TRANSPORTATION DEMAND MANAGEMENT (TDM) THROUGH THE USE OF ADVANCED DATA COMMUNICATION SYSTEMS

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Abstract: A transportation infrastructure must be built in unison with an information infrastructure, and the movement of people, things and information must be apportioned in a suitable fashion among the various means of movement. To do so, we must first understand the potential for interchangeability among the movement of people and things on the one hand and the movement of information on the other; we must also understand the trends seen in the development of information technologies. It is important that we forecast the demand for future movement of people, things and information, and that we make sure that infrastructure construction plans reflect this knowledge.

1. UNIFYING THE CONCEPT OF EXCHANGE SYSTEMS

1.1 Interaction between Transportation and Data Communications

Although traffic generally consists of the movement of people and objects, often the final aim is actually the delivery of information. People move about to meet others, make contacts, attend meetings, hold consultations, or simply to enjoy conversation. Similarly, movement of objects often involves delivery of letters, documents, books, and data.

In recent years, the development of communication systems has led users to rapidly shift from earlier transportation methods to the use of terminal equipment such as telephones, facsimile machines and modems transmitting through electrical cables, telephone lines and optical cables as ways of accomplishing these goals. This transition from transportation to data communications has been going on for a long time. Looking back, we can see that the delivery of information which is now accomplished by telephone was carried out before the Meiji Era (1868-1912) by the delivery of letters and, for urgent matters, the use of messengers. This shift is confirmed by the fact that early telephone rates were based on the annual cost of alternatively employing boys as runners (See Table 1).

As telephones proliferated, people increasingly relied on them for exchanging information and consequently wrote fewer letters. Further, the advent of facsimile machines brought a shift from paper to telephone lines as the medium by which letters and documents were delivered, and modems are similarly replacing paper and floppy disks as vehicles for transfers of data. News which before was communicated via public bulletin boards is now broadcast on television and radio.

Table 1: An Example of Steps in the Shift from Transport to Data Communications

Transport Method		Communications Method	Foreseen Communications Functions
	Letters, messengers	Telephones	Personal phones, personal messengers
	Document exchange	Facsimile	Print quality improvement, color capability

Movement of Items	Newspapers, bulletin boards	Television, radio	On-demand function
	Distribution of flyers and catalogs	Facsimiles, computer communications	On-demand function
	Delivery of books	Modems, display devices	Acceleration of transmission, print-quality display devices
	Delivery of floppy disks and magnetic tapes	Modems, computers	Acceleration of transmission, large storage capacity, data security
Movement of People	Conferences, meetings	Video conferencing equipment	Print-quality large-screen display devices, multiple-user participation, improvement of immediacy
	Sales (product explanation)	Video conferencing equipment	Print-quality large-screen display devices, improvement of immediacy
	In-store purchases	Mail-order	On-demand function, express delivery, high-resolution display devices, electronic payment, data security
	Commuting to work	Telecommuting (working at home), virtual company	Print-quality display devices, improvement of immediacy
	Commuting to school	Electronic classroom	Print-quality display devices, improvement of immediacy
	Watching movies in theaters	Television, cable television	On-demand function, large-screen high-resolution display devices
	Game centers, karaoke rooms	Network games, network karaoke	On-demand function, large-screen high-resolution display devices, multiple-user participation

1.2 Integration of Transportation and Data Communication under the Concept of Exchange

We can examine systems used as exchange channels in terms of expansion of exchange facility space, the items delivered, and the main method of delivery used. Exchange systems can be classified as systems used to transport objects, systems used to transport people, or systems used to transmit information. Data can be transmitted optically or electrically, over wire or by wireless means. Transportation systems are used to move people and objects. Air, marine, road and railway transportation systems are examples.

