IDEA

Innovations Deserving
Exploratory Analysis Programs

Transit IDEA Program

REAL-TIME TRANSIT DATA BROADCAST

Final Report for
Transit IDEA Project 8

Prepared by:
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Transcom International Ltd.

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TRANSPORTATION RESEARCH BOARD
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Innovations Deserving Exploratory Analysis (IDEA) Programs Managed by the Transportation Research Board

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EXECUTIVE SUMMARY

The innovation of this project is the concept of a personal portable receiver (pager) that receives a minute-by-minute broadcast on the location of all Transit buses and that provides a continuous countdown to the next two Transit buses arriving at the passenger's stop of choice. This device is called a Transporter™ (Figure 1).

FIGURE 1 The Transporter.

This receiver is intended to provide accessibility to Transit similar to the manner in which a TV channel changer provides control of a TV or VCR. The Transporter would store favorite used trips and provide a selectable beeper alert to the impending arrival of the next bus, at 8 minutes, 6 minutes, and 4 minutes before arrival, for example.

The intended value of the Transporter is to eliminate unnecessary waiting at stops, increase personal safety and allow persons with disabilities to selectively identify wheelchair accessible buses.

To provide an accurate time-to-arrival countdown, the Transporter will use data from Transit's existing Automatic Vehicle Location systems, which typically poll each bus each minute by radio and request the bus location. (Currently, satellite GPS is used to locate buses). A broadcast of the location of all the Transit vehicles each minute will update each Transporter's time-to-arrival estimate.

The Transporter is intended to be truly portable. Portability means that the user can obtain time-to-arrival information at any time anywhere within the service area, for any stop or route, without having to make a telephone call. The passenger, would enter new stop numbers of interest, as read from bus stop signs, from a Transit guide at home, or from signs poseted in exit areas of stores.

The Transporter's software model is a distributed model, with the Transporter containing all Transit route information and scheduled speeds along each route. The only data required to achieve a time-to-arrival estimate is the broadcast of the location of each bus along each route. This software model was designed for the Transporter but is intended to work equally well on the Internet. Transit could broadcast the location of buses to subscribers to the Internet service, i.e., passengers who might use LAN fileservers at work or personal computers at home. Personal computers could have a variant of the Transporter software to generate time-to-arrivals for users while at work. The Transporter software model thus would become a widely applicable standard output for Automatic Vehicle Location Systems.

This proof-of-concept project accomplished the following:

- A coding method was developed to achieve the decentralized model, which describes a city in terms of bus routes, patterns, stop numbers and schedules within the limits of current pager technology.

- The Transporter's real-time countdown was demonstrated to be accurate and errors during the last 4 to 5 minutes were typically less than 45 seconds. This level of accuracy impressed observers during the tests. Figure 2 shows the Transporter tracking a bus over a 7-minute period. The maximum error is approximately one minute and the bus would have arrived approximately 30 seconds before the time predicted, a deviation corresponding to about 200 meters or 2 city blocks.

The project produced a number of observations, which require further investigation**:**

- A standard 2400 bits-per-second paging channel could serve most cities with populations under 2 to 3 million. The newer 4800 BPS paging systems could offer a wider range of services to passengers, (e-mail,

FIGURE 2 Time-to-arrival plot and Transporter countdown.

- paging, etc.), and serve larger cities. The cost for a paging radio channel in a city the size of Minneapolis could be approximately $300,000.

- Existing Transit AVL systems and route scheduling systems would require upgrading to achieve the Transporter broadcast at a probable cost of $400,000 each. The items requiring upgrading would be scheduling software, AVL system software, the AVL computer, and perhaps the control circuit programming on bus radios. These start-up costs are small for a medium-sized Transit, as the upgrading represents approximately the cost of 3 of the 30 that are typically purchased each year by such a Transit authority.

PROBLEM STATEMENT

Background

Urban bus systems have operated on the basis of schedules for many years. From the passenger's point of view, buses are rarely exactly on schedule: they run early or late depending upon traffic or the mood of the operator. If passengers miss the bus, they often wait 20 to 30 additional minutes. Consequently, passengers routinely arrive 5 to 7 minutes early, and this can be a very unpleasant experience if the weather is cold or if the wait occurs in an undesirable area. In addition, students who like to appear sophisticated to their peers find the curbside wait undesirable, especially when friends drive by in a car. As a result, many passengers are abandoning Transit in favor of automobiles as soon as their economic circumstances permit.

