3. Intermodal Transport

“Mobility enhances the quality of life in megacities, it strengthens global trade and it is a relevant issue for environmental protection” – S, Atiya.

3.1. Introduction

Intermodal transport is not only focussing on passengers or freight, this Chapter’s main focus is on freight, because of the uninformed intermodal freight concept in South Africa. Intermodal passenger transport in South Africa has already been incorporated in Gauteng; the Gautrain is at most famous for its intermodal passenger transport.

Heavy vehicle road transport, which has grown excessively at the expense of rail, is under increasing criticism from other road users, local authorities, provincial and the central government, the current state of rail in South Africa is a considerable worry (Jorgensen, 2004:671). From the early days of transport deregulation, where their growth was welcomed by business and industry long frustrated by poor railway services, there is now increasing public and government pressure to bring traffic back to rail (Jorgensen, 2004:681).

Overloaded and non-roadworthy vehicles, damaged road infrastructure, congestion, safety, accidents, pollution and energy issues are very much in public interest causes the transport system to show signs of inefficiency from a socio-economic point of view. Total freight transport amounted to 1,5 billion tons shipped in 2006, which constitutes an increase of 5.5% from 2005. It is shown that since 1997, all growth has been captured by road, which is a worrying trend. 39% of transport takes place on major corridors, 24% in rural areas, bulk-mining for 21% and metropolitan areas carry 16% of transport (CSIR, 2008:6). Intermodal transport is an excellent policy tool that can support an overall transport systems approach aimed at a more balanced and efficient use of the available transport capacity.
Intermodal Freight Terminals is the weakest links of the intermodal transport, it is therefore necessary to study and investigate terminals for effectiveness and efficiency and make the intermodal freight transport more competitive and attractive and also to improve sustainability (European commission, 2006:3). The pressures that have brought about renewed interest in intermodal freight transport should also be examined, and what the future holds (Lowe, 2005:6). There is a lot of evidence worldwide to prove that the intermodal concept is the future key for fighting the increasing urban congestion. This is obvious in Gauteng and we in South Africa must now act decisively by carefully studying the past mistakes and consider current accomplishments being made by other countries. The time for constant talk and debate is in the past, the future is here now, and it is in our hands (Jorgensen, 2004, 672).

Before the study goes further into this exploration of what intermodal freight transport is about and why it is necessary, it is necessary to be familiar with a few definitions for the variety of terms used in connection with road rail transport, and in intermodal transport in general, and the equipment needed for its operation. In this chapter the intermodality as a whole will be explored, it is summarised in **Figure 7**:

![Figure 7: Introduction to Intermodal Transport](source: Own Construction, 2012.)
3.1.1. Defining intermodal transportation

In the European Union’s white paper of 2001 (White Paper, 2001) places emphasis on encouraging intermodal transportation as the solution to the problems seen in the transportation business. Intermodal transportation defined by Jones et.al. (2000:349) is: “The shipper of cargo and the movement of people involving more than one mode of transportation during a single, seamless journey”.

Multimodal transportation means transportation using several modes, but in its definition does not require any interoperability between modes. Intermodal transportation on the other hand refers to performing a transportation task by interaction of several modes of transportation including the transfer between the modes. The reason why this distinction is made here is because the transfer between modes is an important factor in intermodal transportation. The purpose of transportation is moving commodities between their origins and destinations possibly within a time limit (Pedersen, 2005:3).

The increased time and cost of transportation with transfers is an infuriation that make it less attractive but still plays an important role. The advantage of integrating freight mobility is achieving economies of scale by transporting freights in large quantities using a single transport. Rail transportation was invented to be able to transport large quantities of freight across land. In an intermodal system, or any kind of transportation system where transfers are made, there can furthermore be waiting time at transfer points from the arrival of a service until a departure on another service, which sometimes are time consuming (Pedersen, 2005:4).

3.1.2. What is intermodal transportation?

Intermodal freight transport is the concept of combining two or more modes, to form an integrated transport chain aimed at achieving operationally efficient and cost-effective delivery of goods in an environmentally sustainable manner from their point of origin to their final destination. It implies that intermodal transportation is not limited to freight; people often use varying modes of transport to travel between destinations. This can be
seen in South Africa’s latest project, the Gautrain. It varies from road transport to the station, and then rail transport to the next location, and once again road transport to the final destination.

While some freight movements may use numerous transport modes, such as road, rail or inland waterway or sea shipping, thus makes them multimodal operations. Most of these are achieved by the use of just two modes: generally known as a combined road rail operation. Combined transport operations involve either road haulage or rail freight in combination with sea container services or with air freight operations. Determine the choice of mode or modes includes the cost of service, but sometimes other considerations are decisive. Operational considerations are based on frequency of service, speed of delivery, the availability of special handling facilities, the ability to meet particular packaging requirements and security considerations. It is a fact that in the majority of cases the haulage of goods by road remains the preferred method, and it is this preference which this study, the cause of intermodal freight transport are trying to prevent (Lowe, 2005:1).

No matter what the particular freighting movement is, the core of the whole operation is to utilize the key characteristics of each individual transport mode to its best advantage (which will be discussed in Table 10). Thus road haulage in any combination with rail freighting, inland waterway, short-sea, or coastal shipping may prove to be the most viable options, both economically and operationally (Lowe, 2005:2). This is seen as a beneficial alternative to the adverse impact of heavy trucks on traffic flows both on motorways and in urban areas (especially due to South Africa’s traffic congestion, poor infrastructure and urban growth), although heavy trucks will still be required to serve many road rail terminals, this is because of the numerous freight originators and recipients located in urban areas who are not rail connected (Lowe, 2005:2).

The essence of efficient intermodal transport lies in the use of transfer between road, rail, and other transport modes. This includes terminals which contain systems for easy load and off-load facilities for freight. Such systems provide greater flexibility for the customer, it assure his piece of mind, having seen his freight securely stowed and
sealed in an intermodal loading unit, he knows that it will not be disturbed again until it reaches its final destination (Lowe, 2005:3). Intermodal transport support a lot of sustainability benefits, such as social, economic and environmental benefits.

