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"Managing a Highway Network in the 21st Century Environment"

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Abstract

Before deciding on the direction of road management in the 21st century, the role of roads in the land use context needs to be determined. Based on the changing technology of vehicle propulsion and the use of new technology to manage the safety of vehicles on the road, a whole new era in improved travel is about to unfold.

The traditional public service way of managing roads is unlikely to deliver customer-focused efficient infrastructure based on environmental and societal opinion. This paper sets out some key components that need to be addressed in managing highways in the future, and then describes very briefly a New Zealand proposal. It also raises the issues of managed integration of transport modes vs. the commercial approach of free competition by mode. This paper is based on a paper given by the author in Barcelona 2000 Ref. 2.

Basis of Road Management and Investment

The following components are essential for managing road networking;

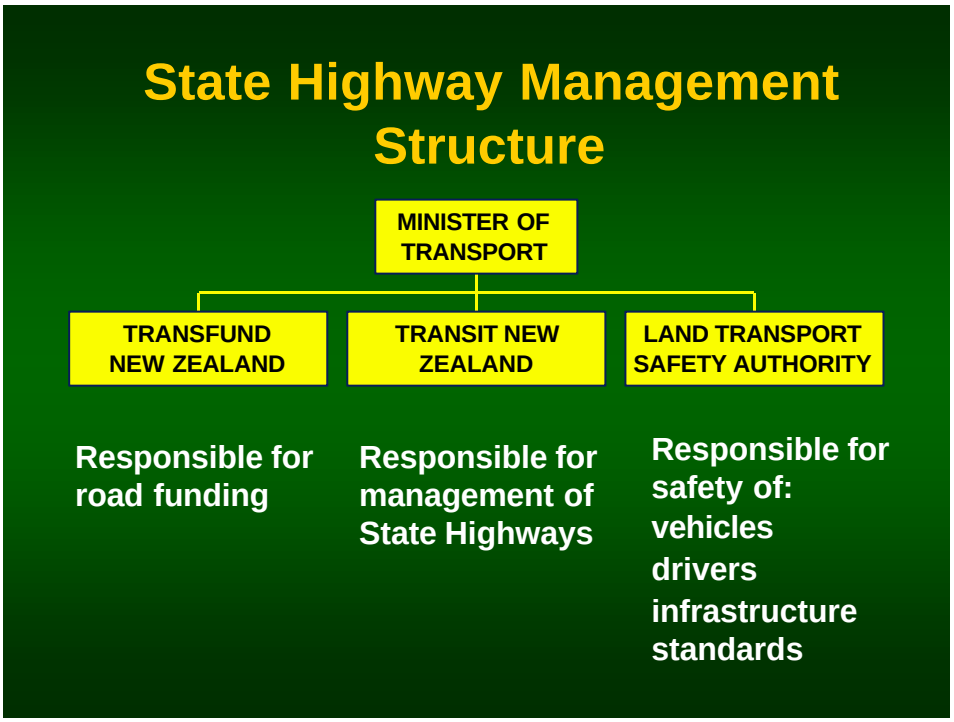
- Clear vision and direction
- An understanding of customer and stakeholder needs
- Translation of customer and stakeholder needs into organisational activities
- Prioritisation and optimisation tools/techniques
- Key performance indicators.

Vision and Direction

Any organistion responsible for a network of roads must have a vision for the future based on any legislation, contract with the Government, and Ministerial requirement. It is desirable for road networks to be managed at arms length from direct Ministerial direction. In New Zealand, the following structure has been adopted.

The Minister of Transport, with the aid of the Minister of Finance, appoints boards for the safety regulatory authority (Land Transport Safety Authority), a funding allocation body (Transfund New Zealand), and a strategic road network manager (Transit New Zealand) *(See Figure 1)*.

Figure 1



Transfund

Main functions are:

- Allocation of Funds from a dedicated fund
- Allocation to state highways local roads, passenger transport and alternatives to roads
- Audit of value for money.

Transit New Zealand

Main function is:

- Strategic highway network operator

- To achieve this the Transit Board has developed;

- Vision: "*A World Leader in Roading Solutions"*
- Mission statement: *"To provide a safe and efficient state highway system which meets the needs of road users and the communities it services"*

- National state highway strategy together with individual highway strategies and some urban overall strategies.

