Planning Sustainable Infrastructure

Unit 1:
Transport Systems – 1
Transport Technologies

Contents

Introduction

In this first unit on the topic of transport, you will be introduced to the transport technologies engineers relate to land transport needs of our communities.

In this unit, you will be introduced to the characteristics of these technologies and the engineering discipline processes that are used to shape them. Apart from walking, all forms of transport technology consist of vehicles, whether cars, buses, bicycles, trains, trucks or ferries. Also of fundamental importance is that all transport technologies also consist of the supporting infrastructure for the technology to become operational. Even walking is no exception here, also requiring supporting infrastructure.

Transport technologies can be divided into two groups. The first group are those we find around us today. This group of technologies have typically been around for many years. They have a historical context and have become increasingly mature. For these technologies, the skills engineers learn are based on the collective engineering knowledge and operational experience of all those years.

Engineers are typically trained in specific technical disciplines and usually find themselves applying their technical speciality at the beginning of their careers. Each transport technology has the need for different combinations of engineering disciplines and it is in applying these skills that engineers typically find their first connection to the transport technology.

The second group of technologies are those that are trend breaking. These can consist of completely fresh approaches to transport supply using emerging new technologies or they can come from innovative combinations of existing mature technologies, or a combination of both of these, into hybrid technologies. Hyrbid internal combustion/ electric vehicles are an example.

The readings for this unit are general background readings to give the reader an appreciation of the tranport technology characteristics, the technical considerations that engineers deal with and some detail on variious emerging technologies. You are encouraged to scan these readings prior to the in class session for the unit. You do not need to know all their content but do develop an appreciation of what they contain.

Our in class session will assume you have done this background scan of the readings. I will be providing a summary of the units key content in class and facilitating discussion, so come along to class prepared to discuss what you have read, your questions, insights and visions.

Learning outcomes

After the study of this unit you will be able to:

- Discuss the characteristics of the different land based transport technologies we see around us today and appreciate how they have matured over the years.
- Understand the technical skills engineers develop in the ongoing application of these technologies today. You will have a basic understanding of the different engineering disciplines and what part each plays in the different modes of transport. .
- Understand the vehicle technology dependencies on supporting infrastructure.
- Understand some of the emerging new technologies and trend breaking futures for transport technology, including innovation through hybrid technologies and modes.

Transport – Today's mature technologies with which engineers work

Land transport technologies provide for movement of people and freight within our cities, between our cities, in provincial areas and rural communities. The following transport technologies discussed in this section are all relatively mature technologies. They have been in our society for at least a half a century and in some of the technology begun many hundreds of years ago. All have benefited from many years of experience and have progressively become more mature as time has gone on.

The most common transport technologies in our communities today are based on motorised vehicles. Cars, motorcycles, buses and trucks are commonly understood to consist of various vehicle technologies. While not common in developed countries, auto rickshaw vehicles are also very common in developing countries. These are often basic three wheel vehicles such as tuk tuks. The technologies in cars are very familiar to anyone who considers buying a car. Engine, braking and road holding performance are characteristics we all relate to in some way when we think about cars, as are the various technologies we learn about from the manufacturers and car testing specialists.

Reading 1.1

Mitchell Beazley Encyclopedias Ltd, 1989, *The New Joy of Knowledge Encyclopedia Volume 5: Transport*, Oriole Publishing Ltd, London, pp. 260 – 263.

What we don't often think about is the technology and engineering associated with the infrastructure these road based vehicles are dependent on. Without carefully designed road curvatures and grades the vehicle cannot perform efficiently. For example, modern freeways/motorways such as the F5 freeway between Sydney and the Southern Highlands have their gradients limited to suit the efficient operation of articulated trucks and cruising speeds for cars and trucks between 80 and 110 kph. Bus ways are another example where gradients are designed specifically for the operation of buses. However, in residential areas, tight curves, narrow roadway and bumps form part of "traffic calming" measures to purposely slow cars down.

The road surface characteristics, drainage design and design for line of sight all influence the level of safety for vehicles and their occupants. So also do run off barriers, road markings, grade separated intersections and multiple and divided roads.

