Module 2

ATIS, TNO, CVO & INTERMODAL FREIGHT

1.1 Advanced Traveller Information Systems

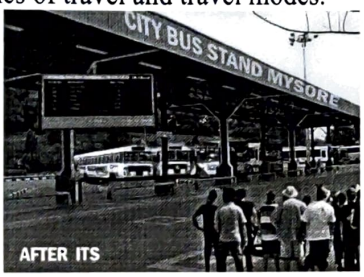
Intelligent Transportation Systems can be divided into two main categories-

- Intelligent infrastructure
- Intelligent vehicles

In both, numerous technologies exist:

- To minimize the risk of an accident occurring
- Reduce injury and fatality rates in accidents
- Provide the driver with valuable, timely information with which to make critical decisions on the road.

Advanced Traveller information systems (ATIS), a part of new technology applications in transportation, which provide accurate and timely information that help travelers to select routes, times of travel and travel modes.



An Advanced Traveller Information System (ATIS) is any system that acquires, analyzes, and presents information to assist surface transportation travellers in moving from a starting location (origin) to their desired destination. An ATIS may operate through information supplied entirely within the vehicle (autonomous system) or it can also use data supplied by the traffic management centres. Relevant information may include locations of incidents, weather and road conditions, optimal routes, recommended speeds, and lane restrictions, all part of the Intelligent transportation system or ITS. The following are the major objectives of ATIS:

- Manage Travel Demand
- Reduce traveler frustration/anxiety
- Increases perceived level of service
- Increases "serenity factor" – reduces Road Rage
- Improve traveler decision making
- Results in more efficient travel
- Creates awareness of alternatives

The advanced traveler information system (ATIS) is one of the most widely used ITS. ATIS implements a wide range of technologies, such as Internet web sites, telephones, cellular phones, television, radio, etc. to assist travelers and drivers in making informed decisions regarding trip departures, optimum routes, and available modes of travel. Table below gives an overview of ATIS.

Subsystem	Functional characteristics
Routing and Navigation	Trip planning
	Multi-mode travel coordination and planning
	Predrive route and destination selection
	Dynamic route selection
	Route guidance
	Route navigation
	Automated toll collection
	CVO-specific (route scheduling)
Motorist Services	Broadcast services/attractions
	Services/Attractions directory
	Destination coordination
	Message transfer
Safety Warning	Immediate hazard warning
	Road condition information
	Automatic aid request
	Manual aid request
	Vehicle condition monitoring
	CVO-specific (cargo and vehicle monitoring)
Augmented Signage Information	Roadway guidance sign information
	Roadway notification sign information
	Roadway regulatory sign information
	CVO-specific (road restriction information)
Commercial Vehicle Operations (CVO)-Specific	Fleet resource management
	Dispatch
	Regulatory administration
	Regulatory enforcement

1.1.1 Systematic Application of ATIS

The systematic application of advanced traveler information system (ATIS) revolves around four basic questions:

1 What?

This aspect describes the information content itself.

- Travel times (e.g., road, bus, rail, light rapid transit (trams));
- Transit schedule information;
- Transit fare information;
- Transit boarding and alighting point information;
- Locations of accidents and incidents;
- Description of accidents and incidents (including location);
- Alternate routes and modes;
- Traffic speeds;
- Traffic delays;
- Queue lengths;
- Door to door multimodal journey times;
- Journey time reliability;
- Travel-related weather conditions;
- Images (still images to full motion, height quality CCTV pictures)

2.2.1.2 Where and when?

These dimensions address the location of the traveller information access point and the timing of the information delivery.

a. Pretrip:

- At home;
- In the office;
- Anywhere (via mobile devices).

b. Enroute:

- Roadside information on variable message signs;
- In-vehicle information systems;
- Private car;
- Transit vehicle;
- Smart bus stops;
- Kiosks at transfer points and public locations.

c. Post-trip:

- At home;
- In the office;
- Anywhere (via mobile devices).

2.2.1.3 How?

This dimension deals with the way in which the data is delivered to the traveller.

a. Variable message signs (VMS)

Often referred to as changeable or dynamic message signs (CMS or DMS), these are signing units, or large display boards that employ information display technologies to impart information and instructions to drivers and other travellers. While the information displayed on the signs is dynamic in that it can be changed quickly through a connection to a computer system, it is a shared medium that constrains the flexibility and customization of the message.

b. In-vehicle information systems

These information delivery devices have display screens and input capability and may also incorporate speech recognition and speech synthesis. These have the potential to support the timely delivery of a wide range of information services, including traveller, weather, sports, news, and stock information.

