Recommendation 454

05/13

Real-time Data Interface

Based on VDV Recommendation 453

→ Schedule Information System

Version 1.2.2

Editing:

Commission for Information Processing

Verband Deutscher Verkehrsunternehmen (VDV)

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RUDY Joint Project
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Project coordination:
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The initial version of the interface was created with funding from BMVBW. This means that the specification is freely available.

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History of changes from V 1.2 to 1.2.1 or 1.2.2

VDV, Winfried Bruns

Position	**Change**	**Author**	**Date**
6.2.2.1	New: Implementation notes	WB	30/01/2012
6.2.1 7.1.7	Hysteresis (Hysterese): Addition: The deviation must be greater than or equal to the specified value before deviations are transferred.	WB	30/01/2012
6.2.2.1	Notes on the 'extra trip'	WB	30/01/2012
6.2.2.3	Addition of prognosis quality levels	WB	30/01/2012
6.2.2.5	Addition of *TimeQualityType (ZeitQualitaetType)*	WB	30/01/2012
5.2.2.3	Inclusion of DirectionText (RichtungsText) from errata of the previous versions: RealStop	WB	05/04/2012
	Addition of the prediction quality appendix	WB	05/04/2012
5.2.2.1	Additional TimeStamp element in RealTrip	WB	16/01/2013

1 Foreword

This VDV Recommendation presents the initial extensions on the basis of the 'Integration Interface for Automatic Vehicle Location and Control Systems' in accordance with VDV 453 Version 2. It deals with interfaces for coupling AVLC systems with schedule information systems. Based on the wide range of different types of AVLC and schedule information systems currently in use, a standardised interface will significantly ease the process of providing comprehensive dynamic passenger information. The aim is to provide a means of making AVLC data concerning the current schedules as well as the real-time data on the actual operational situation available to the schedule information systems, in order to be able to offer the passengers more accurate travel information.

The underlying concept as outlined in VDV Paper 453 version 2 follows the approach of a universal interface for the integration of AVLC systems, which allows the participating transport operators to implement such functionality at an acceptable cost. The technical implementation is based on standard technologies (http/XML). It defines common limiting requirements on the design of the interface and describes the data exchange in detail (subscription procedure). Experience gained from the first practical implementations has already been incorporated into version 2. All references in this paper to VDV 453 relate to VDV 453 version 2.

The modern service architecture with a communication structure based on the subscription method provides a simple means of integrating further services, even to external non-AVLC specific systems. Together with the new interfaces specified here, the available interoperational services are now as follows:

Service	Aims	Document
Reference data service for transfer protection (REF-CP)	Exchange of planned schedules for transfer protection	VDV 453
Process data service for transfer protection (CP)	Exchange of real-time data for transfer protection	VDV 453
Reference data service for passenger information (REF-DPI)	Exchange of location-related planned schedules for passenger information	VDV 453
Process data service for passenger information (DPI)	Exchange of real-time data for passenger information	VDV 453
Process data service for visualisation (VIS)	Exchange of real-time data for the visualisation of vehicles in third-party control centres	VDV 453
General message service (GMS)	Exchange of written information between the control centres	VDV 453
Reference data service for schedule information (REF-SIS)	Exchange of planned schedules for schedule information	**VDV 454**
Process Data Service for Schedule Information (SIS)	Exchange of real-time data for updating the schedule information with current data	**VDV 454**

This VDV 454 paper is based on a proposal that has been worked out by the partners of the BMBF commissioned RUDY project [1] under the overall control of FAW Ulm, which is also to include implementation and testing. Coordination with the wider circle of schedule information system manufacturers and the AVLC industry in general, including transport operators, will be undertaken within the scope of the FOPS 70.0701/2002 research project of the Federal Ministry for Traffic, Construction and Housing (BMVBW) by BLIC, IAV and FAW Ulm under the technical supervision of VDV. This includes consolidation of the specification as well as verification of compatibility with VDV 453. The users of schedule information systems are included via the DELFI workgroup.

This document does not repeat all the basic communication information outlined in VDV 453, it simply references certain important areas.

In the 1.2 version various errors have been corrected and the functionality partially extended. Furthermore, implementation tips have been added, which do not refer directly to the interface specification but are included to clarify use of the interface as well as application and interpretation of the transmitted data.

The associated XML schema caries version number 2.3.

The current XML schema serves as a reference for implementation of the services (see the VDV websitehttp://www.vdv.de/i-d-s-downloads.aspx),

The respective text line represents an explanation of the given application.

2 Introduction

2.1 General Tasks

Schedule information systems are already widely available in Germany. Depending on the level of data integration, the coverage of individual systems ranges from consortium or countywide coverage right through to information systems that offer nationwide coverage. Furthermore, the individual systems are linked via the DELFI network, which facilitates continuous connection information without the need for data integration.

A schedule information system must be able to respond to customer enquiries concerning departure times, arrival times and connections for different periods of time:

- Long-term: 'How do I plan my journey to X next week?'
- Mid-term: 'What's the best way to the opera tonight?'
- Short-term: 'When does the next bus leave from the stop opposite?'

In general, only the published schedules that are valid for longer periods are made available to the schedule information system for all request periods. For the purpose of long-term journey planning, this data represents the most up-to-date and with that the best foundation. However, neither the day-to-day changes in the journey planning nor the current events within the operation can be included in the schedule information on the basis of this data. It is therefore obvious that the quality of information provided in response to mid and short-term enquiries can be significantly improved when using more up-to-date data.

It is extremely important for a good information system that the actual data is not just available for individual stops or connection areas but for the largest possible number or ideally all routes and stops. On the basis of current data, it is possible to implement the following dynamic schedule information functionalities:

- **Stop monitoring** (departures and arrivals board):

  'When do the next buses arrive at this stop?'

  'When do the next buses depart from this stop?'

- **Connection enquiry:**

  'How do I get from A to B?'

- **Passenger travel guide** (information before and during the trip on a 'pre-booked' journey)

  'Now approaching stop...'

  'Receiver vehicle at station X will be missed. Next possible connection with bus number 11'

'Please change to route 13 at the next stop'

- **Commuter information service**(similar to the travel guide service but for regular journeys)

  'Your regular bus is not operating today. Next possible service....'

Current daily planning data, such as the subsequent dispatch of additional trips or cancellations, are recorded in the operational planning and imported into the automatic vehicle location and control system (AVLC) before the start of operation. Actual real-time information, such as current delays, trip failure or short-term disturbances only exist in the AVLC system.

