

A METHODOLOGY FOR INVESTIGATING THE PASSENGER
DEMAND FOR HIGH-SPEED RAIL

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ABSTRACT

This paper outlines the method developed to identify the demand for a Very Fast Train (VFT) between Sydney, Canberra and Melbourne. We provide an overview of the passenger market feasibility study completed in 1988, emphasising the key data and modelling requirements. The integration of revealed preference and stated choice data is a central feature of the approach. We document the stages of data collection in terms of primary and secondary data sources, and the way in which the data are prepared for model estimation and application. Since induced demand is a critical source of demand, we detail the approach developed to obtain estimates of induced demand. The paper concludes with a discussion of the types of policy outputs which were derived, and provides where possible some indicative results.

INTRODUCTION

Interregional travel is currently high on the agenda of many countries throughout the world. In the European context in particular it is tied in with the idea of *Europe without frontiers*. An important element of the growing number of inquiries is centred on forecasting the demand for travel by both domestic residents and international visitors. As part of these investigations, a considerable amount of interest has been generated in the role that high-speed rail might have in the overall transport task. The demonstrations of success in Japan and France have laid the foundations for serious research into the development of technically viable high-speed rail systems which are also both commercially viable and safe.

Within the global contexts being considered for high-speed rail networking, the current knowledge of technological capability has tended to surpass any reliable empirical knowledge of the potential market for fast rail services. Where will the demand come from?, how much will be diverted from existing and growing modal travel?, and how much will be induced?. How will the suppliers of competing modes react to protect their market share, and what are the social consequences of such a major transport initiative?. Answers to these questions are critical to the commercial success of a new modal opportunity; yet surprisingly little effort has been placed on the collection of suitable data to enable effective assessment of these questions. If the passenger demand is not adequate then all ambitious technological feats are to no avail.

The Australian initiative to establish a *Very Fast Train [VFT]* service between Sydney, Canberra and Melbourne recognised the inadequacy of extant data on passenger demand, especially data on the origin-destination travel patterns, identified by mode and trip purpose. Earlier experiences with the dated 1976 National Travel Survey had established a strong case for a new travel survey. This paper outlines the approach taken to develop a new data base, and the procedures implemented to establish the profile of current travel, together with the role that the VFT could play in improving the interregional transport opportunities in South-Eastern Australia. The data represent the most detailed definition of interregional travel in 1987/88 in South-Eastern Australia, and as such provides a rich empirical contribution over and above the primary reason for their collection.

Responsibility for the overall design and conduct of the data collection and development of base year data [e.g. trip tables, modal networks] was given to the Transport Research Centre at Macquarie University. The survey of current demand provided the basis for three independent projections of potential ridership on the VFT, carried out by selected international consultancies, Japan Railway Technical Service[JARTS], SOFRERAIL, and a joint team provided by Hague Consulting Group and Cambridge Systematics. The overall coordination of the Passenger Market Feasibility Study was undertaken by the Transport Research Centre and CSIRO.

The paper is organised as follows. We begin with an overview of the approach and data requirements, followed by a discussion of data sources [both primary and secondary]. The methods used to establish the base data are then outlined, together with some of the most interesting descriptive statistics. A forecasting strategy is then briefly outlined in the context of data needs and assumptions, followed by a discussion on the major assumptions underlying the way in which the data are applied to obtain passenger forecasts for the VFT and competing modes.

AN OVERVIEW OF THE APPROACH

The objective of the VFT passenger marketing feasibility study was to provide forecasts of annual passenger trips by the VFT for the years 1995, 2000, 2005 and 2010. Within the time frame [of 6 months] and budget, the base data and forecasts were specialised to *scheduled* public transport services and car travel. All forms of *charter* service [especially charter coach] and freight are assumed to be sources of additional VFT traffic yet to be added to the overall traffic forecasts.

The major components of the study were [1] the development of a comprehensive data base on revealed and stated preferences for current and future modal trip options; [2] the development of an appropriate method for estimation of the base and future magnitude and composition of travel in the VFT catchment area; [3] the application of the empirical models; and [4] a financial analysis of passenger forecasts. In this paper we concentrate primarily on the first component, and briefly on the other components.

Data Requirements

It is generally accepted that the essential data required for the development of an interregional demand forecasting capability, centred on the future role of high-speed rail, must include the following items:

1. The spatial pattern of existing one-way trips, identified by mode and purpose. The distinction between scheduled and charter services should be made for public modes. The minimal differentiation of purpose should be business, visiting friends and relatives, and other non-business activities.
2. A profile of the characteristics of the population of existing long distance travellers, with particular emphasis on establishing a data base on a sample of actual trips which contains information on the start and finish locations, the mode and purpose, the month of travel, access and egress modes where public transport is the main mode, time away, the socioeconomic composition of the travelling party, and the home address. The latter is required for any follow up interview.
3. A detailed level of service network for a pre-defined interregional zonal system. The data should distinguish access, main and egress stages of a one-way trip, and be able to define interzonal levels of service for all realistic combinations of access, egress and main modes.
4. A zonal level profile of the socioeconomic and demographic characteristics of the residential and employed population. Such data should be defined in terms of the number of persons associated with each data item. The desired data should include total resident population broken down by age, personal and household income, occupation, household size and labour force participation; and employed population broken down by job category.
5. A face-to-face survey of a sample from the market of potential high-speed rail users [which includes existing interregional travellers as well as non-travellers]. The emphasis is on the individuals' stated preferences for alternative interregional travel scenarios in the presence of the high-speed rail option. This information is essential in the determination of the likely modal switching once the new mode is in place. By combining a stated preference

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experiment which emphasises the relative times and costs associated with the available modes, with an experiment concerned with the alternative design possibilities for a future high-speed rail mode, we are able to provide a set of scenario-based forecasts of potential patronage for the new mode. The face to face interview also provides an appropriate medium for obtaining details on the frequency of travel between origins and destinations by each mode for each purpose over a set time period.

The extensive data resource represented by items 1 to 5 above gives the passenger-demand modeller the scope to apply aggregate and/or disaggregate methods. For example, the data under items 1, 3 and 4 constitute the data input for an aggregate zonal model system for trip generation, distribution and modal split. Data items 2 and 3 define the empirical requirements for a set of discrete choice models for trip destination and mode choice, based on individual-specific socioeconomic and contextual data and zonal level of service data derived from the interregional networks. Finally, data item 5 represents a highly disaggregate approach to modelling frequency, destination and mode choice using individual specific data on all exogenous and endogenous variables in the models, measured in both objective and subjective dimensions. Item 1 becomes the external control total for any base predictions from the second and third examples above.

The collection of primary data is typically limited by temporal and budgetary constraints such that longitudinal or annual data are infeasible options. Furthermore, it is likely that a sample of judiciously selected locations will have to be identified for the measurement of existing travel in the catchment area. All of these constraints require the development of procedures to expand any primary data up to the appropriate temporal and spatial contexts required for demand modelling. In the VFT study the timetable required all data under item 2 to be collected during a four week period. Expansion procedures had to be developed to derive annual estimates of travel.

A number of strategies are available for the collection of base data on current origin-destination trip patterns. We selected an approach involving a self-administered questionnaire of a sample of intercepted public transport travellers and a face to face interview of a sample of intercepted car travellers. Intercept sites were selected so as to represent the major traffic interchanges for each type of origin-destination trip. This strategy is the only one which can guarantee that the majority of the surveyed individuals actually travel in the catchment area. This knowledge is essential in interregional travel surveys specialised to a particular catchment area, in order to minimise the amount of irrelevant information or the cost of an expensive screening procedure under alternative strategies in order to ensure that relevant trips are identified.

However, to be able to relate the travel data from the intercept survey to the population representing the potential market for high-speed rail, in the absence of any data on the incidence of non-travel [by purpose and mode], it is necessary to draw a random sample of individuals. Given that attitudinal and behavioural data are required for determining the role of the VFT, it is convenient to complement the intercept survey with a face to face interview, which draws its sample from both the intercept respondents and a random sample of individuals. This strategy then serves the dual purposes of in-depth assessment of the role of the VFT as well as identification of the incidence of current non-travellers, the latter being a subset of the potential VFT market.

In summary, the complete data base was compiled from an number of sources: [A] Primary Raw Data: An Intercept Survey [Essential Spatial and Modal Data] and an Indepth Face-To-Face Interview; and [B] Secondary Raw Data [Derived from Existing Primary Sources]:

socioeconomic and demographic zonal profiles, level of service characteristics of the travel network, projections and growth rates of exogenous variables, existing zonal systems, and trip data [e.g. State Rail of NSW On-Off Counts].

Definition of the VFT Corridor and Zonal System

An essential task is the definition of the corridor/ catchment area and the spatial zonal system. The latter can be used to dictate the level of aggregation required in modelling the physical flows of traffic as well as the nature of data if they are to be derived in the context of a transport network which links the zones.

Alternatively, all model estimation could be undertaken with individual-specific data and the spatial representation summarised post-estimation at a zonal level, using either zone specific or individual specific data in the application of the models. A zonal system is required regardless of which approach to modelling is adopted. Our philosophy was to develop a highly disaggregate zonal system, subject to [i] the availability and reliability of zonal-level socioeconomic and level-of-service network data, and [ii] the appropriateness of this level of detail in the context of the forecasting of VFT patronage. Aggregation to any coarser system is always possible if required.

In defining the catchment area for the VFT, we have assumed that Australia as a whole is a source of potential users. Included in this national coverage are international tourists to Australia. In translating this spatial level of coverage into a realistic representation of the likely incidence of potential VFT patronage, we have divided our zonal system into three sets: the metropolitan zonal system for the two major capital cities at each end of the VFT system [i.e. Sydney and Melbourne], the internal regional zonal system, and the external regional zonal system.