The Minister of Transport in conjunction with the three organisations, known as Crown entities, develops performance agreements for each entity. The performance agreement sets out the Minister's expectations and the performance measures which will be used to judge the effectiveness of the entity.

Understanding Customer and Stakeholder Needs

Any road management structure should be designed to meet the key outputs that road users and stakeholders consider essential, and at the same time gain the efficiencies that can be inherent in private sector provision. This is more likely to be achieved using public sector-owned entities, where the main focus is on the achievement of the five key road user outputs explained below, and not on retaining resources to maintain and build roads. I would suggest road owners need to develop into smart providers which maximise the utilisation of private sector technology and innovation via competition and strategic partnerships.

This means that road managers must concentrate their efforts on determining road users willingness to pay for services, rather than making these decisions in isolation of users. Clearly regulatory, statutory and shareholder responsibilities also need to be met and factored into any pricing for levels of service.

How the publicly-owned smart provider organisations obtain the input from road users is open to discussion and experimentation. One way is to seek input from user groups like the automobile and trucking associations.

Another alternative is to require road network managers to negotiate directly with road user groups. In some cases, such as heavy-vehicle users, these negotiations could be arranged reasonably easily, but this will not be the case for the many diverse owners of light vehicles. This issue will no doubt receive considerable attention in the future.

A third alternative is the use of market research techniques such as customer satisfaction and willingness-to-pay surveys.

Key Road User Outputs

From experience there appear to be five key outputs that road users focus on:

- Safety
- Road system reliability
- Comfort and low stress
- Efficiency
- Price and levels of service.

Safety

There are a number of approaches to road safety. For instance, Sweden has adopted the ethical approach, ie. Vision Zero for accidents. The Netherlands have adopted an environmental approach which separates different types of users in order to minimise accidents. On the other hand, New Zealand has adopted the efficiency approach, where any investment must achieve safety benefits greater than the cost.

Regardless of the vision, the best way to ensure that a network of roads is managed in a safe manner is to develop a safety management system which enables all the activities to be co-ordinated. Transit New Zealand has developed such a system over the last eight years, and has completed the first audit on a trial application. It is now being implemented across the organisation.

The main components of Transit's safety management system are:

1. Management
2. Identifying hazards
3. Road, pavement and bridge design and maintenance
4. Traffic control devices
5. The roadside
6. Vulnerable road users.

In particular, the main thrust of our state highway design and management is:

- Fitness for purpose
- No surprises to the driver
- Balance between mobility and safety.

Safety will be a real winner if new technology is used in road use management. For instance, in-vehicle guidance systems can detect whether a vehicle is straying from its vehicle lane and then correct its movement by over-riding the driver. Likewise, the problem of following too close can be eliminated if vehicle drivers were to accept the use of technology to govern the safe space between vehicles.

Visibility at night and around blind corners makes driving difficult, but with built-in passive infra-red sensors, safe driving will be greatly improved.

In the future, we are likely to see some form of automated highway which should be safer and certainly would allow a greater throughput of vehicles per hour, which would greatly increase the utilisation of the existing road network.

Likewise, improved vehicle design has enabled many safety features to be incorporated which have greatly improved the chances of surviving a crash.

Road System Reliability

Every year, road users are becoming more demanding in respect of delays and road closures. Technology in the future will enable real-time information on road works, accidents, closures from natural events, and congestion to be relayed directly into the vehicle, or made available by a number of communication media forums, including the Internet.

Delays in themselves are not totally unacceptable. However, having little or no information on delay times and alternative routes is unacceptable in the 21st century.

Comfort and Low Stress

Comfort results from a smooth road surface and no sudden unexpected tight curves. By routine measurement of road roughness and then treating the worst lengths, road comfort can be kept at an acceptable level. Low stress comes from good traffic flow, no hold-ups behind slower traffic, and wide lanes requiring less driver concentration and minimisation of conflicting traffic movements. Given the limit on capital for road retrofitting and expansion, technology will have to assist by:

1. Using details of accidents, congestion and other natural events, changing traffic messages either on the road or in the vehicle to minimise travel time

2. Using automated highways which will increase throughput of vehicles per hour per lane, and hence reduce the need to expand the road network capacity.

