To explore the possible complementarily between trucking industry activities and IVHS activities, the study began by reviewing the technologies available to the trucking industry, their adoption and use, and possible broad impacts on the trucking industry. In the discussion to follow, the technology review is reported following a brief overview of the trucking industry. Position finding systems are described first and then the major mobile communication services are identified and their capabilities noted. Developments in Europe and emerging systems are also mentioned. An exhaustive technology survey was not achieved because new products and services are constantly coming on the market, especially from vendors who package services from existing technologies. However, the systems mentioned are the prominent ones and are representative of the emerging capabilities.

The next section looks at the experiences of the users and examines how well the available systems fit the needs of fleet operators. Satellite systems are emphasized because the bulk of operating experience with the most recently developed technologies is with mobile satellite communications systems. The HELP project is also mentioned. Then, we turn our attention to the lessons that are to be learned from the experiences of the early adopters. Three levels of integration are described as a way for fleet operators to realize the full benefits of the new technologies. A discussion of the broader implications of information technologies and further research follows.

The research on which this document stems from the literature, interviews, and a survey. The reader will discover that there are a number of available and proposed technologies systems, and the situation is in flux. In some areas, there is considerable speculation, but not much hard data. While there are engineering-type data on technologies, data on technology adoption, benefits, and uses are often impressionistic. One is reminded of the vaporware mentioned when claims for computer software programs "to be ready yesterday" are discussed! The literature based research involved checking from multiple sources and striving for reasonable interpretations.

The results of a survey of technology adoption and use assisted in interpreting the findings from interviews and the literature review. The survey is discussed in the Appendix where the development of an **IVHS-oriented** truck technology monitoring system is stressed.

2. THE TRUCKING INDUSTRY

Truck services grew first in urban areas and in rural farm-to-market services as trucks substituted for the horse and wagon. Intercity trucking grew later as the state-federal primary road system was developed in the late 1920s and 1930s. New services began to grow, and an examination of market shares indicates that market capture from railroads was essentially completed by the late 1960s. Although on ton mile measures the industry ranks somewhat below railroads, pipelines, and inland waterways, trucks are the dominant freight mode when tons loaded or payments for freight services are measured (Figure 1).

The emerging trucking industry organization was frozen by ICC and state regulation introduced in the 1930s. There are regular route common carriers, contract carriers, parcel carriers, etc. Some firms offer national services, others operate in regional or commodity market niches. With respect to prices, services and conditions of entry into the business, regulation followed the railroad model. The presence of private carriage, owner operators, and agricultural haulers did, however, result in some regulatory deviations from the rail model.

The Motor Carrier Act of 1980 essentially eliminated restrictions on the entry of firms into the trucking business. Established firms could enter new markets as they wished and new firms could enter the business almost at will. As a consequence of the latter, the number of firms reporting to the ICC increased from about 18,000 in 1980 to about 40,000 in 1988. Deregulation also reduced pricing restraints. The result was a period of considerable industry turmoil that continues today. The result important here is fiscal pressures on firms as the trucking business has become increasingly competitive. In 1988 the failure rate for trucking was 134.5 per 10,000 establishments, exceeding the 98 per 10,000 establishments rate for all businesses. With increased competition, profits are low. This dampens the ability of firms to invest in new technologies. At the same time, competitive pressures force firms to increase productivity and seek technologies and operating improvements that will enhance the effectiveness of services offered.