Automatic Vehicle Location systems have been installed in approximately 25% of cities over the past 15 years. Their primary role has been to monitor bus locations to provide feedback to operators on schedule adherence. Buses are polled each minute to determine their location by requesting the number of wheel rotations since the start of the run or a satellite GPS position fix. Buses which are late are advised to catch up, and buses which are early are advised to slow down. In the past, this feedback was transmitted verbally via a control center operator. Presently, modern systems automatically provide feedback to the bus operator in the form of fast/slow warning lights or text readout. In general, AVL systems have produced improvements in the quality of service to customers, traffic permitting.

Telephone advisory services (TeleBus) exist to provide callers with scheduled arrival information. The caller dials a special telephone number (unique to each bus stop, or a group of stops close together) and is advised by a computer of the next two scheduled buses expected at that stop. This form of computerized schedule is helpful to passengers who do not have a schedule or who have difficulty understanding one. Understanding schedules has proven to be a more common problem than thought, as a survey found that 50% of college students had difficulty interpreting a bus schedule. Most TeleBus systems do not adjust for the early or late buses; therefore, the risk of missing the bus still exists, causing passengers to spend the same amount of time waiting as before.

Some TeleBus systems (Go-time in Halifax and Infobus in Hull Canada) provide real-time information derived from AVL equipment. The location of each bus is determined each minute so that arrival times can be predicted based upon current conditions. This has been a significant improvement, but passengers need a public telephone or a cellular telephone once they are away from their home or workplace. In Halifax, a Teledon TV system provides a readout in the form of a real-time countdown for each route at major transfer points and major bus stops. This is a huge improvement, but the information would be better appreciated by passengers if received in the waiting area of the buildings that they have come from. Having the information at the bus stop makes the winter wind a bit more bearable, it would be easier to stay inside until the last moment. The resulting walk and wait would not be significantly different from walking to a cold car and perhaps having to scrape the frost off the windshield.

The Idea and the Innovation

The Transporter envisioned in this Transit IDEA project started with a definition of Transit customers needs. The goal was to make accessing Transit easier, indeed, to make it fun. The Transporter would track the passenger's bus, select a wheelchair accessible bus if needed, and provide an accurate time-to-arrival countdown to eliminate the uncertainty and the wait. The Transporter would function as a bus pass and, with an appropriate reader/interface, could render fully electronic fare payment possible.

The primary innovation is the distributed software model, which would give each receiver full portability. This model opens up the possibility of a truly personal portable device, which could store and monitor favorite used trips. For example, it could be used to receive alerts and a countdown for an express bus in the morning or evening.

The Transporter is intended to be rented or purchased in much the same manner as a pager or a cellular telephone. Originally, the market seemed limited, in that a $10 per month rental appealed to only 5% of passengers (*2*). However, since the Transporter can function as a monthly bus pass, its rental can be bundled with the U.S. Federal tax incentive (*3*) making the device effectively free. In Canada, the equivalent proposal has been tabled by a federal task force (*4)*.

The marketing innovation would be marketing the service through employers who would do the payroll deduction for the employee and pay the service company or Transit the value of the monthly pass and the value of the rental. Other services such as weather information, personal paging or e-mail from the Internet are optional to the user and would be paid for by the user.

Goals of the IDEA Project

- Verify that a standard coding scheme could be designed to describe the full range of Transit routes, patterns, schedules, TeleBus numbers, speeds, distances, etc., that are needed in the Transporter to achieve the distributed processing software model.

- Verify that a broadcast taken from existing Transit AVL systems would provide a real-time countdown accuracy adequate for a passenger's needs.

- To gain experience with possible radio broadcast means, such as FM subcarrier.

- To obtain a real-time feed from an exiting Transit AVL system to use for the trial.

- To obtain opinions from passengers about the utility of the device.

Potential Impact of the IDEA Project on Transit Practice

Transit will be entering the information age, through electronic highways, such as digital cable, two-way cable, fiber-optic cable, Internet, micro-cellular Personal Cordless Telephones, Cellular Packet Data, FM subcarriers, Digital Audio Broadcast, or digital broadcast TV, one-way or two-way paging networks.