The facilities and equipment used in exchange systems can be examined in terms of the space they occupy and their physical configuration. They can be broadly divided into facilities occupying a particular spot or point and facilities that operate or function over a line. Among the former, "point facilities" include airports, harbors, transmitters, and receivers. The latter category, "line facilities," includes roads, railways, and transmission cables. Line facilities require the establishment of channels such as roads, railway tracks, and cables (See Figure 1).

This study takes up the subject of systems used for exchanges (movement) of people, objects, and information. A rational distribution of how air and marine facilities are used in conjunction with roads, railways, information networks, and pipelines to exchange or move quantities of people, objects, and information can be applied to such problems as traffic congestion and environmental destruction. When seeking clues to solutions to these

problems, it seems appropriate to use the concept of exchange systems to gain a comprehensive point of view.

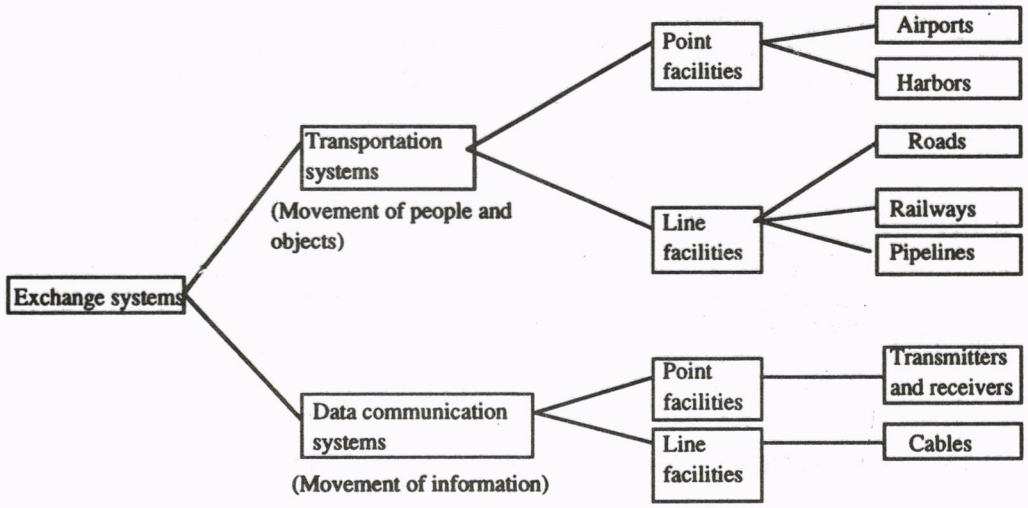

Figure 1: Spatial Distribution of the Exchange Systems

Both transportation and data communication systems are ways of delivering information, and the term "exchange" as used here includes transport of materials. Exchange can be broadly divided by its goal as follows.