3.1.3. Why intermodal transportation?

In South Africa there are a few externalities that must be investigated, we refer to aspects such as the energy crisis, major congestion on the main roads and corridors that will worsen, the lack of road infrastructure, the lack of proper road maintenance, the skills shortage, no proper freight logistics strategy across all levels of government, and the delay in ensuring that the main rail operator provides a service that will attract freight back to rail. Rising fuel and diesel prices will, together with many of these externalities, contribute to even higher logistics costs in the country. This we cannot afford since it will make us less competitive internationally (CSIR, 2008:11).

“The issue of global warming as part of the climate change debate, together with the negative effect of economic activity on our environment, has rarely been more prominent. Concern for the environment will soon be part of the mind-set of a critical mass of consumers and logistics and supply chain operators factoring it into business decisions and in choosing suppliers. ‘Greener’ supply chains will certainly become a requirement in the near future.” (CSIR, 2008:12).

CSIR (2008:23) stated that infrastructure quality is an important factor in determining logistics performance, transport infrastructure is also very important and should be able to satisfy fast growing demands and the competence of private and public logistics service providers is another crucial aspect. The reliability and performance of the supply chain depends on the quality of the service provided by the private sector, along with the ability and attentiveness of public agencies. Quality of service, along with reliability, is an important factor in the age of globalisation and customers tend to value these even more than the costs of the service (CSIR, 2008:23).
So many benefits are announced for intermodal transport overall (Table 9) and combined road rail transport in particular, one could be forgiven for asking why it is only now, at around the end of the 20th century, that it is being promoted (Lowe, 2005:11).

The concept of the system has been in existence for a very long time. The practice of transferring road trailers and containers onto rail wagon for trunk haulage has existed since the earliest days of rail (in the UK). The devices have obviously changed over the years and today’s domestic and international journeys are much longer than the domestic operations in previous years, but the basic principles remain the same. Railways have carried containers on long haul journeys and delivered them locally by road. Simple wooden box containers, have given way to the latest form of steel shipping container and swap body built to international strength and dimensional standards, while road-hauled semi-trailers have developed from simple two-wheeled affairs with ‘cart-like’ springing. Today’s standards these are small and clumsy devices, but then it was an intermodal road rail system, and it worked. The parallel development of technically sophisticated lifting and transfer equipment enables these loading units and semi-trailers to be transferred quickly and efficiently from road to rail for long-haul transport, and back again for final delivery (Lowe, 2005:3).

So, if there is nothing new in this concept, where does the renewed interest come from? It can largely be put down to three key factors (Jorgensen, 2004:681):

- The current road freight industry is overtraded and transport rates are highly competitive and aggressive, thus forcing operators to overload in an endeavour to survive.
- Road transport can concentrate on moving commodities where their advantage of speed and flexibility of certain perishable products and very time-sensitive traffic are most important. This traffic generally commands better rates and will, therefore, be more profitable.
- Since fewer trucks will be far from home, breakdowns, when they occur, will be easier to deal with as less travelling will be required.
Globalization affects transportation demand and creates transportation over greater distances while efficient transportation over greater distances makes globalization possible, thus together creating an upward spiral. Currently the transportation sector produces over 10% of the European Union’s GDP and employs over 10 million people in the transport sector (Pedersen, 2005:5).

![Figure 8: Growth in Traffic by Mode for Freight Transport](image)


From **Figure 8** it can be seen that for freight transportation, short-sea shipping and road-haulage have increased, while rail had declined. Based on the figures of the development in road transportation it is not difficult to understand why congestion has become a big problem in the European Union (Pedersen, 2005:6).

So why is the European Union interested in rail transportation, especially for freight, as the solution when congestion is predominant both in the road and the rail sector? The reasons may be that highway maintenance could be reduced to a sixth of the current costs if only cars were using them, more interesting reason though is environmental issues. The transportation sector was in 1998 responsible for 28% of the CO2 emission
in the European Union, road transportation alone accounted for 67% of the demand for oil and accounted for 84% of the total CO2 emissions from the transportation sector. In total, transportation is 98% dependent on fossil fuels. Even more noticeably, it is expected that the transportation sector will see a 50% increase in CO2 emissions by 2010 (Pedersen, 2005:7).

This is the reasons why intermodal rail transportation is seen as the solution for the future. By combining the positive aspects of environmentally friendly rail transportation with the flexibility of road transportation to give customers access to the rail network, the European Union hopes to reduce the effects on congestion and the environment (Pedersen, 2005:9).

3.2. Urban Freight Transport

3.2.1. Context of urban freight planning

Within logistics transportation is the activity that achieves the movement of freight along a supply chain between point of origin and point of consumption. It creates time and place effectiveness since a product produced at one point has very little value to the prospective customer unless it is available at the point where and at the time when it will be consumed (Stock and Lambert, 2001).

Behrends (2011:14) present a hierarchical three layer model for the analysis of logistics, transport and land-use that consists of the three layers freight flow, transport flow and infrastructure (Figure 9):
The first layer in *Figure 9* indicates the freight flow, which represents supply chains containing nodes and links (it determines the demand for freight transport in terms of shipment size, frequency, lead-time, delivery precision and flexibility). The second layer is the transport network, which translates the freight transport demand (top layer) into traffic. It provides transport services, resulting in actual load unit flows that generate demand for vehicle flows. The traffic is comprehended in an infrastructure layer (layer three) that contains roads and rail tracks on which vehicle movements take place. The layers are linked by markets where supply and demand of the different layers are matched (Behrends, 2011:14).

Logistics is influenced by the mobility of goods, which is enabled by transport networks connecting the spaces between the economic activities. It is the location of the logistic activities in relation to transport infrastructure that determines the nature, origin, destination, distance and the possibility of movements to be realised (Rodrigue et al., 2009).
3.2.2. Integrated transport planning

Cities need to meet social, environmental, political, cultural, economic and physical objectives (Egger, 2006:1239) in order to be considered as sustainable cities. Behrends (2011:16) states three main areas to achieve sustainable urban freight transport; they need to be used in combination: logistical measures, policy measures and technological measures.