3. Warning of obstructions, accidents or other road impediments.

Efficiency

In effect, road users expect an efficient road system which includes the management of traffic, maintenance of the whole highway, innovative construction techniques, and the most effective utilisation of the current road asset.

Technology will play a major role in improving the efficiency of a road network by:

1. Charging for **actual** road use rather than **average** pricing

2. Enabling road construction parameters such as compaction density to be monitored away from the site

3. Being informed in a central location of damage to the road furniture, eg an embedded chip in a road sign will advise the road manager the sign has been damaged

4. Better monitoring of the actual weight of vehicles using the road system

5. Using global positioning systems to control access by extra heavy vehicles to selected upgraded super routes

6. Increasing traffic throughput by automating existing highways and hence reducing the need to expand the road network capacity.

Also, vehicles are becoming more fuel efficient eg. hyper vehicles, which reduces emission levels and enables more travel for the dollar.

Price and Levels of Service

Currently, road agencies or politicians decide the levels of service based on standards or funding availability. In the future, technology will enable lengths of road to be priced for different levels of service, which would mean that road users can decide which options they want. However, a certain minimum level of safety would be required regardless of what road users want to pay. Perhaps the road users should also have the opportunity to trade off safety with mobility.

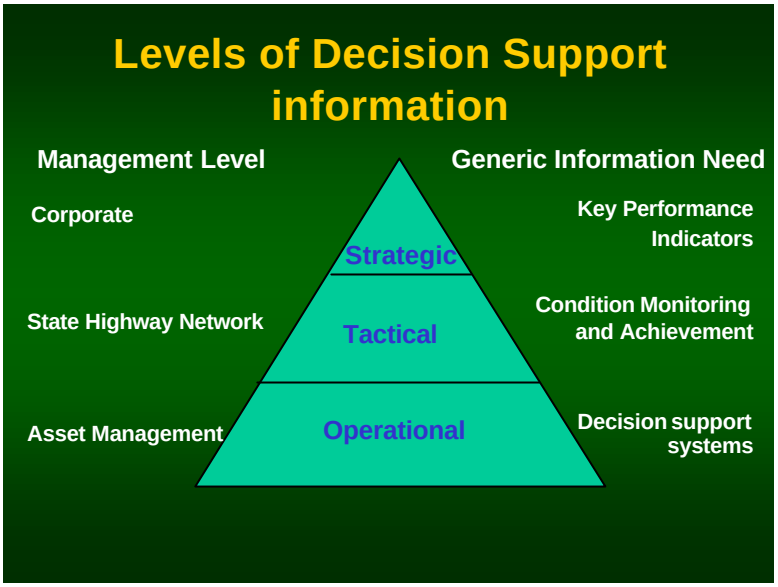
Hand in hand with this ability to trade off different features, road users are likely to want to know what levels of service actually mean on the road. For instance, in the case of a new road they are likely to want to know the design speed value, how the road will fit into the landscape, and what environmental effects it will have.

The use of visual graphics to present the built environment for the road will greatly assist road user understanding of what they are purchasing.

Translating Customer and Stakeholder Needs into Reality

The following methodology for achieving both customer (road user and community) and stakeholders (Transfund as funder, and the Minister) can best be described by the following diagram:

Figure 2



At the strategic level, the Board is responsible for the corporate plan, reporting to the Minister, new policy approval, delegations and prioritisation and approval of significant investments in the road network.

The entity's top management carries out the Board's direction by ensuring the appropriate resources and systems are in place to make sure the road network is managed in a professional, safe and efficient manner and that the goals set in the strategic plan are achieved.

Prioritisation and Optimisation Tools and Techniques

Maintenance is determined annually using a rolling three-year programme from the information contained in a road asset management system. Levels of skid resistance, surface deformation, roughness, deterioration modelling, and accident and safety audits play a significant role in determining the type and level of each maintenance treatment.

In terms of both rehabilitation and new capital investment, New Zealand uses benefit cost analysis. For more than 70% of the expenditure on state highways the New Zealand state highway annual programme is subject to some form of benefit cost analysis.