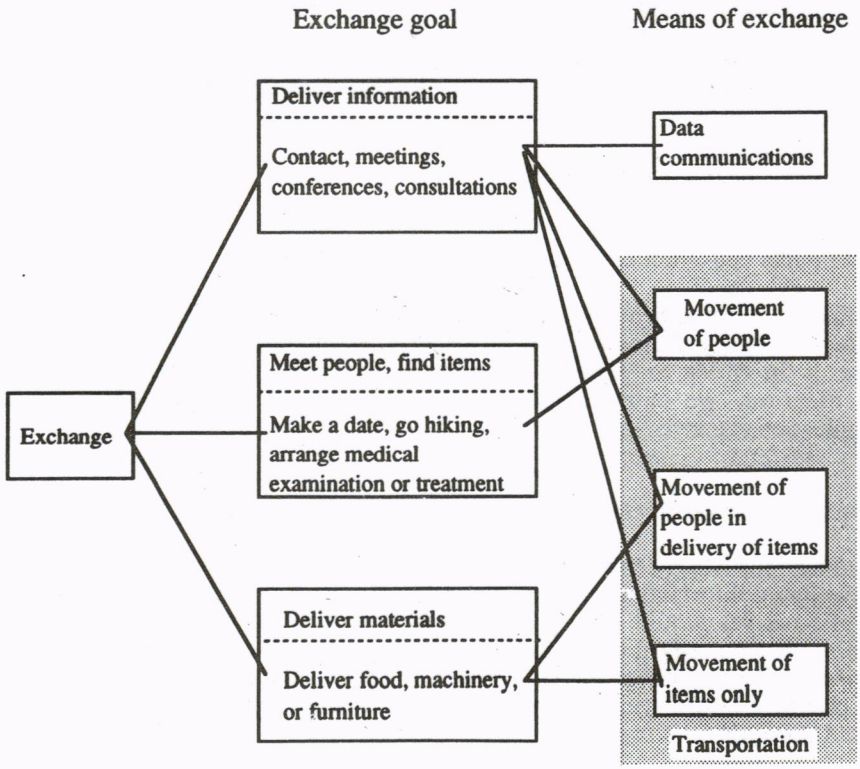

Figure 2: Classification of Exchange Systems by Goals

1.3 Shift from Transportation to Data Communications Depends on Development and Diffusion of Technology

This shift from transportation to data communication depends heavily on development of data communication equipment as well as transmission quality (terminal display quality and transmission speed) and cost. Video conferencing systems require further development because their quality, that is their immediacy, is not yet sufficient to replace live conferences. If the level of immediacy is improved and the systems spread into a majority of offices, much of the physical traffic involved in people attending conferences will become electronic data traffic instead.

The print quality of currently common facsimile machines is not high enough for use in reports, and often after a facsimile is sent, the original document is sent by mail. Data communication is often used for exchanging small amounts of data, but large batches of data are still generally delivered on magnetic tape, and the delivery of newspapers, magazines and books by electronic transmission is not widespread. This gives some indication of how the shift from transportation to data communication depends on quality and cost of data communication channels.

1.4 Management of Traffic Demand by Advancement of Data Communications

The shift in exchange channels from transport to data communication is expected to progress rapidly as a result of future improvements in data communication speed and quality and proliferation of low-cost equipment. In order to further this shift, development of data communication channels indicated in the right-hand column of Table 1 is necessary. Basically, rapid development is recommended in each of the following areas.

a. High-capacity storage
b. High-speed, large-volume communications
c. Display quality equal to paper print quality
d. Large-screen, high-resolution display devices (with display quality equal to paper print quality)
e. Data security
f. Immediacy (natural interface)
g. On-demand, real-time function
h. Personal communications
i. Simultaneous multiple-user participation

Technological development and proliferation of equipment as indicated above will further the shift from transportation to data communication and lighten the load on transportation facilities. In order to predict the rate of the shift from transportation to data communication, we must forecast the development and proliferation of data communication channels.

1. 5 Issues on the Interrelation between Transportation and Communication Systems

Communications and roads complement one another and function as a pair. It is possible that developing information systems and replacing existing traffic with communications-based alternatives would only generate additional traffic demand. Based on Tokyo Government's Department of Urban Planning(1992), relatively long distance business trip can be substituted by television conference. Further, taking advantage of ISDN service, which provides information on shopping, traffic congestion, entertainment, and so on, increased the number of trips.

In one questionnaire surveyed by Edamura (1991) on the use of alternatives, 44% of business respondents gave greater efficiency of work as the top response. The time and

extra capacity produced would thus go toward work and lead to increased traffic volume.

According to Takita, et al. (1993), the information network of the future would reduce the number of trips in Japan slightly, but actually increase the number of trips in Canada. An examination of economic and communications indices shows that a strong correlation exists between the time and frequency of calls on telephone networks, and the transportation of personnel and materials expressed in gross tons. Statistics from Institute for Posts & Telecommunications Policy (1993) indicate that volumes of transportation and data communications expand together (See Table 2). This offers indirect support for the notion that the two activities should be analyzed in a unified fashion.