Until now, operators have only had access to proprietary exchange mechanisms and formats between the tools of the journey planning and schedule information systems. These mechanisms permit the updating of the schedule information system data with the modified schedule planning data on a daily basis and are already being used in productive operation. Prototype interfaces between AVLC and schedule information systems for transferring the real-time operational data have already been tested in various pilot projects. These are also product-specific in design.

With ever increasing numbers of AVLC systems, some regional, and the different planning systems they use, the operators of schedule information systems are being confronted with a huge number of necessary system links. This relates to the different ways in which planning interfaces have been implemented, the real-time data interfaces and in particular the shortfall in compatibility between the different software packages for real-time and planning data exchange. This has restricted the distribution of exchange mechanisms, as they are associated with unacceptable expenditure in terms of time and cost for each individual system coupling. Furthermore, it is almost impossible to guarantee the customer consistent quality standards.

It is a similar situation for the AVLC operator, for whom a common solution for the various services involved in both an AVLC-AVLC link and links to other external systems would be extremely advantageous in terms of purchase and operating costs. Under the initiative of the Federal Ministry for Traffic, Construction and Housing (BMVBW) something is finally being done about the latter. With VDV 453 we have started the standardisation process for a universal interface for AVLC systems.

From a technical point of view, the communication infrastructure for linking heterogeneous computer systems has been separated from the services within the interface. This means therefore that it is well suited to extension in the direction of schedule information systems.

2.2 Requirements on the Data Exchange

2.2.1 Transferring Updated Planning and Operational Data

Within the validity period of a regular seasonal schedule stored by the schedule information system, customer relevant changes have been made in the following areas:

- **Operational scheduling**
  The daily operational planning involves the creation of planned schedule data only. The transfer of this data, prior to the operational day, is relatively non time critical. In the operational processes, this data is overwritten by real-time data whenever there is a deviation from schedule. It is therefore referred to as the *reference data*.

- **Operational control centre**
  Short-term schedule predictions are worked out in the control centre and short-term dispatch actions established. This is real-time data from the current operational processes (*process data*).

Modification data must therefore be transferred to the schedule information system from two different sources. The daily operational schedule exists not only in the schedule planning but also in the AVLC control centre. In the opposite direction however, it is very unusual for dispatcher changes to be re-imported from the AVLC into the planning system.

Furthermore, both sources of data have different time horizons when it comes to their effectiveness. And on the basis of its function as a reference for the real-time data, the planning data must be managed differently in the schedule information system (see below). It is therefore advisable to transfer the operational scheduling data completely separately from the real-time data.

2.2.2 Referencing the Real-time Data

In order to generate updated information, the schedule information system must be able to incorporate the real-time data, which is transferred online, into its planning data and order it accordingly under strict time-critical conditions. This involves:

a) Trip identification via ID or route number etc.
b) Difference forming: Establishing any changes that have occurred

A decisive factor for exact referencing is that the transferred real-time data is coordinated with the planning data held by the schedule information system. The quality of the dynamic information is hugely dependent on this, as initial experiences with prototype installations of such interfaces within the scope of the BMBF research programme 'MOTIV' have shown. In a not insignificant percentage of cases, difficulties were encountered in referencing the real-time data to the planning data. And although the real-time data is of great significance in itself, it can only be used effectively in the schedule information system where there is exact referencing to the underlying database.

2.2.3 Supplying the planning data

With regard to the planning data supply, there are various possible situations, typified below:

- **Identical data sets (ideal case)**
  The AVLC system and the schedule information system have a common base data supply with all planned schedules. Using proprietary update mechanisms, mid-term decisions, affecting the following operational day, are also communicated.

- **Partially identical data sets**
  The AVLC system and the schedule information system only have a common status of the planned schedules. Any further updates are not normally communicated.

- **Inconsistent sources**
  The schedule information system cannot be sure of having the same planned and daily-adjusted schedules as the AVLC interface partner. This inconsistency is caused by organisational conditions such as geographic overlapping, multiple responsibilities between operators and agencies, connection problems or others. Furthermore, technical conditions can also restrict the consistency of the databases. In general, different terms are used in the schedule planning, the AVLC and the schedule information system. This referencing problem is solved by the creation of conversion tables (see chapter 4.3), but these require constant management and updating.

Against the background of the importance of coordinated planned schedule data as a reference, the resulting demands on the exchange of planning data are as follows for the different situations:

Type	Reference data supply
Identical data sets (ideal case)	No further actions necessary
Partially identical data sets	Day to day exchange of modifications to the planned schedules
Inconsistent sources	Day-to-day exchange of all planned schedule information

3 Introduction and Basic Terms

3.1 Structure of the Interface

3.1.1 Communication versus Service Layer

The interface consists of two layers (Fig. 1).

- Communication layer
- Technical service layer

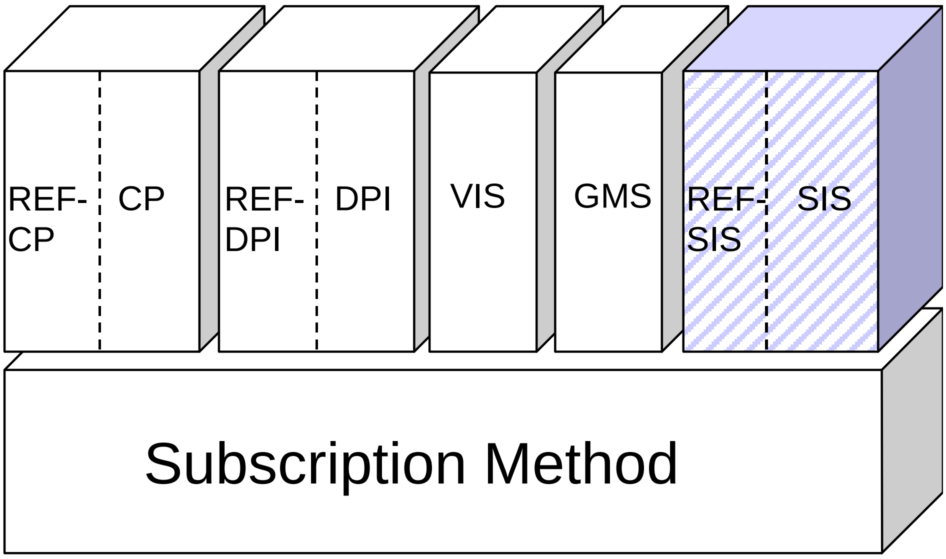

Fig. 1: Overall architecture

The communication layer defines a standard procedure for requesting and then exchanging data. This procedure is hereafter referred to as the subscription method. The data consuming system creates so-called subscriptions, which define the type and amount of data to be exchanged. This definition is technically specific and with that already encapsulated in the technical layer. The communication procedure is the same for all services and represents the interface infrastructure (message referencing, error handling, reset behaviour). Reusing it for the various technical services ensures cost-effective implementation and extension of the interface.