Benefits comprise:

- Vehicle operating cost savings
- Travel time savings
- Accident savings
- Increased comfort
- Reduced noise and less community impact.

Costs comprise:

- Capital costs
- Change in maintenance costs.

Key Performance Indicators

The following are the key performance indicators currently used by Transit New Zealand, but they are improving and extending each year:

- On road maintenance cost/km
- Percentage completion of programme by cost
- Percentage completion of programme by output
- Return on lettable properties
- Roughness
- Rutting, flushing
- Appeals to Planning Tribunal
- Number of bridges with posted weight restriction.

For example, on road maintenance cost/lane km

Target: constant costs

1997/1998	1998/1999	1999/2000
Actual	Actual	Target
US$3,068	US$2,964	US$3,016

Network performance indicators used can be grouped into three parts: efficiency, safety and asset.

The efficiency indicators cover issues such as:

- Cost of maintenance per km
- Geometric efficiency
- Change in road roughness
- Bridge weight restrictions.

The safety indicators cover such issues as:

- Number and cost of crashes
- Compatibility of speed environment
- Sealed carriage width
- Bridge width deficiencies.

The asset indicators would normally include:

- Road roughness
- Rutting
- Flushing
- Skid resistance
- Remaining seal life
- Remaining pavement life.

Example II Rutting
Where the target is less than 1% of network has potentially hazardous ruts (depression in a wheel path exceeding 30mm)

1997/1998	1998/1999	1999/2000	1999/2000
Actual	Actual	Target	Actual
0.05%	0.03%	1.00%	0.02%

Road user satisfaction levels also need to be measured to make sure that a road network manager is interpreting the customer needs correctly, and that the procedures and systems are delivering.

Transit measures on a biennial basis the road user perception of the state highway network by asking questions on the network condition and performance. This sort of external analysis can be very demanding on a road network manager.

Management Structure to Deliver an Efficient Road Network

Having established restraints to operating a highway infrastructure business, eg. government legislation and both user and stakeholder aspirations, it is essential to develop an organisational structure which will deliver on these expectations, and take into account the management components discussed previously in this paper.

However, in the wider policy debate the way a road infrastructure management entity operates can have a profound effect on the performance incentives of the entity and hence its structural form. For instance the state road controlling authority in South Africa has been formed into a government-owned company. This means that this roading entity works under a companies Act with all its reporting and management disciplines.

In an internal review of Transit New Zealand carried out in 1999, with the help of an outside consultant, a number of other road agencies and utility operators were examined (Reference[1]). Given that the government has decided not to form Transit New Zealand into a state-owned company a model base on a Crown entity was considered.

The generic structural options considered were as follows:

1. Reporting lines based around regional operations
2. Reporting lines based around functions, eg. customer services, project delivery
3. Reporting lines based around markets , eg. urban roads, rural roads
4. Reporting lines based around outputs, eg. maintenance, capital works.

Summary of Transit Review

The following was the findings from this report on the above options (Reference[1]):

The four generic organisational structures each have relative advantages and disadvantages. While some potentially promote a stronger focus on customers and efficiency, none of them stands out as being clearly preferable.

This finding is consistent with organisational design literature with observation of organisational design in overseas road agencies.

The literature points to a number of key conclusions:

- There is no one ideal organisational structure. The design of organisational structure must be built around an understanding and evaluation of markets, regulatory frameworks, strategies and competition.

- There has been a strong trend in getting away from "silos". This has involved greater use of project management and team-based approaches in preference to operating along strictly defined business units.

- The shift in balance between divisions ("silos") and teams/project management approaches reflects underlying tensions and trade-offs between:

  - economies of scale
  - the advantages of specialisation
  - the scarcity of specialist resources, and overarching all of these
  - the dynamics of customer requirements which rarely, if ever, fit neatly into the responsibility of a single operating division.

- Over the last decade, there has been a trend toward "delayering" of organisations with the implication of reducing the number of management levels, increasing spans of control, and increasing levels of responsibility down the organisation.

- The outcome of an organisation design review should not be seen as the creation of a static organisation chart, but rather should recognise that organisational design is an ongoing process where the senior management team is continually modifying the organisation, clarifying reporting relationships, responsibilities and control systems.