The reality is that Transit does not have either a broadcast or a two-way communications standard**.** For all practical purposes, the designers of the electronic highways are ignoring Transit. It appears that there cannot be a commercial market for Transit information when each city does its own thing, thereby undermining low-cost mass-produced products, which result from industry standards.

The distributed Transporter model being proof-tested in this project could be a standard for the one-way broadcast forms of the electronic highway mentioned above. For example, the Internet currently does not distribute data according to real-time constraints, but trials are underway to develop a real-time broadcast. This would allow a Transit authority to provide a single feed and have perhaps 10,000 addresses that receive and present the information on standard personal computers.

The paging industry already has Internet e-mail delivered to personal pagers. The combination of a broadcast of bus locations to all Transporters, which is very efficient, and personal e-mail off of the Internet is both very exciting and very useful to millions of passengers. This is especially true when passengers discover that they can obtain the basic service "free" due to the tax incentive. The challenge for the Transit industry is to move quickly to develop standards and to become information providers. The Transporter standard deserves examination, as it is based upon a unique vision of excellence in customer service .

RESEARCH APPROACH

The research approach consisted of first verifying the basic design parameters by reviewing the Transit operations of two cities with advanced systems, Halifax, Nova Scotia and Hull, Quebec. The data collected was compared to the systems in Winnipeg, Manitoba. The following steps were required:

- Define a protocol for handling standard and unusual route designs, and test it by comparing it to the route design information, signage, TeleBus numbers, etc., obtained.
- Define the method needed to identify stop-opposite numbers for passengers to obtain the return route stop number without crossing the street.
- Define standard protocols for identifying wheelchair accessible buses, buses with standing room only, and buses which are running slow.
- Define the data formats for the LOCATION, ROUTE and DISPLAY data streams.
- Evaluate the AVL systems for their compatibility with the Transporter requirements.

Visits were made to Halifax and Hull, and several days were spent meeting with Transit officials discussing the Transporter concept and the feasibility of the Transit authority supporting such an information service. The bus Automatic Vehicle Location technology was examined, and strengths and weaknesses examined for its use as a data source. The quality of the existing service was examined by taking bus trips on the majority of the routes and talking to bus operators and passengers. Printouts of bus schedules, route timing information, and route data such as stop numbers and inter-stop distances were obtained. Printed schedules and city-wide route maps were obtained for all routes.

The data obtained was analyzed and compared to the distributed data model. Issues arose including the existence of unfamiliar practices and the number of variants (patterns) of route design are there (mid-route starts, and mid-route stops, expresses, area detours for a local school, shifting terminal points, one-way loops, multiple destinations, etc.).

These system parameters were combined into a comprehensive functional and technical specification for the Transporter. This specification served as an on-going reference for the development of a proof of concept trial.

The feasibility of obtaining AVL location information directly was examined. The investigator expected to be able to obtain an AVL output for a specific bus from the AVL systems of either Halifax or Hull and to use a copy of that output and format it for broadcast on an FM sub-carrier broadcast. A major FM sub-carrier broadcaster had indicated support for a test of the broadcast.

The second step of the research was to evaluate the Transporter's real-time countdown, with observers desiring to catch a particular bus at a randomly selected bus stop. The resulting levels of accuracy would be studied and the sources of error in the time-to-arrival countdown evaluated. The method to be used was an on-board laptop computer running a tracking program and a Transporter simulation program concurrently. The observers would be provided both an alert to the impending arrival of the bus and the real-time countdown using cellular telephone.

RESULTS

The Distributed Processing Model

The achievement of a workable data model took two attempts. The first model did not adequately compress the data and the first attempt at defining routes needed to be redesigned. It became clear that the initial concept of a route was too general, and a route ended up being defined as a set of patterns. Each bus runs on a pattern, and must be tracked on its pattern. Each pattern has a schedule, which is most often shared with other patterns, but some are unique, such as for the express buses.

The second data model is graphically presented in Figure 3. The generic route shown includes all the possible patterns, including express buses. A pattern starts at a stop, which can be anywhere along the route, and includes all stops in between, unless excluded, and finishes at a stop. Each pattern shares the scheduled speeds between points, and distances, as defined by the scheduler for that time of day.

