loading facilities to ensure that these facilities are being used for their intended purpose. This has been a problem for some time.

The role of urban goods movement, already accounting for one-half of the nation's truck transportation bill, is expected to increase in the decades ahead. The concept of centralized manufacturing has been eroding as small automated plants located near the consuming market are proving to be a more cost-effective alternative to ever-increasing over-the-road transportation and distribution costs. In addition, the concept of zero inventory ("just-in-time") is expected to also increase in popularity in small establishments (manufacturing and retail alike) thereby placing more importance on the movement of decreasing shipment sizes.

The eight examples presented in this paper serve to identify some ideas and options for municipal goods movement project development. Because new goods movement projects are few, evidence of successful and unsuccessful techniques is needed and serves to improve the effectiveness of new projects. It is hoped that this paper satisfies a portion of these information-sharing needs.

REFERENCES

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Directions for Urban Freight Transport Research in Australia

K. W. OGDEN and D. P. BOWYER

ABSTRACT

Some results are reported of a project undertaken to (a) assess the need for further research in freight in Australia, (b) formulate research project statements and identify costs and benefits of such projects, and (c) develop recommendations for further research. The procedures used, which were found to be an effective way of identifying research needs and formulating research priorities and project statements, are documented. The findings of the study are also summarized.

Research in urban freight in Australia has been sustained at a relatively low level in recent years (1). In this sense, it mirrors the situation in North America (2) and Europe (3).

The value of undertaking urban freight research has sometimes been questioned in Australia, as it has in the United States (4). It is sometimes argued that there is little that can be done to influence freight activities, that there is no political or public pressure to tackle freight issues, and that there are few international precedents indicating "successful" freight research. The essential point that these arguments reflect is that there is uncertainty about the value of further freight research.

In the recognition that such uncertainty exists, the Australian Road Research Board (ARRB), together with the Transport Group in the Department of Civil Engineering at Monash University, recently conducted a study with the broad aim of assessing the desirability of further road freight transport system research and the likely payoffs from such research. The specific aims of this study were to
...Assess the need for further research to satisfy information requirements in the road freight transport field,

* Formulate research project statements and identify the nature and order of costs and benefits for particular research projects and programs, and

* Develop recommendations for ARRB involvement in further road freight transport research.

The scope of the study and the level of investigation were constrained in two important ways. First, it applied primarily to road freight transport, although the interface of road with other modes was also considered. Second, it applied to transport system research. The road technology side, which includes the design of pavements, structures, or vehicles, was considered outside the scope of the study.

This paper is oriented toward research in urban freight because the major research needs identified in the project related to urban problems. The only significant exception to this was the role of truck mass and dimension limits. In this way too the study and its findings reflect the U.S. situation, where, notwithstanding a concern for truck mass and dimension limits (5) and for statewide freight planning (6), the primary concerns in freight planning and research appear to be found in urban areas. The output of the present study should thus be of relevance and interest to a wider audience, in terms not only of research methodology (in which there were some fairly novel features) but also in terms of research findings.

INVESTIGATIVE PROCEDURE

Given the wide scope of the project and its broad objectives, it was necessary to develop a research methodology that would ensure that a broad range of inputs could be accommodated. The methodology also had to be compatible with ARRB's committee process (7) because eventually the research findings had to be processed and ranked by priority within this process. It was not considered appropriate to use this committee process in the usual way because, although it includes open forums (to allow discussion on selecting the primary concerns in freight planning and to formulate recommendations on priorities), past experience has shown it is difficult to identify priorities and appropriate levels of research effort in the urban freight field using this process. The reason for this is thought to be that the relatively open-ended nature of freight research, the absence of precedents, and the lack of an ongoing research program have prevented the emergence of a clear consensus on freight priorities.

In the light of this experience, it was believed that the established procedures needed to be complemented by a more comprehensive investigation of freight transport issues and research needs. This project was initiated to undertake that investigation.

Delphi techniques are one means of identifying issues, developing understanding on a subject, and determining a consensus position about future action. They have been several of them in the transport field in Australia (8,9). Consideration was given to using Delphi techniques in this study, and they were seen to be a suitable systematic process for developing understanding about freight transport issues and research needs. However, the resources available to the study were not sufficient to enable the effective use of a full Delphi analysis. An investigative procedure, which might be considered "partial Delphi," was adopted. It comprised the following primary stages and tasks:

* Stage 1. Develop a statement of issues and research needs. This was based on a literature review.

