Delivering Real Time Information: End to end issues

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1 Introduction

1.1 The issue

1.1.1 In the context of public transport, **real time information** (RTI) systems are those systems and services which enable passengers to have current information on the operation of their expected service – rather than merely hoping that the planned timetable is being met.

1.1.2 The most widespread and familiar form of RTI is the at-stop "countdown" service, in which an display indicates the number of minutes until the next numbered service vehicle will arrive. However there are many other options for RTI, which make use of an increasingly rich range of opportunities for data connection and service provision, including services delivered on demand to a person's mobile phone. While the applications that provide these services will be quite different, they all rely on the same base data, namely real time **automated vehicle location** or AVL (see section 2).

1.1.3 This collection of base data is transparent to the passenger but is a complex and technically challenging undertaking, subject to a variety of risks and often involving a number of separate systems operating in series. Understanding and addressing these risks is crucial if the public facing RTI is to be kept to an acceptable level of reliability.

1.1.4 This note outlines some of the key issues that arise in delivering RTI, and may assist as a checklist for project managers.

1.2 Acknowledgments

1.2.1 RTIG is grateful to those experienced professionals who have contributed to the brief notes provided here for sharing their expertise. In particular we would like to thank Russell Gard (Nimbus), Paul Everson (Trapeze) and Chas Allen (Stagecoach).

2 The RTI systems context

2.1 Automated vehicle location

2.1.1 An AVL system is one which establishes the geographical position of a vehicle. It does this in real time and will timestamp the datum. The potential inputs of and AVL system are many and varied (see next section), but the output is essentially limited to "at time T, vehicle V was at point P".

2.1.2 AVL systems are nowadays almost always on-vehicle systems, and likely not to be specifically installed to support RTI provision. These systems take some external inputs (typically GPS, and in future probably Galileo, but potentially occasionally other systems such as LORAN), and combine them with some internally generated data (from accelerometers, cameras, door closures, manual driver entry etc). The algorithms used to fuse the data may be complex, but the aim is always to deliver a "clean" location output. Sometimes too there will be quality-related metadata, for example on what the likely positioning error is.

2.1.3 On-vehicle AVL may be used locally (for example, to drive a fare stage update) but is usually also communicated back to a monitoring centre in real time, so that the service managers know where the bus is.