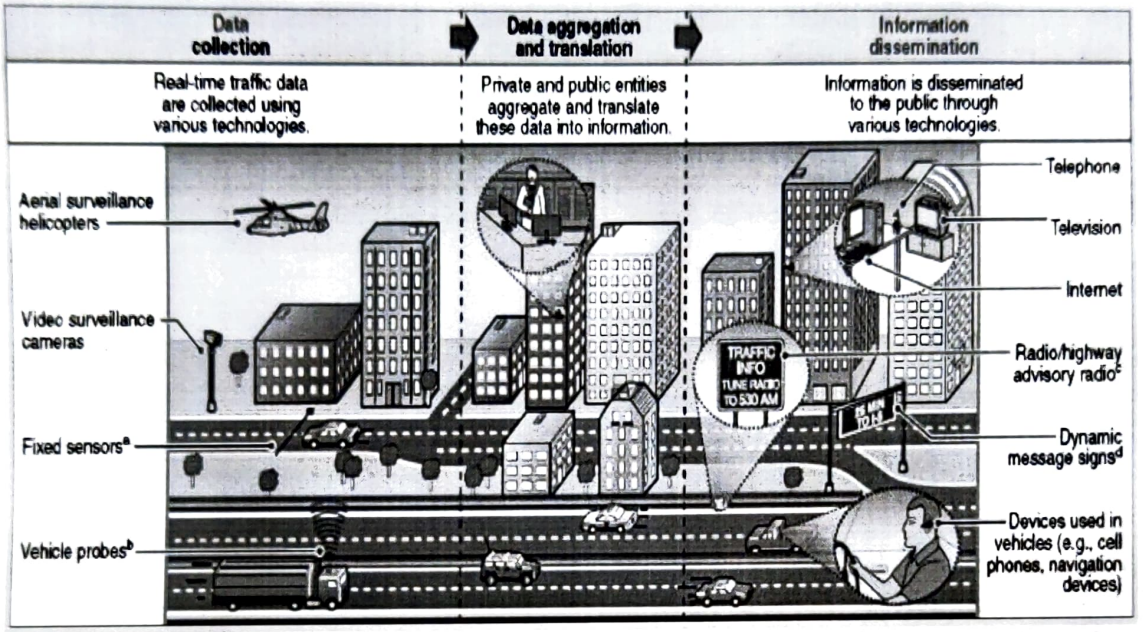
c. Wireless Telephones, Pagers, and PDAs

The latest cellular telephones, pagers, and other handheld devices have advanced paging and even internet access options available. These can be used to deliver traveller information on the move. Most of these devices have a keyboard or other input capability and a display capability and display that can support text messages. The more sophisticated devices have colour screens and graphics capabilities, which support the delivery of graphical traveller information, such as maps and diagrams.

d. Dial-in-telephone or interactive voice responses

A user dials in to a predefined telephone number using a normal push-button, tone-dialling telephone as found in most homes and offices these days. An initial entry menu is spoken to the user by a predefined voice, and then through the use of the dial pad or by speaking commands, the user can navigate through various menus and submenus until the desired information is accessed.

1.1.2 ATIS operations



As Figure illustrates, there are three key facets to the provision of real-time traffic information: collection, processing, and dissemination, with each step entailing a distinct set of technology devices, platforms, and actors, both public and private. Operations essential to the success of these systems are the collection of traffic and traveler information, the processing and fusing of information - often at a central point, and the distribution of information to travelers. Important components of these systems include new technologies applied to the use and presentation of information and the communications used to effectively disseminate this information.

ATIS requires a large amount of data for processing, analysis, and storage for effective dissemination of traveler information to users. The following are the basic requirements for any ATIS system:

- Need for robust, and low-cost, data collection techniques
- Understanding traveler and driver characteristics, needs and responses to ATIS applications.
- Traffic modeling and forecasting of mixed traffic and network characteristics
- Methodologies and models to support ATIS planning, operations and evaluations
- Integration of ATIS data, methodologies, and applications for deployment

Although several attempts to develop ATIS have been undertaken in India, they face the following shortcomings:

- User response and requirements are ignored
- Inadequate data, and typically provides only shortest distance information which is static in nature.
- Limited or no traffic prediction
- Network level opportunities are not fully tapped

- Dynamics is not considered
- Quality, timeliness, accuracy, and reliability are unknown
- Technical feasibility is demonstrated, but commercial viability is unknown
- Piecemeal implementation can lead to scalability, obsolescence, and integration problems

There is a strong need for conducting research on developing ATIS technologies and architectures for Indian roads due to differences in composition, multiple modes, mixed and lane-less traffic, and unique driver characteristics

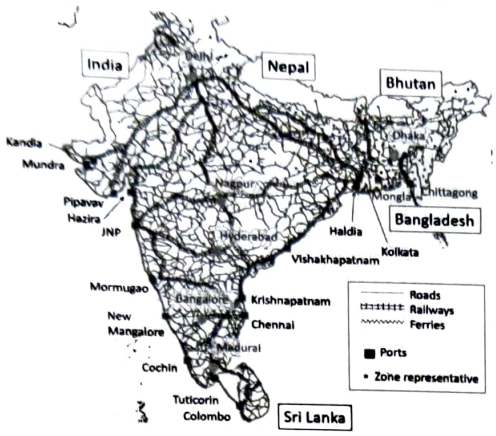
1.1.3 Data Sources for ATIS

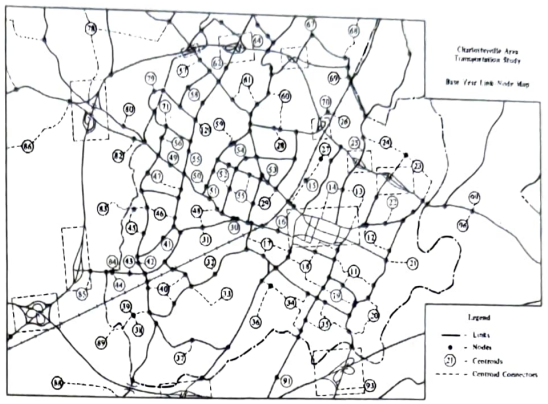
Data sources for traveler information systems include fixed detectors, event information, and mobile sources:

- **Fixed detectors** are typically installed along each travel lane at approximately 0.5-mile intervals. These detectors provide traffic volume and speed data every 20-30 seconds. The data are sent to the transportation management centers (TMCs). Fixed detectors are either embedded in the pavement (loop detectors and magnetometers) or mounted overhead or on the side of the road. Examples include microwave radar, video, laser, and ultrasonic detectors. Module 9, Supporting ITS Technologies, of this ITS Primer provides detailed coverage on vehicle detection.
- **Incidents and other events** are detected by police patrols, incident management teams, and automatic incident detection algorithms based on detector data. Incident information can also be obtained from cellular phone callers reporting events witnessed as they travel.
- **Mobile sources** can be used to estimate travel times between various points in the network. Bluetooth readers and personal and commercial in-vehicle navigation systems (e.g., delivery trucks) can be used to obtain travel times between fixed points. The widespread use of smart phones equipped with global positioning systems (GPS) has significantly increased the coverage and accuracy of data from mobile sources.

1.2 Transportation Network Operations

Networks are fundamental to the study of large-scale transportation models representing an entire metropolitan area, a state, or multistate regions. Systems of interconnected, well-designed, and well-maintained transport modes are critical to the economic well-being and quality of life of nations and their citizens. **Transportation networks** generally refer to a set of **links**, **nodes**, and **centroids** that represent the infrastructure or supply side of the transportation. A *link* is a portion of the highway system that can be described by its capacity, lane width, and speed. A *node* is the end point of a link and represents an intersection or location where a link changes direction, capacity, width, or speed. A *centroid* is the location within a zone where trips are considered to begin and end. Network design is fundamental to effective transportation systems.





1.2.1 Transportation Network in India

Roads are a primary method of transportation, used daily all around the world to transport people and cargo. India has the second largest road network in the world of about 63.86 lakh Km. This comprises National Highways, Expressways, State Highways, District Roads, Rural Roads, Urban Roads and Project Roads.

Table 1.1: Road Network in India as on 31st March, 2019

Category of Road	Length in Km	% Share of Total Roads
National Highways (NHs)	1,32,500	2.13
State Highways	1,86,528	3
District Roads	6,32,154	10.17
Rural Roads (including JRY Roads)	45,35,511	72.97
Urban Roads	5,44,683	8.76
Project Roads	3,54,921	5.71
Total	**63,86,297**	

Road transport carries about 90 percent of the total passenger traffic and 67 percent freight traffic. The Indian Railways track is spread across a massive 115,000 km, making it the largest rail network in Asia and the world's second largest network operated under a single management. It runs more than 20,000 passenger trains daily, on both long-distance and suburban routes, covering 7,325 stations across India. India has 128 airports, including 15 international airports. India has 13 major and 199 minor and intermediate ports along its more than 7500 km long coastline.

It is important to keep in mind that highway transportation is part of a larger transportation system that includes air, rail, water and pipeline transportation. While highways play a dominant role in both passenger and freight movement, in many applications there are critical interfaces among the various transportation modes. For example, many air, rail, water and pipeline freight movements involve highway transportation at some point for their initial collection and final distribution. Interfaces between modes, such as those at water ports, airports and rail terminals, create interesting transportation problems but, if handled correctly, can greatly improve the efficiency of the overall transportation system.

1.2.2 Characteristics of Efficient Transport Network

An Efficient Transportation networks operation can be defined as an integrated set of strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system. Benefits of **Efficient Transportation networks operation** include the following:

- Improved quality of life
- Smoother and more reliable traffic flow
- Improved safety
- Reduced congestion
- Less wasted fuel
- Cleaner air
- Increased economic vitality
- More efficient use of resources (facilities, funding)

1.2.3 Network Operation Strategies using ITS

Table below provides examples of Transportation Systems Operation strategies and associated ITS devices that enable better decision making:

Transportation Systems Operation Strategies and Approaches	Enabling ITS
Active Transportation and Demand Management	Variable speed limits, part-time shoulder use, ramp meters, dynamic pricing strategies, dynamic way-finding signs
Arterial Management	Advanced traffic controllers, real-time detection
Connected and Automated Vehicle Deployment	Roadside units (RSUs) and on-board equipment (OBE)
Demand Management	Mobility as a service and mobility on demand applications
Emergency Transportation Operations	Closed circuit television (CCTV), stream height gauges, bridge scour detection, inspection drones, evacuation route monitoring, and signal timing plans
Freeway Management	Real-time detection, closed circuit television
Freight Management	Oversize/overweight permit tracking, virtual weigh-in-motion sites, commercial vehicle safety inspection systems
Integrated Corridor Management	Decision support tools
Road Weather Management	Road weather information systems (RWIS), fog warning systems, mobile temperature sensors, friction sensors, materials usage tracking, flow tracking applications
Safety Management	Intersection collision avoidance systems, enhanced pedestrian, and bike crossing sensors
Special Event Management	Pre-planned traffic signal plans, event area surveillance
Traffic Incident Management	Technology enabled service patrol vehicles, law enforcement data sharing, incident detection algorithms, drones
Transit Management	Transit signal priority, real-time schedule information
Traveler Information	Dynamic message signs, 511 phone, 511 websites, and smart phone applications
Work Zone Management	Queue warning systems, work zone travel time systems, late/early merge systems, intrusion alert systems