* Stage 2. Conduct a series of small discussion sessions. These refined the statement of issues and needs and identified research topics.

* Stage 3. Draft research proposals. These address the research topics that are of common interest in the road transport sector.

* Stage 4. Conduct a workshop. The task of the workshop is to consider the draft proposals and possible priorities with the aim of developing positive recommendations for further research. This provided input to the executive committees.

In the balance of this paper each of these tasks and the output from them are described.

IDENTIFYING ISSUES AND RESEARCH NEEDS

Investigative Framework

A preliminary though comprehensive review of Australian freight transport research was conducted as a means of focusing on issues of current concern (1). This revealed that freight research was being undertaken in several broad subject areas, but such a review in itself could not tell much about the current issues and emerging research priorities.

It was thus considered that a systematic investigative framework, based essentially on identifying issues in relation to freight transport objectives, was necessary to aid identification of research needs.

The investigative framework recognizes three distinct, though related, components of freight research:

1. Freight issues that are related to the objectives and constraints of the freight system.

2. Actions that may be taken to resolve one or more of the issues. These may be thought of as broad policy options (e.g., regulation) or specific schemes (e.g., traffic management).

3. Research tasks that are needed to either investigate the issue or appraise the application of action in response to an issue or issues.

These three components are related but quite distinct, and the challenge is to determine how research can be applied either to an issue or to assessing possible actions in relation to it. Their relationship is shown in Figure 1 in which X is the appropriate research project to appraise the effect of action P on issue A. Without loss of generality, X may also be considered an analysis of issue A, or an appraisal of action P, without any cross-reference between A and P being involved.

Objectives and Constraints

The desirable starting point for any consideration of freight transport research is the identification of the objectives that the freight system is intended to serve and the constraints on the system.

This immediately raised the question of "whose objectives?" because the objectives of different participants in the freight process will be different and in many cases will be in conflict with those of other participants. Without being flippant, it may be said that the analysis of the objectives...
Governments have available a range of possible actions that can be taken in pursuit of these objectives or to satisfy the constraints (3,10). These options include:

- Regulation of the industry structure, of the activities of the industry, of the driver, of the vehicle, of vehicle use, and of land use;
- Subsidy and taxation;
- Traffic management;
- Infrastructure for investment and maintenance;
- Training and education;
- Consultative mechanisms;
- Public ownership or divestment;
- Demonstration projects; and
- Technology and design (especially vehicles, pavements, and structures).

Possible Actions

As shown in Figure 1, research may be directed either at specific issues (which arise in relation to the objectives and constraints) or at particular actions (i.e., the application of particular schemes or policy options to those issues). The following list is considered indicative of the sorts of research that might be necessary to assist in the resolution of particular issues or to appraise particular actions that have been taken in practice.

- Development of analytical techniques: supply models, demand models, and impact models;
- Costing analysis;
- Development of information bases and monitoring techniques;
- Basic or exploratory investigation (i.e., assessment of the nature of an issue and its importance);
- Market research, especially in the commercial sector; and
- Development of general procedures methodology for planning, evaluation, impact assessment, and forecasting.

Determination of the appropriate research tasks and specification of the research method were major tasks in the research proposal development stage.

Statement of Issues and Research Needs

Using the investigative framework outlined previously, a discussion note was prepared that included details of the framework itself and statements that represented an initial attempt to define current freight transport issues and research needs. To facilitate the conduct of discussion sessions, this initial set of issues and needs was related to the objectives:

- Service quality,
- Economic efficiency,
- Environmental and safety impacts,
- Distributional effects,
- Cost recovery, and
- Energy.

RESEARCH TOPICS

Process

The statement of current issues and research needs constituted a working document to assist in the process of determining the perceptions of others in the freight transport field on issues and research needs. It specified relevant research topics and indicated the nature of possible payoffs.

To facilitate this process, a series of discussion sessions was arranged, in which the authors led a loosely structured discussion on the general topic of freight research. The discussion note was circulated ahead of time to stimulate response and to guide discussion.

