is 2.5 days.

On the other hand, if the recommendation for a central high density storage library is implemented the level of transaction will rise sharply. Assuming that 25% of the collections are placed at the central store, about 5% of total demand has to be met from there. Since total transactions in all five member libraries is 16,000 per day, 5% of this amount or 800 transactions daily will be made with the central store. This increased level of activity will imply that the size of a package can be as large as 50 pounds. A recalculation of the rates on this basis will give us the relation between delivery time and cost per pound of Figure 3. Again U. S. Mail provides the cheapest means of delivery, but this time the difference between the U. S. Mail rate and that of the second best alternative in rank (which now is FAUL-operated vehicles) is negligible. There is a significant saving



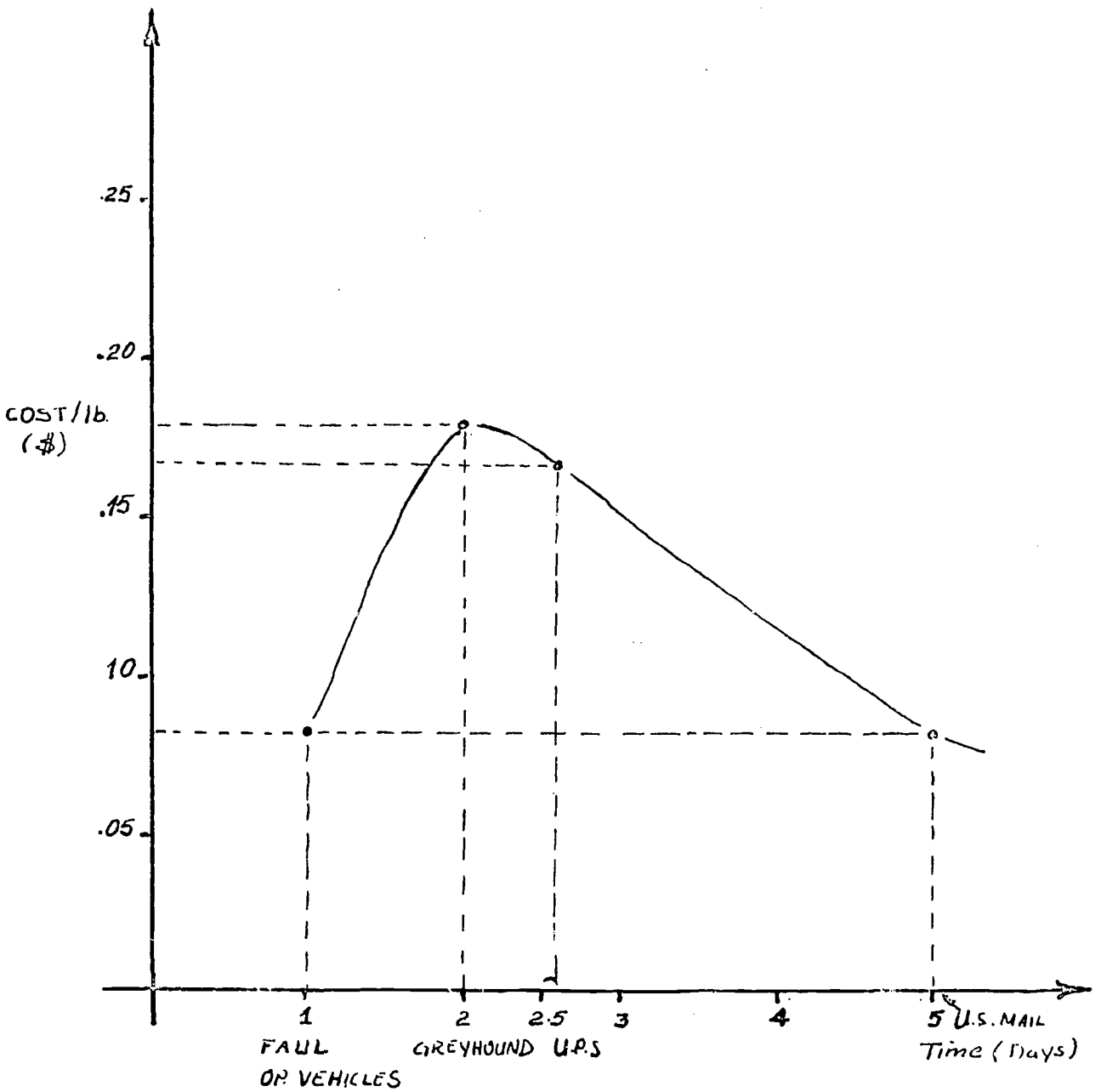
Transport Cost vs. Time of Delivery
(PRESENT SYSTEM)

Fig 1



TRADEOFF CURVE

Fig. 2



TRANSPORT COST VS. TIME OF DELIVERY
(PROPOSED SYTEM)

Fig. 3

in time by adopting the FAUL-operated delivery system. Clearly, with a central storage library--and the increased load that will result--the FAUL-operated delivery system is the overall best alternative.