The technical services are in turn built on the communication layer and address various application areas such as transfer protection, dynamic passenger information, etc. The services are independent of one another, allowing any number of services to be implemented. This guarantees application-specific implementation.

3.1.2 Reference Data versus Process Data

The data exchanged via the technical services can be split into two classes:

- Reference data (planning data)
- Process data (real-time data)

In the services of VDV 453 (CP, DPI) the exchange of reference data provides a basic data supply for the subsequent exchange of process data.

The exchange of reference data generally represents an alternative to the exchange of data at the level of data management. The implementation and use of a reference data service depends on the application case as well as the technical operational requirements. Each individual service can therefore consist of two separate technical services. Within the interface, the process data exchange and reference data exchange are implemented as two separate independent technical services.

These statements also refer to the schedule information service of VDV 454. Here however, the reference data service (REF-SIS) also has an inherent quality. With the exchange of daily updated schedules, it complements the pre-planned schedule information with recent changes, which significantly improves the quality of information provided to the passenger.

3.1.3 Controlled Subscription Method

There is firstly the possibility of mutual control of the data traffic. The strengths of the subscription method are recognised in the transmission of large volumes of data (segmentation, limitation). Contrary to the transfer protection and dynamic passenger information services, the selection possibility offered by the subscription method, which allows the volume of data to be reduced to interesting data only, is of secondary importance in the schedule information interface, as the operator of such systems is generally interested in all available data.

The interfaces can also be integrated into the existing configurations of technical systems. This allows a modular design and step-wise implementation of the given objectives. This represents a cost advantage for the AVLC operator, as the infrastructure already in existence for the services of the AVLC-AVLC coupling can also be used for REF-SIS and SIS. This means there is no need for any new installations or the need to learn new handling practices. However, the communication infrastructure does need to be newly installed at the schedule information system level. There are also cost benefits here, which arise due to simultaneous usability for many different data sources. The interface described here allows several AVLC to simultaneously exchange data with several schedule information systems and vice versa (m to n relationship).

The base communication procedure, which is based on the subscription method, is explained in chapter 5.2. In order to avoid any inconsistencies, this document simply references VDV 453 in its explanations without repeating the description of the methodology.

3.2 SIS, Schedule Information Data Service

3.2.1 Overview

This paper describes an interface between automatic vehicle location and control systems (AVLC) and schedule information systems for the largely automated transmission of current schedule and operational status information.

It is designed as a new service extension to the AVLC integration interface as outlined in VDV 453 and consists of a set of two mutually coordinated part services:

REF-SIS: Schedule information reference data service
Up-to-date planned schedules for mid-term enquiries

SIS: Schedule information process data service
Real-time data from the operational procedure for short-term enquiries

These two services are implemented as modules of the communication infrastructure in accordance with the subscription method and with regard to VDV 453 represent supplementary services within the general basic infrastructure. They fit into the overall concept of the AVLC universal interface and with that have all the advantages of this new technology.

The common architecture of VDV 453 and VDV 454 is represented in Fig. 1. The schedule information service can be implemented independently of the VDV 453 services. It therefore represents a stand-alone implementation module in the sense of the VDV interface architecture.

3.2.2 The REF-SIS and SIS Services

The functionalities of the two services, REF-SIS and SIS, have been developed to ensure mutual compatibility. REF-SIS transports the planning schedule data and SIS the real-time data relating to the current operational situation. Both services can be used individually. However, the overall quality is much improved if both services are used between the two interface partners, so that the real-time data can be related to the previously transmitted planning data.

The reference data service (REF-SIS) communicates the data from the operational planning, the process data service (SIS), the real-time data and dispatch actions from the current operational procedures of the AVLC control centre. The reference data service is deactivated after transmission of the planning schedule data, whilst the process data service runs in parallel to daily operation.

Both services incorporate cancellations as well as additional trips and any changes to trips or their attributes. As the schedule information system usually only knows the trips that are relevant to the passenger, the AVLC should only transmit these productive trips to the schedule information system. Otherwise, the schedule information system would offer services that do not actually carry any passengers.

