Technology Transfer Using Electronic Bulletin Board Systems

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One technology transfer mechanism used by some Local Technical Assistance Program (LTAP) technology transfer (T^2) centers is the electronic bulletin board. Through the use of a transportation-related electronic bulletin board system (EBBS), one can obtain public domain software, send and receive messages and announcements, learn about publication listings, and access other resources of transportation and traffic engineering knowledge. The success of an EBBS as a mechanism for technology transfer depends on the computer fluency of potential users, system maintenance and reliability, the cost of access, and the quality of products and marketing. The results of a research project that evaluated the performance of five transportation-related electronic bulletin board systems operated by LTAP T^2 centers are described. Information was collected from T^2 centers through interviews and raw bulletin board system log files. Utilization models that quantify the T^2 center EBBS experience are presented. This experience base can be used to establish guidelines for similar EBBSs in other public works sectors.

To speed the process of transferring transportation technology developed at federal laboratories to state and local governments and the private sectors, Congress passed the Stevenson-Wydler Innovation Act of 1980 followed by the Technology Transfer Act of 1986. These acts mandate that all federal agencies such as FHWA develop active programs for transferring technology. The Rural Technical Assistance Program (RTAP) was developed by FHWA to achieve the economical improvement of rural roads and bridges through a program of training and technical assistance for local government officials and technical staff (*1*,*2*). The goal of RTAP is to transfer highway technology to over 38,000 local highway agencies across the United States.

In 1991, RTAP was expanded to include urban areas and renamed Local Technical Assistance Program (LTAP). The largest and most prominent of the technical projects carried out under LTAP is the Technology Transfer Program for local transportation agencies. This project has created a national system of 51 LTAP centers that are referred to as technology transfer centers or "T^2 centers." The objectives (*2*) of T^2 centers are to

- Establish mechanisms for transferring highway technology to rural officials;
- Improve the flow of technical information among FHWA, state departments of transportation, universities, and rural officials;
- Encourage the use of new, cost-effective technology by rural officials; and
- Test innovative technology transfer methods.

T^2 centers maintain mailing lists of rural officials in the area, publish quarterly newsletters, provide local officials with information on new technology, provide technical assistance, conduct seminars, and perform self-evaluations. Some technology transfer mechanisms used by the centers include traveling "roadshows" that offer training and technology to local officials, "how-to" manuals, technical bulletins, videotape libraries, hotlines, and satellite training classes.

One technology transfer mechanism used by some T^2 centers is the electronic bulletin board system (EBBS). An EBBS is a computer hardware and software system that allows computers to communicate over a standard telephone line (*3*). There are thousands of microcomputer-based EBBSs around the country and many that deal in part or primarily with transportation-related topics (*4*). Through the use of a transportation-related EBBS, one can obtain public domain software, send and receive messages and announcements, learn about publication listings, and access other resources of transportation and traffic engineering knowledge. The six EBBSs given in Table 1 were established for technology transfer as special projects of LTAP T^2 centers (*4*). INFOTAP, PC-TRANSport, UTEC/T2, MTU T3C, and Transporter are operated by the California, Kansas, Northwest, Michigan, and Texas T^2 centers, respectively. McLink is operated by McTrans. Although none of the EBBSs have a toll-free telephone access to users, most of the systems are otherwise free.

EBBSs can make a difference in achieving the objectives and goals of technology transfer by saving money and time through increased productivity. This paper describes the results of a research project that evaluated the effectiveness and usefulness of transportation-related electronic bulletin board systems in T^2 centers. Information was collected on the use of T^2 centers EBBSs as well as on the evolution of the systems and plans for future operation. This paper attempts to quantify the experience base and suggest guidelines that can be used in similar EBBSs for other public works facilities. Specific objectives of this research are to

- Measure the size and operation of current EBBS aplications in T^2 centers;
- Evaluate the effectiveness of transportation-related EBBSs for information exchange among transportation professionals and other public officials; and
- Draw conclusions regarding the usefulness and applicability of the various EBBS services that are provided.