Thus, focusing on the potential as an alternative prevents calculation of information exchange volume. Without a clear understanding of the correlation between information communications and traffic, we will not be able to make proper predictions of information exchange volume and traffic volume. We will not be able to develop an overall concept of exchange system encompassing roads, railways, communications and other elements. Further research is required in this area.

Table 2: Indices of the Correlation of Data on Telephone Usage and Other Social Activity

	Gross production of tertiary industries within prefecture	Passenger transportation personnel	Cargo shipped (gross tons)
Number of calls	0.965	0.989	0.739
Duration of calls	0.955	0.994	0.746

(At the level of prefectures or states)

2. SYSTEMS USED FOR EXCHANGE: BASIC STRUCTURE AND CURRENT SITUATION

2. 1 The Basic Characteristics, Structure and Categorization of Data Communication Systems

Data communication systems involve the creation of various networks that employ circuits and enable transmission at various speeds. The expansion of data communications has been made possible by the application of optical fiber networks and the rapid development of high-quality equipment that can handle large volumes of data at high-speeds. Table 3 shows information network services currently available in Japanese market.

Table 3: Structure and Categorization of Information Telecommunication Systems

Connection methods	Category	Features
	telephone network for subscribers	*Used for transmission of voice, facsimile, and data.
	telecommunications network for subscribers	*These are generally called telex networks. Although, with the advent of new media such as data communications and facsimile communications the use of this media has decreased in relative terms, high demand still exists for it as a form of international telecommunications.
	DDX network	*These networks offer faster transmission of data at higher quality.

Users are linked to switchboards; users select receiver of information by means of electrical signal (number dialed); communication lines are set up to connect with users receiving and sending information; users are released from old signals when new signals are received.	ISDN	*Previous telecommunications networks were set up according to the type of data being handled. Today, however, various types of information can be processed in different forms and sent and received on the same telephone line: for example, voice, data, and facsimile can all be handled on the same telephone line. Moreover, the rising need for higher transmission speed can be met. ISDN was developed in response to the rising tide of international communications to provide networks that can handle different communication signals such as voice, data and facsimile at high speeds on the same line.
	facsimile telecommunications network	*Facsimile networks differ from the conventional use of facsimile over regular telephone lines. They will offer common functions to all users, and the terminal equipment will be made as simple to use as possible. The differences between charges based on the distance between sender and receiver will be narrowed.
	videotext telecommunications network	*Information is sent directly from an information center to user terminals, often as visual information in the form of talk.
	mobile telecommunications network	*Car telephone networks, ship telephone networks, and networks of public phones on trains are examples. Each of these types, which will operate independently, will be linked to regular telephone lines and other networks.
Exclusive lines are set up for designated users and organized according to the type of information being handled and the speed at which it is sent.	exclusive line	*These can be broadly divided into general exclusive lines and high-speed digital lines. Each line can be further subdivided. Many businesses use these types of lines. *Over 1,000,000 general exclusive lines and 20,000 exclusive high-speed digital lines were in use in 1992.

2.2 ITS Development and Construction of an Information Network

In Japan today, efforts are being taken to establish a road Intelligent Transportation System" (ITS), and work is progressing on the construction of an optical fiber information network. Roads and other forms of transport are essential to the nation's economy, so the Ministry of Construction is conducting research and development projects with a view to establishing an intelligent road transportation network. For their part, the Ministry of Posts and Telecommunications and other bodies are calling forcefully for the construction of an information network, in order to satisfy the needs of an information society and to deal with such problems as the aging of the Japanese society.

2.2.1 Ministry of Construction's Efforts To Build an Intelligent Transportation System

To construct better road transportation systems for the 21st century, it is necessary to integrate man, automobiles, and roads and to advance the progress of the ITS (See Figure 3). While it is, of course, necessary to improve the safety and efficiency of road transportation, it is also necessary to support the free movement of individual cars. In searching for new transportation systems, Japan, Europe, and the United States. have come up with almost the same concepts and objectives (See Figure 4).