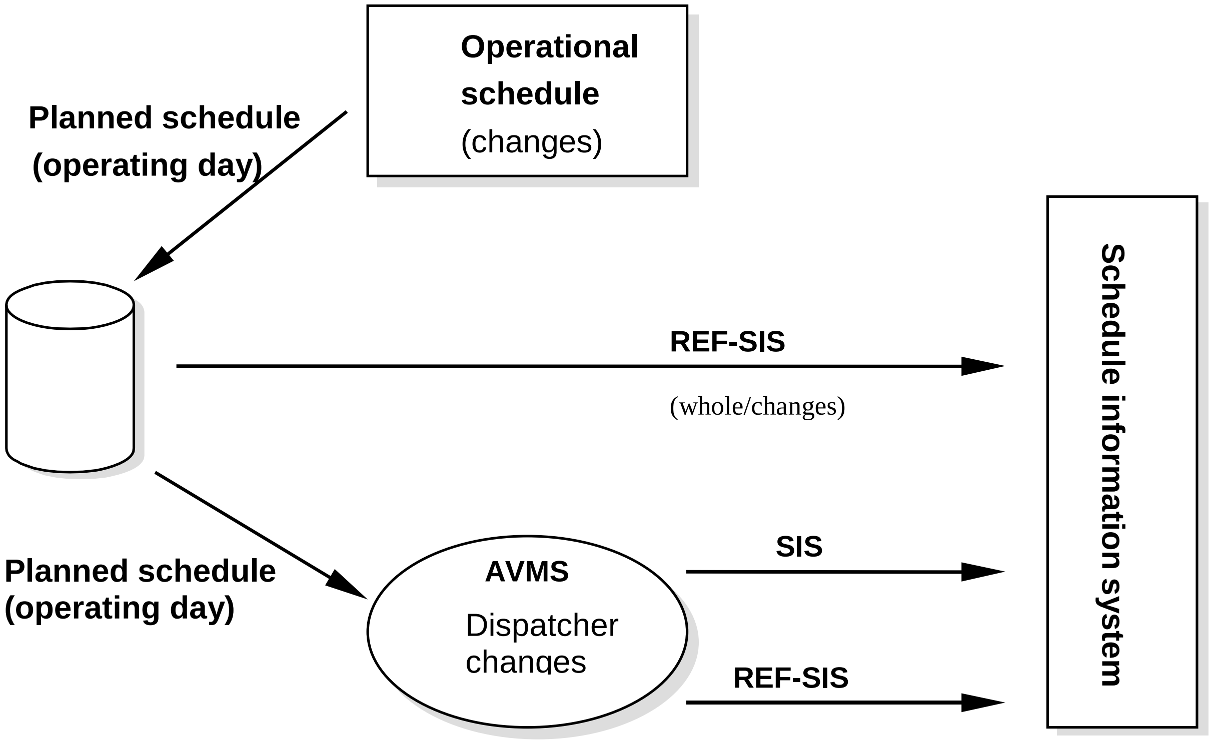

Fig. 2: Application area of REF-SIS and SIS

Fig. 2 represents the functional system architecture with the REF-SIS and SIS interfaces.

REF-SIS can be used on its own if the application partners accept the accuracy offered by daily updating of the data for the schedule information system.

REF-SIS can be used in two different versions, in order to take into account the different limiting conditions of the existing planning data supply:

1. Transfer all schedules for the operational day
2. Only transmit the changes to the planned schedules

If the planning database is provided on both sides, REF-SIS is designed to automatically transmit the daily deviations from this base.

The SIS service is also independent of REF-SIS, which means that in projects with ideal planning data supplies, the REF-SIS service can be omitted.

Generally however, REF-SIS is used to improve the planning database for SIS service referencing and with that to guarantee the quality of the dynamic schedule information. The quality of the reference data supply of the schedule information system depends on the used systems and the organisational conditions and must be checked in each individual project. From the view of the system partner, the use of REF-SIS is strongly recommended.

The data that is exchanged in these services is always related to the schedule. The general message service of VDV 453 is used to transfer text messages.

Overall, the design of the REF-SIS and SIS service pair takes into full account the variety of practical limitations imposed on and by the application partners. This satisfies the technical prerequisites for wide distribution.

3.2.3 Functional Scope of REF-SIS

The reference data service REF-SIS communicates the changes between the planned schedules in the schedule information system and the schedules in the AVLC that are updated on a daily basis.

It is possible to transmit the following information:

- Cancellation or addition of trips
- Change to pattern, stop out of use
- Change to mode of transport / vehicle equipment
- Bay / platform change
- Changes to attributes (passage, no alighting and no boarding, extra trip, provision for cycles, unscheduled stops, info texts)

Reference data exchange is either full or differential. Full data exchange involves the complete daily schedule being transferred to the schedule information system. This schedule replaces the planning data from the seasonal schedule (planned schedule that is valid for a certain length of time).

In differential mode, only the changes with regard to the seasonal schedule are transmitted. In order to be able to carry out this type of data exchange, both schedules must be based on common planning. Within the context of a subscription request, a unique reference to the base schedule or a reference to the seasonal schedule is specified, from which the base schedule can be derived.

The reference data service therefore not only updates the data of the schedule information system but also provides a referencing system, by which the subsequent real-time data can be more easily and quickly incorporated into the complete database of the schedule information system.

3.2.4 Functional Scope of SIS

The real-time data exchange complements the planned schedules with up-to-the-minute information that is given from the current traffic-related or operational situation. This is trip-related information. It may be caused by traffic problems (delays, congestion) or dispatch actions (diversions, reinforcement trips, turnarounds). On an operational level, the results of dispatch actions are understood as short-term planning data but are transmitted within the process data interface.

The sovereignty of the information remains with the AVLC. For example, it is not the actual delays that are exchanged but the prognosis.

In general, the validity sequence in evaluating the available information is as follows:

- Process data
- Reference data
- Seasonal schedule data

Aside from the addition of pure real-time data (e.g. schedule status), the process data service “overwrites” the planning data (e.g. path changes) from the reference data service or the seasonal schedule if there has been no exchange of reference data.

Fundamentally, this deals with:

- Cancellation or addition of trips
- Change to pattern, stop out of use
- Change to mode of transport / vehicle equipment
- Bay / platform change
- Schedule deviations (delayed/early) upon violation of a threshold value; stop specific
- Traffic jams
- Vehicle capacities / passenger loads
- Changes to attributes (passage, no alighting and no boarding, extra trip, provision for cycles, unscheduled stops, info texts)

3.2.5 Limitation to the DPI Service

It is important that schedule information systems have access to actual data concerning not only individual stops, connection or display areas but for as many of the routes and stops as possible within the AVLC network. This is the only way a schedule information system can calculate connections in the route network that take into consideration the real-time data. Some of these requirements can also be covered by the REF-DPI and DPI services that exist in VDV 453. To ensure the efficient processing of the data in schedule information systems it is essential that it is provided in an adequate structure on the basis of trips and transferred as such rather than as a sum of the DPI signs at individual stops. The handling of this volume of data with the dynamic passenger information would be extremely uncomfortable for both interface partners. The DPI service considers the transmission of real-time information from the point of view of the stop, the SIS service takes a network wide view.

3.3 Meta Data, Matching the Stops and Routes

As a schedule information system has to integrate data from several different operations and even various agencies into a single compound database, it cannot be assumed that the same codes are used to represent the same stops and routes in the AVLC and the schedule information system.

Stops, routes and other data are therefore formed into meta data. The IDs used here must be agreed bilaterally. This then demands the creation of allocation tables between the meta data IDs and the local IDs.

The meta data must be agreed between the two communication partners in each case. Universal agreements are not required.

The meta data types are as follows:

- **StopID (HaltID, stops):**

  The level of division of the stops (stop or stopping point) need not agree on the two different sides. It is only important to ensure the meta stop can be matched to a locally known object on both sides.

  Example:

  Under meta ID 4712 the AVLC interprets the stopping point "Central Station Tram Platform 2". The schedule information system on the other hand matches it to tram stop area 5, of stop 2011, 'Central Station'.

- **LineID (LinienID, route):**

  The meta route must be matched to the locally known route on both sides.

- **DirectionID (RichtungsID):**

  For every route, the trips are arranged in one or more directions (e.g. outward and return). The DirectionID allows matching with the locally known directions.

- **ProductID (ProduktID):**

  The product allows a classification of the transport vehicle. The meta product must be matched to the local product.

  Examples of product classes are: 'High-speed trains', 'long-distance trains with surcharges', 'local trains', 'city buses', 'regional buses', 'commuter trains', 'underground trains', 'trams', etc.