In the light of organisational design theory, overseas practice and the analysis of the options above, a key issue to consider is whether there is a case for moving away from an organisation which underlies Transit's existing structure; that is, a structure which uses predominantly regionally-based reporting lines.

The absence of a compelling case in this regard led the Review Team to focus on structural design options which retain reporting lines based around regions (*see Figure 3*).

However, a project-based approach to major projects was adopted to develop skill levels and capture expertise across the organisation rather than in any particular region.

Resources

The key to operating any organisation is to correctly determine the skills needed and then either buy them in or train existing staff. A good human resource strategy which includes individual job requirements, training, remuneration policy, performance monitoring and succession planning is essential. Also, an organisation needs to develop personal accountability, empowerment and opportunities to innovate, as well as a safe working environment.

Physical resources such as office furniture and other equipment are also essential.

Systems

System development in any road management organisation is imperative in order to deliver the desired outcomes. Systems should be based on proven and currently operating systems, where possible. Whether you are purchasing an off-the-shelf system or developing one from scratch, it is imperative that considerable effort goes into the front-end analysis of the customer's needs and scoping the size of the project. Pilot testing is very advisable before rolling out any system. Development of system components one at a time, but capable of integration and interoperability is, however, essential. Systems that Transit have employed or developed from scratch are included in Attachment 1.

Procurement Strategy

It is essential that a road controlling authority decides on its procurement strategy vs use of in-house resources. TNZ has decided that the bare minimum in terms of in-house resources must be sufficient to carry out the client role as a road controlling authority.

As a general rule if a professional services function is being carried out full time each year for a number of years it might be prudent to consider retaining it in house. It is very unlikely that design and supervision of projects would fit this requirement. In-house physical work - both maintenance and construction are very

unlikely to be as efficient as those sourced from a competitive market. This is primarily based on efficient utilisation of resources and the competitive nature of the activities.

Once you establish what should be out-sourced then it is essential to develop a long term procurement strategy for both maintenance and construction.

Maintenance Procurement

A traditional approach to procuring maintenance is to have either the client (road manager) or a consultant working for the client instructing a contractor on what maintenance to do, followed by measure up and management based on work done.

At the other end of the scale you can develop a long term facilities management contract which places considerable onus on the contractor to maintain the road to a certain standard over a long period of time. Clearly there are options in between these two extremes.

Transit New Zealand has to date basically used the conventional form of contract but three years ago moved to establishing some 10-year contracts known as "performance specified maintenance contracts". To date we have obtained 15-20% real savings over that already obtained from the other contracted out maintenance work.

Construction Procurement

The following figure gives an indication of Transit New Zealand's construction procurement model. (see figure 4).

Selecting the Project Development and Delivery Management

The following are the key drivers of the construction long term procurement strategy (LTPSc)

- Key focus of LTPSc is to assign risk to the party best able to manage it
- Lump sum contract form is an effective tool to deliver this
- Only those elements that cannot be quantified or scoped or are not best managed by the supplier will remain as M&V or cost plus
- Development Phase: Lump sum where can adequately scope, otherwise measure and value or cost plus
- Delivery Phase: >$1M LS rapidly, <$1M LS over time

Conclusion

In managing a road network there needs to be a clear vision established, based on road user and stakeholder expectations and then translation of these desires into performance on the road. Internal systems which set priorities, obtain funds, and deliver to set performance measures are essential. Actions need to be based on continuous improvement with an antenna up for new opportunities and developments, which can make the system more efficient or provide better services.

Intelligent network systems offer real opportunities to improve the efficiency and safety of highway networks. However, many institutional structures now in place for management of publicly owned highway networks do not provide the right incentives to ensure that the full potential of intelligent transport systems is exploited.

This technology development, combined with far more demanding road users, means it is essential that network managers break away from conventional thinking and look at how all the components of these highway networks will combine to produce the most cost efficient and affordable infrastructure consistent with customer needs and willingness to pay. Those of us who do not pick up this challenge and move with the opportunities being opened up will not survive the next decade in the highway management field.

Many writers conclude that the present transportation system is not sustainable due to the finite availability of fossil fuels, the environmental damage caused by emissions, the consumption of land for roads, the effects or costs of crashes on communities, and the cost of congestion.