Reading 1.2

Mitchell Beazley Encyclopedias Ltd, 1989, *The New Joy of Knowledge Encyclopedia Volume 5: Transport*, Oriole Publishing Ltd, London, pp. 248 – 251.

Reading 1.3

National Association of Australian State Road Authorities, 1976, *Policy for Geometric Design of Rural Roads*, Ambassador Press, Granville, pp 64 -73

Non-motorised vehicles and walking largely have the same dependencies on infrastructure as motorised vehicles. Though, the type of infrastructure is able to be somewhat more flexible than for motorised vehicles. Bicycles are accommodated on roads and specialised cycle ways. Incompatibility with heavier motorised transport requires infrastructure that separates the two in some situations for safety reasons. Gradients for bicycles are more restrictive than for cars and trucks, but the curvatures can be much tighter allowing more flexibility in routes. Roadway surface characteristics need to be similar to those needed for motorised vehicles; however the structural strength can be less due to lighter loading.

Walking also requires pathways with certain gradient characteristics and pavement surface characteristics. Overly steep grades present difficulties for older and less able members of the community and uneven and slippery pavement present fall hazards. With more members of the community needing to use wheel chairs or motorised chairs many foot paths need to be step free.

Reading 1.4

Roads & Traffic Authority NSW, *NSW Bicycle Guidelines*, Roads & Traffic Authority NSW , Sydney, pp. 10 -14.

Guided transport technologies are the second most common group of land transport technologies. The most common vehicles include trains, metro, high speed trains and lightrail or trams.

These vehicles are even more closely connected to the supporting infrastructure than road based vehicles. As the name "guided" suggests, the steering of these vehicles are entirely dependent on the physical interface with the infrastructure they are connected to. For most, this is provided by a steel wheel on steel rail interface.

An exception are some of the metro and light rail vehicles which are rubber tyred but still steer by the interface with either steel rail or concrete trackway. Guided busways are also a hybrid connection of buses that fit into this category. Guided transport vehicles are often externally powered by contact with electromotive power technology along the full length of the guideway. Trains, high speed trains and light rail are powered by overhead catenary, while metros can be either overhead catenary or an electrified third rail adjacent to the wheels.

All guided transport vehicle operations are totally bound by the infrastructure they share. The movement of vehicles is controlled with technology that is a mix of vehicle and infrastructure to enable safe separation between vehicles. This is less stringent for light rail vehicles sharing roadways, where the vehicles are operated more according to the road rules. The vehicles are also unable to pass each other freely as on roads. Passing can only occur at locations where "passing" infrastructure has been put in place and when the "passing" infrastructure is set to coordinate the passing movement with other vehicles.

Unlike most road based technologies, guided transport technologies only set down and pick up passengers at locations where infrastructure has been provided for passengers to get on or off the vehicle, similarly for freight transport. However, road based vehicles on motorways share much the same characteristic with vehicles only able to stop or exit the infrastructure at designated locations.

Reading 1.5

White, P., 2008, *Public Transport: Its Planning, Management and Operation*, Routledge, London, pp. 78 – 96.

Reading 1.6

Alstom Transport, 2009, *AGV Full speed ahead into the 21st century*, Alstom, France.

A third group of technologies are those of ferries and canal barges. They seem a little unusual when discussing land transport. However, while they are on water they are typically used to meet land transport needs.

Ferries at first glance would seem to mostly consist of the vehicles, or vessels in this case. However, they too have a dependence on supporting infrastructure for them to operate. The waterways are mostly naturally occurring but in some locations require channels to be deepened and require navigational aids to be positioned along the route. The major infrastructure for ferries is at the wharfs where people board or disembark. Suitable boarding structures (and dredging in some cases) to enable the required water depth, together with waiting and interchange areas are key infrastructure elements to enable ferries to function.

Not common in Australia but very common in other countries are the canal boat technologies for land transport of freight. The canal boat vessels are again only part of the picture. The technology associated with canal transport is equally the technology of the infrastructure that makes up the canal. Many canals are combination of navigable rivers and manmade canals. In navigable rivers some locations require channels to be deepened and require navigational aids to be positioned along the route. Where canals are constructed, the engineering can be as complex as for roadways. Grades, earthworks and water retention engineering are key challenges. The most complex technology is that associated with locks, in moving a vessel from one water level to another.