Discussion sessions were conducted with persons from several Australian state road authorities,
state and federal government transport agencies, and railway systems and with particular individuals with
knowledge and expertise in the freight transport field.

It is of interest to note that, although in many
cases the views of persons involved in the discus-
sions were "predictable" given their affiliation, this was by no means universally so. In some ses-
sions opinions varied significantly among individ-
uals from the same organization, reflecting the
varying perspectives on freight issues and research
needs within an organization. This experience demon-
strates the value of the discussion sessions in
bringing to light different perspectives and opin-
ions in a professional environment in which most in-
dividuals can feel free to express personal views,
not necessarily "organizational" views.

Freight Transport Issues

A primary outcome of the discussion sessions was a
clearer statement of current freight transport is-
ues and their relationship to the broad transport
objectives outlined previously. These are summarized
hereafter. To emphasize the commonality of these is-
ues among industrialized countries (31), recent re-
search elsewhere is cited. No priority ranking is
implied.

Service Quality

Three specific issues relating to service quality
were identified:

1. Performance criteria and standards. It is
 generally recognized that the requirements from the
freight transport system vary across user segments
and thus the importance of particular performance
criteria varies across segments. Three such criteria
are price, service frequency, and reliability of
time of delivery. These criteria also have impor-
tance for road infrastructure and urban structure
planning because they could influence the amount of
travel and the value placed on travel time. However,
little hard information exists on either the rela-
tive importance of criteria or their inferences for
road planning (12-15).

2. Industry structure and viability. The ability
of the industry to deliver a desired service is
influenced by its structure, as is its ability to
conform with community expectations relating to such
factors as safety, environmental protection, and
cost recovery. Just as the freight market comprises
numerous submarkets, so the freight sector is char-
acterized by specialized activities and functions
(e.g., forwarders, line-haul operators, local de-

delivery firms, owner drivers, loading agents, own-
account carriers). It is a necessary prerequisite to
informed policy and planning for freight that the
role and contribution of each sector of the indus-
try (and indeed of the industry as a whole) be
known and understood. Moreover, because freight
movements can be a good indicator of wider economic
performance, more attention to monitoring the
freight sector could have wider benefits (2,16,17).

3. The freight task. An increased understanding of
the size and patterns of freight movement, and of
the factors affecting demand, is necessary to aid
transport planning. Also, there are major defi-
cencies in current techniques for modeling the gen-
eration and flow of commodities and vehicles, modal
split analysis, and freight forecasting (3,18-24).

Economic Efficiency

Four specific issues were identified:

1. Economic growth. Although it is known that
transport costs are a significant component of the
costs of production, it is not known whether savings
in these costs would contribute to economic growth
(i.e., the extent to which such savings are really
transfer payments). This is particularly significant
in that improving "efficiency" might lead only to a
growth in unemployment. This does not negate the im-
portance of efficiency objectives (especially where
export traffic is concerned), but it does emphasize
the importance of considering distribution effects
(25).

2. Industry productivity. Transport costs are
part of the costs that affect final prices of com-
modities. Their significance varies considerably
from item to item. There is little comprehensive
Australian data that would show how important physi-
cal distribution management (pdm) costs are in rela-
tion to other costs of production, nor of transport
costs within pdm costs (26,27).

3. Urban transport network effects. That urban
traffic congestion, terminal delays, and certain
restrictive operating practices affect freight costs
is axiomatic. What is not understood, however, is the
effect that these costs have on such aspects as
truck productivity (e.g., number of deliveries per
day); viability of industry in the locality; and
choice of mode or form of operation, including own-
account operation (18,21,28,29).

4. Freight system efficiency. A periodic review
of the suitability of the various industry param-
eters (e.g., vehicle mass and dimension limits) and
related investment needs should be undertaken. Tech-
nological advances in road and vehicle design, or
changes in the relative importance of production
factors (e.g., labor, energy) mean that a revised
set of conditions may be "optimum" (5,30).