It became clear that the Transporter model was becoming a hybrid between the run-cutting and scheduling programs used by Transit and the AVL system software used to track Transit buses. Currently, the two fields of software are mostly independent, but the ideal is a fully integrated approach. A Transit authority that endeavors to become "Transporter compliant "would have to review both sets of software to ensure that they are compatible. The current state of the art often requires a certain amount of "hand massaging" to get the AVL system to track the buses that the schedulers deem necessary for proper service. The ideal is to fully integrate the two functions, but as a minimum**,** a standard output file from the scheduling program could be input directly into the AVL and Transporter systems.

Toward that end, the Transporter's requirements have been studied by the AVL system software supplier to Halifax Transit, (SIRIUS Solutions) and their scheduling software supplier (GYRO). The main difference is that a scheduler uses a minimum number of timing points to optimize schedules and bus runs. A larger number of timing points adds to the complexity of the optimization process. At the other end, the AVL system tends to need many more timing points to better define the expected position of the bus at any given minute.

A bus operator is required to take a fixed time between timing points, which are usually transfer points. What happens in between timing points depends on route characteristics such as traffic and time of day. Schedule adherence usually is based upon operator experience. For example, an operator might anticipate traffic congestion at a certain intersection each morning, and "boot it" earlier on the route, to allow for more time to get through the congestion. An AVL system that is trying to provide minute-by-minute feedback to the operator on schedule adherence, or to provide accurate input to a real-time TeleBus system, needs to have many more timing points. The historical times between these points need to be statistically gathered by time of day (at the limits, each

FIGURE 3 Generic route including all possible patterns.

stop is a timing point). This set of statistics is the computer form of operator experience. The end result of having detailed statistics would be more accurate feedback to the operator and more accurate TeleBus predictions.

The Transporter model fits in between the older scheduling art and the real-time TeleBus/AVL art. Because passengers obtain a real-time countdown, any initial error would be by the AVL positional scans which track the bus to the stop. Passengers would learn the quirks of their favored used trips and gain experience the same way that the operator does. There is ample opportunity for PC-based Transporter software on the Internet or a LAN to use software routines to develop its own experience for a customer's favorite trips. The simplest method would be to have the software track the error by time of day and time of week. For example, the customer could be advised as to the time-to-arrival and the probability that the bus will arrive 1 or 2 minutes earlier than predicted.

The conclusion reached was that the needs of the Transporter were less onerous than that of a real-time TeleBus system, and that the Transporter needed less sophisticated AVL software. The primary need was for the scheduling program and the AVL system to use identical sets of definitions for timing points, patterns, and timing periods. The needs of the Transporter model of decentralized processing necessitate strict standards in the Transit industry.

Accuracy of the Transporter Time-to-Arrival Countdown

The accuracy of the Transporter proved to be better than expected. Perhaps it should have been obvious that the one-minute positional scan of the AVL system would provide good accuracy. The actual experience of tracking the bus and watching the prediction was needed for the observers to feel comfortable with the concept.

Buses tend to track their schedule reasonably well, unless some unusual event occurs. The Transporter cannot predict the unusual event, but it can track a bus that is behind or ahead of schedule.

Figure 4 is a close-up of the last five minutes of a Transporter prediction of the time-to-arrival countdown. The graph is designed in a descending left-to-right format to assist in the easy visualization of the ever smaller time-to-arrival predictions as the bus approaches

FIGURE 4 Time-to-arrival plot and Transporter countdown.

the stop on the right (at zero). When the bus was 750 and 350 meters from the stop, it was delayed by other stops at intersections, or waiting for traffic. This is readily seen from the vertical grouping of data points, and is immediately suggestive of the fact that progress to the right of the graph has halted (the bus is not getting any closer to the stop, and the time-to-arrival is getting smaller).

Figure 2 includes a 30-second delay being added to the 60-second AVL scans. This would be the normal condition for an AVL system in which the AVL scans are each one minute, and an additional 30 seconds (on average) of time passes before the (adjusted) real-time data is broadcast over a radio system. It is immediately clear that a twice-a-minute broadcast, in which 50% of the data is from new AVL scans, would increase the Transporter's accuracy. Although the data collected so far suggests that this extra level of accuracy is not critical, it could increase passenger approval. For that reason, the Transporter system specification was modified to include a code for the broadcast frequency, i.e., once each minute, once each 30 seconds, etc.