  Product classes are useful, for example, for splitting the journeys into fare-based structures or for modelling transfer times ('The monthly pass is valid on all local buses and underground trains' or 'Transfer time between the long distance trains and city buses is 5 minutes, unless otherwise indicated at the stops').

  The TransportModeText element of a route comprises the local name of the mode of transport used on the route. The TransportModeText should not be confused with the product. Two routes of different operators can belong to the same product class (e.g. 'tram'), but carry different TransportModeTexts (e.g. tram train or city tram).

- **VehicleTypeID (FahrzeugTypID):**

  The vehicle type is used to describe the level of equipment in the vehicle. Within a city bus route for example, the individual trips can be served by buses with very different features. For people in wheelchairs or mothers with prams it is important to know whether there is a ramp or lift, or whether the bus is a low-floor bus offering easy access.

- **ScheduleVersionID (FahrplanVersionID):**

  The schedule version is used to denote a special status (version) of a planned schedule.

3.4 Estimation of the Data Volumes

Limitation of the exchanged volumes of data by the XML parser and connecting lines can represent a challenge for the suggested specification. For this reason, definitions have been made to restrict the volume of data on which the limiting estimations are based.

3.4.1.1 Assumptions

The generic 'LineSchedule' structure consists of n 'ScheduleTrip' structures, which in turn consist of m 'ScheduleStop' structures. In the sub-structures, it is possible to overwrite the details of the above lying category. The agreement is as follows: The fields in the sub-structures are optional and need only be completed and sent in the case of deviation. This avoids the transmission of redundant information. Information, which relates to the entire trip or even route, should be transmitted at the highest possible level.

The minimum data for transmission includes (see section 6 :Technical Services):

ScheduleTrip

- TripID (FahrtID)
  - TripName (Fahrtbezeichner)
  - OperationalType (Betriebstag)
- Possibly also ProductID (ProduktID) or VehicleTypeID (FahrzeugTypID)

ScheduleStop (SollHalt)

- StopID (HaltID)
- Departure time (Abfahrtszeit)
- DeparturePlatformText (AbfahrtssteigText)

RealTrip (IstFahrt)

- TripRef (FahrtRef)
  - TripID (FahrtID)

- TripName (Fahrtbezeichner)
- OperationalType (Betriebstag)
- LineID (LinienID)
- DirectionID (RichtungsID)

RealStop (IstHalt)

- StopID (HaltID)
- DepartureTime (Abfahrtszeit)
- RealDeparturePrediction (IstAbfahrtszeitPrognose)

In the model calculation it has been assumed that the schedule information system is informed with a change in delay of more than 2 minutes. With a pure change to the delay, then in accordance with the progression rule only the stops at which the schedule status changes are reported (assumption: every 10th stop). The schedule information system extrapolates the value of the last reported delay along the route until the next delay value is reported. In the case of dispatch actions the complete timetable is transmitted.

Using figures based on experience, the percentage share of delayed trips has been calculated for discrete delay stages under 'normal' conditions and for the extreme case of 'heavy snow'. These discrete stages represent the times at which the AVLC sends a message to the schedule information system in accordance with the hysteresis setting of 2 minutes.

Change messages with x min delay (SIS) in % of all trips

Trips with	Normal conditions	Heavy snow
< -2 min early time	5%	5%
> 2 min delay	50%	80%
> 4 min delay	20%	55%
> 6 min delay	10%	40%
> 8 min delay	5%	30%
> 10 min delay	1%	25%
> 20 min delay	0%	20%
> 30 min delay	0%	15%
> 40 min delay	0%	10%
Dispatch actions	5%	25%

It has been assumed for the calculation that under normal conditions delays are completely compensated, i.e. every trip is started and ended punctually. A trip delayed more than 10 minutes under regular conditions therefore, results in two entries in each delay row of the table However, when calculating the data volumes in cases of heavy snow, it is assumed that although trips can be started on time it would not be possible to compensate the delays. Neither method corresponds exactly to the actual operating conditions, but can be accepted as a good enough approximation for the purpose of our calculations concerning data volumes. Characteristic for the behaviour of a system under extreme conditions is firstly that significantly more (almost all) vehicles are delayed and secondly that many are severely delayed which means that the necessary message exchange increases per trip as the delay continues to increase.

Not taken into consideration:

- Transfer of connections (REF-SIS)
- Additional trip-specific or stop-specific information (see comments on optional fields)
- Additional attributes of the individual XML tags (30 byte / data element assumed)
- http protocol overhead

3.4.1.2 Estimation of the Data Volumes

For large-scale operations (60,000 trips/day, 40 stops/trip) this yields:

Total daily volume for REF-SIS:	300 MB	
Total daily volume for SIS:	90 MB	(normal conditions)
	270 MB	(heavy snow)

For a mid-sized transport authority (10,000 trips/day, 30 stops/trip) this yields:

Total daily volume for REF-SIS:	38 MB	
Total daily volume for SIS:	12 MB	(normal conditions)
	36 MB	(heavy snow)

3.4.1.3 Transmission Capacities

If we assume that data exchange is distributed evenly throughout an 8-hour day in the SIS process data service, then a mid to large-scale operation requires a connection with a minimum net transmission rate of 1.4 kB/s or 9.4 kB/s respectively for the purpose of exchanging process data. When operating under severe traffic conditions, delayed updating of the schedule information system must be considered due to the uneven distribution of messages at peak times. However, using data compression it is possible to reduce the large XML files to around 10-20% of their original size and with that to save on line capacity. This has not been taken into consideration in the data volumes listed above. When using data compression all relevant parties must have sufficient computing power to carry out data compression and decompression without significant time delays.

The REF-SIS reference data service generally exchanges the entire schedule once or twice a day. Although this takes place outside the peak times, in the worst cases, transmission to the schedule information system can take up to 1 hour. Data compression is also advised here. With data compression, the minimum requirement on the link for a mid / large-scale operation is a net transmission rate of approximately 2.2 kB/h or 16.7 kB/h for the reference data exchange. As this service deals with the transmission of large volumes of related data and the transmission times have a significant role to play, the bandwidth of the available transmission path has a direct influence on the time required for data matching in the schedule information system.

3.5 Assessment of Data Actuality

The process information with which a system creates schedule information is fundamentally aged by the step-wise processing through various different systems.

Position messages from a vehicle are generally processed by the AVLC in cycles, formed into predictions and then passed on to the schedule information service.