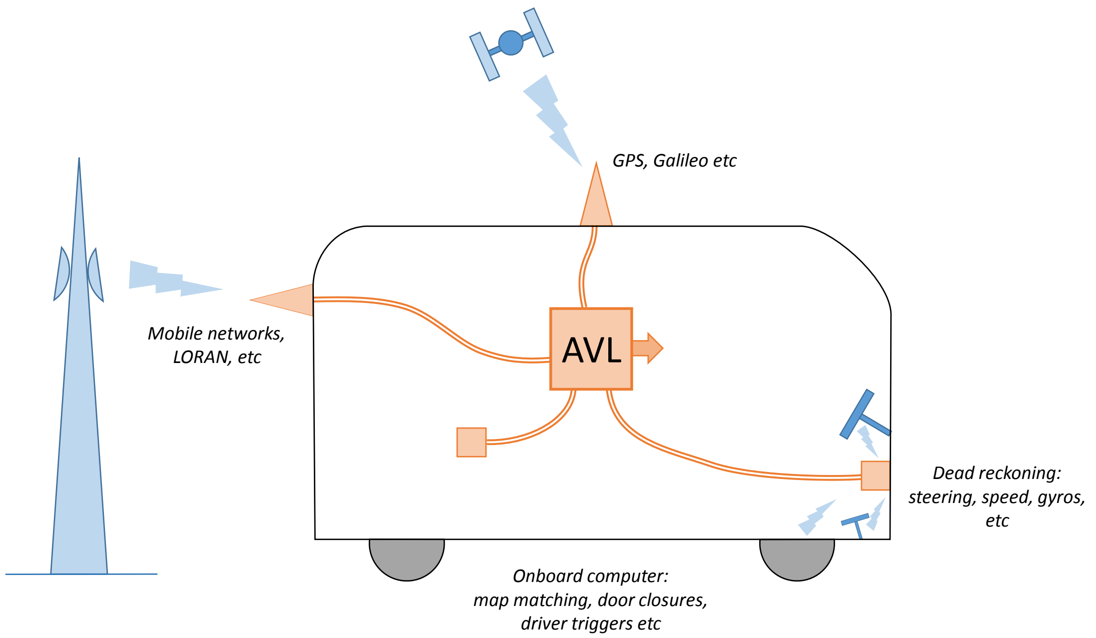


Figure 1: AVL is the collated output of location detector systems

2.1.4 Off-vehicle systems have been used in the past, but are now quite rare on buses (though still widely used on track-based services such as rail and tram). These typically make use of roadside detectors that can identify the passage of a specific vehicle. Some are free standing, ie need no vehicle involvement (for example, ANPR systems) while others rely on an on-vehicle device ("tag and beacon" systems, historically based on special-purpose comms but more likely today to be RFID-based). These systems may or may not be able to identify the vehicle locally – for example, while ANPR can capture the plate read, the bus may only be identified once this is matched with a schedule of vehicle VRNs at the monitoring centre.

2.1.5 Off-vehicle systems are limited compared with on-vehicle systems, because they can only identify when a vehicle is at a specific point.

2.1.6 Hybrid systems are possible too, in which both on-vehicle and off-vehicle AVL data are gathered – either to be combined for greater accuracy or resilience, or for different purposes.

2.2 Real time information systems

2.2.1 "RTI" is a broader term (and indeed is widely outside the transport sector), and refers to any dynamic data in which periodic or occasional provision is not appropriate.

2.2.2 In the bus context, the most widespread and familiar form of RTI is the "countdown" service, in which an at-stop display indicates the number of minutes until the next numbered service vehicle will arrive. However there are many other options for RTI, including:

- Using kiosks, PCs, smartphones etc for display, rather than fixed special-purpose signs
- Displaying the location of (moving) vehicles on a map or line chart, rather than time to arrive at a specific point
- Showing projections for arrival at the passenger's destination rather than arrival at his point of departure
- Providing a real time journey planner across several modes, taking into account the running status of each mode and the necessary interconnections
- Offering route, time or mode alternatives based on a range of passenger preference parameters
- Providing generalised disruption information, or warning of projected/potential disruption (eg in the event of heavy snow forecast)

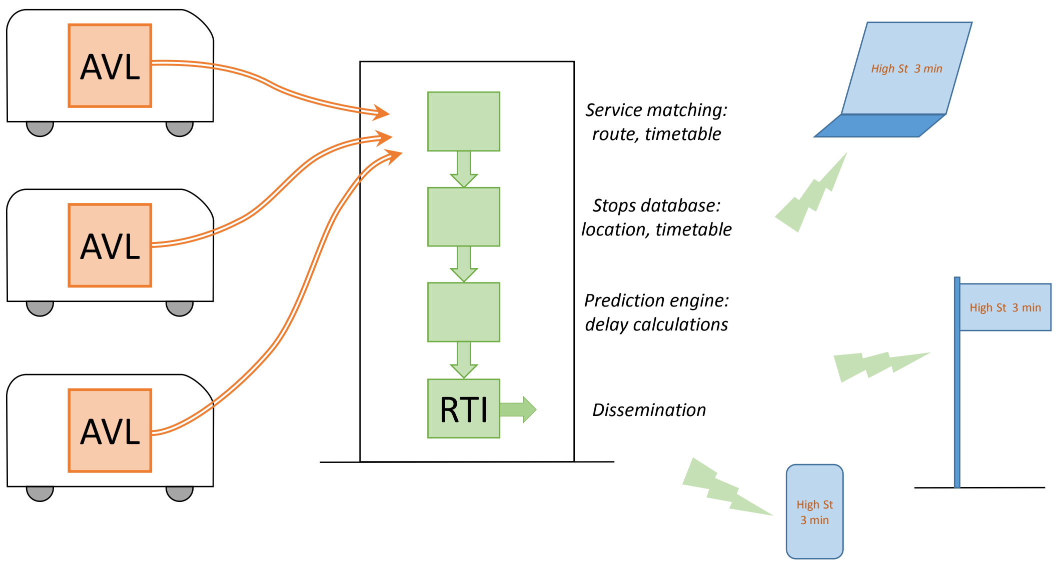


Figure 2: RTPI is service-relevant information available for passengers

2.2.2 The term RTI also covers information that is of use to an operator rather than to a passenger. For instance, while a passenger will normally wish to know arrival times at stops (where the service can be accessed), the operator will want to know its running situation between stops too, for example to control schedule adherence; and will also be interested in other dynamic data such as bus loading, engineering information, and fuel status.