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TABLE 1 Transportation-Related Bulletin Board Systems at T^2 Centers

Organization	EBBS	Startup Date
Institute of Transportation Studies (ITS) System Unit University of California, Berkeley	INFOTAP	Sept. 84
McTrans Center for Microcomputer in Transportation University of Florida	McLink	Mar. 90
Kansas University Transportation Center T^2 Program	PC-TRANSport	1986
Northwest T^2 Center Washington State Department of Transportation	UTEC/T2	1986
Michigan Transportation T^2 Center Michigan Technological University	MTU T3C	1988
Texas Department of Transportation Texas A & M University	Transporter	1984

This paper suggests that success of an EBBS as a mechanism for technology transfer will depend on four factors:

1. Overall computer fluency of potential EBBS users and access to training,
2. System maintenance and reliability,
3. Cost of access, and
4. Quality of services and products that are available and marketing directed toward potential new users.

These factors can be viewed as barriers to be overcome if an EBBS is to generate enough use to justify continued operation. Although computer fluency is not essential for users of EBBS, individuals who use computers regularly as part of their daily responsibilities are more likely to learn how to use the required communications software and want to acquire other software obtainable from an EBBS. A computer-fluent staff is more likely to be found in urban rather than rural areas and in large rather than small organizations. Because most T^2 centers have had a small urban and rural focus, limited use of EBBSs by T^2 centers to date is not surprising. Three of the five EBBSs evaluated herein are either in very urban states or have a mission that extends beyond their state boundaries. Some centers provide brief EBBS connection instructions and operating tips to potential users in newsletter articles (*5–11*). Utilization of EBBSs could be encouraged by providing communications software training and access demonstrations.

Little information is available on the frequency of EBBS file updates, system crashes, and off-line time. Backup systems are essential in ensuring continuous availability to users.

EBBS access costs include long distance telephone connect time cost and staff cost. These costs are a minimum of $12.00/hr for long distance connection and $20.00/hr for staff (assuming an engineer). Thus, the minimum cost to a user for a 15-min call is approximately $8.00. This cost is justified if the information has a significant time value. Alternatively, newsletters, technical reports or program/data diskettes may provide a more cost-effective means of accessing information. Although the use of 800 access numbers would encourage some additional users of EBBS services, the often significant staff time cost will remain a barrier.

Existing EBBSs provide a variety of services and products (*12*). In general, the functions of T^2 center electronic bulletin boards include the following:

- Uploading and downloading shareware and public domain computer programs for transportation engineering and public works management;
- Sending and receiving electronic mail and messages;
- Notification of upcoming conferences, seminars, workshops, training courses, and meetings;
- Lists of publications, research abstracts, and available videotapes;
- Announcements of job vacancies;
- Tips on using computer programs and the bulletin board; and
- Data base searches.

All centers reported downloading software as the primary EBBS activity. Although most systems provide electronic message services, centers recognize that messages are used infrequently. Some EBBSs have evolved to provide services that differ from the original purposes. For example, the original purpose of the Northwest T^2 center EBBS was to distribute microcomputer application programs written by city and county traffic engineers. In addition to distributing software, this system now provides on-line information regarding revisions and amendments (general special provisions) to standard specifications and other official state department of transportation documents (G. Crommes, Northwest T^2 Center, unpublished data). Recently, the MTU T3C system installed the Michigan Accident Location Index (MALI) data base that comprises 100 MB of statewide traffic accident data accumulated during the past 2 decades (*13*). Callers can retrieve data in a standard report format for use in analysis. Because MALI was installed in October 1992 (subsequent to this analysis), its impact on MTU T3C system usage was not measured.

Five T^2 center EBBSs will be evaluated empirically using four categories of performance measures:

1. Number of users. Measures include total number and percentage of target audience reached. Also important are changes over time and duration of active use.
2. Level of use. Measures include number of calls and number of activities performed by callers.
3. System cost. Measures include both start-up and operating cost.
4. Cost-effectiveness. Measures include system cost per user and system cost per call.