Particularly for the SIS process data service, we must ask how old the data actually is and to what extent this age must be considered in the context of issuing schedule information.

The individual processing stages must be analysed and the resulting times accumulated.

The following figures are estimations based on the experiences of AVLC and schedule information system manufacturers.

The following stages and times are to be expected as delays:

- **Recording and transmitting the vehicle location (AVLC)**

  Vehicles are usually recorded in so-called polling cycles. The vehicles are polled in series and their data processed. There is a minimum polling cycle that is determined by the network capacity and the number of vehicles. In the systems of today, this is generally between 15-90 seconds.

  As an alternative to this method, some AVLC systems communicate with their vehicles on an event-triggered basis. Here the vehicle determines its own schedule deviation and reports it to the AVLC after reaching a set threshold. Here the delays are typically between 5-15 seconds.

- **Transmission to the schedule information service (transfer via VDV 454)**

  This concerns the time that is required to transmit a message from the AVLC to the schedule information system. This includes the packaging of the information into the structures of VDV 454, transmission via a data line as well as the unpacking from XML back into binary data. Exact estimations are difficult here as the composition of the systems as well as the amount of data permit a lot of leeway.

  Single figure second values are to be expected.

- **Entry into the database (schedule information system)**

  If the data is available on the side of the schedule information system interface, then it must be entered into the global database. The necessary reference data must be located and extended or changed accordingly. Estimations from the manufacturer are in the range of 3-10 seconds depending on the extent of the changes.

This yields a complete delay within the information chain in the region of 2 minutes. To this must be added further delays on the side of the schedule information service, e.g. the transmission of an SMS. Overall, the delays are small enough to be able to issue short-term information.

3.6 Time Formatting

As the ISO Format 8601 supports several representations, the same solution as that used in VDV 453 is applied for the REF-SIS and SIS services:

Every piece of time information is related to UTC (Coordinated Universal Time). Deviations from this time zone are coded in accordance with ISO 8601 (e.g.: 2000-04-07T18:39:00+01:00).

Without a specification of time difference, the time is already in UTC. In this situation there may also be a subsequent Z (2002-04-30T12:00:00 corresponds to 2002-04-30T12:00:00Z). In other words, the first 19 characters are obligatory and correspond to local time or UTC.

This method of time representation avoids any problems with summer/winter changeover.

4 'Basic Infrastructure' Interface Description

4.1 Foreword

The specification described in this document extends VDV 453 with a further technical service. The following chapter describes the basic principle as well as the necessary extensions and modifications. In addition, the definitions made in VDV 453 concerning the areas of 'architecture' and 'basic infrastructure' are also valid within VDV 454.

4.2 Subscription Method

The so-called subscription method defines a common basic communication structure, on which all technical services are based. The subscription method consists of a set of request and reply messages, which define an asynchronous communication structure.

The concept follows the client-server model. System A (server) can make data available to another system B (client).

The concept is event-based. The data changes on the basis of an action in the server system (A), which is then communicated to the client system (B) (see Fig. 3).

The client and server first agree which information is to be exchanged. This is achieved by so-called subscriptions. Subscriptions are defined on the client side. The client sends a subscription request to the server and with that registers interest for specific data (step 1). The data concerned is defined within the actual subscription request. After confirmation from the server, the client can expect a subsequent supply of data.

The server (A) then informs the client (B) about new or modified data by means of a corresponding message (step 2). The client (B) can then retrieve the corresponding data from the server (A) (step 3).

In order to detect a server breakdown, status requests can be periodically sent to the server. With a status reply, the server confirms its functionality (step 4).

Subscriptions have a life span as defined by the client and once expired are automatically deleted by the server. Deletion can also be achieved prior to this by the client (step 5).

An exception to this definition is given by the REF-SIS subscription, it is quit immediately once all requested planned schedules have been transmitted (see 6.1). It must be re-initiated by the schedule information system (client) for the transmission of additional data.