Environment and Safety

In this case, four issues were thought to be im-
portant:

1. Significance of truck-related road safety.
Although trucks are involved in some 15 percent of
accidents in Australia involving fatalities, they are
overrepresented relative to vehicle-kilometers of
travel, and most fatalities are not participants in
the road freight industry. There is some research
activity on truck-related safety issues at present,
but it would probably be true to say that these is-
ues have not been pursued as vigorously as other
aspects of safety research. Thus there is a need for
improved understanding of the nature of the truck
accident problem (17,31,32).

2. Development of truck accident countermea-
sures. This issue follows from the first; the dif-
ference is that this one is focused on development of countermeasures as a follow-on from the analysis
conducted of accident patterns.

3. Noise, emissions, and vibration. These three
environmental issues probably represent the three
most noticeable forms of environmental problems as-
associated with trucks, and, in each case, trucks are
significant or are perceived to be significant
contributors to the overall problem (26).

4. Intrusion into residential streets. Concerns
related to the intrusion of extraneous vehicles in
residential street networks have come into promi-
enance in Australia in recent years and in some cases trucks figure in those concerns. A range of measures to tackle traffic intrusion has been developed, but it is probably fair to say that trucks have not been treated as seriously as cars in these developments. Three aspects are involved: first, the development of means of keeping extraneous trucks out of residential neighborhoods; second, how best to cater for trucks that have legitimate business in the area; and, third, the problem of truck parking.

Distributional Effects

The two current issues of concern in relation to this objective were

1. Equity: beneficiaries of subsidies. Within the objective that the freight system should provide an acceptable balance between societal and private benefits, an issue of current concern is that of who benefits from existing freight subsidies. The presence of rail deficits and, perhaps, less-than-full road cost recovery implies subsidies, and it is not known to whom these subsidies are benefits, or what the social and economic effects of these subsidies might be.

2. Regional development. The issue here is the extent to which the availability and quality of freight services within a region (including a metropolitan region) contribute to the amount and location of economic growth, and rearrangement of the location of a given level of growth by transport system attributes.

Road Freight Cost Recovery

The primary issue was the contribution of heavy vehicles. It was generally agreed that the marketplace is the best determinant of mode use provided that the correct signals on true costs are transmitted to the market. If heavy road freight vehicles are not paying their way, the market may receive inappropriate signals. Moreover, governments are concerned, for financial reasons, that such vehicles should pay their full share of costs of infrastructure provision and maintenance. For both of these reasons, road freight cost recovery is important. However, at the moment there is little consensus on whether heavy commercial vehicles "pay their way." There is lack of agreement on both sides of the ledger: on the cost side, concerning the proportion of road costs allocatable to trucks and, on the revenue side, about which taxes should be regarded as "charges" for the use of roads.

Energy Consumption

Two issues were regarded as significant:

1. Energy consumption audit. Knowledge of the fuel consumption patterns in the road freight sector is essential to the formulation of policies relating to energy consumption. Although broad estimates of total fuel consumption by the road freight sector do exist, there is little knowledge of consumption patterns within the sector. That is, the relative contributions of interstate freight, local urban deliveries, and so forth are not known.

2. Fuel conservation. Although there is currently no oil crisis, the memory of past "shocks" remains. Thus strategies for conserving fuel within the freight transport sector and ensuring its availability to this vital sector remain important requirements.

Research Topics

The second outcome of the discussion sessions was a lengthy list of specific research topics and indications of the areas in which payoffs might accrue from research (these topics are listed in the Appendix). This information provided the basis for formulating specific research proposals.

Research Proposals

The list of research topics (Appendix) was examined critically with a view to the development of specific research proposals. This involved the implied priority ranking of research topics and, in some cases, the amalgamation of two or more related topics into a single research proposal.

The priority ranking of projects reflected the implicit or explicit importance attached to them by the participants in the previous phase, the extent to which they were judged to be capable of producing worthwhile output within an acceptance time and budget, and their potential relevance to ARRB's interest groups (primarily state road and traffic authorities).

In this way, five research proposals were prepared. The aim of each, and the links to the research topics listed in the Appendix, is as follows:

1. Freight system data and information needs. The aim of this project would be to assist the making of decisions relating to road policy development and road planning design and maintenance by establishing the forms and sources of freight transport information appropriate to assist such decision making. This proposal addresses research topics (g), (h) and (i) relating to Service Quality (Appendix).