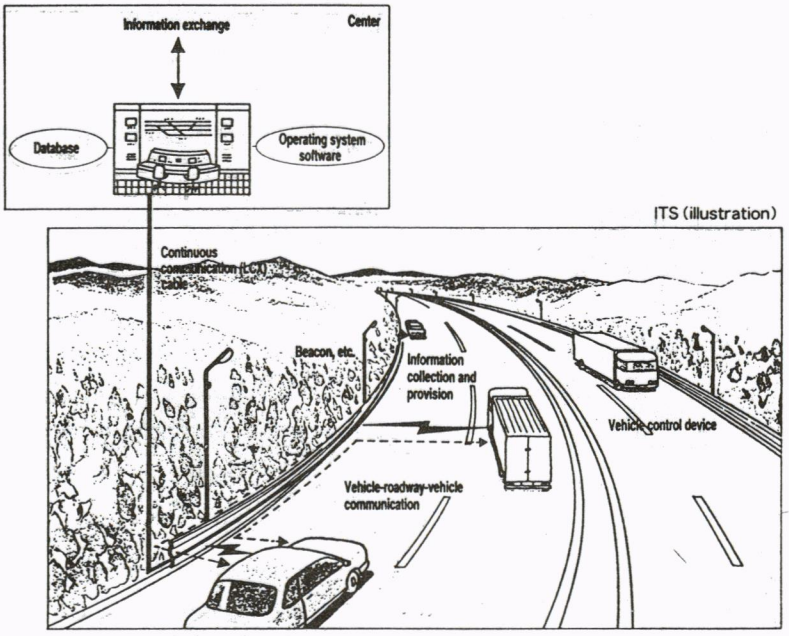

Figure 3: ITS Image

Countries that have advanced in certain fields are linking up to cooperate in projects ranging from basic research to applied technology. The IVHS plan is being implemented by the United States, DRIVE II and PROMETHEUS are being developed in Europe, and Japan is promoting the ITS. Throughout the world, countries are committing to advance these wide-ranging projects and various industries are participating in the planning of these projects.

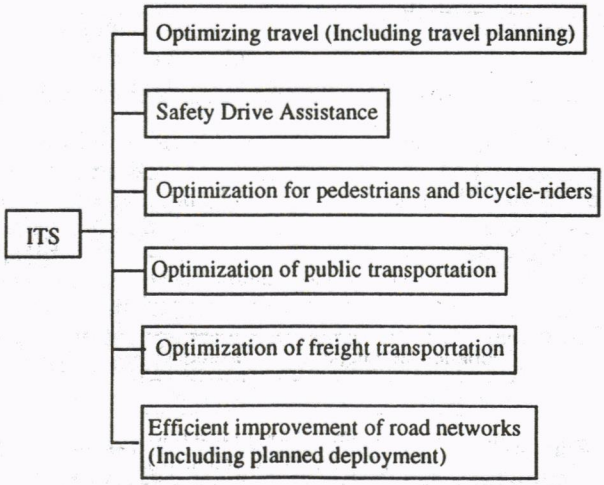

Figure 4: ITS Development Goals

At the core of ITS is an information and communications system that creates a close link between roads and the vehicles which pass over them. Information from cars on traffic congestion and accidents, information provided by sensors on the road surface and data on weather conditions is collected at the information center. The center processes this information and then transmits it to drivers in time to assist them in driving. This two-way communication of information will be improved so as to achieve the three objectives of improved safety, better transport efficiency, and greater comfort. In addition, this system will contribute to the protection of the environment by saving energy and reducing exhaust emissions.