6.4 Optimum Location of a FAUL Central Storage Facility

With as many as 800 transactions being made by the central storage library each day, it is absolutely necessary to have the storage location at a point that will allow the fastest delivery to each of the five institutions. In other words, the location must be such that total travel time is minimized. Our discussion is based on the assuption that FAUL-operated vehicles are used as means of delivery because this alternative has been proved to be the overall optimum if the concept of a central store is accepted. The home base of the vehicles will be at the central store. In addition to carrying material between the central store and the member libraries, the vehicles will also deliver library material and one or two passengers from one institution to another.

The distances and travel times between the five member libraries are given in Table 1. A minimum of two vehicles must be operated to meet the requirements of an 8-hour working day for an operator, avoid overnight stay, insure continuation of the operation in case of breakdowns, and insure efficient handling of large volumes of load. With these constraints the comparison of travel times, with each of the institutions considered as home base at a time, is given in Table 2 below:

TABLE 2

Home Base	Best Routes	Travel Time	Work Time	Distance
Binghamton	Bing-Buff-Roch-Bing	9.00	10.00	420
	Bing-Ith-Syr-Bing	4.00	5.00	193
	Totals	13.00	15.00	613
Rochester	Roch-Ith-Buff-Roch	7.25	8.25	320
	Roch-Bing-Syr-Roch	7.00	8.00	310
	Totals	14.25	16.25	630
Ithaca	Ith-Buff-Roch-Ith	7.25	8.25	320
	Ith-Bing-Syr-Ith	4.00	5.00	193
	Totals	11.25	13.25	513
Syracuse	Syr-Bing-Ith-Syr	4.00	5.00	240
	Syr-Buff-Roch-Syr	6.00	7.00	320
	Totals	10.00	12.00	560
Buffalo	Buff-Roch-Syr-Buff	6.00	7.00	320
	Buff-Ith-Bing-Buff	8.75	9.75	403
	Totals	14.75	16.75	723

From the table it is clear that the optimal location for the center would be either at Ithaca or Syracuse. Since the difference in total mileage between the two locations is not very large, the time constraint suggests that the Syracuse area should be chosen as the home base. The vehicles will operate on two routes; one route is Syracuse-Binghamton-Ithaca-Syracuse and the other is Syracuse-Buffalo-Rochester-Syracuse. The south-bound route takes only 5 hours of working time and the west-bound route takes 7 hours. The vehicle operating on the south-bound route could be utilized two more hours for deliveries between the storage library (which will be off-campus) and Syracuse University or for other needs of

the center. The routes to be followed by each vehicle is shown on the map of Figure 4.

To facilitate the movement of material between the institutions, the calling order on each route can be reversed every other day. For example, if the calling order on the west-bound route was Syracuse-Buffalo-Rochester-Syracuse on the first day the order would be Syracuse-Rochester-Buffalo-Syracuse on the second day so that materials could be transported between Rochester and Buffalo without going through the center. As for material going from a node on one route to another node on the second route, transfer has to be made at the center. This will merely involve the transfer of material from the west-bound vehicle to the south-bound vehicle or vice versa.