AVAILABLE DATA

Available data for measuring the performance of transportation-related bulletin board systems includes user attributes, call attributes, call activities and estimates of system start-up and operating costs. The quantity and quality of EBBS data vary from center to center. Differences in the available data result from differences in the capabilities of EBBS software used as well as each center's policies on the level of data needed to monitor system performance. Raw data were obtained for INFOTAP, McLink, PC-TRANS, UTEC, and MTU. For this project, data attributes are divided into three types:

1. *User Attributes.* User attributes characterize each EBBS user during a particular month and during the period covered by the available data. In general, user attributes obtained from each EBBS include first name, last name, city, state, country, first call date, and time of first call. Other user attributes from particular systems include
   a. Phone number, zip code, and agency (for McLink only),
   b. Number of calls, number of downloaded files, number of uploaded files, and computer type (for PC-TRANS, McLink, and MTU only); and
   c. Birthday, number of messages put on the system, and transportation engineering interest area (in MTU only).
2. *Call Attributes.* Call attributes characterize each incoming call. Call attributes data were obtained from INFOTAP, McLink, PC-TRANS, and UTEC. Call attributes include caller identification, call date, and time. The frequency of calls from each user, number of calls with activities from each user, distribution of in-state and out-of-state calls, and number of calls per month can be derived from call attributes data.
3. *Call Activities.* Call activities characterize the activities or actions during each call. Call activities data were derived from INFOTAP, McLink, PC-TRANS, and UTEC EBBSs and tabulated for each month. Call activities data include activity type, file names associated with relevant activity types, and action time. Activity types include downloaded file, uploaded file, aborted file, operator paged, read mail, read message, read newsletter, read bulletin, search file, and displayed file. The level of detail of call activities varies among the EBBSs because of differences in system administration policies and bulletin board software. The frequency of each activity type and primary usage of EBBSs can be derived from call activities data.

Estimates of start-up and operating costs were also obtained from T^2 centers. Start-up costs associated with an EBBS include acquisition of appropriate computer hardware and software, phone line installation and staff training time. Software costs range from \$20 to \$1,500. The median cost for a single line personal computer (PC) system is \$200. Hardware requirements for running an EBBS are minimal. A 286-level PC with a 20-MB hard drive is sufficient (*3*). If a maximum hardware and software cost of \$1,500 is assumed with a 5-year amortization period at 7 percent interest, the monthly cost is approximately \$30.

After hardware and software installation, primary costs for operating an EBBS include a dedicated phone line and system operator staff time. Operators of existing T^2 center electronic bulletin boards spend 2 to 5 hr/week maintaining the system. Assuming 12 hr/month of operator time (3 hr/week times 4 weeks/month) at \$15/hr results in staff costs of \$180/month. Adding a phone line at \$20/month to staff, hardware, and software costs yields a total cost of \$230/month. Other management and staff time costs required to provide technical assistance are viewed as part of the overall T^2 mission. That is, an EBBS from a cost allocation viewpoint is just one of several ways centers provide technical assistance to agencies and individuals.

T^2 centers that support extensive data bases require hardware systems that can store large amounts of information and process complex queries with reasonable retrieval rates. These data bases will also require more operator maintenance. For example, the MALI data base currently requires 100 MB of storage and will be expanded to 200 MB in the near future (D. Calomeni, Michigan Transportation T^2 Center, unpublished data). Thus the reader should note that hardware and software costs for an EBBS that supports access to large data bases, such as MALI, are higher than those estimations given above.

User Attributes

The total number of different individuals who used each EBBS ("users") during the period for which data were available is shown in Table 2. The wide range in the number of users is, in part, explained by the differences in the number of months represented by the data. A wide range also exists in the number of users for which activities were recorded. Records indicate that only 16 percent of PC-TRANS users, in contrast to 93 percent of McLink and UTEC users, engaged in some form of activity. The problem here is that only two of the five systems recorded more than three basic activities: file download, file upload, and abort. Other activities, such as read bulletin and search files, were not recorded. Consequently, subsequent analysis of activity levels must be carefully qualified because of the level of detail provided by the raw data.