1.2.4 Components of Network Operations using ITS

Fundamentally, the following components need to be considered when developing ITS that enables Transportation Systems Operations:

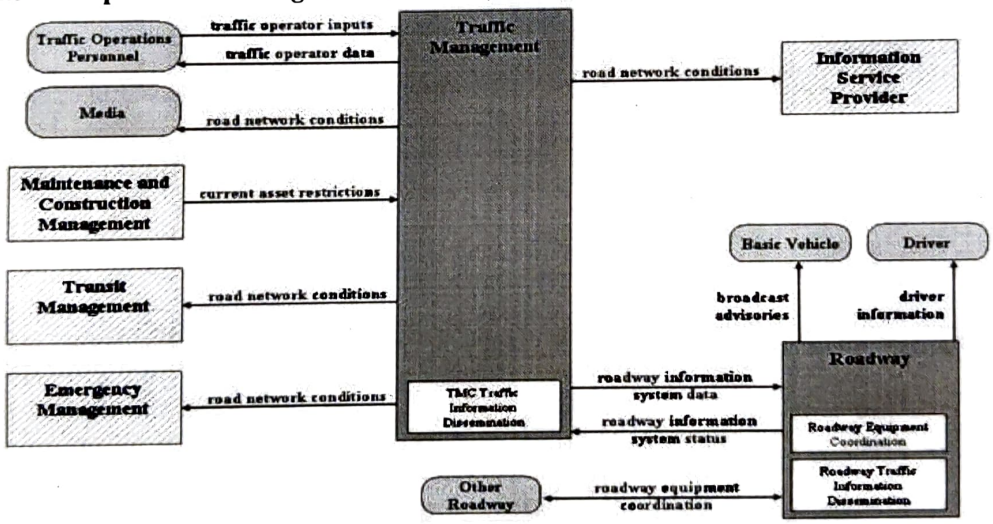
i. **Centers** - gather information from a variety of sources including field devices, other agencies, and vehicles that are typically integrated through hardware and software to make a variety of command-and-control decisions.

ii. **Field Devices** - equipment installed primarily within right of way or within the road that feeds data into associated centers to make effective operational decisions.

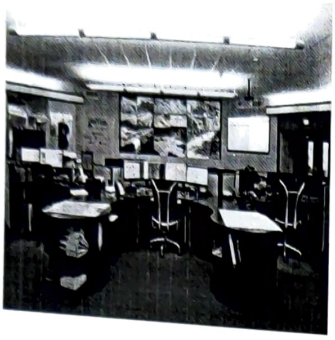
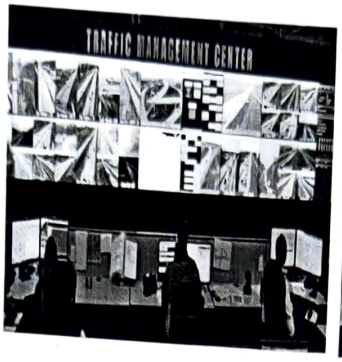
iii. **Communications** - connects centers to field devices and is critical to making timely and effective operations decisions. Takes the form of robust, redundant communications and targeted remote wireline or wireless communications that typically ensures defined continuity of operations thresholds. For very critical communications connections, there is often an added level of hardening, such as encasing conduit in concrete or designing access points to be maintained during extreme weather events.

iv. **Vehicles, Pedestrians, Bicycles, and other Forms of Surface Transportation** - feed the data to the centers from field devices via communications. As smartphones continue to advance with widespread coverage, more applications are using the devices to support a wide range of transportation applications.

1.2.5 Transportation Management Centers (TMC)



A Traffic Management Centre (TMC) is the hub of transport administration, where data is collected, and analysed and combined with other operational and control concepts to manage the complex transportation network. The transportation management centers (TMC) are the heart of any Transportation Systems Operation. TMCs come in many shapes and sizes, with differing functions, hours of operation, scope, and hierarchy. Some TMCs are operated 24/7/365, depending on the scope of their role in managing transportation, while others may have limited hours focused on peak travel times or special events. Figures below show examples of several TMCs.

TMCs typically are comprised of similar elements including the following:

- **Control Room** - Usually a secured environment that houses operator workstations and high visibility displays.
- **Workstations** - Depending on the scope of the TMC, there may be anywhere between one and several dozen workstations that allow operators the capability to control field devices based on data and other sources.
- **Server Room** - One of the costliest parts of the TMC where servers and other IT equipment are located that support the TMC functions. Server rooms are typically equipped with raised floors, special heating, ventilation, and air conditioning systems, and specialized inert-gas fire suppression. To help manage costs and to provide an added level of redundancy, many TMCs are transitioning to cloud-based services applications and data storage.
- **High-Visibility Displays** - One of the main ways of providing situational awareness beyond workstations is large displays. Displays can range from complex video walls to a series of large monitors positioned at key locations in the TMC.
- **Dedicated Staffing** - TMCs require staff with a special set of skills that are becoming increasingly more complicated as enabling systems become more complex. Many TMCs are staffed through private sector contracting.
- **Partner Organization Cooperation** - Whether virtual or in person, many organizations gain value in working side by side. Examples of partners working closely in person or virtually with transportation (highway) organizations include law enforcement, transit, emergency management, regional planning organizations, and tolling.