The internal regional zones are that subset of zones which, on available secondary data, are likely to contain the residential locations of the greater majority of potential users [and indeed the intercept locations for potential international tourist users]. The external regional zones are consequently those which are not in the internal regional set. All zonal boundaries are configured as one or more contiguous local government areas [LGA's], defined on the 1986 boundaries at the time of the 1986 Census. The level of aggregation of LGA's increases as we move further away from Sydney, Melbourne and Canberra. In total there are 137 zones, with 44 in Sydney, 55 in Melbourne, 3 in the Australian Capital Territory, 13 for the rest of N.S.W., 15 for the rest of Victoria, and 7 for the rest of Australia.

The Interregional Base Data

The development of primary and secondary data was undertaken in the context of satisfying three demand forecasting applications: [1] The demand for total passenger travel between each origin and destination for each key purpose and mode; [2] The implications on mode-specific passenger forecasts of changes in the quantity and quality of service offered by each competing mode [including any new modes]; and [3] The provision of insights into the influences on traveller behaviour and attitude which can assist in the development of a marketing strategy.

The Intercept Survey

The intercept surveys represent the most important data resource of the study. They consist of separate data sets for each of the existing interregional passenger transportation modes; namely plane, car, coach and train; collected at selected locations within the VFT catchment area. Travellers were intercepted at airport terminals and on board coaches and trains, and at roadside sites.

They were asked to supply information on the characteristics of the current trip such as the origin and destination, purpose, duration, access and egress modes, composition of the travelling party and selective household socioeconomic characteristics. The primary roles of the intercept survey data are the construction of origin-destination trip tables and, together with network level-of-service data, as the empirical input for disaggregate modelling of modal and destination travel demand.

The emphasis of the intercept survey was to collect objective data on the intercepted one-way trip. Essential information was sought on the following items:

1. Origin and destination of the trip
2. The main purpose of the trip [to and from]
3. Duration of stay if not at home
4. Accommodation type if not at home
5. Number and composition of the travelling party
6. Access and egress mode if the linehaul mode is not a car
7. Whether the trip was with a tour or organised party
8. The fare type for the linehaul mode if not a car
9. Who is paying for the trip if not a car trip
10. The annual frequency of trips between the current O-D pair
11. Ability to use other linehaul modes
12. Socioeconomic characteristics of the respondent [sex, age, occupation, drivers licence]
13. Socioeconomic characteristics of the respondent's household [number and composition, number of cars, household income]
14. Residential address
15. For car trips only: the presence and reason for any stopovers en route, and whether a caravan or roof luggage was present.

The data were collected by sampling over a seven day period at each site during the period mid-November until early December 1987. Different sampling strategies were adopted for each mode to allow for the different characteristics of the modal populations. For example, for air, given a budget determined gross sample of 30,000 intercept surveys in Sydney, Canberra, and Melbourne, and an average loading of 100 passengers per flight, 300 flights were sampled. This is equivalent to 42 daily departures over a seven day period. These departures were allocated among the major domestic carriers and airports in accordance with the current patterns of departures throughout each day. Full details of the intercept sampling scheme are available on request. Some key statistics on the intercept survey are given below.

1. The data base consists of 29,982 trip records, an overall response rate of 71.73%. The highest response rate was for the car mode [95%] while the lowest was for the train. This might be expected given that a face to face interview was conducted with the car travellers,

We had to rely on the support of the train conductors for a large component of the distribution of the rail survey. The conductors were somewhat disinterested in the survey. The response rates for plane and coach are respectively 64% and 80%.

2. The two major domestic airlines [Ansett and Australian] are well represented in the air data. The car sites each provide a rich sample size, with the greater emphasis on the north-south traffic. The east-west traffic through the Officer site represents the most important road interchange not in the north-south direction.

3. At least 40 percent of all trips commenced from home and at least 33 percent finished at home. Thus over 70 percent of all trips are home-based. Work-related trips dominate air travel, while *visiting friends and relatives* dominates travel by the other modes.

4. Over 40 percent of all trips involve returning to the origin on the same day; suggesting that a lot of non-plane trips are not the very long Sydney-Melbourne type trip. The great majority of interregional travel involves a period away less than 8 days.

5. As expected, any travel involving one or more overnight stays at the destination uses private accommodation much more if the trip was by coach or train.

6. Nearly 90% of all car trips are undertaken from the origin to the destination without a major stop; and nearly 80% of all plane trips involve an adult travelling alone.

7. The dominating modes for accessing the linehaul public modes are taxi and private car. The same applies for the egress trip.

8. One in five air trips involves some form of fare discount or concession. Over two-thirds of all plane trips are paid for by an employer, supporting the widely held view that the majority of business trips are on a full economy ticket.

9. Nearly 90 percent of all trips by public modes are by Australian residents, so in the data base we have captured a significant sample of international tourists, especially from Japan, U.K. and Europe, and New Zealand.