The location of EBBS users (in state versus out of state) is of interest to identify the market being served. As shown in Table 2, two EBBSs are serving an in-state market almost exclusively, whereas McLink and PC-TRANS are serving a national market. Table 2 also shows the extent to which EBBSs are serving users that do not have direct service from an in-state EBBS. Over one-half of McLink and PC-TRANS users live in a state without an EBBS. International use exists but

TABLE 2 User Attributes, Call Frequency, and Duration of EBBS Use

User Category (Months)[a]	INFOTAP (46)	McLink (11)	PC-TRANS (15)	UTEC (5)	MTU (13)
	Cumulative User Attributes				
Total Users[b]	538	278	88	116	168
w/activities	43%	93%	16%	93%	-
w/o activities	57%	7%	84%	7%	-
In-state	58%	27%	20%	87%	88%
Out-of-state	40%	69%	76%	5%	12%
States w/ EBBS	65%	43%	44%	87%	90%
States w/o EBBS	33%	53%	51%	5%	10%
International	1.3%	2.8%	1.2%	0.9%	-
	Call Frequency				
Called Once (% of Total)	252 (47%)	120 (43%)	48 (55%)	58 (50%)	54 (32%)
Multiple Calls					
Single Day (% of Total)	47 (9%)	36 (13%)	4 (5%)	10 (9%)	-
Multiple Days (% of Total)	239 (44%)	122 (44%)	36 (41%)	48 (41%)	-
	Duration of System Use (Months)[c]				
Multiple Days Users					
Mean	10.9	2.7	2.7	1.1	-
Std. Deviation	12.3	2.7	2.8	1.0	-
Maximum	45.2	9.8	9.2	3.5	-
All Users					
Mean	4.9	1.2	1.1	0.5	-

[a] Number of months of EBBS data
[b] Total number of users during the period with data
[c] (Date of Last Call - Date of First Call + 1 day) / 30 days/mo.
- Indicates data unavailable

is very limited, with McLink having the highest level at nearly 3 percent.

The number of active EBBS users varies substantially from month to month. Figure 1 shows the change in the number of users per month for each EBBS over a 4-year period from October 1987 to October 1991 during which data were collected. Our initial expectation was that the graph of monthly users would follow an *s*-shaped growth curve, with slow initial growth followed by rapid growth leading to a plateau of slow growth. However, Figure 1 indicates that none of the EBBSs for which monthly data could be developed showed this expected growth curve. Instead, two EBBSs show declining trends. One shows an increasing trend and the fourth has too few data to determine a trend. One problem here is that only McLink data represent the startup pattern. Although other EBBSs have been in operation for several years, data for their initial operation were not available.

The change in users per month depend on new users attracted to the EBBS and retention of prior users. The extent to which users make multiple calls is shown in Figure 2. Table 2 contains a summary of frequency and duration of EBBS use. The percentage of one-time callers ranges from a high of 55 for PC-TRANS to a low of 32 for MTU (not plotted in Figure 2). Longer tails on the curves in Figure 2 suggest, but do not guarantee, a longer time period as a regular user. Users who have made more than 20 calls are not shown in Figure 2. Such users account for 4 percent of INFOTAP users and less than 1 percent of other system users.

The time spent as an "active user" can be computed as the difference in time between the first and last calls. For users who have made multiple calls, the average time spent as active users is presented in Table 2.

Call Attributes

Three EBBSs—McLink, UTEC, and MTU—with the greatest level of use averaged 83 to 95 calls per month (four to five calls per weekday). Thus, even with long calls of 15 to 20 min, access to these single-line systems should not be a problem. The least-used EBBS averaged less than one call per weekday (15.4 calls per month).

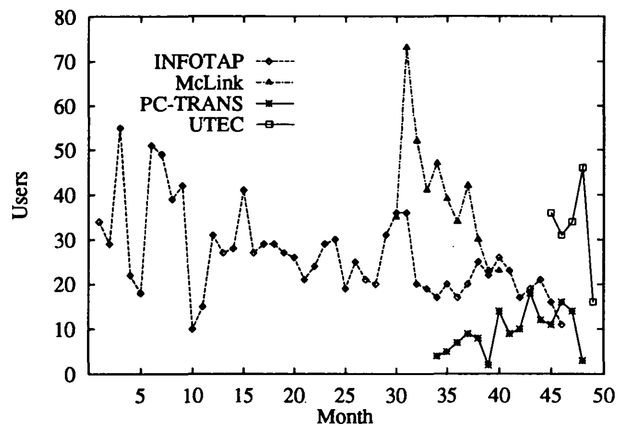

FIGURE 1 Number of users per month for each EBBS.