The American Trucking Associations publishes annual motor carrier reports based on data from the Interstate Commerce Commission. Summarizing data for 1,567 carriers of property reporting to the Commission, the 1989 Report indicated a return on capital of 5.82 percent. This limited return on capital has been the situation in the industry and its subdivisions for the last decade. One result has been aging
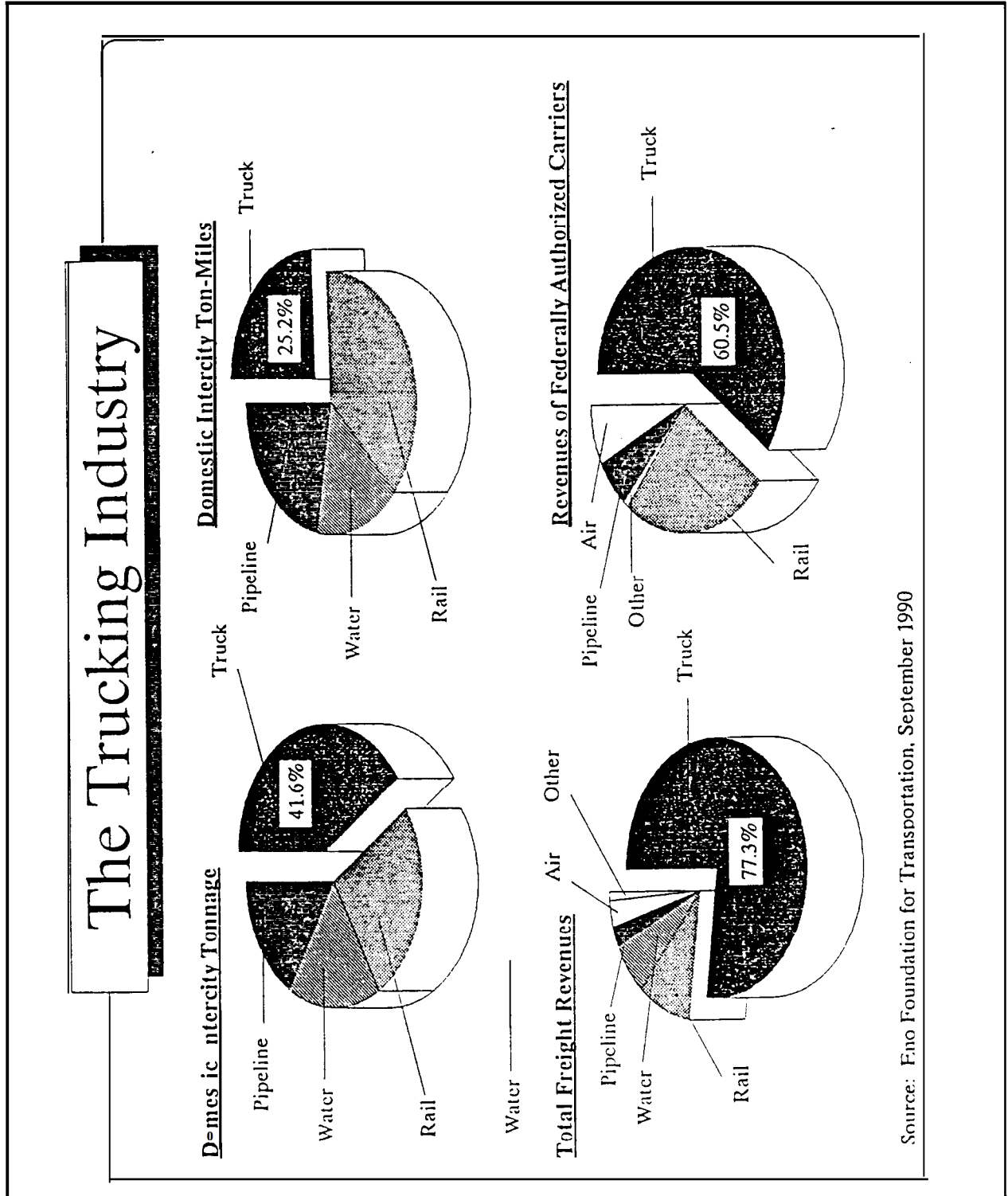
The Trucking Industry

Domestic Intercity Ton-Miles

Truck

25.2%

Pipeline

Water

Rail

Demeс ic ntercity Tonnage

Truck

41.6%

Pipeline

Water

Rail

Water

Revenues of Federally Authorized Carriers

Truck

60.5%

Air

Pipeline

Other

Rail

Total Freight Revenues

Air   Other

Truck

77.3%

Pipeline

Water

Rail

Source: F.no Foundation for Transportation, September 1990

Figure 1: The Trucking Industry [I].

Positioninn and Communications

of equipment, and, as stated, the lack of capital productivity has a problematic effect on investment in new technologies. Technologies with high rates of return are needed.

With respect to steps available to improve productivity, a recent unpublished consultant's report suggests, in order of usefulness:

Preventive maintenance
Driver education
Incentive systems
Vehicle-specific fuel monitoring
On-board communications systems
Computer management of maintenance
Computer-aided dispatching
Scheduling to avoid traffic
High capacity equipment
Trip computers
Electronic data interchange
Owner operators
Full service leasing

We have reproduced this list in spite of the non availability of the source document and lack of information on how usefulness was measured, because it is representative of the topics stressed in the trade literature.

Discussing these steps to improve productivity with firms, respondents repeatedly refer to 1 and 2 percent improvements as steps are taken. However, there are costs associated with actions, and the returns may not be additive. Would there be gains from increased preventive maintenance if equipment was full service leased? Would the gains from computer-aided dispatching be constrained by scheduling to avoid traffic?

Seven of the thirteen steps make use of computer and information technologies, which are the focus of this study. The expectation of the researchers is that the consequences of the uses of these technologies depend on interrelationships. The consequences of technology uses will be great if ways

are found to interrelate technology uses. This is a synergy, or the-whole-is-greater-than-its-parts, expectation.

In the environment in which the industry is operating, service differentiation is the key, especially for small carriers. On the demand side, production and distribution have been reorganized by the adoption of flexible manufacturing techniques and Just-In-Time (JIT) inventories. (A recent survey of shippers reported that 70 percent of manufacturers have or plan to soon have a JIT scheme in place[1].) Experts agree that there is a strong trend towards integrated logistics, where procurement through material flow and consumer delivery are managed holistically[2]. In this environment, the reliability and quality of transportation services is often as important to shippers as price [3].

Transportation managers of firms and managers providing third-party services emphasize integrated or interactive activities. Today, the themes circulating among logistics managers and found in professional literature, such **as the Journal of Business Logistics,** stress the integration of transportation and marketing, uses of electronic data interchange, and the relationship between transportation services and direct buying strategies. This emphasis on integration goes beyond JIT services, and it envisions trucking services integrated with many facets of production and distribution activities. Again, interaction and integration have priority.

To this point we have referred to the industry that provides for hire trucking services using about 800,000 trucks. The discussion in this report will continue that emphasis because this sector is seen as the largest market for communications and positioning technologies. Trucks are used in many ways other than for hire, with by far the largest proportion used for personal purposes (Figure 2). However, some of the not for hire categories, such as the trucks used by electric utilities, provide market niches for advanced technologies.

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