AVL systems have the characteristic of scanning their buses in strict sequence. This means that all scans are at a maximum of 60 seconds apart, but if the number of buses on the street is small, such as during off-peak hours, the scan could be completed in less than 30 seconds. In this circumstance, the Transit could consider doing a repeat scan for the entire active fleet, or some portion of the active fleet. Transit authorities that wish to implement a Transporter system could improve accuracy by making this software change to the AVL/C system.

Inherent Transporter Location Errors

The Transporter real-time broadcast consists of describing the bus location along the route or pattern by giving the sequence number of the stop which the bus has passed and the distance away from the next stop, in subdivisions of 100%, 75%, 50% and 25% of that distance. There is an inherent error involved in slotting the actual inter-stop position into only four graduations. It would be preferable to use 8 or 16 divisions. However, each additional level of accuracy increases the binary word length of the transmitted location which is kept to the minimum of two bits (i.e., the four levels of accuracy) in order to minimize radio data volume.

Figure 5 indicates 86% of the inherent errors in slotting the bus on the route studied is under 15 seconds, with the maximum error being 27 seconds. The maximum error occurs when the inter-stop distances are large. The Transporter can limit the size of the error by adding "phantom" or non-existing stops to the route to subdivide these long stretches into smaller distances. The current thought is to set the maximum duration between stops to be 2 minutes, such that the maximum inherent error in the location broadcast is 30 seconds or less.

Another inherent error is the need to assign the inter-stop travel times into duration codes. Again, there is a need to minimize the word length, in order to conserve memory space on the Transporter, hence a coding scheme is used. It inherently provides accuracies to +/- 13%. As can be seen from Figure 5, the error is of a small magnitude, i.e., with 78 % of the errors being of 6 seconds or less.

The Broadcast

An FM sub-carrier broadcast was set up by a participating company in the Winnipeg area. The effort to use the broadcast was abandoned when the error rate was found to be too high. The broadcast included error detection, but not correction, as the software correction schemes required too much CPU time for the receivers to keep up in real time. In any case, the consequences of missing some data was not significant for the carrier's current commercial use. It became clear that this system would not function as a Transporter broadcast.

A subsequent set of meetings with a pager design team in Ottawa led to significant optimism about using a pager system as a platform to broadcast real-time transit information. The one unknown was the need to modify the pager network software to give strict priority to the Transit data. It was clear that a dedicated paging channel would be needed for the metropolitan area served by Transit. A cost estimate was received for an additional frequency for the city of Winnipeg, at US $200,000.

Programming of an AVL Output

The achievement of real-time output feed from either the Halifax Transit or Hull Transit did not prove possible. In Halifax, the computer was too heavily loaded, and in Hull, the programs were not available for modification without returning to the original designer. Another approach had to be used to track a bus for the proof of concept. A laptop computer was programmed to provide the vehicle position in real-time, by having an observer on the bus provide visual location input each half city block. The positional data was then used as input to the Transporter simulator, which provided the time-to-arrival countdown to the stop of choice of the observers along

FIGURE 5 Transporter location errors.

the bus route. Cellular telephone was used to relay the beeper alert and time-to-arrival countdown to the observers. Simultaneously, data was collected on bus location, the Transporter's readout and the time of day to provide a data file for later analysis. This technique worked very well, and it gave an insight into the challenges of obtaining the correct route and schedule information. This task was carried out manually from printouts and other information, and it took 10 times longer than expected (5 days instead of one-half day per pattern). It became clear that the ideal tool for assembling the Transporter data files was a set of programs that used the computerized schedule files as input and had a graphical user interface. Such a tool could be built around either the ARCINFO or MAPINFO PC software programs.

Opinions of Observers

The evaluation of the Transporter by passenger/observers was challenging because there wasn't a product to compare it to. A demonstration approach was used, where the passenger attempted to access a bus using the Transporter information alone. Passengers/observers were asked to comment on their experience as compared to accessing a bus normally and in relation to their expectations of the product. This type of evaluation invited very subjective opinions. Some expressions were quite interesting: "It's 100 times as accurate as I expected!" and, "It sure beats a schedule!"

The data for each test run was tabulated in a graph format for the passenger/observer to verify later if desired.

The preliminary statistics gathered on the arrival time error (deviation) demonstrated that the errors seen at the bus stop would be under 1 minute. The error that occurs over a longer time period, such as from 8 minutes away, can be twice as large, due to traffic, etc. None of the observers were able to discern an error over the long time period. Errors in the last two minutes were of the most interest to the passenger/observers. Observers found that they could see the bus when it was 1 minute away, hence it was found that the final exact error became irrelevant to them. The perception was that a prediction error of under 1 minute was precise because the bus could be seen, and in their opinion it had arrived.