In general, local authorities consider freight a private industry. Local transport planning and sustainable development focus on passenger transport rather than on freight transport issues. Freight transport in the urban area is not yet fully understood and there is an absence of efficient approaches for planning such activities (Crainic et al., 2004:120). A widely recognised requirement for reaching sustainable transport is integrated transport planning (ITP). Many cities have not yet found acceptable solutions to help improve the urban movement of goods (Dablanc, 2007:284). The European Commission highlights the importance of integrated solutions (European Commission, 2006:10) and strongly recommends that authorities must develop and implement Sustainable Urban Transport Plans (SUTP). SUTP is an integrated approach. The SUTP aims to improve qualities of the planning approach by using procedures and actor relations as well as designing planning instruments to guarantee the efficient implementation of policies and procedures.

3.3. Intermodal Transport

This now examines the intermodal concept and the benefits that can grow from innovative and imaginative systems which take the best of both the road and rail mode, to the mutual advantage of both. Intermodal systems include terminals, transhipping equipment and moving equipment, link-ups and a wide range of general logistical considerations.
3.3.1. Benefits of intermodal transport

Logistics costs are currently negatively affected by the rising fuel prices. This is possibly the one aspect of most concern to supply chain managers in South Africa. This, together with the energy crisis, multitude of large infrastructure projects, and the serious congestion, severe skills shortage (CSIR, 2008: 10) and sustainability concerns.

Cargo that is not properly secured can cause severe accidents and lead to the loss of cargo, lives, vehicles, ships and airplanes; along with the environmental damage it can cause. This significant increase in security promotes the intermodal industry and guarantees businesses that their goods will be moved without problems or delays. Trucks produce large amounts of noise and air pollution, which makes neighbourhoods unpleasant to live in. Intermodal transport can improve community quality of life if fewer trucks are on the roadways. Overall, there is a cost savings as well, because it is cheaper to ship by rail or water than by truck (Anon, 2005:9). The following table highlight some of the main benefits for intermodal freight transport (Table 9):

**Table 9: Benefits for Intermodal Freight Transport**

| Principle benefits of intermodal transport: | • Significant energy cost benefits which will ensure more sustainable transport |
|                                           | • Lower transit costs over long journeys (cost effective) |
|                                           | • Potentially faster delivery times in certain circumstances (increasing speed of intermodal operations) |
|                                           | • Traffic congestion in urban areas can be reduced (if smaller vehicles are used for collection and final delivery and fewer heavy trucks on roads) |
|                                           | • A more environmentally acceptable solution to congestion and related problems (emission of noise and fumes, and damage caused to the built environment by vibration etc.) |
|                                           | • Reduced consumption of fossil fuels (since the long haul section |
of the route is more fuel efficient)

- Safer transit for dangerous goods
- Reduce losses and damages
- Road accidents and related costs will be reduced
- Separation of freight movements from a ‘people’ environment.

Source: Own construction from various sources, 2012.

Rising fuel prices, toll rates and road taxes effects on travelling between Durban and Gauteng is a serious concern. “Each road rig consumes between 275 and 300 litres of diesel fuel. The operator pays between R302.50 and R330.00 in fuel taxes. This compares to between R0.53 and R0.58 per km. In addition, toll road fees are R392.00 (if all five toll units are considered). This amounts to about R0.68per vehicle kilometre although the actual sections tolled are only about 258 km in length. The actual toll charge per km is, therefore, R1.52 per km of actual toll road. Since the government has stated most emphatically that the fuel tax is not a road user fee, and the fact that Spoornet and other rail operators pay this in full as well, only the toll fee can be seen as a road user charge. As only 258 km of the N3 is tolled and R392.00 is paid, then the heavy vehicle is only paying the R0.68 per km for the total road distance. If the real cost per km is R5.46, this included the fuel fees, and then the minimum shortfall is about R4.78 per km. At 570 km, that equates to an under recovery of R2724.60 per trip, or about R75.68 per ton for a 36 ton payload. Considering the fact that typical road charges on this route range from R110 to R 125 per ton for flat-deck 36-ton full-loads, it can be imagined the effect of an additional R75.00 per ton. At current traffic volumes, this is costing the South Africa tax payer over R1250 million a year” (Jorgensen, 2004:682). Note that this has been the costs about 8 years ago, the fuel and toll rates have increased significantly, which makes it a serious concern for road transport companies.

The logistics costs as a percentage of gross domestic product (GDP) declined from 16.2% in 2005 to 15.7% in 2006. Transport constitutes the major component of logistics costs at 5.9%; it is worrying that it has increased by 0.7% from 2005 to 2006.
The other stack elements have remained relatively constant and even decreased over the same time period (CSIR, 2008:6).

In a previous sub-section of this Chapter the advantages of the different freight transport modes are mentioned, in Table 10 the advantages will be discussed. The idea is to utilize the key characteristics of the transport modes that the best combination will be clear.

**Table 10: Advantages of Different Transport Modes**

<table>
<thead>
<tr>
<th>Transport modes:</th>
<th>Benefits:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road (Truck)</td>
<td>• Door-to-door service (Road transport is not limited to a fixed route)</td>
</tr>
<tr>
<td></td>
<td>• Accessibility (Road networks are directly accessible)</td>
</tr>
<tr>
<td></td>
<td>• Freight protection (Handling and transhipment of freight is limited through the door-to-door delivery ability)</td>
</tr>
<tr>
<td></td>
<td>• Transit time and flexibility (In the case of congestion one can use an alternative route)</td>
</tr>
<tr>
<td></td>
<td>• Capacity (Carrying capacity is adaptable and can be readily increased)</td>
</tr>
<tr>
<td></td>
<td>• High frequency (High service frequency can be maintained as a result of the small carrying capacity and high speed of road vehicles)</td>
</tr>
<tr>
<td></td>
<td>• Fuel and prime mover investment costs can be significantly reduced</td>
</tr>
<tr>
<td>Rail</td>
<td>• Commodity flexibility (Almost any type of commodity can be conveyed by rail and in special train compositions)</td>
</tr>
<tr>
<td></td>
<td>• Large volumes (Bulk loads can be carried over longer distances, the carrying capacity is not as limited as road transport)</td>
</tr>
<tr>
<td></td>
<td>• Lower cost (If loads carried over long distances)</td>
</tr>
<tr>
<td></td>
<td>• Less polluting effect on environment</td>
</tr>
</tbody>
</table>
- Congestion (Rail transport is not subject to traffic congestion)
- Weather (Rail transport is less affected by inclement weather than other modes of transport)
- Safety (Rail wagons are not as easy to hijack as road vehicles)
- High speed (Average trip speeds over long distances can be very high, especially if shunting and the special composition of train sets are not required)
- Private sidings (This gives the customer the ability to load and unload at their facilities when convenient)
- Cost and energy efficient (When utilisation of carrying capacity is high, both energy and costs are efficient over long distances)
- Accident safety record (It has a very good record, especially with hazardous materials)