Whilst all of the vehicles and infrastructure engineering discussed in this section are relatively mature already, these transport technologies continue to be fine tuned with the application of the latest general improvements in technology. The effect of this is to increase their effectiveness and efficiency for meeting land transport needs and adding to the ongoing legacy of experience.

Reading 1.7

Kemp, R., 1998, *Drive Systems for High Speed Trains*, Paper presented to Transportation Research Board, Washington.

Exercise 1.1

Based on your understanding of the readings for the mature technologies discussed, speculate for two of the technologies that you know, what aspect of the technologies you think could continue to improve. Do you think the improvements need a step away from the current technology or do you think it is more about evolving what we already have? Explain your reasons.

Transport – Basic technical skills engineers use

Land transport technologies over the past few hundred years have all involved engineers.

Earlier, it was discussed that an engineer's first involvement with transport technologies is to apply their core technical skills. However, as engineers work with mature transport technologies they develop an understanding from the legacy of experience that has gone before them and develop specialised knowledge of the vehicles and infrastructure characteristics.

Engineers involved in designing cars include those with mechanical, electrical and even chemical core engineering skills. We find specialisations from these broad disciplines into braking, vibration, lubrication, materials, electronics and process engineering to name some of these specialisations.

Design of new vehicles requires strong interaction with stylists, consideration of the ergonomic aspects of vehicles through to engineering that enables the vehicle to be manufactured on the production line. There is also a well established framework for car design in the Australian Design Guidelines with specific design requirements focusing on safety. In reading 1.8 you will find a summary example of the design guidelines for passenger vehicles.

Reading 1.8

Vehicle Safety Standards Branch, 2009*, Third Edition ADRs – Applicability Summary Passenger Vehicles*, Department of Infrastructure, Transport, Australian Government, Canberra

Over the past 20 years, similar engineering skills have also been applied to other passenger vehicles, particularly those where the passenger safety risk could be significant due to high numbers of passengers. Integration of style with engineering for passenger comfort has also become significant over the past 20 years, particularly where it is an important aspect to attracting passengers from car or air transport. Style is most apparent in high speed trains and light rail vehicles but is also becoming apparent in recent metro and suburban trains. The need for engineers to be style minded in their engineering is similar now to what is common place in the car industry.

For the same reasons style is also seen as important in creating liveable spaces at transport interchanges and stations. Urban designers, architects and engineers now work closely together to create the spaces needed to be attractive to passengers, meeters and greeters. Core engineering skills include civil, structural, mechanical and electrical disciplines with specialisations in areas such as geotechnical, building structural, hydraulics, heating/ventilation/ air-conditioning, low voltage electrical and fire engineering.

For road and guided transport infrastructure, civil, structural and geotechnical engineering are significant core engineering disciplines common to each of these infrastructure areas. Specialisations include geometric layout, earthworks, soil, drainage, tunnelling, ventilation, fire, communications, environmental and bridge engineering. Road infrastructure also includes specialisations in road pavement and road safety equipment. Guided transport infrastructure also includes specialisations in high and low voltage electrical power distribution, signalling control technology and track technology.

Reading 1.9

Mitchell Beazley Encyclopedias Ltd, 1989, *The New Joy of Knowledge Encyclopedia Volume 5: Transport*, Oriole Publishing Ltd, London, pp. 252 – 257.

Reading 1.10

Esveld, C., 2001, Modern Railway Track 2nd Edition, MRT Productions, Zaltbommel, Selection of pages from 14 to 579

The tabulations shown on pages 12 , 13 &14 show the infrastructure that supports the transport vehicles discussed above. The tabulations also show the broad engineering disciplines and the specialisations normally associated with the vehicles and infrastructure.