The Face To Face Survey

The intercept surveys provide an appropriate mechanism for identifying current patterns of travel, and in defining the characteristics of the population of travellers participating in particular types of mode and purpose-specific trips. The medium of data collection limited the information to the intercepted trip. A face to face [FTF] survey provides a complementary source of information in much more detail on the profile of annual interregional travel. Using the face to face interview medium in the respondent's residence [if a domestic respondent] or at the international airport departure lounge [if an international tourist], enables us to delve in more detail into the underlying reasons for particular types of travel behaviour.

The face to face survey is directly concerned with the potential role of the VFT. The data collected can be used to identify the extent of switching to the VFT, as well as aiding in the preferred design of the overall VFT service. Separate sampling strategies were developed for the domestic resident and international tourist surveys. The former was able to draw on the intercepted travellers as a partial basis for sampling, whereas the latter had

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to be developed without the benefit of any information on the sampled population from the earlier phases of the study.

Domestic Residents Survey

The sampling frame for the domestic-residents survey is the population of individuals permanently residing in the predetermined catchment area of the VFT. This population includes individuals who have undertaken interregional travel within the corridor as identified by the intercept survey, and individuals who have not travelled in the corridor in the last 12 months.

The sampling strategy involved a stratified random sample from the intercept respondents, enriched by a sample of individuals drawn from a random sample of households from predefined sample frames for a number of major and minor population centres. The selection of the population centres for the entire survey was based in part on the residential locations of the intercepted respondents but also on the need to cover a number of key geographical localities where it was argued that our knowledge of potential VFT travel was important. The selected centres are: Sydney, Newcastle [NSW], Melbourne, Wollongong [NSW], Canberra, Bowral [NSW], Brisbane, Goulburn [NSW], Cooma [NSW], Merrimula [NSW], Traralgon [VIC], and Bairnsdale [VIC].

The sample from the intercept surveys was drawn from a multiple stratification in terms of population centre, current mode and current purpose of the intercepted trip. The sample of households selected from the random sample were drawn from address lists of ABS blocks within each of the population centres. Within each randomly sampled household, an individual was selected by random selection.

The allocation of the sample to the intercept and random sub-populations, given the budget-determined maximum number of interviews, is mainly decided by the level of accuracy required for identifying the extent of the non-travelling population. It can reasonably be assumed that a significant proportion of the random sample would have travelled in the catchment area during the last 12 months, and thus the intercept sample are indeed a representation of the greater percentage of the population. Since sample size is determined by the amount of variability in the data required from a particular population as well as the precision required, then given our a priori assumption on the incidence of no travel in the corridor in the last 12 months, we recommended that 20 percent of the theoretical sample should be drawn from the household address lists of non-intercepted travellers.

The field work began in mid-December and ran through into the first week of March, 1988. The survey was both complex and time consuming with an interview time varying between 35 and 55 minutes. With up to 8 - 10 callbacks due to the difficulties of making an effective contact over the Christmas holiday period, the completion of 2116 effective interviews in 12 population centres over 11 weeks was a major achievement.

The total number of completed surveys was equivalent to an overall response rate of 85.0% [based on the completed sample and refusals]. The success rate [i.e. effective sample as a proportion of total letters mailed out to potential respondent addresses] is 55.77%. The residential locations of the respondents were: Sydney 702, Goulburn 71, Melbourne 439, Cooma 70, Canberra 344, Merrimula 70, Brisbane 50, Bairnsdale 73, Wollongong 72,

The International Tourist Survey

The absence of a fixed address and the likelihood that the person would no longer be in Australia prevented the domestic-resident survey procedure from incorporating a sample of international tourists. A sample of tourists was an essential data source since tourism is a major market for the VFT service. Sampling potential tourists at their country of origin was not financially feasible. Instead we selected the major international departure locations within Australia and conducted the face to face survey with a sample of departing tourists.

The two major departure points are the International airports in Sydney and Melbourne. Departing rather than arriving tourists are the appropriate sampling frame because of some acquired knowledge of the Australian context, which is vital for a comprehension of the survey questions. Although some knowledge of the socioeconomic and trip characteristics of tourists are known from the International Tourism Survey undertaken from time to time for the Tourism Authorities in Australia, little is known of the characteristics of the population of departing tourists on the days of our survey.

A total of 300 interviews were targeted, with 200 in Sydney and 100 in Melbourne. We highlighted the Japanese tourist, employing the assistance of a Japanese interpreter for one full day at Sydney airport. The sample was anticipated to be dominated by English-speaking tourists who were not accompanied by a large farewell contingent.

The Contents of the Face to Face Survey Instruments

The FTF survey emphasised four types of data: [1] A summary of annual interregional travel in the catchment area [diasaggregated by origin, destination, purpose, mode, route, season and size of travelling group]; [2] Stated Choice experiments in which the respondent chooses from alternative travel time-cost scenarios defining each of the available modes [including the VFT], and alternative service scenarios for the VFT; [3] Attitudinal questions associated with the VFT, such as possible package deals, location of stations, frequency of use, relevance of a number of travel attributes, ticketing arrangements etc., and [4] The socioeconomic and demographic profile of the respondent and his/her household members. We will briefly expand on the main stated choice experiment for the domestic resident's survey. The International Tourism Survey was very similar, but simplified.