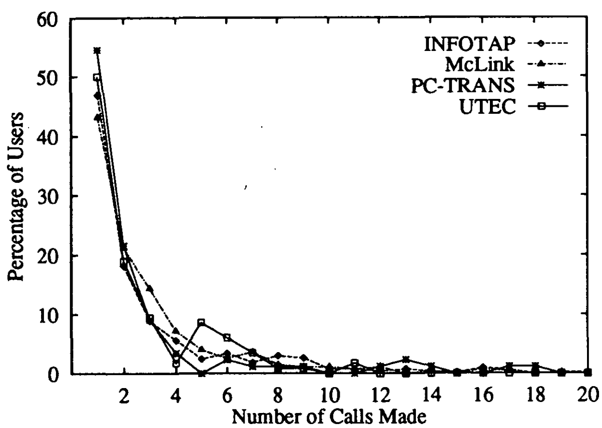

FIGURE 2 Frequency distribution (percent) of total users by number of calls made.

Information about "activities" that are associated with each call varies widely. The percentage of calls with activities ranged from a low of 16 for PC-TRANS to 80 for McLink calls. Information about activities during calls is more limited than is information about activities of users. Thus, comparisons between systems with respect to the purpose of calls must be made with care.

The proportion of in-state calls to each EBBS varies from 28 to 93 percent. In general, the proportion of in-state calls is higher than the proportion of in-state users. The difference is particularly great for McLink, which has 48 percent in-state calls but only 27 percent in-state users. Although differences in long distance phone rates may make an EBBS more accessible to local in-state users and thus generate more frequent use, a more important factor is probably more direct communication and marketing that can be provided to in-state users.

EBBS calls tend to originate from in-state and other states that have an EBBS. This percentage of total calls ranges from 48 to 95 with up to 21 percent being attributed to calls from other states with an EBBS. Thus, an in-state EBBS clearly does not satisfy the entire demand for EBBS services in a state.

Call Activities

Call activity analysis is based on data recorded by EBBS operating systems. Substantial differences exist in the level of activity recordkeeping between EBBSs. As shown in Table 3, all EBBSs record file downloads, uploads, and aborted activities, but only McLink and UTEC systems record details of other activities such as reading mail, listing files, or viewing systems of file statistics. A separate survey of EBBSs revealed that although each system has the capability of viewing messages, bulletins, and other information, only two of the five systems record such activities.

To the extent that call activities can be compared, Table 3 shows that except for McLink, file downloads are by far the most common activity. Primary McLink activities involve reading and listing, whereas file downloading accounts for only a small percentage of recorded activities.

EBBS UTILIZATION MODELS

Performance evaluation of EBBSs requires an understanding of relationships among users, calls made by users, and activities generated by calls. Ideally, the number of users and other attributes could be modeled as a function of EBBS target groups and the extent of marketing and promotion. Such detailed models are beyond the scope of this effort; however, we will make a simple comparison between EBBS client group size and the actual number of EBBS users. Next, we will estimate the number of calls, given the number of users. One might expect a direct relationship between the number of calls and the number of users, but whether the relationship is similar across different EBBSs and whether it is stable over time is unknown. Similarly, one might expect a direct relationship between activities and calls. However, given the varying levels of activity details that are recorded in each EBBS system log file and differences in the utility of EBBS information available to users (files versus messages versus newsletter, etc.), the relationship between activities and calls is likely to be unique for each EBBS.