2.2.2 Efforts Taken by Other Ministries and Agencies To Establish an Information Network

With a view to completing an optical fiber network stretching throughout the country by the year 2010, the Ministry of Posts and Telecommunications is implementing its Plan for Advanced Telecommunications Infrastructure To Facilitate Daily Life in the Regions (see Table 4)

Table 4: Outline of the Plan for Advanced Telecommunications Infrastructure To Facilitate Daily Life in the Regions

Project Names	Facilities
Local Government Network	* Library stocking material for image media * Equipment for transmitting and receiving * In-house transmission circuit * Building for the Center * Other
Tele-Work Center	* Building for the Center * Facilities to support tele-work * In-house transmission circuit * Other
New-Generation Regional Cable Television Network (rural project)	A cable television system broadcasting independently * Equipment for transmitting and receiving * Building for the cable sector * Transmission circuit facilities * Other
New-Generation Regional Cable Television Network (urban project)	Establishment of an advanced cable television network with highly advanced applications
Center To Promote Information Interchange	Construction of a core center to promote exchanges among different projects aiming at raising regional telecommunication services to advanced levels

In the case of the city of Hamamatsu, an advanced network will be established in public institutions offering medical treatment, education and welfare services. The network will connect such public institutions as hospitals, schools and City Hall. Because of the extremely advanced nature of the project, a research group has been set up, comprising industry, the academic sphere and government. A network will connect the regional information center (which will become the core facility of the network) with public institutions and other bodies, and a bi-directional, high-volume telecommunication infrastructure will be constructed, primarily for the transfer of moving images. A working group was established in 1994 to conduct four types of practical experiments in improving administrative services and compiled experimental plans.

The Ministry of Education is providing assistance for the establishment of a system offering learning opportunities and information; plans call for the system to be installed in all prefectures by the year 2000. The Ministry is also taking steps to establish the

functions of a national center that will provide information on education, culture and sports; the National Education Center is to act as the core institution.
The maintenance of health, medical treatment and welfare are all services which have a direct bearing on citizens' lives. This is why the Ministry of Health and Welfare is working towards the establishment of an "information welfare society." In the information welfare society, everyone will be able to use an optical fiber network connected to their homes. The network will be used for such purposes as arranging for the rental of equipment to look after the infirm in the home, or obtaining information on services offered by local facilities, or making reservations. People will be able to remain at home while they consult a doctor. Medical institutions specializing in a certain field will be able to provide diagnostic support to general medical institutions (through the real-time use of images, for example), thus making it possible for institutions situated close to the patient to offer advanced medical services.

3. PLANNING THE EXCHANGE SYSTEM

3.1 Concept of the Exchange System

The system can be classified by modes of movement, in accordance with the basic concepts used in planning conventional facilities. In this sense, it can be divided into traffic systems that move people and goods, and information systems that move information (See Figure 5). However, as mentioned above, conventional traffic often includes the movement of people and goods for the purpose of communication, PR, information and other forms of information transmission and exchange between people. This study proposes the concept of exchange system that incorporate conventional facilities used to move information, that have a high degree of compatibility with one another.