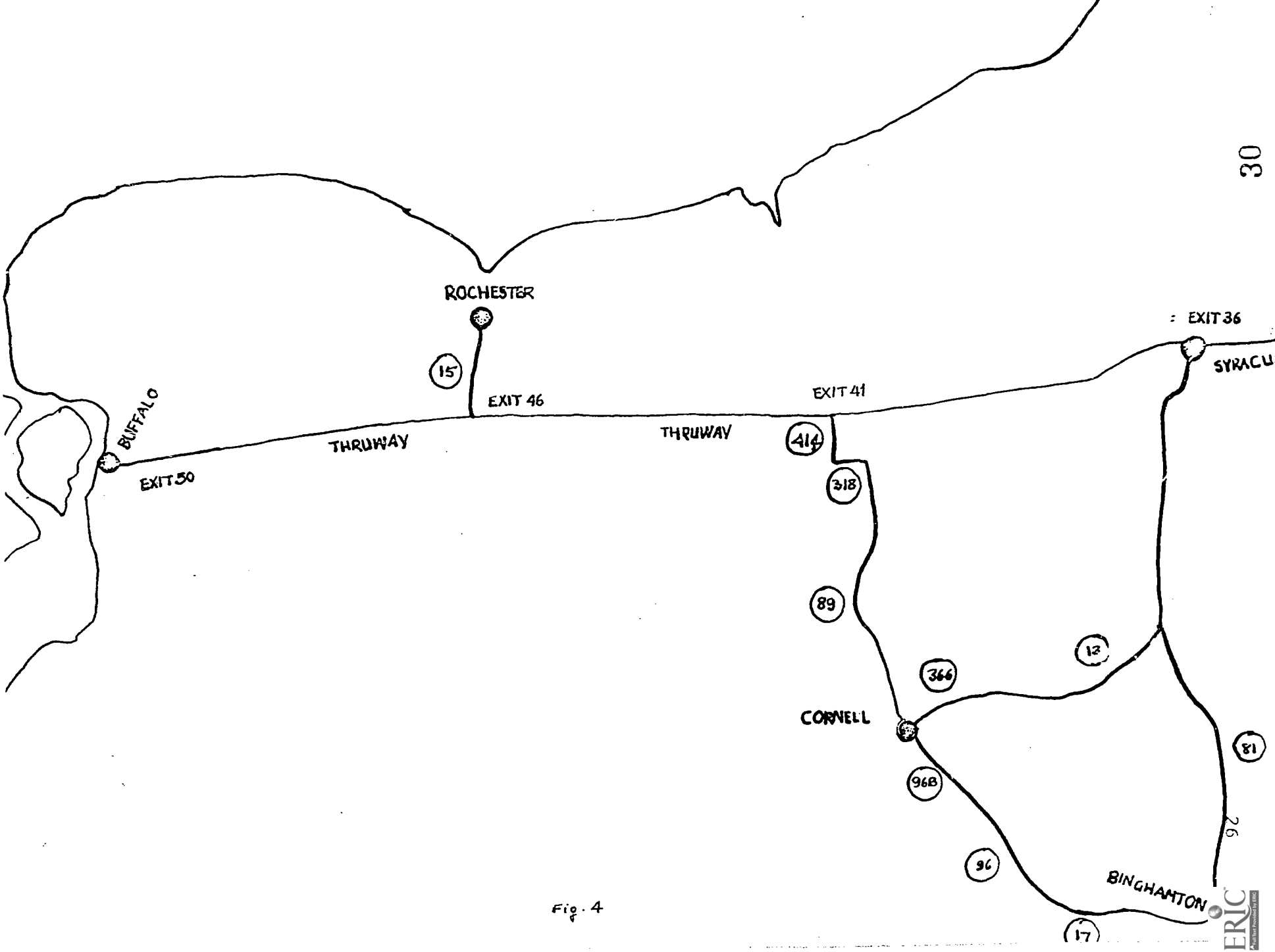

ROCHESTER
15
EXIT 46
EXIT 41
EXIT 36
SYRACUS
BUFFALO
THRUWAY
THRUWAY
EXIT 50
414
318
89
366
13
CORNELL
81
96B
96
BINGHAMTON
17

Fig. 4

7.0 IMPLEMENTATION OF CENTRAL STORAGE

There are two alternate systems for central storage:

1) Yale System
2) Randtriever

The Yale System is an improvement over a conventional library in that it tries to maximize space utilization. t provides only 22" wide aisle instead of the conventional 32-36" aisle. In addition, books are shelved according to size rather than subject matter. The books are classified into 4-6 size categories and are usually shelved on fore-edges. Books are shelved higher than the usual 7'6". The available shelf space is fully utilized. If all these space saving devices are combined, it is possible to shelve as many as 60 volumes per square foot in contrast to 12-15 volumes per square foot in conventional libraries.

The Randtriever System is essentially a computer-controlled shelving and book retrieval system where automatic handling and storage are combined. Books are placed in metal boxes measuring 8"x12"x15". Each box and the books in it have machine-addressable code numbers. The code numbers are also recorded in book or computer catalog files.