2.2.3 The dynamic input to an RTI system, therefore, is (or includes) AVL data. These data then need to be matched with information that identifies the vehicle with a service, identifies the position in space as a point on a route, and compares the timestamp with the service timetable. Additional data (such as engine temperature) will be routed to the appropriate systems. General data (such as roadworks) will be sourced from elsewhere, or entered manually.

2.2.4 A specific complication is that the various data processing steps may be (and often are) divided between two or more organisations, and this is not always done in a uniform way. For instance, a small operator might link its AVL data directly to the appropriate local authority, while a large operator might undertake its own journey matching and even prediction, passing fully-processed RTI to the LA for collation and posting on signage.

2.2.5 As an additional complication, the functions involved in processing AVL into RTI can be performed – in whole or in part – within the ETM itself. In particular service matching is often done on-board. The argument is that maintaining full (static) timetable information on all ETMs is relatively straightforward to manage, and makes the buses more flexible to *ad hoc* service changes in service.

3 Measuring success

3.1 Service goals

3.1.1 The aim of RTI systems is to provide information that is timely, reliable and relevant to passengers, through their preferred access channel.

3.1.2 Some of this will be highly dependent on individual passenger preferences. While in general simpler solutions will be easier to get right, as more complex offers have more places to fail, even the simplest solutions will suffer from a range of challenges.

3.1.3 Relevance is hard to monitor other than by asking passengers whether the service met their needs. Timeliness and reliability, however, are more amenable to objective systems analysis.

3.1.4 This section identifies some possible measures to monitor as Key Performance Indicators (KPIs) for an RTI system. It concerns measures testing a system *outputting* to a downstream application. These are necessarily general and may need to be adapted for relevance to a specific local context.

3.2 ETM to centre

3.2.1 This paragraph describes the potential characteristics and KPIs for a link from a ticket machine to a server. The output can be measured at the input point to the RTI party system if required – the choice of this depends on who is responsible for the over air communication links.

- **Polling rate.** The polling rate is the stated rate at which messages are sent by a single ticket machine to the server, and if the server is the ticket machine server, forward to the RTI server. Measurement is by view of the event log for the RTI system (checking receipt frequency) or, if confident, the stated and evidenced value from the feed system supplier. This is a simple measure of system capability – 10 to 12 seconds is regarded as a minimum polling rate for effective vehicle tracking and cleardown of displays.
- **System Receipt Lag.** This is a factor of the comms between ETM and Server system. The time of an average message is noted and the receipt of that message. RTI systems usually do this automatically and report on it. It is possible to audit this manually and as a sample exercise this may be useful where the report is doubted. This identifies issues where there are throughput problems between vehicle and server.
- **System Process Lag.** This is a factor of the RTI system. The time of the message receipt is noted and the reaction to that message at RTI system output is compared. RTI systems usually do this automatically and report on it. It is possible to audit this manually and as a sample exercise this may be useful where the report is doubted. This identifies issues where the RTI system isn't handling messages received by it.
- **System Delivery Lag.** For each receiver of data (e.g. SIRI and other forwarding messages) from the system, the system will hold the time between receipt into the ETM Server and delivery to each subscription.
- **Number of buses reporting.** A time(s) is chosen each day – usually peak – 0830 and 1500 – and the number of buses tracking is compared to those scheduled to track at that time. (This could, instead, supplied for each hour of the operational day 5am, 6am etc) There are simple reports within the RTI system that identify this. In terms of the RTI system this is a very simple measure and measures operator and feed system performance. In our view no notice should be taken of buses not equipped or similar – this is academic to the RTI. This identifies issues with on bus equipment.

- **Journey tracking percentage.** This is also a historic report. At the end of each day/week, a summary of the total number of journeys/trips operated is compared to the number actually tracked (where tracked is defined as having specifically cleared down 70% of stops on that trip) and reported as a percentage. This identifies network blackspot and driver input issues which can be followed through.