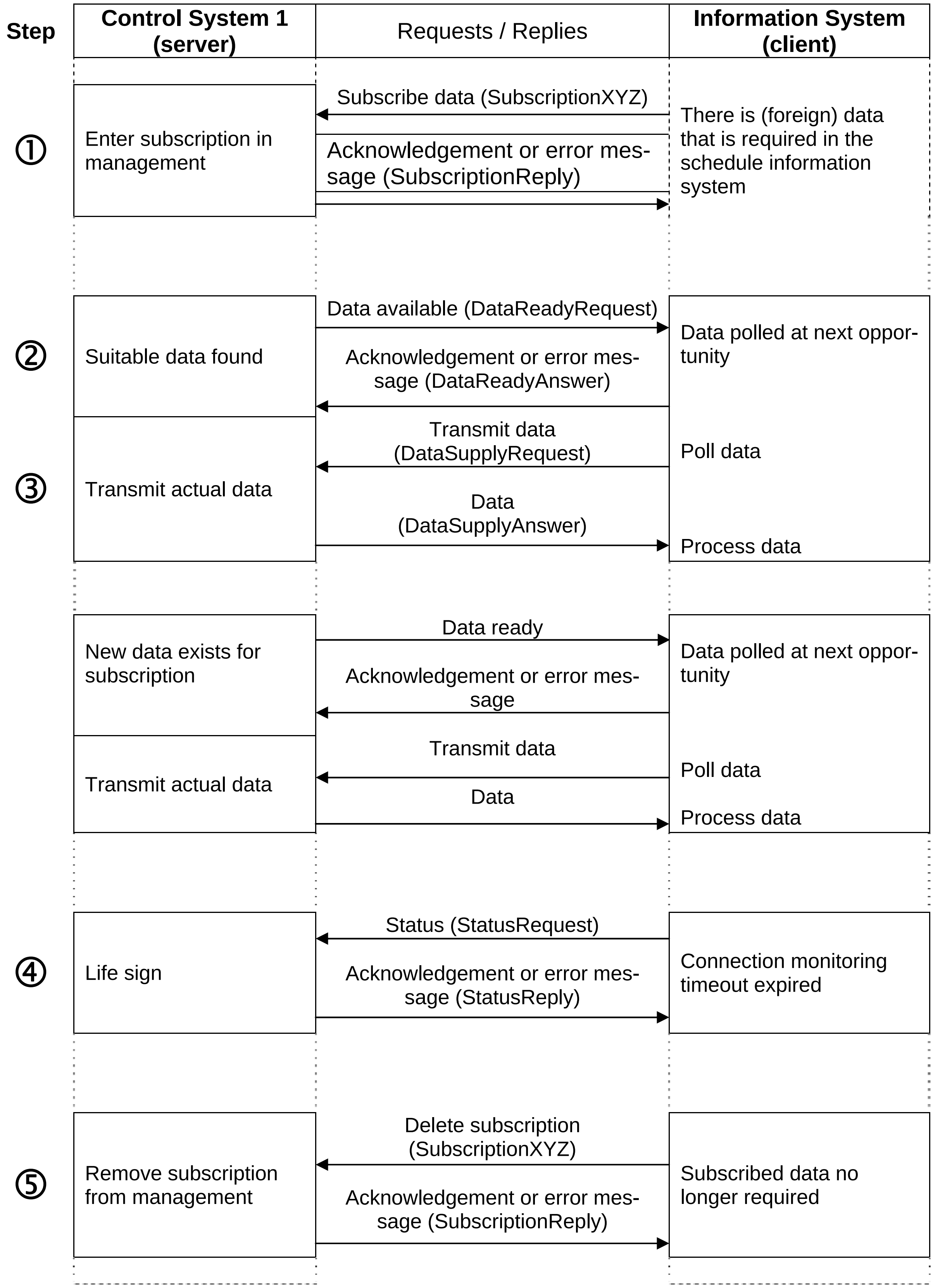

Fig. 3: Communication procedure for the subscriptions

The services are managed separately, according to service type. Subscriptions are referenced via so-called SubscriptionIDs. A SubscriptionID (AboID) is unique within a service. The client is responsible for assigning SubscriptionIDs (AboIDs).

A detailed description of the subscription method is given in VDV Recommendation 453 along with the procedures following a break in connection or in case of error.

4.3 Protocols

Two protocols are used in the interface:

HTTP/1.1 as the transport protocol

XML 1.0 for recording the technical data

4.4 Service Codes / Request URL

Every service in VDV 453 has a unique code (see VDV 453, chapter 5.2.3). The additional codes for the schedule information service are as follows:

- 'sisref' for the reference data service of the schedule information interface
- 'sis' for the process data service

In accordance with the conventions for target addresses (request-URL, VDV 453, chapter 5.2.4) a status request to the process data service of the schedule information interface, for example, would read:

```
http://serverhost:8080/fremdbetriebskennung/aus/status.xml
```

4.5 Common Data Types

The majority of data types of VDV 453 are also used within VDV 454. The data types of VDV 454 therefore are integrated into the schema of VDV 453. .

The following data types are reused in VDV 454 and for this reason are not described again here. If the data types contain sub-types, these too are used again.

The English aliases (see chapter 9) also remain valid.

Element	**Type**	**Description in (VDV 453)**
SubscriptionRequest (AboAnfrage)	SubscriptionRequestType (AboAnfrageType)	Chapter 5.1.2
SubscriptionReply (AboAntwort)	SubscriptionReplyType (AboAntwortType)	Chapter 5.1.2
DeleteSubscription (AboLoeschen)	DeleteSubscriptionType (AboLoeschenType)	Chapter 5.1.5
Confirmation (Bestaetigung)	ConfirmationType	Chapter 5.1.2

Element	Type	Description in (VDV 453)
	(BestaetigungType)	
DataSupplyRequest (DatenAbrufenAnfrage)	DataSupplyRequestType (DatenAbrufenAnfrageType)	Chapter 5.1.4
DataSupplyAnswer (DatenAbrufenAntwort)	DataSupplyAnswerType (DatenAbrufenAntwortType)	Chapter 5.1.4
DataReadyRequest (DatenBereitAnfrage)	DataReadyRequestType (DatenBereitAnfrageType)	Chapter 5.1.3
DataReadyAnswer (DatenBereitAntwort)	DataReadyAnswerType (DatenBereitAntwortType)	Chapter 5.1.3
TripID (FahrtID)	TripIDType (FahrtIDType)	Chapter 6.1.5
TripIDExt (FahrtIDExt)	TripIDExtType (FahrtIDExtType)	Chapter 6.2.4.4.1
TripInfo (FahrtInfo)	TripInfoType (FahrtInfoType)	Chapter 6.2.3.3.1
LineID	LineIDType	Chapter 6.1.6
Product ID (ProduktID)	ProductIDType (ProduktIDType)	Chapter 6.1.7
DirectionID (RichtungsID)	DirectionIDType (RichtungsIDType)	Chapter 6.1.6
StatusRequest (StatusAnfrage)	StatusRequestType (StatusAnfrageType)	Chapter 5.1.8
StatusReply (StatusAntwort)	StatusReplyType (StatusAntwortType)	Chapter 5.1.8

4.6 Use of the Optional Fields

The volume of data that needs to be transported within the scope of a schedule information interface significantly exceeds those of the services in VDV 453.

The use of optional fields is therefore more predominant to reduce the data volumes.

Whilst the presence of optional fields in a message within the technical services of VDV 453 indicates the technical support of a functional characteristic (e.g. quick cleardown), optional fields within VDV 454 are primarily used to reduce the data volume.

This means that the optional fields are only sent (where possible), when changes to the known information are to be communicated. In the case of an initial message this relates to the changes with regard to the planned schedule (reference data service or seasonal schedule), in the case of a subsequent message it relates to the changes with regard to the last message. If there are no changes to the values, these optional fields can be omitted with a renewed sending of the message. The previously sent values remain valid.

The planned schedule data is valid (reference data service or seasonal schedule) until the time at which the first message with optional elements is received.

This special use of optional fields excludes the use of XML default values.

5 Technical Services

5.1 REF-SIS (REF-AUS) Reference Data Service

This service has the task of transmitting daily updated planned schedules for all known routes within the AVLC to the schedule information system. This improves the quality of mid-term information and eases the referencing between real-time messages in the SIS service and the planned schedule. However, it is not absolutely essential for the functioning of the real-time data service.

The REF-SIS service is also used to transmit information concerning the planned connections and the linking of trips, in which the passenger is able to remain seated in the vehicle.

Due to the many advantages, systems that are able to provide the REF-SIS service should always use it. The cooperation between new, more powerful AVLC and schedule information systems will profit in particular.

A REF-SIS subscription is ended immediately after all requested planned schedules have been transmitted. It must be re-initiated by the schedule information system (client) for the transmission of additional data. This usually occurs in daily cycles.

As the schedule information system usually only knows the trips that are relevant to the passenger, the AVLC should only transmit these productive trips to the schedule information system.