The Time-Cost Trade-Off Stated Choice Experiment

When a new alternative such as the VFT is being evaluated, it is desirable that the population of potential users be involved in the assessment process. The FTF survey provides an opportunity to identify the role of the main travel characteristics associated with the VFT and existing modes. We adopted the view that it is the set of underlying attributes of a mode [i.e. travel time, cost, on-board service etc] together with a potential travellers socioeconomic characteristics which define the level of relative satisfaction associated with each competing mode. In order to determine the likely use of the VFT it is

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necessary to study the choice process in the context of alternative travel attribute scenarios.

The approach is known as the Stated Choice method. It is a relatively advanced procedure for determining the probability of an individual selecting a mode of transport out of the offered set when the set contains both existing and new modes. A respondent was offered a scenario of modal attributes for each of the modes in the choice set, and asked to choose one of them. The process was repeated a number of times by varying the levels of the modal attributes and seeking a further choice response. This process of systematically varying hypothetical combinations of modal attributes provides a powerful mechanism for revealing the role of the attributes influencing the choice of mode. This provides a very rich empirical framework for studying the potential use of the VFT under alternative scenarios for both the VFT and its competitors. The approach was implemented within each of the major market segments under study.

In designing the experiment we considered a number of items, the most important being:

[1]. Whether the response of interest requires the individual to rank, rate or choose. Ranking and rating are common responses for stated preference designs where the interest is in determining the ordering or strength of preference amongst alternative modes. Where the interest is in identifying which mode will be selected when offered with a competing set of modes, a stated choice design is preferred. The latter is adopted in this study.

[2]. The number of relevant attributes and the number of levels that will enable a meaningful assessment of the role of these attributes in the choice of a mode. Experience suggests that three attributes at three levels enables us to design an experiment which is both statistically useful in that sufficient variability in the offered scenarios is achievable as well as comprehensible to the respondent.

[3]. The actual levels of the mode attributes should relate to the individuals experience in travel. Hence it is essential that a number of situations be defined for the one experiment which use different levels of the travel attributes so that the respondent is able to respond in a context close to the one currently experienced. This is also very important when evaluating the potential role of a new mode, since we are able to evaluate it relative to the current empirical context of the respondent.

[4]. The motivation for the experiment must be absolutely clear to the interviewer, and that the precise implementation rules must be adhered to. For example, the design we have developed requires the interviewer to select the correct set of design showcards according to the respondent's current travel experience, and then to randomly select three of the 16 available choice sets associated with that experience context. Failure to adhere to this process of selection can lead to the possibility of the respondent treating the exercise as an unrealistic game, and to bias associated with the unequal representation of the 16 choice set situations.

The stated-choice experiment was designed in terms of 5 modes [car, plane, train, coach and VFT] and two linehaul attributes [travel time and cost]. Access and egress times and costs were held constant for each mode for each respondent and were included in the calculation of the door-to-door times and costs. The three levels were defined as low [L], medium [M] and high [H] and measured as a combination of travel time and cost for the linehaul mode. In theory there are 3^5 [=243] combinations of levels across all five modes, ranging from LLLLL to HHHHH.

The current design can be reduced to 16 choice sets if we are only interested in studying the independent effect of each attribute. Choice designs which are comprehensible to the respondent are typically main-effects only designs. The benefit in using a systematic approach to the design of the experimental scenarios rather than an ad hoc allocation of levels to modes and choice sets, is that the amount of information obtained is typically greater and that the data enable more robust estimates of the parameters of the travel variables in a mode choice model [such as the logit model]. The latter occurs because the variables are orthogonal or very lowly correlated. The full factorial design was collapsed to 16 different choice situations, each with different time and cost levels for the five modes [Table 1].

Table 1. Time-Cost Stated Choice Design

Choice Set Number	Modal Alternatives					Choose One:
	Car	Plane	VFT	Train	Coach	
1	L	L	L	L	L	
2	L	M	M	H	M	
3	L	H	H	M	M	
4	L	M	M	M	H	
5	M	L	M	M	M	
6	M	M	L	M	H	
7	M	H	M	H	L	
8	M	M	H	L	M	
9	H	L	H	H	H	
10	H	M	M	L	M	
11	H	H	L	M	M	
12	H	M	M	M	L	
13	M	L	M	M	M	
14	M	M	H	M	L	
15	M	H	M	L	H	
16	M	M	L	H	M	

Fourteen different replications of design were created, with the range of time and cost levels determined by the travel distance and fare type. Seven of the sets were for full economy travel, and seven for business/first class. Each of the seven sets related to a typical distance travelled, ranging from a very short trip averaging 120 kilometres, to a very long trip averaging 1700 kilometres. The distance/ticket type times and costs for each mode for low, medium and high are then available to select from according to the respondent's recent trip experience.