3.3 Centre to display

3.3.1 This paragraph describes the potential characteristics and KPIs for a link from a central RTI server to a system providing a display service. The output can be measured at the input point to the third party system if required – the choice of this depends on who is responsible for the communication links.

- **System Lag** (this could be split into Receipt/Process and Delivery lags as above). The RTI system could be fed from a SIRI feed where the messages are received in batches, many up to 10 seconds old. This means much of the lag is in delivery and not related to the speed of processing messages. Also note that lag stats should be held per data source (e.g. per SIRI subscription). This is a factor of the RTI system. The time of an average message receipt into the RTI system is noted and the receipt of that message at the CMS system input is compared. This may need collaboration between the CMS and RTI systems. It is possible to audit this manually and as a sample exercise this may be useful where the report is doubted. This identifies issues where the RTI system isn't processing messages received by it, or where the messages are too old or batched in such a way to be unusable.
- **Journey tracking percentage.** This is also a historic report. At the end of each day/week, a summary of the total number of journeys/trips operated is compared to the number actually tracked (where tracked is defined as having specifically cleared down 70% of stops on that trip) and reported as a percentage. This is compared with other data to locate issues. When used here, it identifies whether information is being lost on processing within the RTI system
- This report is a test of the **prediction algorithm**. Effective RTI systems provide reports which show the predicted time of arrival when the scheduled time for arrival is, say, 10 minutes away. The report allows analysis of the predictions as the arrival time approaches, and then shows the difference between the '10 minute' predicted time and the actual arrival time at a stop. It tests the reliability of the information sent to the passenger.

3.3.2 In addition, a measure is needed for the **responsiveness** and **consistency** of various channels to displaying messages received from the RTI system. This can only really be done on the street. It quantifies the effect of differing assumptions in the main (eg does "1 minute" refer to a delay between 30 seconds and 90 seconds, or between 60 and 120 seconds?).

3.3.3 Measurement is best undertaken by looking at a bus approaching a stop on the RTI operator console (if available) and comparing actual arrival to arrival on the console, and comparing both to arrival on a screen/app/web interface. It is only effective as a manual process and if undertaken regularly (either by the RTI supplier or by the RTI system owner). There should be no more than 30 seconds difference.

3.4 Summary

3.4.1 The table below summarises the KPIs discussed above, with their function and possible target values.

Measured characteristic	**Description**	**Affected characteristic**	**Example target value**
Polling rate	Number of seconds between SIRI compliant messages	Cleardown at stop	Once every 10 to 12 seconds
System Receipt lag	Difference between date/time stamp on messages and receipt into incoming queue	Timely and accurate RTI data provision to system outputs (SIRI etc)	2 seconds max
System Process lag	Difference between date/time stamp of message receipt and message processing	Timely and accurate RTI data provision to system outputs (SIRI etc)	2 seconds max
System Delivery lag	Difference between date/time stamp on messages and delivery to all endpoints	Timely and accurate RTI data provision to system outputs (SIRI etc)	2 seconds max
Percentage of buses identified within the system as tracking	%ge of equipped buses tracking into the receiving system.	All RTI	97% plus
Journey tracking percentage	Percentage of journeys tracking and identifying more than 70% of stops over a day	All RTI	90% plus
System lag (could be split into Receipt/Process and Delivery lags)	Difference between date/time stamp on messages received by the RTI System and actual time of receipt into third party system	Timely and accurate RTI data on bus and at stop	1 second max
Journey tracking percentage	Differential Percentage of journeys/trips tracking and identifying more than 70% of stops over a day in the Ticket machine output feed as compared to the RTI output feed	All RTI	99% plus
Real Time prediction accuracy	That predictions made 10 minutes before arrival at timing points are no more than x seconds different to actual arrival time	Accurate predictions	60 seconds variance on average