CONCLUSIONS

The distributed software model for providing Transit real-time information is workable. The accuracy obtained is more than adequate for good customer service. The model will work for the Internet, real-time TeleBus and the Transporter service.

The potential impact of improved customer information and convenience in the Transit industry is unknown. However, it is inevitable that Transit authorities will start to innovate their own methods to take advantage of the current revolution in information technologies that is underway.

The success of implementing a low-cost Transporter depends upon the existence of a mass market. A mass market will result from the creation of an affordable product that brings significant advantages to its owner. A product standard is needed to create this market, and this product standard needs to be adopted by the majority of Transit companies. The Transit passenger market is small in comparison to the pager market, which turns out millions of products each month. Transit passengers can only be served through a cooperative arrangement with Transit authorities which must be convinced that it is in their interest to invest in providing high quality real-time data to support the information industry.

As a minimum, the Transporter software model needs to be developed for the Internet. A trial city that can readily adapt its AVL system to provide a Transporter compatible broadcast needs to be located. The results of such a demonstration would assist in creating a Transit standard.

REFERENCES

1. Scaled up from an estimate received for a smaller Canadian City.
2. Transcom International market survey, Winnipeg, June 1, 1993.
3. "Passenger Transport," Nov 22, 1993.
4. Task Force on Economic Instruments and Disincentives to Sound Environmental Practices, Nov. 1994.

GLOSSARY

Automatic Vehicle Location System	A means of locating buses along each bus route and determining deviations with respect to the schedule
beltline route	A route which travels in one direction only at its start end or destination end. This reduces the time needed to serve a looping boulevard through a subdivision. This type of service is combined with the shifting terminal point.
Global Positioning System (GPS)	A set of U.S. military satellites that broadcast synchronous timing signals that allow receivers to triangulate their location on the earth's surface. Buses can mount receivers on their roof.
mid-route start	During p.m. rush hour a bus is often added to the route in the downtown to assist in picking up the return-to-home passengers from the downtown.
pattern	A variant of a normal bus route, such as to pick up children at a local school or an express bus that stops at a reduced set of stops. Some routes are made up of 6 or 8 different patterns.
route	A bus service following a set of streets. A simple route is one that has an inbound and outbound pattern. Complex routes might include express buses, buses serving alternate destinations, and buses which start mid-route and exit mid-route.
split route	A route that serves two or more destinations, usually by alternating buses. Passengers on the route need to differentiate the buses by destination if they travel to the end of the route, but otherwise they can use any bus on the common or shared part of the route.
shifting terminal point	Buses start their route, or finish their route at terminal points. Toilet facilities are usually provided for the operators at the end terminal points, and the operator is usually given a 5-minute layover. A route serving a subdivision might have the bus finish its route at a terminal point prior to entering the subdivision in the morning and at the exit to the subdivision in the evening to minimize the stranding of passengers on the bus while the operator takes a rest stop.
wheel rotation system	An AVL system that counts the number of wheel rotations to the bus from the start of a route and forwards the count to the control center when polled by radio.
mid-route exit	At the end of the rush hour a bus is often removed from service mid route, such as midway on a through-city route
time-to-arrival countdown	The Transporter provides a countdown in a similar manner to a space vehicle launch. For times longer than 10 minutes, the count is by minute, but for less than 10 minutes, the count is by minutes and seconds. This eliminates the mental computations associated with schedules.
timing period	The time interval in the day during which a scheduled time between timing points is in effect. For example, the a.m. rush hour slowdown might start at 07:30 and finish at 08:30. Each day usually has several timing periods, a.m., a.m. peak, morning, noon peak, afternoon, p.m. peak, and evening. Weekends and holidays typically have fewer, such as a.m., daytime, and p.m. The Transporter uses timing period increments to define timing periods.
timing period increment	Timing period increments consist of 256 slots per day, with 10-minute slots from 00:00 Hrs to 06:00, 5-minute slots from 06:00 to 18:00 Hrs, and 10-minute slots thereafter. The day is 30 hours and 40 minutes long to allow for a day schedule to start at 04:00 and finish the following morning at 02:30 a.m., for example.