**Rail-Road**
- Saving on journey time
- Reduced consumption of carbon fuel
- Less pollution from exhaust emissions
- Reduced heavy traffic flows on motorways
- Fewer road accidents
- The need for unpopular overnight road runs is eliminated and difficulty in attracting good drivers is effectively addressed

**Ship**
- Technology (can track containers and tell when a problem occurs)
- Network efficiency (schedules and routing of freight will save time and money)
- Energy efficient
- Lower costs

Source: Own construction from various sources, 2012.
Opportunities to develop a fully operational intermodal network are available through existing programs that encourage the development of intermodal freight capacity. Many in the transportation industry support improvements to intermodal freight facilities. This support is due to the potential efficiency of intermodal systems as we reach the limits of our highway infrastructure capacity (Anon, 2005:5).

3.3.2. Intermodal concepts and systems

This section reviews Integrated Rail Road Transport (IRRT) and how the modal shift potential can be improved. It starts with the general characteristics of IRRT and the different transport networks designs and terminals.

3.3.2.1. Characteristics of Intermodal Transport

There are four basic transport modes for carrying out the movement of goods (road, rail, air and water). Because the modes vary in economic service characteristics (speed, availability and flexibility), capacity and cost structure and each mode is the key option for a certain type of transport movement (Stock & Lambert, 2001). Table 11 provides a comparison of the financial and service characteristics as well as the external effects of the four main transport modes.

Table 11: Financial, Service, Transport Flow and External Effects Characteristics of Freight Transport Modes

<table>
<thead>
<tr>
<th></th>
<th>Road</th>
<th>Rail</th>
<th>Water</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial characteristics:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance fixed/variable costs</td>
<td>Moderate.</td>
<td>Low.</td>
<td>Low.</td>
<td>High.</td>
</tr>
<tr>
<td></td>
<td>High variable costs, low fixed costs.</td>
<td>High portion of fixed costs.</td>
<td>High variable costs, low fixed costs.</td>
<td>High variable costs, low fixed costs.</td>
</tr>
<tr>
<td>Service characteristics:</td>
<td>Speed (time in transit)</td>
<td>Availability</td>
<td>Delivery accuracy</td>
<td>Loss and damage</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------</td>
<td>--------------</td>
<td>------------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transport flow characteristics:</th>
<th>Market coverage</th>
<th>Predominant traffic/goods</th>
<th>Length of haul</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Point to point.</td>
<td>Terminal to terminal.</td>
<td>Terminal to terminal.</td>
</tr>
<tr>
<td></td>
<td>Terminal to terminal.</td>
<td>Low medium value, medium high density.</td>
<td>Terminal to terminal.</td>
</tr>
<tr>
<td></td>
<td>Terminal to terminal.</td>
<td>Medium to long.</td>
<td>Medium to long.</td>
</tr>
<tr>
<td></td>
<td>Terminal to terminal.</td>
<td>High value, low medium density, small shipments.</td>
<td>Medium to long.</td>
</tr>
</tbody>
</table>

| External effects (per ton-kilometre): | |
|---------------------------------------|-----------------|---------------------------|----------------|
| Accidents                             | High.           | Low.                      | Low.           |
| Noise                                 | High.           | Moderate.                 | Low.           |
| Air pollution                         | High.           | Moderate.                 | Moderate.      |
| Climate change                        | High.           | Low.                      | Low.           |

|                                 | Low.           | Moderate.                 | Moderate.      |
|                                 | Moderate.      | Low.                      | Very high.    |
The central idea behind intermodal transport is that the service and cost advantages of each transport mode are combined in order to improve the overall efficiency of the transport system. The biggest distance is performed by large scale transport modes like rail, inland waterways, short sea shipping or ocean shipping. Road transport is assigned to the short haul, or the collection and distribution of freight. Intermodal transport thus increases the reach of the larger modes of sea and rail and enhances the efficiency of the transport system (Behrends, 2011:28).

If IRRT wants to get market shares it has to be competitive with all road transport. The relationship between sustainability and risk of lowered costs is vital for the design of competitive IRRT systems.

### 3.3.2.2. Intermodal systems

Traditional Piggybacking (Trailer on Flat car) was the earliest form of the intermodal concept, have first been used during the 1830’s. This system is still used in many countries but it has not been functional in South Africa because of severe height restrictions (due to traditional loading specifications) and the fact that most of our main lines are electrified. Nevertheless, many road loads, riding on normal semi-trailers, could be loaded on rail wagons since height restrictions would not be a problem.
### Table 12: System Services

<table>
<thead>
<tr>
<th>System services:</th>
<th>Discussion:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Piggybacking system (Trailer on flat car)</strong></td>
<td>The road vehicle drives onto a flat-car and is secured, either with the prime-mover in place or being driven off (is fitted with securing twist-locks). The cargo travels part of its way via truck and the rest of the way by train. It has many advantages, since the road prime mover and accompanying trailer are not transported as well. This creates an opportunity for this expensive equipment to be used for other business, including collection and final delivery of containers. Cargo containers provide more flexibility for piggybacking, since they can be loaded onto water carriers as well as flatcars and flatbed trucks.</td>
</tr>
<tr>
<td><strong>The Road-Rail system</strong></td>
<td>It operates with a standard closed road trailer fitted with retractable road axles and having end coupler points. This is reversed onto a special rail bogie. This system can accommodate an entire train of up to 130 units being assembled in this manner. This eliminates the need for expensive materials handling equipment. It is highly cost-effective when compared with simple over-the-road hauling. Unitrans has the rights to use this system in South Africa but difficulties in reaching an operating agreement with Spoornet have delayed this project for years.</td>
</tr>
<tr>
<td><strong>Fishy back system (“Trainship”/ “Containership”)</strong></td>
<td>The cargo is loaded into a truck trailer (fishyback), a railroad car (trainship) or a container that also spends part of its shipment time on board ship or barge.</td>
</tr>
<tr>
<td><strong>Birdyback systems</strong></td>
<td>This service refers to shipments which have air travel as part of their modes of transport. Air transport generally requires some intermediary surface travel, since airport terminals are not usually located near manufacturing, harvesting or extraction sites, and those sites are in general not equipped with their own private airstrips. Intermodal air-truck shipments are often seen as merely formalising the process and putting it under unified management.</td>
</tr>
<tr>
<td><strong>Low body systems (Iron Highway)</strong></td>
<td>A low rail bed wagon, having a continuous platform that articulates to accommodate a truck-tractor on one section and the road trailer on the other has been introduced where height restrictions rule out normal piggybacking. An advantage of the system is that there is a</td>
</tr>
</tbody>
</table>
The Push-pull Cargo Sprinter