The choice design emphasises the linehaul times and costs for an individual adult traveller. The linehaul cost had to be adjusted on the showcard to represent the size and composition of the travelling party. We assumed that a child travelled by a public mode at one half of the adult fare. The showcards also contained details of the access and egress times and costs. To keep the overall experiment realistic in the context of our interest in the linehaul choice, we used a previous question to establish the access and egress times and costs associated with using each of the public modes for the particular trip being evaluated. This trip was identified by the respondent as a recent or most frequent type of trip. The

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predetermined access and egress data, the choice design linehaul costs and times, and the number of adults and children describe the time-cost scenario for a mode within a choice set showcard. Since the intention was to analyse the data by pooling it across the sample or market segment, it was sufficient to require a respondent to make a choice on three replications of the choice set. To do this systematically, the interviewer was required to shuffle the showcards and to randomly select 3 cards. The choice response was noted on the questionnaire together with the showcard number for each of the 3 replications.

The actual times and costs used are not strictly of relevance provided they are within a range of realism to the respondent. The aim of the experiment is to provide the data necessary to identify the relative positioning of the VFT and the other modes in respect of the marginal utilities attached to each of the travel attributes. This knowledge of positioning can then be used to adjust the travel demand model estimated using the revealed preference data from the intercept survey in order to predict the switching towards the VFT and hence modal market share. In this role it performs a critical task.

Other Items: Induced Demand

A series of attitudinal and opinion questions were included in the questionnaire. The most important questions were designed to assist in establishing the extent of induced demand for the VFT. Experience in Japan and France is that induced demand has in some circumstances been found to be as high as 30% of total traffic. The following questions were central to the inquiry:

[1] *Are there any trips in the corridor [map] which you would like to make, but for reasons connected with the difficulty of travel, you or other members of the household do not make? [If no, go to [3]].*

[2] *Why don't you travel there by car/train/coach/plane? [A list of possible reasons supplied]*

[3] *For whatever reason, do you think your household's travel might increase in the Sydney-Canberra-Melbourne corridor if the VFT is available?*

[4] *Could you estimate the possible increase in travel between the following places for business and non-business purposes? The respondent was asked to distinguish between trips that would be made on a regular basis, and a once-and-for-all trip made just for the novelty value of the new service.*

The first two questions were designed to identify the presence of latent demand and the possible constraints on travel by the available modes in the VFT catchment area. The reasons include the non-availability of a mode, cost, time, safety, inconvenience and discomfort. The last two questions are designed to provide an estimate of the possible increase in travel between a number of key population centres or regions for business and non-business travel if the VFT were introduced. One manner in which the responses to these questions could be used to estimate induced demand is set out in the final section on model estimation and forecasting.

Selective Descriptive Statistics from the Domestic Residents' Survey

The amount of annual travel in the South-Eastern Region of Australia is quite substantial. The mean numbers of one-way trips for the various trip purposes are 19.7 [with a standard deviation of 23.6]. Thus close to 10 round trips take place per year per respondent. The range on this mean figure is quite substantial, with many persons undertaking no trips, and some people having over 150 trips per annum. The mean number of annual one-way trips for each trip purposes are 7.47 [business], 5.24 [visiting friends and relatives], and 4.68 [other non-business]. These figures suggest that all three travel markets are significant generators of travel. These data, however do not in themselves provide any commentary on the role that the VFT can have in each of the markets. To determine this we have to consider the responses to the experimental and attitudinal questions.

The profile of the current trip used in the stated choice question is summarised below:

Mode: car = 46.5% plane = 32% coach = 12.8% train = 8.6%

Fare: First = 4.4% Business = 8.4% Full Economy = 35% Discount Economy = 6.4%

Car Mode = 45.8%

Purpose: Business = 32% VFR = 38% Sightseeing = 10.2% Snow Skiing = 0.007% Sport = 2% Social group = 2.45% Beach Vacation = 2.4% Visit Weekender = 0.003% Other = 11.5%

The choice experiment provides a large number of observations on modal choice in the presence of the VFT for each of the major market segments. Individuals currently using each of the four linehaul modes for each of the three main trip purposes with the most common ticket types are all represented in the data. The data confirm the view that the great majority of business trips by public modes are on a full economy ticket. Slightly less than 40 percent of business trips by a public mode [mainly plane] are first or business class. A breakdown of the choice responses for the time-cost trade-off are given below. The results are presented in Table 2 for different situations: ticket type, trip purpose, trip distance, and current travel experience context.