The primary target audience for EBBS services is likely to be recipients of quarterly newsletters that all T^2 centers are required to publish. Table 4 presents data on newsletter circulation volume and the estimated number of EBBS users as obtained from T^2 center staff. Table 4 also gives the actual number of EBBS users as determined from system log files. The primary reason for the discrepancy between numbers of estimated and measured users is that occasionally EBBS operators will purge the user base of longtime inactive users. INFOTAP has the largest total "measured users" because operational data for nearly 4 years were available. For INFOTAP, the value of "estimated users" reflects an estimate of the number of active users. For McLink, PC-TRANS, UTEC, and MTU, the value of estimated users is the cumulative number of users over the EBBS's life rather than the number of currently active users. For all systems, average measured users, "average users/month" is based on actual users each month over the period for which data were available. EBBS staff-based estimated users is roughly 10 percent of regional newsletter circulation volume, excluding McLink's national newsletter and PC-TRANS's national magazine. Average

TABLE 3 Frequency Distribution of Call Activities

Activities Transactions	INFOTAP	McLink	PC-TRANS	UTEC	MTU
DOWNLOADED	75.99%	12.88%	69.86%	45.38%	82.33%
UPLOADED	3.01%	0.80%	1.37%	0.50%	17.67%
ABORTED	18.20%	4.54%	26.03%	6.25%	-
OPERATOR (SYSOP) PAGED	0.96%	0.00%	-	0.75%	-
NOT ENOUGH TIME	1.84%	-	2.74%	-	-
READ BULLETIN/MAIL	-	25.3%	-	11.38%	-
READ MESSAGE/FILE	-	7.0 %	-	5.6%	-
READ NEWSLETTER	-	3.15%	-	7.88%	-
SEARCH NEWFILES/FILE	-	4.8%	-	3.50%	-
AREA MESSAGE/LIST AREA	-	34.9%	-	7.25%	-
LISTED AREA	-	31.74%	-	-	-
DISPLAYED INFORMATION	-	1.12%	-	4.88%	-
COMPLETED FILE	-	1.33%	-	-	-
VIEW SYSTEM/FILE STATISTICS	-	4.1%	-	6.6%	-
Total Activities	2495	3393	73	800	283

- Indicates data unavailable

measured users per month, in turn, are about 10 percent of estimated users at least for McLink and UTEC systems. Clearly, EBBS usage rates as a percentage of newsletter circulation are small for any 1 month. However, California data on total users over several years demonstrate a much higher level of market penetration on the order of 20 percent. On the basis of "estimated total users," market penetration for UTEC and MTU systems are on the order of 10 percent.

EBBS performance can be evaluated by relating calls to users. Table 5 presents aggregate data on calls per user for two temporal levels: the cumulative level, over all the months for which data were available, and the monthly level. At the cumulative level, calls per user are remarkably similar considering the wide range of periods examined. Three of the five systems are within the range of 3.6 to 4.5, with one system substantially lower and one substantially higher. Clearly, the "average" user makes multiple calls to the system over a period of several months. However, as shown in Figure 2, the general pattern for distribution of users by call frequency decreases in the number of users as the number of calls made increases. At the monthly level, the ratio of average number of calls to average number of users falls in the range of 1.6 to 2.6. Thus, although the average number of users per month varies considerably among systems, the level of use per user (calls per user) is quite similar.

An estimation of the number of calls per month based on a single ratio of calls per users for each EBBS will not be valid if the ratio changes over time or if the relationship between calls and users is nonlinear. A plot of calls per user versus month revealed no consistent upward or downward trend over time for any of the EBBSs. Separate plots of calls versus users for each EBBS showed highly linear relationships.

Linear regression models for calls per month as a function of users per month are presented in Table 6. All models have reasonable explanatory power (R^2 of 0.77 or larger). Regression coefficients for users are highly significant, but constant terms are not significantly different from 0 at the 0.05 level. Negative constant terms, although not statistically significant,

TABLE 4 Target Audiences Versus Actual Users

EBBS	Newsletter Circulation	Estimated Users[a]	Measured Users	Average Users/Month
INFOTAP	3,000	120-150	538	26.4
McLink	22,000	425	278	39.9
PC-TRANS	5,000 (N)[b] 24,000 (M)	320-510	88	9.5
UTEC	2,300	300	116	32.6
MTU	3,400	300	168	-

[a] EBBS staff estimates of users
[b] (N) Quarterly newsletter; (M) Bi-monthly magazine
- Indicates data unavailable