	Vehicle	Engineering Discipline	Specialisation
Motorised	car	mechanical, electrical, chemical	body design, crash design, braking, dynamics/vibration, suspension, internal combustion engine, drive train, process engineering, electronics, materials & lubrication
	motorcycle		
	auto rickshaw		
	truck		
	bus		
non motorised	cycle	mechanical	braking, gearing, suspension, process engineering
	no vehicle (walk)		

Infrastructure Type	Infrastructure	Engineering Discipline	Specialisation
road	earthworks	civil, mechanical , electrical	road design, geotechnical,soil, tunnelling, civil structures, pavement, drainage, tunnel ventilation, fire
	tunnels		
	drainage		
	pavement		
	bridges	structural	bridge structures
	signage	mechanical, electrical	mechanical design, road safety, lighting, control equipment
	traffic control equipment	mechanical, electrical	
	lighting	mechanical, electrical	
	safety equipment	mechanical	
	roadside service centres	civil, structural, mechanical & electrical	road design, pavement, drainage, building structural, Heating Ventilation and Airconditioning, fire
pathways	earthworks	civil	pathway design, soil, civil structures, pavement, drainage
	drainage		
	pavement		
	bridges	structural	bridge structures
	signage	mechanical, electrical	mechanical design, road safety, lighting, control equipment
	traffic control equipment	mechanical, electrical	
	lighting	mechanical, electrical	
	safety equipment	mechanical	

	Vehicle	Engineering Discipline	Specialisation	Infrastructure Type	Infrastructure	Engineering Discipline	Specialisation
Guided	light rail/tram metro, train, high speed train, freight train	mechanical, electrical, chemical	body design, crash design, braking, dynamics/ vibration, process engineering, diesel motors, electrical traction, electronics, communications, signalling, materials & lubrication, airconditioning	Train Corridors	earthworks	civil, mechanical , electrical	road design, geotechnical,soil, tunnelling, civil structures, pavement, drainage, tunnel ventilation, fire
					tunnels		
					drainage		
					track stucture	civil	track
					bridges	structural	bridge structures
					lighting	mechanical, electrical	mechanical design, lighting
					electromotive power	electrical, structural	Substation, overhead wiring, building & steel structures
					train control centres and communications	electrical	electronics, computing, communications
					signalling	electrical	signalling
					Interchanges/stations	civil, structural, mechanical & electrical	road design, pavement, drainage, building structural, Heating Ventilation and Airconditioning, lighting, fire
					fleet maintenance facilities	civil, structural, mechanical & electrical	track, overhead wiring, signalling, road design, pavement, drainage, building structural, Heating Ventilation and Airconditioning, fire
					freight yards		

	Vehicle	Engineering Discipline	Specialisation	Infrastructure Type	Infrastructure	Engineering Discipline	Specialisation
Water based	ferry canal boat	marine, mechanical, electrical	marine, diesel engines, low voltage electrical, communications, fire	Waterways	natural waterways	civil, mechanical , electrical	dredging, canal design, road design, geotechnical, soil, civil structures, pavement, drainage, fire, environmental
					canals		
					locks		
					wharfs		
					carparks		
					waiting areas	civil, structural, mechanical & electrical	building structural, Heating Ventilation and Airconditioning, lighting, fire
					signage	structural, mechanical, electrical	steel structures, mechanical design, navigation aids
					communications	electrical	electronics, computing, communications
					lighting	mechanical, electrical	mechanical design, navigation aids, lighting

Transport – Emerging trend breaking technologies that engineers are exploring.

Imagination is something we all have to some degree. It has been imagination that in the past has led to what we now consider the mature transport technologies. Each of them would have at some time been trend breaking. Today, community values and aspirations have continued to change. They reflect a desire for change to meet the issues our societies and indeed the planet face today. The realisation that the earth and its resources are not unlimited and the need to be good stewards is an awareness that is growing. Communities and governments strive to identify visions of their communities to which they can aspire.

These needs inspire some engineers to continue to look for trend breaking technologies that they believe will make a difference. Trend breaking technology comes when engineers share a vision and imagine new ways to meet that vision. But for the vision to develop it also needs to be founded in the experience of the mature technologies. Before taking a technology in a different direction it is important to test the change against the current technology state. The engineer needs to know what the intended functions of existing technologies are and how well they meet those functions in order to shape the imagined into a real technology that is appropriate.