Examples of the most prevalent tools used in TMC include the following:

- Highway-Oriented Advanced Traffic Management System (ATMS)
- Arterial-oriented Advanced Traffic Management System (ATMS)
- Advanced Traveler Information System (ATIS)
- Multi-modal / Integrated Corridor Management (ICM) Decision Support
- Work Zone/Special Event Management
- Emergency Management Dispatching
- Network (Telecommunications) Operations

1.2.6 Planning of Transportation Network

Many opportunities exist to foster collaboration between planners and operators and to incorporate Management & Operation strategies into the transportation planning and decision-making process. The planning for operations discussion earlier provides a good framework for establishing linkages between operations and planning. In particular, there are seven areas where Transportation Systems Management & Operation strategies can be incorporated into the transportation planning process:

- Incorporating system operations stakeholders into the transportation planning structure
- Establishing system operations goals and objectives
- Defining operations performance measures for the transportation planning process
- Using ITS technologies for data collection and sharing
- Using operations-oriented analysis tools
- Identifying Transportation Systems Management & Operation strategies to be included in the plan
- Sharing funding and resources.

1.2.7 Benefits ITS in Transportation Network Operations

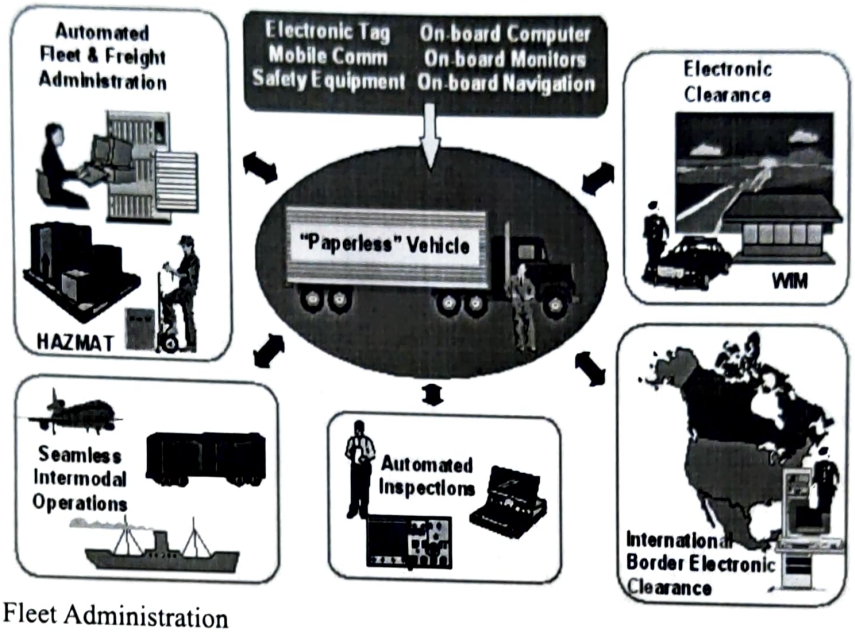
Following are the major benefits of using the ITS in Transportation Network Operations:

- Improving Network Capacity-maximise the use of the infrastructure available
  - Improved Traveller Mobility
  - Route Finding And Navigation
  - Traveller Information
  - Productivity (fleet managers, transport authorities, and toll agencies)
  - Policy Goals (sustainable transport)
- Safety Benefits-significantly reduced road traffic accidents
- Environmental And Social Benefits
- Benefits To Network Management - improvement in network efficiency.
- Security Benefits - network security to ensure operational resilience.

1.3 Commercial Network Operations

Transportation cost is a key component of logistic cost and contributes around 40 % of the logistic cost. In India, it is around 6 percent of GDP. An efficient, integrated, and seamless transportation system is the need of the hour to achieve the ambitious growth rate. ITS applications for intermodal freight and commercial vehicle operations sit at the intersection of commercial interests, economic productivity, public safety, and security. They cover goods movement by all surface modes, including their interfaces with air- and water-based modes. Efficient transportation of domestic and international freight (shipments of raw materials and intermediate and finished goods) is vital to any countries economy. The global pandemic in 2020-21 emphasized the importance of efficient supply chain management. ITS is critically important for order processing, delivery scheduling, and freight asset management so that goods can be in the hands of consumers when needed. E-commerce, which had been spearheaded by leading online retailers with their free and same day shipping, increased substantially during the pandemic when many retailers were closed, or consumers found it

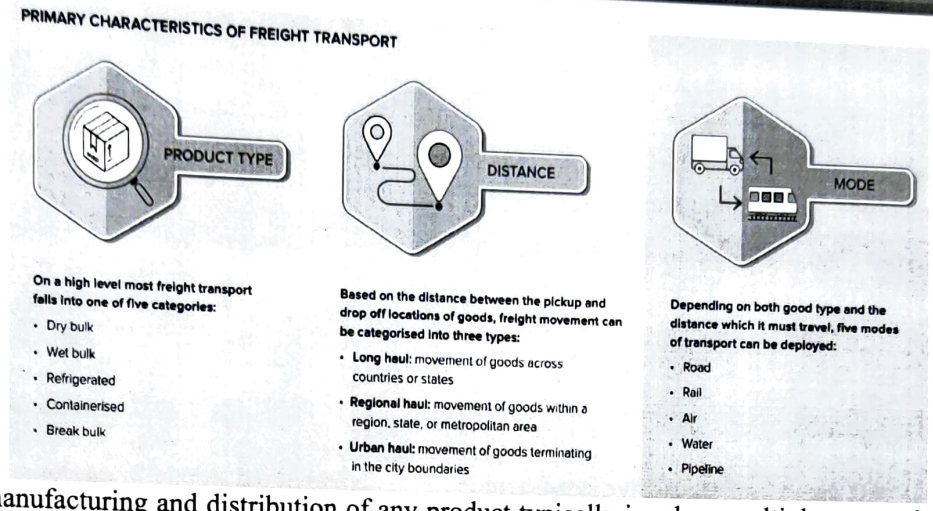
easier and safer to order online. **Commercial vehicle operations (CVO)** encompass a range of industries, including service and repair vehicles, private buses and taxis, and trucks. (Most prominent segment of CVO: trucking companies). Components of CVO include:



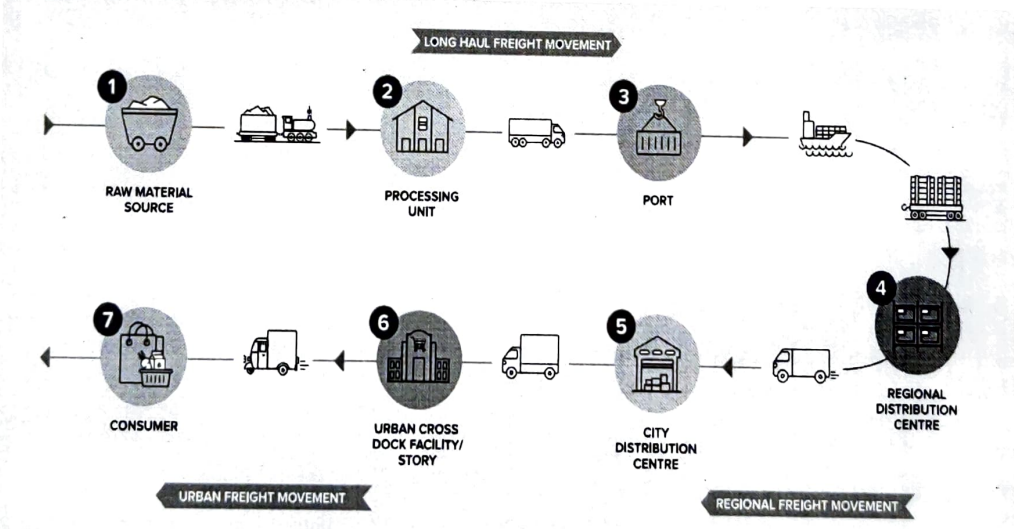
- Fleet Administration
- Freight Administration
- Electronic Clearance
- Commercial Vehicle Administrative Processes
- International Border Crossing Clearance
- Weigh-In-Motion (WIM)
- Roadside CVO Safety
- On-Board Safety Monitoring
- CVO Fleet Maintenance
- Hazardous Material Planning and Incident Response
- Freight In-Transit Monitoring
- Freight Terminal Management

1.3.1 Supply Chain Management

Logistics refers to the Process of moving and storing goods as they make their way to the consumer. As products are made, they move along a supply chain until they reach the consumer. To move those goods, the logistics sector combines vehicles and warehouses, all of which are selected to efficiently move and process them. The types of vehicles and storage facilities selected are typically based on the type of goods being moved and the distance over which they are being moved. This process of supply chain managers efficiently deploying and using a set of vehicles and warehouses to move goods through the production process to their final use by consu**mers is critical to the wellbeing of communities and economies.** Below figure describes the primary characteristics of Freight Transport:



The manufacturing and distribution of any product typically involves multiple types of modes. For example, consider a product made in Malaysia, bought by a consumer in India. The raw material may be transported to the processing unit by rail. The finished goods may be shipped overseas on a container vessel, across the country by rail, brought to a distribution centre by a truck and LCV, and finally delivered to the store by a three-wheeled goods vehicle where it is sold to a consumer.



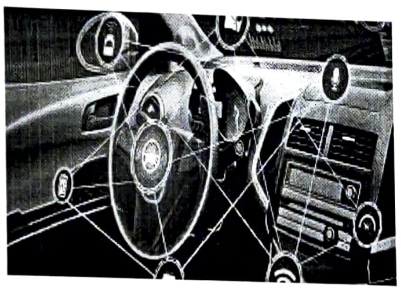
1.3.2 Technologies used in CVO

Like most industries today, ITS have influenced the goods carrier industry in many different ways. The following provides examples of the types of technologies that are currently being marketed:

- **Fleet scheduling and navigation**: Carriers use ITS and freight management data in managing transportation assets, whether they are a fleet of tractors, intermodal containers, truck trailers, or labor management. The technology and online communications combined with GPS help in maintaining truck location information and

combined with other data can be used for not only routing an individual truck on a specific customer order, but identifying and planning the next and later loads to help plan the driver's day. Carrier scheduling often incorporates transportation navigation services, congestion alerts, and avoidance technologies and data.