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Table 2: Preferences For VFT and Current Modes

PERCENT	FARE PURPOSE				FIRST PREFERENCE				
	Y	BF	B	NB	PLANE	CAR	COACH	TRAIN	VFT
OVERALL	83	17	32	68	13.8	29.2	3.8	5.7	47.5
Y FARE	100	-	22	78	11.7	32.7	4.0	5.7	46.0
BF FARE	-	100	77	23	25.0	13.3	1.7	5.0	55.3
B PURP	59	41	100	-	33.3	9.7	3.0	1.7	54.7
NB PURP	94	6	-	100	4.7	38.0	5.3	7.7	44.3
[YFARE BPURP]	100	-	100	-	35.3	11.0	0.0	1.3	52.8
[YFARE NBPURP]	100	-	100	-	4.7	38.0	5.3	7.7	44.3
[BFFARE BPURP]	-	100	100	-	31.0	8.3	0.7	2.3	57.0
[BFFARE NBPURP]	-	100	-	100	5.3	30.3	4.3	15.0	45.3
SHORT A	86	14	17	83	0.7	64.0	2.3	6.3	26.7
SHORT B	83	17	27	73	3.3	34.5	4.0	5.7	53.0
MEDIUM A	92	8	16	84	4.3	36.0	7.3	4.7	48.0
MEDIUM B	77	23	38	62	9.3	20.0	3.3	4.7	62.0
SYD MEL	81	19	43	57	25.3	15.0	3.0	8.0	48.7
LONG A	85	15	33	67	31.0	18.3	5.3	3.3	42.3
LONG B	82	18	42	58	43.7	12.7	4.7	1.0	38.0

The summary statistics suggest that the VFT is viewed as an appealing mode for interregional travel. The appeal varies between the markets, with its highest popularity being displayed in the medium distance [700 kilometre] travel market, particularly for plane trips currently for non-business purposes. However, with the possible exception of the non-business car market, especially for short trips [averaging 120 kilometres], the VFT captures over 50 percent of each market. Although there is a strong view in the literature that stated choices and attitudinal data tend to overpredict, the substantial preference for the VFT documented in Table 2 is extremely encouraging.

The VFT is expected to have a significant inducement effect on interregional travel [Table 3]. Some of this effect will be due to residential and employment relocation; however a lot will be additional trips in a category not previously travelled.

Table 3: The Induced Effect of VFT

[The overall percentages of individuals who would contemplate additional travel within each frequency]

	Business	Non-Business
1 trip	2.08	10.8
2 trips	1.58	8.5
3 trips	0.82	3.6
4 plus trips	2.00	5.5
1 novelty trip	0.52	6.0

The novelty trip just to try the VFT is surprisingly small with the exception of trips to Sydney, especially from Canberra. The non-business purpose appears to offer a greater amount of induced travel than the business trip; presumably because at this point in time there is a better appreciation of latent demand for discretionary pleasure than for business trips.

THE MODELLING AND FORECASTING APPROACHES

The separate forecasts produced by the different consulting groups shared the common base of this data set, but drew to different extents on time series, cross-sectional and stated preferences evidence for their conclusions. In the following two sections we restrict ourselves to only one of the approaches, being that developed by Hague Consulting Group and Cambridge Systematics Inc. Further details of the design of the stated preference questionnaire, and the analyses that led to forecasts of induced and diverted traffic, are given in Gunn, Bradley and Hensher [forthcoming].

Generation of the forecasts involved six steps:

1. Analysis of observed travel patterns
2. Analysis of statements of preferences
3. Reconciliation of these two demand analyses
4. Production of the overall growth model
5. Assembly of mode choice forecasting module, and
6. Production of forecasts.

The essential features of the approach were a market growth model, a mode choice model, and a set of forecasts of the exogenous variables. Together with scenarios of the future for modal fares, income and tourism growth etc. a set of VFT passenger forecasts were prepared. We will briefly sketch these steps.

The base year trip tables for home-based and non-home based [production-attraction] trips for business, visiting friends and relatives, and other non-business travel were factored up using growth factors for trips produced and attracted. An iterative proportional fitting [IPF] technique was implemented in which the rows are factored by the production zone growth factors, then the columns by the attraction zone growth factors in an iterative way until a balance is obtained. The growth factors reflect predicted growth in trip making per household, and growth predicted from trips induced by the VFT. Other sources of growth such as land use change is not included in the forecasts. Induced trips are defined to include the increased frequency of travel by existing travellers plus new trips by persons not currently travelling in the corridor plus trips diverted from destinations outside the corridor.

The mode choice model for the base year was estimated in two stages. First, a revealed preference model of the multinomial logit form was estimated using the intercept data file on existing modes. Level of service and socioeconomic data were used to explain the current choice of mode. Next a stated choice model of the same logit form was estimated, but the choice set included the VFT and any other relevant modes as elicited from the choice experiment. The stated choice model provided the relative magnitudes of the crucial taste parameters [including the mode-specific constants] which indicate the positioning of the VFT in utility space relative to the existing modes. This data was then rescaled to reflect the relative positioning of the modes in the revealed preference model, producing an empirical mode choice model capable of determining the probability of an

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individual selecting the VFT when faced with a particular time-cost and socioeconomic scenario. Given that the intercept data were choice based, appropriate weightings were applied to allow for this.