TABLE 5 Overall EBBS Utilization Levels and Cost-Effectiveness

Utilization Measure (Months)[a]	INFOTAP (46)	McLink (11)	PC-TRANS (15)	UTEC (5)	MTU (13)
			Cumulative Data		
Users	538	278	88	116	168
Calls	2397	1045	231	415	1162
Activities	2495	3393	73	800	283
			Cumulative Performance		
Calls/User	4.46	3.75	2.63	3.58	6.92
Activities/Call	1.04	3.25	0.32	1.93	0.24
			Monthly Performance		
Avg. Users	26.4	39.9	9.5	32.6	-
Avg. Calls	52.1	95.0	15.4	83.0	89.4
Calls/User	1.97	2.38	1.62	2.55	-
			Cost-effectiveness		
Cost/Call[b]	$3.80	$2.10	$13.00	$2.40	$2.20
Cost/User[b]	$7.60	$5.00	$21.10	$6.10	-

[a] Number of months of EBBS data
[b] Based on monthly operating cost of $200 per month
- Indicates data unavailable

TABLE 6 Regression Models for Relationships Between Monthly EBBS Calls and Users and Monthly EBBS Activities and Calls

		Monthly Calls			Monthly Activities		
EBBS	n	Const Term	Coeff for Users	R²	Const Term	Coeff for Calls	R²
INFOTAP	46	-2.4 (-0.51)	2.1 (12.5)	77.4%	6.4 (0.56)	0.92 (4.6)	31.3%
McLink	11	-14.3 (-1.3)	2.7 (10.2)	91.1%	-25.1 (-0.61)	3.5 (8.8)	88.5%
PC-TRANS	15	-3.8 (-1.2)	2.0 (6.9)	76.9%	-3.9 (-1.4)	0.57 (3.8)	48.4%
UTEC	5	-46.8 (-1.6)	4.0 (4.6)	83.6%	-31.6 (-0.9)	2.3 (6.1)	90.1%

Note: "t" values in parentheses

suggest that months with fewer users have lower rates of calls per user than months with many users. This results in regression coefficients for users being larger than overall ratios for calls per user shown in Table 5. The most extreme example is the UTEC model with a regression coefficient of 4.0 compared with the overall calls per user ratio of 2.55. The most important result here is the stability of calls per user ratio, both over time and for wide fluctuations in number of users.

The final relationship considered is between activities and calls. Ratios of activities to calls for cumulative data on EBBS utilization are presented in Table 5. Ratios for monthly performance data are the same as those for cumulative data and thus are not repeated in Table 5. As discussed earlier, ratios of activities to calls vary widely because of EBBS software recordkeeping capabilities. Nevertheless, analysis of monthly performance data reveals consistently linear relationships between activities and calls for all EBBSs. In addition, there are no apparent trends over time. The resulting regression models are presented in Table 6. INFOTAP and PC-TRANS models have relatively low explanatory power (R^2 of 31 percent and 45 percent, respectively), but regression coefficients for calls are highly significant. Although constant terms are not statistically significant, inclusion of constant terms does affect the call's coefficient value slightly. As for calls versus user regression models, the activity versus calls models exhibit a high degree of stability over time. The value of the regression coefficients, however, depends on the definition of activities and the extent to which activities are recorded by each EBBS operating system.

EVALUATION OF EBBS PERFORMANCE

Performance can be measured by number of users, level of use, and system cost. Cost-effectiveness measures can then be developed in terms of users per unit cost and utilization per unit cost. In theory, system performance should consider current operating costs and should be monitored monthly. If system performance goals are not being met, then corrective action can be taken in a timely manner. The problem is that the primary measures of system performance, calls per month, and users per month are quite variable. Over its 46 months of operation, calls per month for INFOTAP varied from 15 to 110 with an overall average of 52. Because operating costs should be quite stable, the cost-effectiveness measure, cost per call, for INFOTAP was also highly variable. Thus, major decisions about EBBS operation should be based on long-term trends rather than on month-to-month variations.

Cost-effectiveness of the five case study EBBSs is presented in Table 5. Cost-effectiveness measures are based on monthly performance and are computed using a common operating cost of $200/per month ($180 for staff time and $20 for phone as explained earlier). The cost per call generally ranges from $2.10 to $3.80 with one outlier at $13.00. The cost per user ranges from $5.00 to $7.60 with one outlier at $21.10.