- **Sensors:** The freight transportation industries have long used cargo and freight condition sensors. Perhaps best known, temperature sensors and recorders improve the quality and accountability for perishable shipments. Pressure and toxic substance sensors enhance the safety of hazardous materials shipments. Accelerometers tied with GPS help ensure that highway impacts and shocks stay within contracted limits, help assign responsibility for problems, and help map problem patterns.
- **Communications:** Vendors developed on-board computers integrated with satellite-based location determination systems. Satellite-based, wide-area telecommunications complemented the location determination capabilities. As cellular phone capabilities and coverage matured, many fleet-oriented ITS tools migrated to dual mode or strictly cellular communications. The computers and communications tools monitored and reported data from on-board sensors for cargo condition, mechanical performance, cargo security, and driver emergencies.



- **Advanced Driver Assist Systems (ADAS) technologies**: Several features that are now called ADAS are already available on many new trucks and are increasingly used within the industry. These include adaptive cruise control, lane keeping assist, and automated emergency braking.
- **Truck parking facilitation:** Truck Parking Information Management Systems use ITS to collect and disseminate information on the availability of truck parking. These systems collect data on parking availability with equipment installed in rest areas to detect vehicles occupying parking spaces or counting vehicles as they enter or leave a rest area. This is used to identify available parking and disseminate the information to drivers through websites, dynamic messaging signs, and smartphone applications.
- **Compliance with Government safety and customs regulations:** Trucks have on-board sensors and devices to collect operating information that can be used for reporting compliance with hours of service, truck inspections, and monitoring truck safety. They also have the technology for communicating with weigh stations, including the ability to bypass physical inspection locations. Fleet scheduling and dispatching systems for the motor carrier compile the driver operations data which is then used for reporting to transportation departments.

1.3.3 Benefits of using ITS in CVO

The following are the major benefits to CVO sector by using ITS technologies:

i. **Safety**
   a. Reduced congestion at weigh stations will reduce accident risk.
   b. Law enforcement will be able to concentrate its efforts on high-risk and uninspected carriers and operators.
   c. Fewer trucks pulling in and out of weigh stations reduces accident risk for motor carriers and passenger vehicles.

ii. **Simplicity**
   a. Simplified, automated screening and targeting of high-risk operators improves enforcement efficiency.
   b. Standardized data exchange results in a simpler workday for motor carriers, drivers, and regulators alike.
   c. Low risk carriers, vehicles and drivers face fewer and simpler roadside inspections.
   d. Applications can be easily filed from the motor carrier's administrative offices.
   e. Motor carriers can get better information quicker from regulatory and enforcement agencies

iii. **Savings**
   a. Electronic screening will eliminate the need for truckers to stop for unnecessary weight and safety inspection, saving time and money.
   b. Automated reporting and record keeping technology will reduce costly paperwork for government and motor carriers.
   c. Motor carriers no longer have to go in person to file applications at each of the agencies that regulate the company's business.
   d. Government agencies will be able to process license and certificate applications more quickly and accurately.
   e. Electronic screening will reduce the number of stops and starts commercial vehicles must make, thus reducing fuel consumption and time idling in lines at weigh stations.
   f. The flow of goods from manufacturer to distributor to consumer is streamlined and on-time deliveries will improve.
   g. The new technologies are cheaper to install and use than constructing new weigh stations.
   h. Electronic screening technologies allow government agencies to shift personnel and resources from processing paperwork to other tasks.
   i. States will be able to more effectively collect taxes and other revenues.

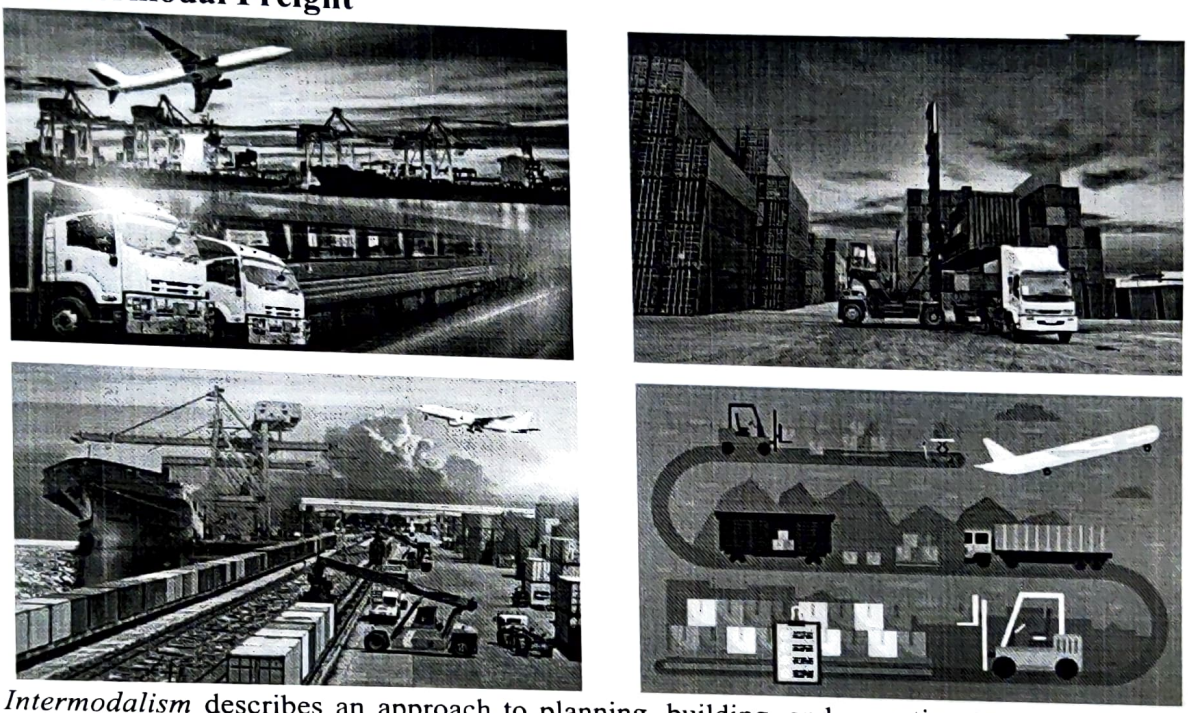
1.3.4 Future trends expected in CVO using ITS