For each zone pair, the total number of trips obtained from the overall growth model are distributed between modes by the application of the integrated RP/SC mode choice model, after distributing all travellers to a number of *personal factor* categories. The latter distribution involves the implementation of a *Synthetic Sample* technique, involving;

1. Drawing a prototypical sample of travellers/trips from the intercept survey data base, ranging across all traveller factor categories [income, age, duration of stay, purpose, group size etc.],
2. Deriving expansion weights for each sample element to match required totals as well as to maintain realistic marginal distributions for each factor in turn, and
3. Use IPF to achieve this with marginal distributions based on the intercept survey, adjusted for zone-to-zone and year-to-year variations in incomes, household sizes and population age structure.

The assessment of induced demand always requires careful treatment, given historical evidence that many respondents will overstate the frequency with which they will use such a new service. To minimise this effect, both the questionnaire and the analysis were designed to allow a distinction to be made between:

- [a] existing *suppressed* demand, trips which would currently be made but for the unattractiveness of existing travel modes, and
- [b] new *generated* demand, trips which were only newly thought of in the context of the new service being available.

By focussing only on the first category of latent demand, asking how many of these potential trips would be made given the new travel facility, the method aims to exclude the least reliable of the conjectured *extra* trips from the central forecasts. This was done by cross-tabulating annual trip-frequency [4 levels: non-travellers, 1-9 trips, 10-29 trips and >29 trips] by latent/no latent demand, and would/would not use VFT. By a further cross-tabulation of annual trip frequency by latent/no latent demand and trip purpose of additional trips, we were able to obtain percentages of the sample in each category and the average number of generated round trips in each category.

The total average number of suppressed latent demand round trips for each category of trip for each travel frequency class can be derived by weighting together according to the proportions in each frequency class in the new random traveller subset of the data. These figures are derived for the base year in terms of overall average round trip rates per household for study area residents. The growth factors for households can then be applied, and the forecasts when stratified by origin and destination, added into the forecasts derived from the diverted traffic. Non-resident latent demand is also calculated by the same procedure using the non-resident sample from the FTF survey.

THE MAJOR EMPIRICAL RESULTS

Extensive sensitivity and scenario analyses were undertaken, with travel times, fares, income growth, values of time, fare discount policies and tourism growth varied. The base case assumptions were:

1. 1% income growth per annum
2. Discount fares policy for children only
3. Value of Time Savings of \$30 for business and \$13 for non-business.
4. Demand growth after 1995 of 2.2% per annum
5. Base year trips of 21.9 million [=9.2 Syd-Melb equivalent trips].

The resulting forecasts in the base year of 1987, together with forecasts for 1995 are given in Table 4 both with and without the VFT. These Forecasts for the Base Scenario do not include novelty-induced travel, charter coach diversion, induced charter VFT, and inducement due to suitable marketing of visits to Australia. The 1995 VFT passenger forecast [in Sydney-Melbourne equivalent one-way trips] is 6.6 million, comprising 4.2 million of diverted trips, and 2.4 million induced trips. Thus of the 11.4 million forecast passenger trips in 1995 without the VFT, the introduction of the VFT under the base scenario will lead to a modal diversion of 4.2 million trips. Sensitivity testing on a number of important variables such as fare for VFT and competing public modes, the value of time savings, income growth and oil prices was undertaken, with variations as much as 20% higher or lower on some items. The sensitivity testing suggested an overall range of forecasts of VFT traffic in 1995 of 4.49 million to 7.38 million. Variations in the value of time [plus or minus 20%], income growth [0%, 2.4%], tourism growth [plus or minus 3%] alter the base case results by a small amount.

Table 4 Base Case Passenger Forecasts in Sydney-Melbourne Equivalent Trips

1987	No	VFT	
Car	=	4.3	million
Plane	=	3.3	million
Coach	=	1.3	million
Train	=	0.3	million
1995	No	VFT	
Car	=	6.1	million
Plane	=	3.6	million
Coach	=	1.4	million
Train	=	0.3	million
1995	With	VFT	
Car	=	4.5	million
Plane	=	1.9	million
Coach	=	0.7	million
Train	=	0.1	million
VFT	=	6.6	million
1995	VFT Ridership By Prior Mode		
Car	=	1.6	million
Plane	=	1.7	million
Coach	=	0.7	million
Train	=	0.2	million
Induce	=	2.5	million

CONCLUSION

In this paper we have outlined the substantial data collection exercise undertaken to establish an appreciation of the nature and composition of travel in the VFT catchment area of South-East Australia. The efforts have enabled the study team to produce forecasts of passenger traffic based on the very best and current data, informed by independent forecasts supplied by the consultants. Although the debate on the merits of the VFT will continue for some time, the project has contributed substantially to our knowledge of current interregional travel in the busiest corridor in Australia.

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Reference

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