This system has been developed to provide short haul services between harbours or inland warehouses and private sidings in industrial areas. The fact that it has power units at each end makes it possible to shunt sidings, irrespective of access direction.

Source: Own construction from various sources, 2012.

In general piggybacking, trailer-on-flat-car and road-rail systems are the three main intermodal systems in use worldwide. New systems will emerge to deal with specific situations in the future (Jorgensen, 2004:679). There have been focused on new techniques or systems that can reduce this cost and time. The systems can reduce the costs for road rail intermodal transport and increase the speed of the operation at combined terminals, resulting in up to a 50% reduction in the economic breakeven distance for intermodal freight movements (European commission, 2006:11).

3.3.2.3. Transport networks and terminals

3.3.2.3.1. Corridors

Current policy and legislation relevant to the shaping of patterns of urban development in South African cities explicitly promote a range of policy approaches or strategies which can be seen to be aligned with certain of those associated with the ‘smart growth’ or ‘new urbanism; movements (Wilkinson, 2006).

Smart growth and new urbanism will shortly be discussed, smart growth is a collection of land use and development principles that aim to enhance our quality of life, preserve the natural environment, and save money over time. Smart growth principles ensure that growth is fiscally, environmentally and socially responsible and recognizes the connections between development and quality of life. Smart growth is being represented by 10 principles (US Environmental Protection Agency, 2010):
1. Mixed land use
2. Compact Building design
3. Range of housing opportunities
4. Foster a unique neighbourhood identity
5. Sense of place
6. Preserve open space and natural beauty and environmentally sensitive areas
7. Nurture engaged citizens
8. Direction of development and encourage growth
9. Multiple transportation options
10. Cost effectiveness

New Urbanism elements fall under the concept of smart growth, which are, maintaining development through the promotion of non-fragmented growth, practicing economic sustainability and integrated regional planning.

The White Paper on National Transport Policy (SA, 1996) proposed certain key policy actions to provide for urban restructuring and efficient land-use or transportation interaction:

- Establishment of structures (all tiers of government) which facilitate integrated planning of infrastructure, operations and land use in a co-ordinated manner;
- Regulation of land use development at local level so that development approval is subject to conformity with integrated land use/transport plans;
- Land use frameworks, guidelines and policies to channel development, particularly employment activities, into public transport corridors and nodes.
- Development priority will be given to infilling, densification, mixed land use and the promotion of development corridors and nodes;
- Containment of urban sprawl and suburbanisation beyond the urban limits will be addressed through provincial spatial development plans;
- Decentralisation which disperses employment activities must be discouraged, except in specific cases where it is favourable in terms of decreasing total transport costs and travel times on the basis of an integrated land use plan;
- Unrestrained car usage and subsidised car parking will be contained through the application of policy instruments which could include strict parking policies, access restrictions for private cars, higher licence fees, road pricing
or area licensing. Restraint on private car usage will however not be implemented independently of improvements in the quality of public transport.

The main objective is to develop a freight flow modal that maximizes the benefits of sustainable and intermodal transport. Another objective of the development of intermodal solutions is to identify different corridors for improvement. Corridor traffic can be defined as the link between origin and destination in different metropolitan areas. By implementing intermodal solutions it will transfer the corridor to a combination of primary traffic (end-to-end) and metropolitan traffic (short distance distribution); this will perform effectively if there are central hubs on both ends of the long distance corridor (Van Eeden & Havenga, 2010). The following table defines transport typologies:

**Table 13: Definition of Transport Typologies**

<table>
<thead>
<tr>
<th>Traffic type</th>
<th>Primary</th>
<th>Corridor</th>
<th>Rural</th>
<th>Metropolitan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk, low-value (rail only, mainly export coal and iron ore)</td>
<td>Higher value, mostly manufacturing and some agriculture</td>
<td>Mostly agriculture</td>
<td>Mostly final delivery</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>Long</td>
<td>Long and short</td>
<td>Medium and short</td>
<td>Short</td>
</tr>
<tr>
<td>Origin-destination (OD) pairs</td>
<td>Few, usually one-directional</td>
<td>Few long-distance ODs; many ODs at end points</td>
<td>Many</td>
<td>Many</td>
</tr>
<tr>
<td>Major challenge</td>
<td>Global competitiveness</td>
<td>Spatial organisation, efficiency</td>
<td>Development</td>
<td>Congestion alleviation</td>
</tr>
<tr>
<td>Logistics approach</td>
<td>Ring-fenced, bulk rail systems</td>
<td>Intermodal solutions</td>
<td>Effective road feeder system</td>
<td>World-class commuter systems and effective freight delivery</td>
</tr>
</tbody>
</table>


Thus the results will give an indication about the spatial distribution of impacts, about the change induced by a modification of the modal and/or spatial split of a freight traffic volume and so to pinpoint more critical regions (Arnaud, 2006). Map 1 demonstrates the gross value added distribution in 2009, areas that are under pressure of high levels of population densities. The country's population is largely concentrated in the eastern and north-eastern parts of the country, nearby settlements on the primary road network, while the western half of the country is sparsely populated. The highest concentration of
population is located in the Gauteng area, in the City of Johannesburg, City of Tshwane and Ekurhuleni Metropolitan Municipality, as well as in the coastal cities of Cape Town and eThekwini metropolitan areas. There are also significant concentrations of population along the KwaZulu-Natal coastline and around areas such as Pietermaritzburg, Ulundi, Richards Bay and Empangeni (SA Risk and Vulnerability Atlas, 2009).