The following are future trends that can be expected using ITS technologies:

- Autonomous Vehicles
- Trucking ADAS and ADS (Automated Driving Systems) automation- automatic emergency braking and adaptive cruise control.
- Cooperative ADS and increased truck platooning

- Truck Parking Availability System
- Smart corridor and similar infrastructure
- Electric Trucks and Electric Charging Stations
- Continued advancement of Last Mile Robotic delivery vehicles
- Artificial Intelligence to enhance supply chains
- Freight data sharing and coordination
- Workforce implications of new and emerging technologies

1.4 Intermodal Freight



Intermodalism describes an approach to planning, building, and operating transportation that emphasizes optimal utilization of transportation resources and connections between modes. An intermodal freight movement is the coordinated and sequential use of two or more modes of transportation for the completion of a trip, where the responsibility is usually assumed, or coordinated by, a single party. Intermodal freight moves door-to-door from shipper to consignee, optimizing its use of transportation modes, involving ocean, air, rail or highway as best suited to the customer's requirements. Today these disparate modes operate in parallel and sometimes cooperatively, but each largely retains its own distinct ownership and operating patterns. Each mode is a system which is comprised of:

- A network of infrastructure: roads, rails, waterways;
- Terminals where cargo transfers between modes; and
- Vehicles which carry cargo
- Each mode also has its own Government regulatory framework and funding system.

Currently, commercial activities in India generate about 4.6 billion tonnes of freight annually, which results in over three trillion tonne-km of transportation demand at a cost of INR 9.5 lakh crore. *Components of the Freight Transportation System* are:

1. Maritime Transportation
2. Rail Transportation
3. Pipelines
4. Highway Transportation
5. Air Transportation

1.4.1 Data in Freight ITS

The information types listed below represent the types of transportation information supported or used by freight ITS

- **Traffic and infrastructure information**: Real-time traffic information effectively improves traffic flow and the efficient usage of roads.
- **Vehicle and freight location information**: This type of transportation information enables the tracking and tracing of freight through the transportation network.
- **Freight condition information**: Such information is related to the physical attributes of the product during transportation operations.
- **Freight positioning information**: Such information is related to the placement and sequencing of the products when they are stored or being shipped.
- **Warehouse operations and inventory information**: Such transportation information includes information related to the number of items in the warehouses, customers' orders for different items, loading and unloading times for different orders and information about the contents of different warehouses.
- **Cargo information**: Information regarding types of shipped items, their attributes (such as model, class, size, colour, weight, price and ID number, as well as other kinds of data that depend on the type of items), sender information, receiver information and information regarding the quantity of shipped items is a significant factor for the control and management of transportation operations.
- **Vehicle identity information**: Information such as the type and class of vehicles, their registration numbers and other identification information is used in different transportation operations for transportation resource management.

1.4.2 ITS technologies in Intermodal Fright

The various types of ITS technologies which can be used in Intermodal Fright Management are:

- **Traffic control and monitoring systems**: Such systems are created for controlling and managing traffic flow by providing information regarding traffic situations, such as collisions, congestion, traffic flow speed and vehicles on the roads to be used by authorities or by logistics service providers.
- **Weight-in-motion (WIM) systems**: These systems are created for to control and weigh vehicles (reduce damages to the infrastructure such as roads or bridges) to increase transportation safety and reduce the damages caused by overweighted vehicles.

- **Delivery space booking systems**: These systems allow the space for parking to be booked for a specific vehicle to load or unload freight during a specific time period.
- **Vehicle location and condition monitoring systems**: These systems provide real-time information about the position of the vehicles on the map by transmitting the information via satellite.
- **Route planning systems**: Such systems are used to plan transportation routes in response to road situations.
- **Driving behavior monitoring and control systems**: These systems analyse the speed and acceleration of drivers during transportation operations, and they provide feedback for improving driving.
- **Crash preventing systems**: Technologies such as sensors are used in these systems to reduce the probability of accidents.
- **Freight location monitoring systems**: The application of RFID (Radio Frequency Identification) tags without the need of direct light contact for scanning has created an advantage for transportation operations.
- **Freight status monitoring systems**: The application of different sensors for measuring the physical attributes of goods, such as temperature, humidity, impact level, light level and vibration level, can create improvements in transportation operations.

1.4.3 Benefits of using ITS in Intermodal Fright Management

The following are the major benefits of using ITS technologies in Intermodal Freight

- Safety
- Productivity
- Mobility
- Energy and environmental impacts
- Efficiency
- Customer satisfaction
- Increased Level of Security.
- Reduces Highway Congestion

~&$#END#$&**~**

Note: Refer Textbooks.