2. Freight transport in urban road investment. The aim of this project would be to develop techniques to specifically evaluate freight-related benefits in urban road investment decisions. This proposal addresses research topics (b) and (p) relating to Economic Efficiency.

3. Criteria for management of trucks in urban areas. The aim of this project would be to develop guidelines for explicit consideration of trucks in urban traffic management schemes, both to facilitate freight flow and to reduce the adverse environmental impact of trucks. This proposal addresses research topic (k) relating to Economic Efficiency.

4. Heavy vehicle considerations in traffic signal design. The aim of this project would be to refine those parts of the Australian traffic signal design guides that are affected by trucks (in particular, settings for yellow and all-red) and to develop guidelines for the explicit inclusion of truck factors in area traffic control systems. This proposal addresses research topic (k) relating to Economic Efficiency.

5. Audit of cost recovery studies. The aim of this project would be to improve the information base for consideration of financial cost recovery in the transport sector by conducting a technical audit of network studies to establish a benchmark for further research or policy development. This proposal addresses research topic (g) relating to Road Cost Recovery.
The final phase of the project involved conducting a 1-day workshop at the Australian Road Research Centre in Melbourne to critically appraise, refine, and rank in priority order the research proposals. The invitees were, in the main, persons who had participated in the earlier round of discussion sessions, and the workshop provided an opportunity for interaction among people with different backgrounds and perspectives.

The research proposals were refined and modified as a result of the workshop deliberations, and three of the proposals were recommended to the executive committee for inclusion in ARRB's 1984-1985 research program:

- Freight system data and information needs,
- Freight transport in urban road investment, and
- Heavy vehicle considerations in traffic signal design.

The workshop also indicated that the other two proposals and several of the research topics in the Appendix were relevant to other traffic and transport agencies. Liaison with these agencies is continuing with a view to implementation of research to address these topics.

CONCLUSIONS

The primary conclusions of this paper relate to the procedure reported here for developing research priorities in freight transport in Australia. The procedure was found to be effective in that

- It facilitated the identification of a range of specific issues of current concern;
- It provided a mechanism for generating research topics, and based on those, for developing draft research proposals;
- It provided a means of refining these drafts into detailed research proposals;
- It proved to be an effective information exchange among persons from a range of organizations; and
- It served to heighten awareness of the importance of freight issues within transport planning agencies.

A general guideline might also be drawn for use of the procedures for formulating research directions: the effort to conduct a systematic investigation of issues and research needs would appear to be justified when a consensus on research directions in a particular area is proving difficult to attain.

REFERENCES

(k) Traffic management techniques directed at urban trucks
(l) Efficiency in resource allocations between modes
(m) Efficiency of terminal operations (including modal interchanges)
(n) Analysis of effects of past road freight deregulation
(p) Development of methods of incorporating freight considerations in urban transport planning
(q) Benefits and costs of large combination vehicles

A.III Environment and Safety
(a) Relationship between truck, driver, location, environment, and so forth (if accident data permit)
(b) Effect of quality licensing on safety
(c) Feasibility of public truck parks and bans on on-street truck parking
(d) Analysis of culpability in truck-involved accidents
(e) Effects of enforcement (loads, speeds, maintenance, etc.) on accidents
(f) Truck braking (especially LCVs)
(g) Truck noise

A.IV Distributional Effects
(a) Effect of transport system efficiency on level and location of economic activity in a city or region
(b) Effects of freight subsidy, deregulation, etc. on viability and social structure of country towns

A.V Road Freight Cost Recovery
(a) Technical and constitutional feasibility of introducing an NZ-type road user charges system
(b) Equity in road taxes between passenger and freight
(c) Development of an efficient, equitable method of collecting road user charges from trucks
(d) Deterioration of roads under load and overload
(e) Determination of "correct" level of charges for trucks
(f) Technology of road pricing for trucks
(g) "Audit" of literature and studies on cost recovery
(h) "Social" cost component in roads expenditure

A.VI Energy
(a) Dissemination of energy research results to truck operators, in the form of guidelines, etc.
(b) Contingency planning against sudden energy shortfall
(c) Fuel economy performance of large combination vehicles

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