EBBS cost-effectiveness for delivery of technical assistance is assessed by considering alternative modes for delivering comparable products. For example, an alternative mode for distribution of software is by diskette and U.S. mail. For comparison, consider a telephone hotline with distribution of requested technical publications by FAX. Assuming 6 min per call with staff time at $15.00/hr plus a $2.00 FAX cost, the total cost per call is $3.50. This cost per call for FAX is well within the range of EBBS case study costs per call.

SUMMARY AND CONCLUSIONS

Data on users, calls, and activities were available for five EBBSs. In general, the data were analyzed at two levels: first, as total cumulative values covering the time periods for which data were available and second, as monthly time series looking at both the monthly average and variation over time. In addition, the average time that users participate in each system was computed.

User attributes showed that two systems serve a national market, two are regional, and the fifth serves both a national and regional market. In general, the distribution of calls is more likely to be in state than is the distribution of users. Some users are attracted from other states that have an EBBS, suggesting that unique services are being provided by each EBBS.

The change in the number of EBBS users from month to month did not follow the expected growth curve. Instead, users per month followed a downward trend for two of the systems, an upward trend for one system, and no trend for the fourth. There is also considerable month-to-month variation within the trends.

Calls per month followed a pattern similar to that for users per month. Although there is considerable variation for all systems, the variation takes place within a relatively narrow band of one to three calls per user, and the trend over time is essentially flat. Thus, the needs and incentives to utilize EBBSs appear to be similar across the systems and stable over time.

Examination of the distribution of users by number of calls made shows that most users made only one or two calls during the periods studied. Normalized distributions based on percentage of users are very similar for the four systems that could be compared. The small proportion of repeat callers is consistent with the relatively short duration of system use on the part of callers. Mean duration of use is typically about 10 percent of the total months for which data are available.

The small proportion of repeat callers suggests a reason for decline in users and calls for two systems. Initial system marketing should generate use by the most computer-fluent individuals who are highly motivated to gain access. Once the initial demand is satisified, subsequent marketing must reach individuals who are less motivated and computer fluent; thus the number of users declines. Information on marketing and services offered over time is needed to test this hypothesis.

The level of call activity record keeping is a function of EBBS software capabilities and administrative policy decisions. File download and upload information was available for all five systems; however, details of other common activities such as reading mail or displaying information were available for only two systems. With the exception of McLink, file downloads were the dominant activity for all systems and, with the exception of MTU, file uploads were quite rare.

EBBS staff estimates of users and actual measured users should have some relationship to target audience size as measured by T² center newsletter circulation volume, but the relationship is not perfect. Nevertheless, for systems with a target audience composed of individuals who receive the regional newsletter, we roughly estimate an optimistic utilization rate of 10 to 20 percent over the extended life of the EBBS. Utilization models relating users to calls and calls to activities using linear regression, were much more successful. These regression models have reasonable explanatory power with highly statistically significant regression coefficients and, as expected, constant terms were not statistically significant. In addition, these models are not biased by any trends over time. Note however, that for these models, "users" is an independent variable; thus, the decline in users over time for two systems is not modeled.

Finally, system cost-effectiveness was estimated based on an assumed common operating cost of $200/month. With the exception of one system, the cost per call ranges from $2.20 to $3.80. This range is entirely consistent with the estimated cost of a telephone hotline and FAX method for delivering printed materials and is likely to be highly competitive with the cost of alternative modes for distributing software.

This research has demonstrated the ability to quantify the attributes and the operation of a diverse set of EBBSs for transportation-related technology transfer. Operation and performance data exhibit some remarkable similarities, particularly call frequency distributions and calls per user data. Performance measures provide an initial basis for assessing the effectiveness of an EBBS as a tool for technical assistance and information exchange. Clearly there are potentially large economies of scale because staff costs are essentially independent of level of use. If more technical assistance activities are tailored to the EBBS environment and marketed effectively, the cost of technical assistance might be substantially reduced. We suggest that activities with the greatest potential include timely information that can be packaged in a computer file for downloading by users in the field.

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