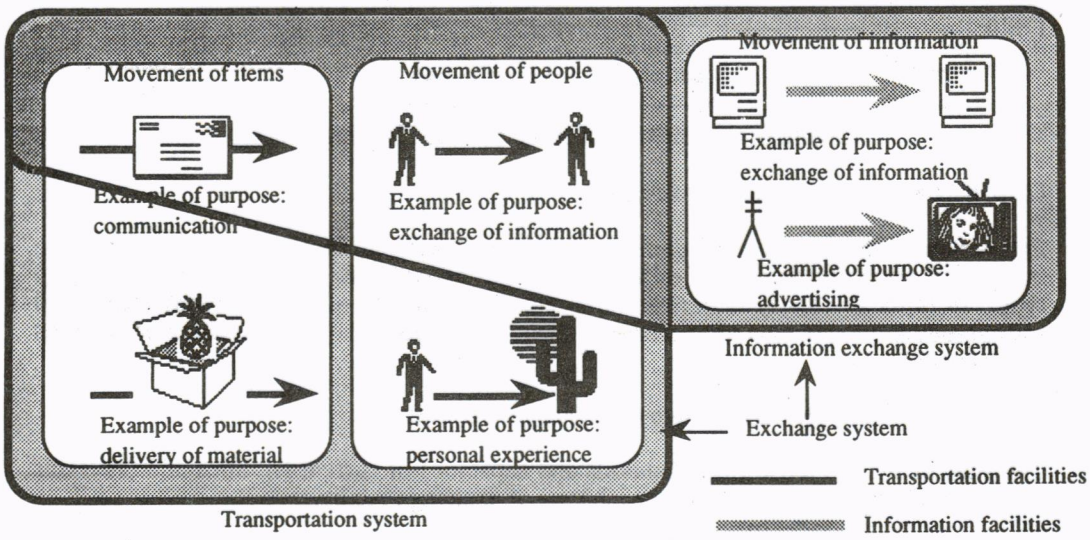

Figure 5: Conceptualization of Exchange System

3.2 Progress in Exchange System Planning

In planning exchange systems, surveys of existing transportation facilities and information-related facilities such as communications and electric power facilities must be

conducted in combination with estimates of demand, and plans must be made for establishment of new facilities and for demand coordination (See Figure 6).