The user looks up the code number in the catalog either at the home library or the center and places an order at the operator's desk or by telephone. The operator punches the request into the small computer which performs an immediate check on the availability of the requested book. If it has been checked out it gives a "no" response to the operator. Otherwise, it commands the moving column between the ranges. The movement is performed on tracks fixed to the floor and the ceiling. On each column is a picker which moves vertically and takes a box off a shelf (or replaces it). The column then moves

to the end of the range and places the box on a conveyor belt which delivers the box to the computer console where the electronic control verifies the correctness of the transaction. An operator takes the appropriate book from the box, charges it out in a computerized system to the borrower, and gives the book to the patron and sends the box back to the shelf. This procedure is reversed when the book is returned. On the average such a transaction takes 25 seconds. It can be combined with automated circulation control systems such as the IBM 1030 or Colorado Instruments C-Dek systems now under study in FAUL libraries.

Assuming that the requests arrive randomly (i.e., a Poisson input) having 800 transactions per working-day (8 hours), will give us a calling rate of 100/hr (λ). Since the service time is 1/2 minute per book, the service rate (μ) will be 120 books per hour. Thus the average busy time (ρ) is:

$$\rho = \lambda/\mu = 100/120 = 0.833$$

Therefore, one operator can handle the order under normal conditions. In practice two operators are to be employed to avoid service interruption in case of the absence of one operator. The second operator can keep busy with the conversion of new acquisitions into machine readable form and new transfers to the central storage.

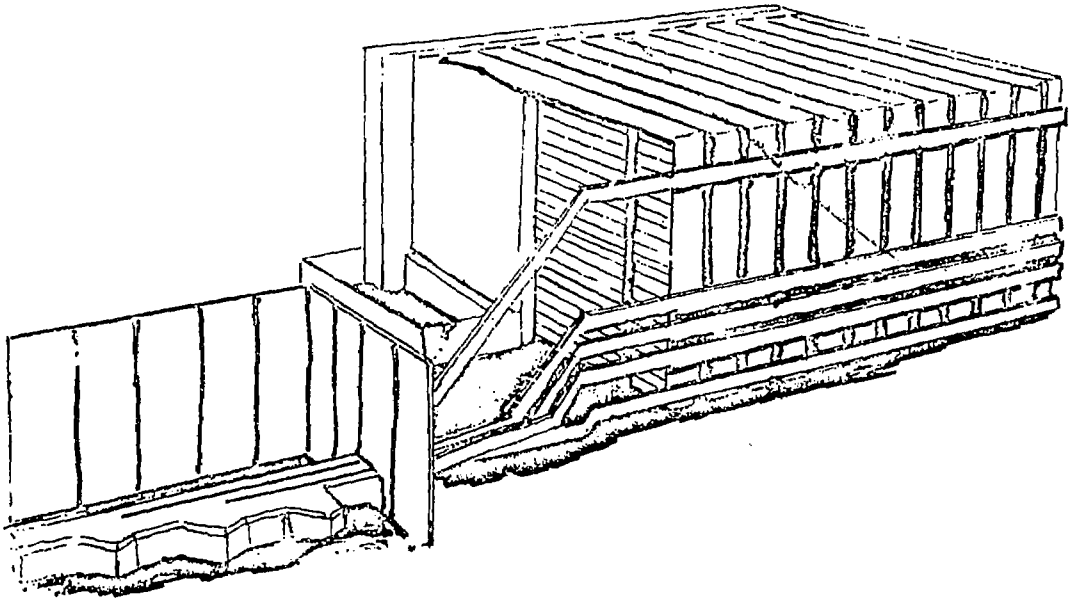
In case of computer breakdown, the Randtriever system should have a provision that will permit manual retrieval of books. For loading and unloading as well as retrieval of books during computer breakdowns, three pages will be employed one of which could be a stand-by driver. The whole operation of the central store will be under the supervision of a professional librarian. Thus the personnel cost will be as follows:

Quan.	Personnel Type	Annual Payment
1	Supervisor	$14,000
1	Stand-by driver	$ 9,000
2	Computer operators	$24,000
2	Pages	$12,000
6	Total	$59,000
	Annual cost per volume = $59,000/2x10^5 =	$0.03

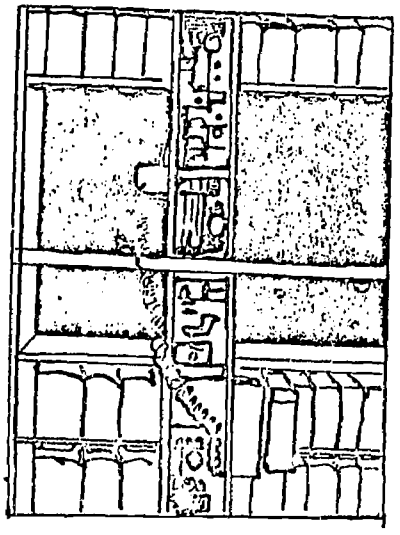
In contrast, the Yale system would require many more pages and circulation desk clerks. To handle 800 transactions per day it is estimated that 20 employees will be needed:

Quan.	Personnel Type	Annual Payment
2	Supervisors	$28,000
5	Circulation-desk Clerks	$50,000
8	Pages	$48,000
2	Cartologer/Typists	$16,000
2	Loaders	$12,000
1	Stand-by Driver	$ 9,000
20	Total	$163,000
	Annual cost per volume = 163,000/ 2x10^5 =	$0.08

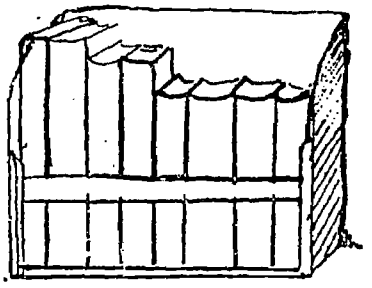
Although the Yale System of storage is cheaper, Randtriever makes maximum use of storage space and provides the fastest service. Since the trend in libraries appears to be toward automation and computerization, the selection of the Randtriever System will bring benefits in the long-run in that it can adjust itself to technological development. An equally important consideration is the fact that wages and salaries will continue to increase sharply and the Yale system, which has a large personnel component, will result in higher unit cost per year while Randtriever remains relatively constant.



RANDTRIEVER



COLUMN AND PICKER



BOX

7.1 Future Expansion and Acquisitions

Although at the initial step an estimated 2,000,000 volumes will be housed in the central store, there will be a constant adjusting flow of less frequently used books from each of the institutions to the central store. Since the estimated total acquisitions are 500,000 volumes per year about one-fourth of that number, or 125,000 volumes, will be placed in compact storage. This implies that the high density facility must permit expansion. Because the Randtriever system economizes space, it has far more expansion capabilities as compared to other systems.

Another area of cooperation among the FAUL members, through the realization of the central storage, will be in "assigning some specialized acquisitions areas to each institution."[12/] There appears already to be some serious movement in that direction by the presidents of the member universities.

7.2 Communication

All five member libraries are already connected by Teletypewriters. The central store could be hooked to all five by installing a similar terminal there. Or, if the system becomes relatively self-contained, communications among the members can be controlled through store and foreward communication computers.

When a member of a university requires a certain book or material which his university does not have, a request is passed via a terminal to the Central Storage Library or to another member library. The vehicle will pick up and deliver the material as described under the transport operation above.

12/ *Annual Report of Syracuse University Library*, May 1970, p. 43.

8.0 SUMMARY AND CONCLUSION

The Five Associated University Libraries have similar space, cataloging and acquisition problems. In addition they all are facing severe budget difficulties. It was out of an understanding of the commonality of their problems that they agreed to coordinate activities and cooperate in as many areas as possible. At present, the main line of cooperation appears to be in the delivery of interlibrary loan material.

If the transaction between the member libraries remain at the current level, then the problem to be solved is "how to speed up deliveries." From among the alternative delivery systems considered, FAUL-operated vehicles provide the fastest delivery. However, at the current rate of transactions the load will be small and as a result the cost of delivery (per volume or per pound) will be excessively high. Under such circumstances the best "cost-delivery time" trade-off appears to be represented by United Parcel Service. (A separate study of interlibrary loan trade-off has been completed by FAUL and will be published in the immediate future. That study supports this conclusion.) Because of in-library and other administrative delays, at present it takes as long as ten days or more between the placement of a request and the delivery of the material. A system is only as good as its weakest link, and in-house procedures should be streamlined as much as possible.

In addition to materials transportation all five member libraries are facing an even more serious problem, namely that of the lack of storage space. Detailed annual cost comparisons presented in this study clearly show that it is advantageous to all of them to construct a high density storage library at a central location. Almost incidentally, such a decision will also solve the delivery problem in that there will be enough load to justify operation of FAUL-owned vehicles at very low unit expense.

In theory there could be other approaches to analyzing the space and transportation problems. However, the only systematic and uniform basis for comparing all aspects of the problem is the cost model. In particular the annual cost approach used in this study enables the evaluation of the future alternatives on the basis of a common yardstick.

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