What they fail to do is project their thinking into the future where technology developments are likely to radically change these current conditions.

Hyper or hydrogen vehicles could greatly reduce the dependence on fossil fuels and the effect of emissions on the atmosphere, and also reduce the noise level and contaminates running off the pavement. Safety will dramatically improve with the introduction of technology, which will hold a vehicle in its lane on the road at an appropriate distance behind a vehicle in front.

Better road management and, possibly automated highways, will greatly improve traffic throughput, and hence reduce the need for more traffic lanes.

As proper road pricing is introduced, transport decisions will start being made, based on actual costs. Passenger transport will then be more viable, and congestion will reduce. Also, proper pricing will raise the funds to carry out essential capacity improvements. It is anticipated that the most difficult environmental effects of roads to overcome will be the severance of communities. This is where better land use planning allows for such corridors, and they are

planned into developments. Also, other forms of transport such as walking and cycling need to be catered for in any road network.

In the meantime, demonstrated accountability for excellent road management as outlined in this paper will assist in providing a safe and efficiently run road network.

Disclaimer: Any views expressed in this paper are those of the author and do not necessarily reflect the views of either Transit New Zealand or the Government of New Zealand

Reference

1 *Review of Organisational Structure* – Stage I. Discussion Report September 1999, Transit New Zealand

2 *How to Manage and Organise a Road Network"*, 2nd Eurasphalt & Eurobitume Congress Barcelona 2000

Attachment 1

Information Technology Systems

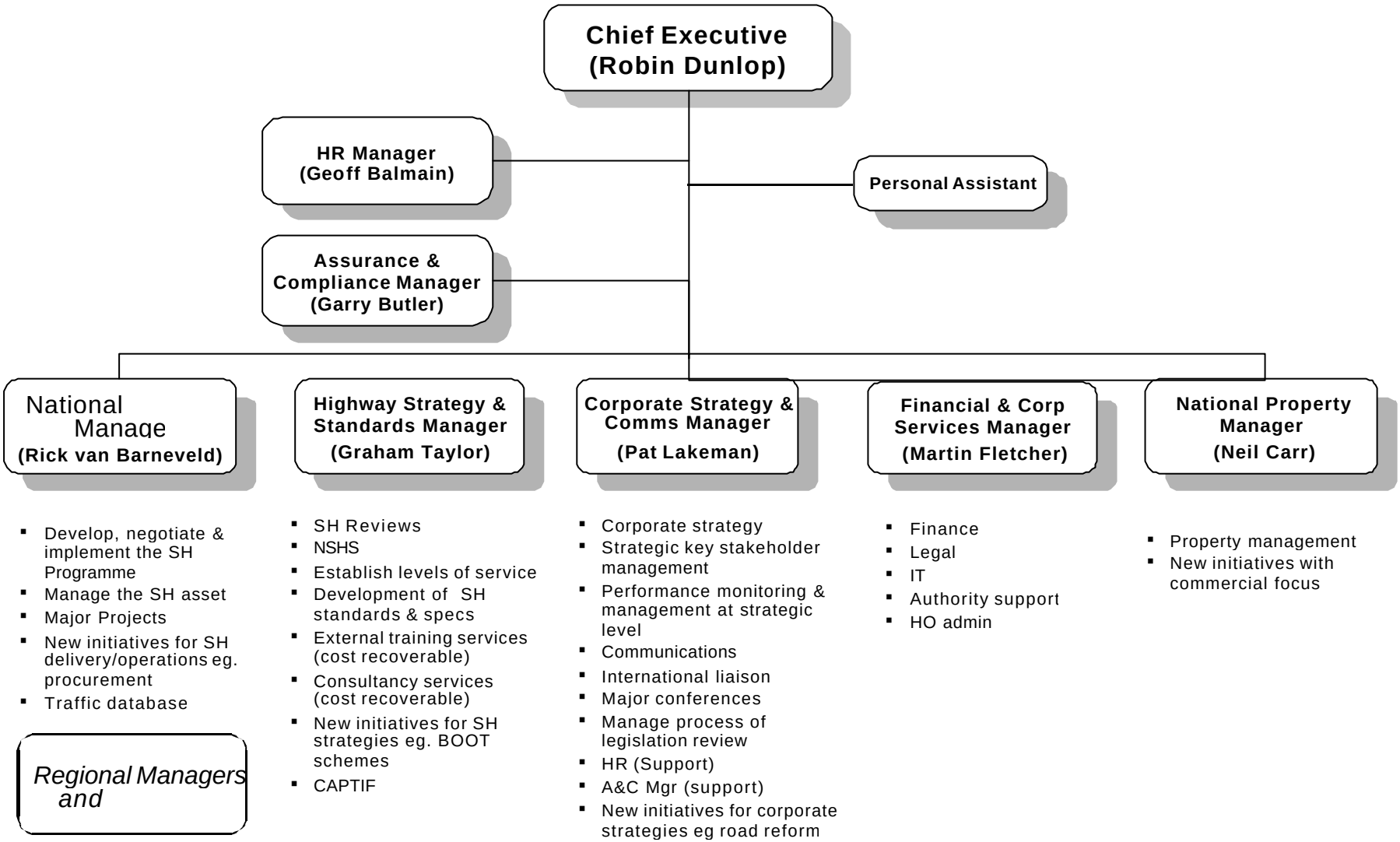
Information system development in any road management organisation is imperative in order to deliver the desired outcomes and to harness new opportunities. Systems should be based on proven and currently operating systems where possible. Whether you are purchasing an off-the-shelf system or developing one from scratch, it is imperative that considerable effort goes into the front end analysis of the objectives, the users' needs and scoping the size of the project. Pilot testing is very advisable before rolling out any system. Development of system components one at a time, but capable of integration and interoperability is, however, essential. It is therefore important to have an overall Information Systems Strategic Plan to provide a vision for the delivery of systems. The plan should weigh up the importance of meeting immediate business requirements and the strategic move towards the vision, which will itself be reviewed. Systems that Transit have employed or developed from scratch are:

Systems	Description
National Optimisation of Maintenance of Assets by Decade (NOMAD)	A 10-year forward planning software tool for maintenance planning and achievement monitoring. It assimilates data from all data sources identified to provide inputs into the 10-year programme determination.
PROMAN	PROMAN is a national project financial management system. It allows the financial status of individual projects be accessed immediately and facilitate the re-direction of surplus funding throughout the national network. Network Management Consultants access PROMAN and input their work directly via the Internet and the remote access architecture in Transit.
Property Acquisitions & Disposal System (PADS)	Property Consultants access PADS and input their property management work directly via the Internet and the remote access architecture in Transit.
Transit Overweight Permit System (TOPS)	A system to process Overweight Vehicle Permits. For each bridge, the (VAI) and (VGI) values that trigger specific conditions of travel for a small set of test trucks, will be calculated and stored in an SQL database. Any truck that requires checking is modelled as one

	of the test trucks. The truck's Vehicle Axle Index (VAI) and Vehicle Gross Index (VGI) are calculated and these values compared to the VAI and VGI trigger values for each bridge. The correct condition of travel for each bridge is then output.
Traffic Monitoring System (TMS)	Traffic data from traffic monitoring devices and telemetry sites is loaded by the Consultants through the Internet. The data are processed and reports are produced for the regional offices and consultants as references and resources for managing the network.
Palladium	To provide Transit staff with online access to key manuals, Authority Submissions and key documents; and to provide document owners an effective means to update and version control their documents.