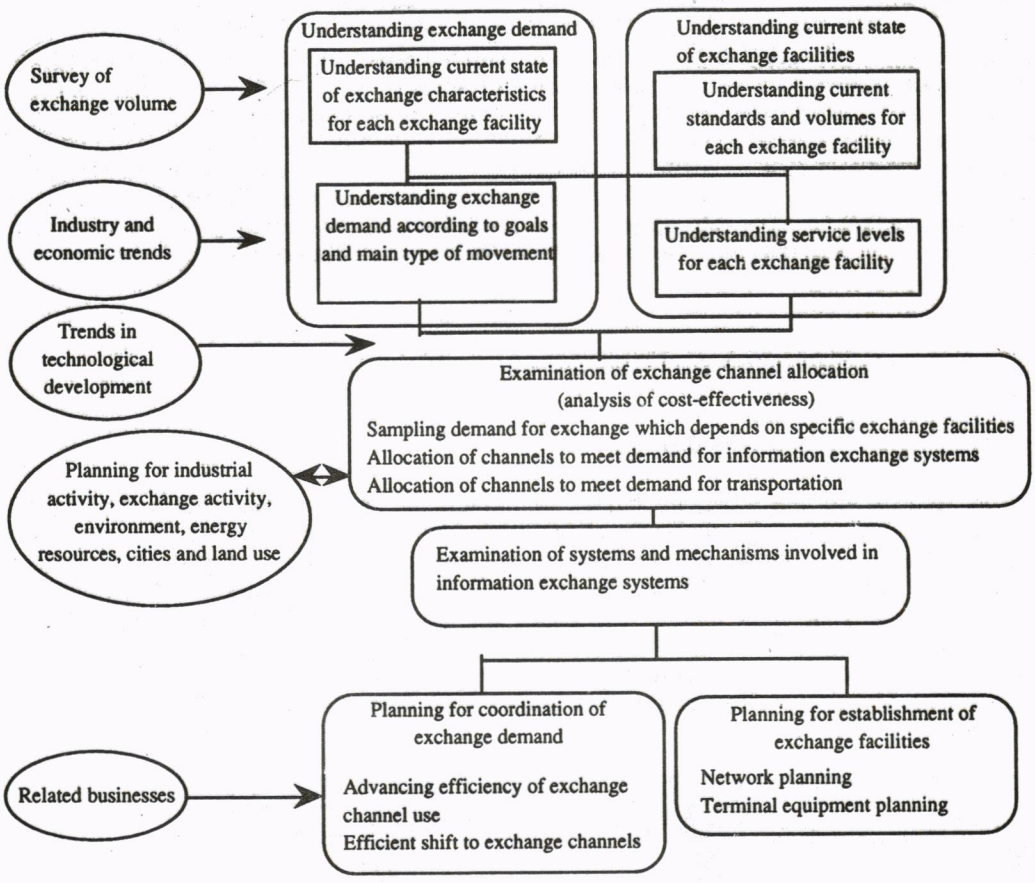

Figure 6: Outline of Exchange System Planning Process

(1) Understanding demand for exchange

Estimation of future exchange demand should be based on current social and economic trends with an understanding of exchange volumes and patterns for each exchange facility type. In order to clearly understand the interchangeability of the communications and transportation components of exchange demand, this demand must be understood in terms of users goals.

(2) Understanding the current state of exchange facilities

The state of service territories, standards and capacities of current facilities and the levels of service should be determined for each type of exchange facility.

(3) Examination of the allocation of exchange channels

We must distinguish exchange which depends on specific exchange facilities from that which is highly flexible. Allocation of transportation facilities and communication facilities should be considered with an understanding of the service levels of current facilities for transportation which is highly interchangeable with communications and the impact on these facilities of shifting. With regards to exchange which will not be absorbed

by information exchange systems, we must further examine allocation of transportation channels.

(4) Examination of systems and mechanisms involved in information exchange systems

We should examine new systems and mechanisms related to establishment and use of information exchange systems.

(5) Planning establishment of exchange facilities

Plans must be formulated for establishment of exchange networks and related facilities.

(6) Planning coordination of exchange demand

Methods must be examined for advancing the efficiency of facility use and the allocation of exchange channels.

4. CONCLUSION AND FUTURE ISSUES

(1) Interchangeability of communication and transportation

It is expected that information exchange volumes will grow rapidly in the future, it remains unclear just how much current transportation will be absorbed into information exchange systems in the form of telecommuting. In particular, it is thought that the shift from human traffic to information traffic will have a strong impact on transportation congestion, land use, regional and urban composition, and social structure and values. It is essential to carefully predict the nature and likelihood of these impacts.

(2) How development of information exchange will change transportation

With the development of information exchange, the magnitude of the shift to communications will correspond to the distances involved, and current patterns of transportation are expected to change. It is necessary to understand changes in transportation patterns as they will apply to each transportation facility and to plan appropriate adjustments to transportation facilities.

(3) Survey scheme for understanding exchange demand

Past surveys of transportation demand have been conducted by different transportation organizations and addressed passenger and freight traffic separately. Further, surveys on transportation purposes such as commuting, business travel, and private travel, have addressed these separately and thus cannot be directly used for planning allocation of exchange channels. It is necessary to establish survey schemes and systems which will enable us to gain a unified understanding of exchange volumes.

(4) Establishing information networks

Until now, the infrastructure of information systems has been built piecemeal by telephone companies, electric power companies and cable television companies, all working independently.

Land-use rights must usually be acquired to establish line facilities such as cables for optical fiber circuits and electric lines. Areas along roads are best suited to use for such facilities because of following reasons.

a. Roads are the only channels available that link homes to be connected to communication lines.

b. Road transportation and data communications are both part of the overall structure of exchange activity. The distribution of demand for the two exchange channels is much the same. Places where there is a high volume of demand for roads often also have a high demand for data communication. It therefore makes sense--and it is relatively easy--to set up cable facilities along roadways.

c. The basic structure of road systems is that of a network whose channels are structured into various classes. Accordingly, their structures lends themselves to the laying of cables for data communications networks.

As part of its road construction program, the Japanese Government's Ministry of Construction has begun the establishment of a network of Communication Cable Boxes (CC boxes) which are underground bundles of optical cables, on the proposition that these could be used commonly by various operators which own wire systems. It is necessary to put in place an information network as a first link in the broader exchange network and to coordinate and organize facilities and operations.

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