4 Technical interface issues

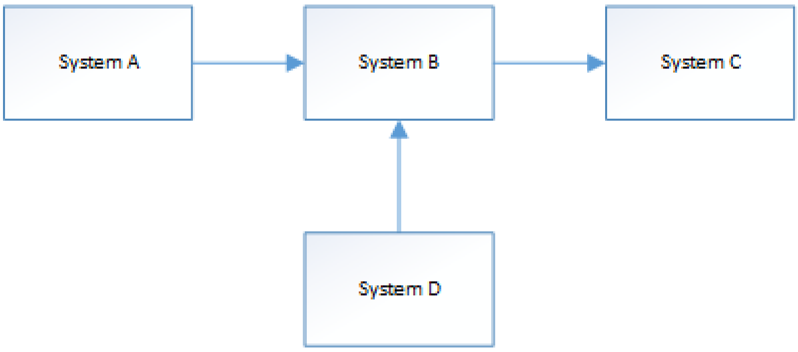
4.1 Architecture

4.1.1 RTI involves links between several different technology systems, conencted together through a series of functional roles and data exchanges. Reliable RTI therefore depends not only on each system doing its job, but on the links between them being well understood, well managed and maintained, and currently operational. Management tools such as standards compliance and service level monitoring are likely to be helpful.

4.1.2 As the systems involved may belong to different organisations, this may involve commercial as well as technical agreements. Advice on these is out of scope for this document: it is assumed that the necessary insitutional arrangements are in place and accepted by all parties, and that any restrictions this imposes are addressed in the end to end system design (for instance, no system is dependent on data where there is no agreement to supply it).

4.2 Generic considerations

4.2.1 A typical multi-component system might look like this:



4.2.2 In this diagram:

- System A is the source of data
- This is then processed through (and possibly modified by) System B, taking into account additional information provided by System D
- What comes out of this is provided to System C for users to interact with

4.2.3 For example, System A might represent an on-bus AVL device, System B a central fleet management system, System D an external traffic management system (providing data on network congestion), and System C a public RTI service.

4.2.4 In this architecture, the aim is clearly that the data presented by System C accurately reflects the data in System A. However there are a number of reasons why this might fail to be the case, for instance:

- A system makes "unauthorised" changes to the data it receives
- Some data fails to be transmitted because of software or configuration issues
- Some data fails to be received because of software or configuration issues

- Some data fails to be received because of problems with the communication channel
- Some data is received but not understood
- Some data is received but not understood
- Synchronisation of processes is not fully achieved
- Hardware is faulty

4.3 RTI application

4.3.1 In the context of RTI systems, the following table shows some of the more common ways in which these kind of problems manifest.

Description	Example
Data from System B adds to data sent from System A	System A used for timetables and doesn't include duty information needed in an RTPI system.
Data from System B replaces data sent from System A with that received from System D	System A uses local Operator codes which are replaced by National codes
System C does not import all the data received from System B	GIS information that was available in system A is not required by system B, so not imported and therefore not available to System C.
System B re-generates data for itself / ignores the data from system A	Geometry (track) information in system B is in one format e.g. OSM whereas System A is OS ITN
Failure of the transmitting system to convert its' internal data into a format that can be distributed.	Older systems may allow non-NaPTAN stop codes to be used. These can't be exported in TXC
Software or configuration issue that results in data not being transmitted.	System A may hold data for multiple Local Authorities, but configured to only export data for a single LA System A may be configured to export CIF rather than TXC
Software failure of the transmitting system or receiving system	Simple, good old software failure
Failure of the receiving system to receive (not listening)	Transmitting and receiving systems appear to be working, but the communication channel is in a state where no data is communicated.
Failure of the receiving system to be able to process the received data (schema validation, interpretation)	TXC schema validation Interpretation of TXC Ability to match operator codes and other reference data
Failure or delays arising within the communications medium.	Dropped or corrupted packets No mobile coverage (AVL)
Faulty hardware	Especially on-bus, at stop display, ticket machine.

	Results in data not being sent.
Invalid data that can't be processed by the downstream system	Driver enters invalid duty into ticket machine Invalid NaPTANs Unrecognised data e.g. downstream system is not configured to show data, other than from Operator X. Data from Operator Y is included, it's not processed.
Interpretation of data (system B / C don't know how to interpret the data published by System A /B)	Local versus national operator codes Reference data in one system that doesn't match that in another (ServiceIDs, TripIDs, etc)
Synchronisation of data between System C and System A arising from the delays of the receiving system to be process the received data into a state that it can be used.	e.g. regional Traveline versus national Traveline versus GTFS – all have different update frequencies that introduce time lags between the data in each system.