Transit New Zealand Head Office

Figure 4 **19 March 2001**



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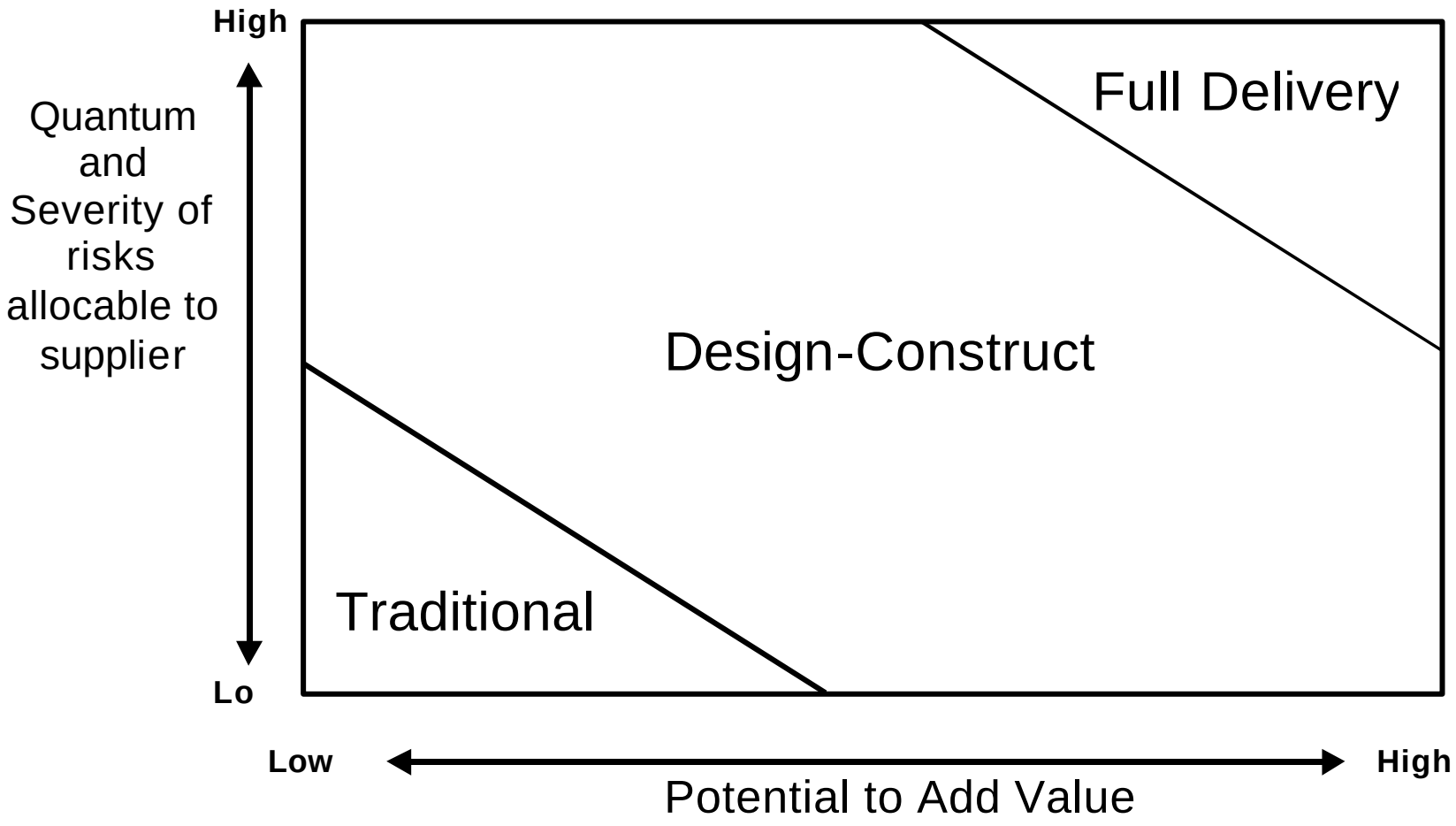
Selecting the PDDM

Figure 4



PDDM often dependent on resource consent conditions...

Dr Robin Dunlop was born in New Zealand and graduated from the University of Canterbury with a Bachelor of Engineering in 1968 and a Ph.D in Roading in 1972. He is currently Chief Executive of Transit New Zealand, and previously held a number of positions in New Zealand Rail and Ministry of Works and Development, as well as working for six months in the Transport and Road Research Laboratory in Crawthorne, England. He has presented many technical papers in New Zealand and worldwide, including carrying out consultancy tasks and training sessions for the World Bank and International Road Federation on roading agency structures and management. He is the Past President of the Road Engineering Association of Asia and Australasia, a member of the Council and Chairman of Austroads, a Director of the International Road Federation Washington, a Fellow and Vice Chairman of the Chartered Institute of Transport New Zealand, President of the Central Branch of the New Zealand Institute of Management, and a Member of the Institution of Professional Engineers NZ. He is also a director of a number of private companies.