Map 1: GVA Distribution 2009, high densities of population.

Source: CSIR, 2011.

SA Risk and Vulnerability Atlas (2009) indicates the calculated population change by municipality between 1996 and 2007 (Map 2), highlight the increased patterns of concentration and the pressures brought by urbanisation as well as continuous expansion of the metropolitan regions and major settlements and towns on major
access routes and movement corridors. Population declining forms a central band from north to south in the driest and least hospitable part of the country; this is illustrated by the white areas on map. Associated with that, metropolitan areas seem to have experienced the largest growth; this is illustrated by the dark brown areas on the map (Gauteng and the port cities of Cape Town and eThekwin).

Map 2: Population Density 2008, areas with higher levels of social vulnerability.

Source: CSIR, 2011.

Another type of area that experienced significant population growth are those in former Bantustan areas which also have significant population concentrations, but are generally not economically sound urban services nodes (often people living in poverty, lacking infrastructure and governance capacity and with relatively low GVA) (SA Risk and Vulnerability Atlas, 2009).
Tourism plays an extraordinary role in the transport sector of South Africa, this helps identify corridors which are seen as attractions, which in this case South Africa exhibits a highly uneven and polarised tourism space economy. The major geographical poles of activity are concentrated in and around the three main metropolitan areas of the country and centre upon Cape Town, Durban and Johannesburg. Overall, however, total national tourism spends remain highly concentrated in South Africa’s major urban centres. Figure 10 shows the polarised character of the contemporary South African tourism space economy. The five most important centres for estimated tourism expenditure are Johannesburg (14%), Cape Town (12%), Pretoria (8%), Durban (7%) and Ekurhuleni (6%) (Rogerson, 2006).

![Figure 10: Total South African tourism space economy.](image)


The total South African freight transport market of 297 billion ton-km in 2008 is depicted by typology in Figure 11. Rail has captured 13 billion ton-km of the corridor traffic, contributing 5% to the total transport demand. In 2008, the remaining 119 billion ton-km
were hauled over long distances by road carriers, and should be seen as a market share for rail. This is especially proper for the high-density corridors (Van Eeden & Havenga, 2010).

\[\text{Figure 11: Freight transport by typology}\]


The stagnation in rail is clear, all growth over dense corridors happens within the road mode, which expanded by more than 70% over 13 years. This growth would be understandable if the corridors in question were short or the density per corridor low. In these instances the economy will have to absorb this growth in the road mode. Cheaper options are, however, available in intermodality, if the density per corridor can be calculated as sufficiently high. In South Africa’s case, as observed by the national freight flow model, the spatial efficiency objective of the corridor freight market segment is not achieved. If this density is sufficient to entertain an intermodal solution, future investment should be considered in such solutions (Havenga & Pienaar, 2012). Trends
in movement over the various corridors have performed differently in terms of growth over the past 13 years. The growth is depicted in Figure 12.

Figure 12: Movement over corridors performance towards growth.


Havenga & Pienaar (2012) have identified that growth on the densest road freight corridor, route between Gauteng and Durban was relatively slow and achieved 26% growth, but this is also the corridor that is probably the most overstretched in the country because of current density. The Gauteng to Cape Town corridor achieved 135% growth over the time period, almost all on road. This is perhaps the greatest error in South Africa's infrastructure planning framework, as this is also the longest corridor and should, by any standard, be more rail-bound than the rest, this is a significant indication on which corridors to improve when road transport moves to rail transport through intermodal transportation.
The Gauteng-Durban and Gauteng-Cape Town corridors being the two most attractive corridors, contribute more than 50% of the ton-km for the transport typology (Figure 11). The higher relative position of the Gauteng-Cape Town corridor highlights the intrinsic principle of rail economics and the advantages of shifting freight from road to rail (even though less freight is moved on the corridor). Rail freight is the favourable transport mode, because it is less cost dependent on distance than road freight.

The most significant future volumes are also expected on the Gauteng-Cape Town and Gauteng-Durban corridors, when looking at the 30 year forecast in Figure 13.

![Figure 13: Corridor growth in the top six corridors.](source)


Solutions must be identified that will lead to more efficient, effective and sustainable balance between road and rail freight transport to address SA’s high logistics cost and strained logistics capacity. The market segmentation analysis indicated that SA has two high-density, long-distance corridors (Gauteng-Durban and Gauteng-Cape Town) which are ideal candidates to implement intermodal solutions. This will fully be discussed later on in this study (Chapter 4).
3.3.2.3.2. Networks

Transport networks are composed of nodes and links. Nodes can be goods supply points, goods demand points, and points where value adding activities, consolidation of goods and transhipment between vehicles are carried out. Links represent transport activities connecting these nodes and are served by vehicles using infrastructure. Different options for transport network design are discussed by several IRRT researchers (Woxenius, 2007b). Woxenius (2007b:735) defines six significantly different theoretical designs from the perspective of a transport system operator:

![Figure 14: Six Transport Network Designs](source: Woxenius, 2007b:735.)

In a Direct link, trains run directly between an origin and a destination terminal without handling along the way. It is easy to operate and provides good transport quality and economy for transport flows over long distances. In a Corridor, trains pass several terminals on their route between start and end terminal. They offer regular service and higher frequencies and allow for the integration of terminals with smaller demands in a network of IRRT. In a Hub-and-spoke network one mode is the hub and all the unit loads call this node for transfer. At the spoke terminals trains are loaded which meet at a hub, where the loads are sorted to the outbound trains to the destination spoke terminals. In Connected hubs networks, short feeder trains connect several terminals of a region to a hub where the loads are consolidated for the long-distance transport (direct link with regional consolidation). In a Static routes design a number of links are used on a regular basis and several nodes are used as transfer points along the route.
Dynamic routes provide maximum flexibility by designating links depending on actual demand (Behrends, 2011).