As was discussed earlier, these trend breaking technologies are either completely fresh approaches to transport supply using emerging new technologies or they can come from innovative combinations of existing mature technologies, or a combination of both of these, into hybrid technologies. Some examples of emerging trend breaking technologies we are familiar with are hybrid cars and maglev trains.

Hybrid cars as we know them today are a putting together of internal combustion engines and electric motors that uses the efficiency of both power systems where they are greatest. The following readings give a deeper understanding of the characteristics and development for this type of car.

Reading 1.11

General Motors/CSIRO, 2000, "Presentation Papers", *Launch of Concept Hybrid*, General Motors/CSIRO, Sydney.

Reading 1.12

Masuda, Y., 2009, "Automotive Technologies Towards Low Carbon Society", *WCTRS-SIG11 International Symposium Transport and Climate Change(TRaCC)*, Toyota Motor Corporation, Nagoya.

Many engineers and indeed the car industry see this emerging technology as a transition technology to either fuel cell or electric cars in the future. However the hybrid internal combustion/electric car is seen as an interim technology that will be the norm for quite some years. At present the idea of a hydrogen based car is dependent on a hydrogen economy developing. This has been an idea that I can remember being discussed widely back in the early 1970's and filled young people like myself (at the time) with enthusiasm. However, the use of hydrogen still has a number of challenges. One of the challenges is to how to produce the hydrogen in an energy efficient and low carbon way.

Maglev trains are a magnetically levitated and propelled type of guided transport. There have been two types of developments taking place, electro magnetic normal conducting Transrapid and electro dynamic super conducting tehnology by Japan Railways. These emerging technologies have been in development since the 1960's. The Transrapid 09 reached commercial operations readiness in the late 1990's and has been introduced in only one project thus far at Shanghai. The Japanese superconducting MLX01, which is a higher speed but more complex technology than the Transrapid, is about to be introduced on the Tokyo to Osaka line into commercial operation. The following readings provide more of an understanding of the technology associated with each of these maglev trains.

Reading 1.13

Transrapid International, "*Compendium of Presentation Papers",* Thyssen Transrapid, Germany.

Reading 1.14

Noda, T., 2009, "The Tokaido Shinkanson and superconducting maglev- contributing to a low carbon society", *WCTRS-SIG11 International Symposium Transport and Climate Change(TRaCC)*, Central Japan Railway Company, Japan.

Other emerging technologies include bimodal freight systems with vehicles that can run on roads and rail, personalised rapid transport such as the Austrans technology (http://www.austrans.com, Jan 2010), maglev roll on roll off high speed platforms for high speed shunts of road freight between cities and hybrid maglev applications to heavy rail systems to reduce track loading and increase grade climbing abilities of trains.

It is prudent to notice that the time from when ideas have been first imagined can be long and drawn out. It does of course take time for the ideas to develop into operational technology, a significant effort is always required to get to a minimum level of maturity. However, more often the transition from technologies being replaced to the emerging technology depends on using up the value of the investment already made in the original technology. The challenge for governments is how to economically and at low risk shift from one technology to another. For community it is how to adjust what we are used to, sell the old car and buy the new technology car for example. The challenge to industry is when to let go of generating income from the old technologies and their prior investments to invest in the new technology.

Readings

Reading 1.1

Mitchell Beazley Encyclopedias Ltd, 1989, *The New Joy of Knowledge Encyclopedia Volume 5: Transport*, Oriole Publishing Ltd, London, pp. 260 – 263.

Reading 1.2

Mitchell Beazley Encyclopedias Ltd, 1989, *The New Joy of Knowledge Encyclopedia Volume 5: Transport*, Oriole Publishing Ltd, London, pp. 248 – 251.

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National Association of Australian State Road Authorities, 1976, *Policy for Geometric Design of Rural Roads*, Ambassador Press, Granville, pp 64 -73

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Roads & Traffic Authority NSW, *NSW Bicycle Guidelines*, Roads & Traffic Authority NSW , Sydney, pp. 10 -14**.**

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White, P., 2008, *Public Transport: Its Planning, Management and Operation*, Routledge, London, pp. 78 – 96.

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