Direct links are the best rail product wherever full trainloads with the required frequency can be organised. Since most freight flows on road are transported over shorter distances and/or are too small to facilitate full trains, the modal shift of IRRT in this system is limited (Behrends, 2011:31).

### 3.3.2.3.3. Terminals

Terminals contribute significantly to the cost and transit time in intermodal transportation, there should be focussed on the development of terminals to enable modal transfers. The physical aspects of terminals in urban areas are complex by the desire to maximize the tax base (through commercial substitutes), rather than transportation, intermodal, and supply chain facilities (Dewitt & Clinger, 2000:5).

The location of terminals plays an important role in the selection of intermodal transportation. It is often the initial drayage move and terminal operations that increase the transit time and costs of intermodal transportation services (Konings, 1996:3). Physical closeness of terminals reduces transit time from the origin point to the intermodal transhipment point. The location of terminals affects the area within which customers can be expected to use intermodal transportation. Nierat (1997) presents a method based on spatial theory to determine the uptake areas for intermodal terminals depending on the service frequency and efficiency, the main conclusion is that intermodal services are only efficient for customers in a relatively small geographical area around the terminals with commodities travelling distances over 400 km. These results support the claim that terminal location is important for intermodal transportation services to be efficient. The transhipment function performed in terminals is a vital element in linking networks. The terminal functions and performance requirements of the terminals depend on freight flow characteristics, the type of linking network and its location in the network. There are four terminal types, which vary in their function in the intermodal network (Woxenius, 2007a):
1. Start and end terminals: Direct links or corridor networks handle large volumes, which are split into smaller flows for further transport on road.
2. Intermediate terminals: Corridors handle a limited number of unit loads, which are transhipped at intermediate nodes for distribution in the terminal region.
3. Hub terminals: A hub-and-spoke or connected hubs network handle an extensive throughput of load units. The load units are transhipped between different trains.
4. Spoke terminals: A hub-and-spoke or connected hubs networks consolidate small volumes of load units into bigger flows.

Besides its active function as an interface between transport modes, the intermodal terminal is also an interface between different organisations representing local, regional, national and international levels of transport organisations. The nodal space became a set of locations promoting the efficiency of different transport networks and offering a higher level of integration. They include the functions of composition, transfer, interchange and decomposition as set in Figure 15 (Rodrigue, 2006:3).

![Figure 15: The Intermodal Network Mode](image)

Source: Rodrigue, 2006:3.
At the present time in South Africa, industrial park development has been uncoordinated and has led to a dispersion of establishments, often far from rail facilities (Jorgensen, 2004:679). In the future, well-designed intermodal terminals will have to be carefully located and have innovative layouts and handling systems. There is an awareness that intermodal transport is not competitive with direct road haulage and it is true that due to the fact that there are extra links in the supply chain there is the possibility of delays. The growth of intermodal transport increases the demands being made on handling technology and it makes the initial and final road transport arrangements even more critical. The increased road traffic around intermodal terminals can threaten accessibility. It is necessary to move containers cheaply and quickly, with reliability and flexibility. There is also a place for small private terminals railway and road operators should co-operate over establishing intermodal facilities that will be to their long-term benefit but government must facilitate the process (Jorgensen, 2004:680).

In intermodal road or rail transportation automatic terminal operations are not common. It is therefore reasonable to expect that a new generation of terminals will be implemented in the future and by this means improve the modal transfers in intermodal transportation.

### 3.4. Improvement potential for Intermodal Transport

Although a modal shift from road to rail is desirable, there are also studies which are more pessimistic about its potential contribution to the sustainable development of the freight transport sector. Here are 2 reasons for the pessimism:

1. Limited modal shift potential:

Intermodal road rail transport (IRRT), is a logical step for maintaining flexibility. By far the biggest distance is performed by rail where the units are combined with other shipments, while road transport is assigned to the short-haul, or collection and distribution of freight (Bontekoning et al., 2004:3). The line between regional pre and post haulage by road and the interregional long-haul on rail is the intermodal terminal. In
this way, IRRT increases the reach of rail and enhances the efficiency and flexibility of the transport system (Behrends, 2011:5).

Since most freight flows are transported over shorter distances and/or are too small to facilitate full trains, the potential of IRRT to contribute to the sustainable development of the freight sector is marginal at best. While the volumes of individual shippers are often too small for IRRT, the total transport demand of several shippers in the same urban area may be sufficient to achieve volumes, which are economically viable for intermodal services (Behrends, 2011:5).

2. The environmental advantage of road over rail:

Rail operations are normally considered environmentally friendly since rail is more energy-efficient than road. However, electrical trains using renewable energy are not completely emission-free since they emit particles mainly originating from wear of rails, brakes, wheels, and carbon contact strips (Fridell et al., 2010: 240). Another significant unsustainable impact of rail is noise in urban areas (CE Delft, 2008) and on existing railway networks the freight train is the main source of noise (Oertli and Hubner, 2008:4). Rail infrastructure also demands significant amount of land and causes separation effects in urban areas as well as impacts on nature and landscape (CE Delft, 2008). Often, the rail freight terminals are located close to the urban core (CBD) while the shippers and receivers of intermodal freight, e.g. wholesale and freight forwarding are located at the urban periphery with good connection to highway intersections (Hesse, 2008:340). A modal shift mainly decreases CO2 emissions, and hence the global impact, while air pollution and traffic impacts on the local level may increase. The improvement potential of a modal shift therefore depends on the conditions of the road and rail transport chain.

Intermodal transport continues to be significant in the movement of freight. Overall, intermodal transport, both containerized and multi-mode non-containerized has performed satisfactorily in the last half of the 20th century as logistics has grown as a profession and responded to deregulation (Dewitt & Clinger, 2000:2).
However, to encourage and allow broadly defined intermodal transport to become as effective and efficient as it needs to be for the future, four issues need to be addressed:

**Table 14: Issues Regarding Future Global Market and Supply Chains**

<table>
<thead>
<tr>
<th>Issues</th>
<th>Description</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue 1:</td>
<td>Role in Hyper-competition of Supply Chains</td>
<td>The internationalization and globalization of resources and markets will place demands on intermodal transport in ways never witnessed before. The competitive world of the future may well be centred between global supply chains and their supporting modal and intermodal capabilities. Customers in the future will be indifferent to global sourcing issues and will expect their order to be delivered at the right place, at the right time, in the right condition, and for the right profit.</td>
</tr>
<tr>
<td>Issue 2:</td>
<td>Focus on Changing Customer Requirements</td>
<td>The marketplace of the future will have a diversity of demand worldwide and a multiplicity of sourcing and trading patterns. All of this diversity will be in response to customers’ expectations and requirements for small and quickly delivered lot sizes or shipments. Customers will expect the intermodal and transportation systems supporting supply chains to be focused on speed, flexibility, variance elimination, and relationships with other members of the supply chains that permit profit potential for all. The intermodal capability will have to be integrated and seamless, with better connections between the modes at all points.</td>
</tr>
</tbody>
</table>
### Issue 3: Knowledge and Skills for New Operational and Information-Communications Technologies

To be able to optimize transport options, managers will have to be highly knowledgeable in all of current and future intermodal options and alternatives. This need may well drive heightened transportation education at all levels, from elementary and secondary education to fundamentals at the undergraduate level, managerial issues at the master’s degree level, and conceptual or strategic issues at the doctoral level. It will also require an understanding of the fundamentals of line haul and terminal structure, capacity, and execution so as to understand the options and alternatives in dealing with growing constraints on the operational side. All of this knowledge and the resulting management are driven by current and future technology and information capabilities and advances.

### Issue 4: Focus on Management, Coordination, and Integration of Infrastructure and Resources by Private and Public Sectors

Infrastructure and equipment capacity can be evaluated in two contexts, static and dynamic. Static infrastructure and equipment capacity is purely the physical space available for line-haul or terminal operations and the non-moving carrying capacity of the equipment. Dynamic capacity (concern for the future) deals with the throughput that is derived from operating static infrastructure and equipment capacity. Information systems are becoming significant and critical to this effective coordination and integration.

Source: Own construction from Dewitt & Clinger, 2000:3.

One of the biggest issues in South Africa is the poor infrastructure of facilities and modes. The following figure shows the different types of modes and their issues.
3.5. Approaches to determine the value of intermodal transport in the future

Intermodal concepts will be an important and critical factor in the success of competition among supply chains of the future, even more significant roles in global supply chains will require (Dewitt & Clinger, 2000:6):

- Understanding of supply chain management;
- The needs and requirements of the marketplace;
- The skills and advances in information and communications technology;
- And the continuing challenges and constraints on transport infrastructure.

Intermodal transport has received so many honours over recent years that it is difficult to summarize the future impact of this mode of transport. Logistics professionals expect that purpose-built, high-speed, unit-load freight trains carrying swap bodies and containers will be the most cost-effective way to make deliveries in the 21st century (Lowe, 2005:13).

Major corporate freight shippers are becoming increasingly concerned on a strategic level to direct their operations towards the most environmentally favourable transport modes, given that costs are satisfactory and that services are sufficiently frequent, fast
and reliable to meet demanding delivery schedules (Lowe, 2005:14). In the future customers will continue to request (Dewitt & Clinger, 2000:6):

- Faster supply chain delivery of their goods (Speed will continue to be a necessary factor for intermodal transport);
- Better implementation of the supply chains, represented by quality and reliability;
- More access to information through the use of information and communication systems. There will be a need for education and training for those who are new and old to the idea of integrating shipping modes (Anon, 2005:10);
- Finally, they will want all of this done more cheaply or profitably, consumers will begin to demand a better shipping system as the industry becomes more efficient and profitable (Anon, 2005:10).

Overall, intermodal concepts need to become faster, better, smarter, and more profitable. It is and will be a crucial factor in the future of the supply chain (Anon, 2005:10). Intermodal transport is being spurred on by ever-restrictive measures, and by the ability of intermodal options to eliminate road congestion, lorry traffic bans, and goods vehicle drivers’ hour restrictions (Lowe, 2005:13). These possibilities must be worked on to benefit from any intermodal system that is put in place (Anon, 2005:11).

Significant intermodal link-ups between all the modes will be to the benefit of South Africa in general. Everyone will benefit; there will be fewer road rigs on major highways, less urban traffic congestion and the number of accidents will be reduced. Trucking company management, drivers and the traffic authorities will have fewer sleepless nights. Many truck drivers will not have to work such long hours and will be closer to home and be able to spend more quality time with their families. Private motorists will suffer less road rage since they will not be caught-up behind trucks. There will be less pollution from engine exhausts, and most importantly, the pavement will less stress and road maintenance budgets will be greatly reduced. Railway operators will be able to concentrate on running trains (safely, efficiently and on time). As traffic volumes increase, operating costs will be reduced and a portion of this can be passed off to
users. Rural communities will be empowered to control their own transport and distribution requirements and there will be significant job creation opportunities (Jorgensen, 2004:683).

3.6. Conclusion

This chapter presented theoretical concepts that are relevant for answering the questions about intermodal freight transport. Gone forever are the days of individualism, with the concept of intermodalism it is a new vision for seamless movement within two or more modes of transport. With significantly less wear and tear on the truck and on the roads it uses, there will be less stress on the driver, less environmental harm to the general public of all towns, less damage to the ozone layer, and less consumption of our limited and much threatened fossil fuel reserves. Sustainability benefits significantly from intermodal transportation.

However, to be a competitive alternative to direct ‘door-to-door’ lorry transport over long distances, intermodal transport must offer frequent schedules, fast transit times, a high degree of reliability, and all at a cost that fully meets the expectations of markets with the keenest service requirements (Lowe, 2005:6).

This Chapter aims to develop an understanding of establishing urban freight transport. A framework for urban freight transport needs to include the logistics, transport and land-use elements. To achieve a sustainable urban freight transport system an integrated planning approach is necessary. A requirement for developing a strategy towards sustainable intermodal transport is to know how the different measures affect the sustainability performance (Behrends, 2011:38).

This Chapter introduced corridor transport movement, it has identified the two most important corridors, which is the Gauteng-Durban and Gauteng-Cape Town corridors. These will fully be discussed in Chapter 4, where these corridors will be the study areas which will go simultaneously with the policies and legislation.