5.1.1 Schedule Data Request (SISRefSubscription (AboAUSRef))

The subscription request for planning data is represented by the *SISRefSubscription* structure and contains the following elements:

Definition of *SISRefSubscription (AboAUSRef)*

SubscriptionID (AboID):	(attribute) The SubscriptionID (AboID) references the subscription of planned schedules.
ValidUntilTimeStamp (VerfallZst):	(attribute) Specifies the time to which the subscription is valid
TimeWindow (Zeitfenster):	Two time points ('valid from' and 'valid until'), which establish the time window for the validity of the planning data. The times relate to the departure time at the departure stop. Even if the departure time lies within the time window but the trip leaves it at a later point, the entire trip is still transmitted in one piece.
LineFilter (LinienFilter):	(sub-element, optional, multiple) Filter, restricting the routes for which the planned schedules are to be requested. No specification: No route filter. All routes known to the AVLC are transmitted.

BlockID (UmlaufID):	(optional, multiple) Filter restricting the block numbers for which the planned schedules are to be requested (alternative to LineFilter).
ScheduleVersionID (FahrplanVersionID):	(optional) This only includes changes with regard to the previously reported seasonal schedule with the specified VersionID. (Meta datum, see 4.3) No specification: No ScheduleVersionID. The AVLC transmits the entire planned schedule.
DataAvailableUntil (DatenVorhandenBis) :	(optional) Specifies the time to which the data is available, with regard to the status of the seasonal schedule with the given ScheduleVersionID.
WithProtectedConnection (MitGesAnschluss):	(optional) Specifies whether the transfer information, for which transfer protection is active, is also to be transmitted.No specification: Transmission without connection information

5.1.1.1 Time-based Restriction of the Data *(TimeWindow)*

The time points in the *TimeWindow (Zeitfenster)* structure refer to the respective departure times at the departure stop.

Definition of *TimeWindow (Zeitfenster)*	
ValidFrom (GueltigVon):	Start of the time window for the transmission of planning data.
ValidUntil (GueltigBis):	End of the time window for the transmission of planning data. Even if the end of a trip lies beyond the specified time window, the information about the whole trip is still transmitted.

The time period of the data to be transmitted can be further restricted with *ScheduleVersionID (FahrplanVersionID)* and *DataAvailableUntil (DatenVorhandenBis)* : If the *ScheduleVersionID (FahrplanVersionID)* of a SISRefSubscription request matches the schedule version of the AVLC, only the data in the time window defined by *DataAvailableUntil (DatenVorhandenBis)* to *ValidUntil (GueltigBis)* is sent. If the *ScheduleVersionID (FahrplanVersionID)* of the new *SISRefSubscription (AboAUSRef)* request does not match the version of the schedule of the AVLC, all data in the time window from *ValidFrom (GueltigVon)* to *ValidUntil (GueltigBis)* is sent.

5.1.1.2 Route-based Restriction of the Data *(LineFilter)*

The *LineFilter (LinienFilter)* structure allows the schedule information system to select individual routes of the AVLC system. If there is no LineFilter (LinienFilter) specified for the subscription, this implicitly implies transmission of data for all routes known to the AVLC. In other words, the AVLC can decide which routes it wishes to send data for.

Definition of *LineFilter (LinienFilter)*	
LineID (LinienID):	Identifies the route; meta datum (see 4.3).
DirectionID (RichtungsID):	(optional) This value is a meta datum (see 4.3). It typically identifies the outbound and inbound journey of a route. No specification: No direction specified. The AVLC transmits the planned schedule of the entire route, independent of the direction of the trip.

In place of an identification via the route or *LineID* it is possible to use an inter-operational referencing via the *BlockID* for a block-based representation of the schedule. It is not automatically possible with meta data in the sense of the VDV 453/454 Papers, as block numbers are assigned dynamically by the schedule and duty planning systems and change on a daily basis, contrary to the route numbers. Even the internal block number of the schedule planning system may not be known to the AVLC personnel. It is therefore necessary to use a different code to select a subscribed block. In the example of the graphical schedule for a single agency the following procedure has proven useful: After selecting one or more (all) routes, references to the corresponding blocks of the current operational day are reported by the AVLC to the visualisation system in the form of route/run numbers. On the basis of these references the user can select the desired blocks for display. It is not clear how this referencing can be extended to systems with several AVLC, which in the case of commonly served routes even describe the same physical blocks.

In the following example the schedule information system polls planned schedule data from the AVLC for route '10' in all directions. Data is to be sent for 24 hours starting at 9.30am on 21.7.2001. The subscription should be sustained for almost 2 months.

```
<AboAUSRef AboID="2" VerfallZst="2001-09-15T09:30:47">
            <Zeitfenster      GueltigVon="2001-07-21T09:30:47"
                              GueltigBis="2001-07-22T09:30:47"/>
            <Linienfilter>
                  <LinienID>10</LinienID>
            </Linienfilter>
            <FahrplanVersionID>22233</FahrplanVersionID>
</AboAUSRef>
```

A further method of breaking up the XML messages into smaller individual packets is offered by using the PendingData attribute in the DataSupplyAnswer element in the basic communication service.

In order to reduce the data volume it is possible to exchange only the changes instead of the entire schedule. However, there must be a guarantee that the daily updated schedule of the AVLC originates from the same database as the seasonal schedule of the schedule information system. The daily planned schedules generally exist as updates of the seasonal schedules. Over time, the deviations from the original seasonal schedule become greater. To use this function of the interface, the specific status of the active schedule version in the schedule information system is made known by specifying a ScheduleVersionID in the subscription request. If the same or an earlier version is active in the data sender, then it need only transmit the changes to the planned schedule in the REF-SIS service, i.e. changes with regard to the common status of the schedule version.

Non matching schedule versions in the two systems are acknowledged by a bilaterally agreed error message in the subscription reply (error class 200-299 'reference data violation', see VDV 453 Version 2, chapter 6.1.10). In this situation the subscription is not set up.

5.1.2 Transferring Data (SISMessage (AUSNachricht))

All data transmissions for a subscription (planning data, real-time data and connection information) are conveyed in the *SISMessage (AUSNachricht)* element.

Definition of *SISMessage (AUSNachricht)*	
SubscriptionID (AboID):	(attribute) The SubscriptionID (AboID) references the subscription created by the request.
LineSchedule (Linienfahrplan):	(optional, multiple) Contains the planned schedule (of a part) of a route. Used in the REF-SIS service.
DatedBlock (SollUmlauf):	(optional, multiple) Used for the block oriented transfer of the dated trips.
RealTrip (IstFahrt):	(optional, multiple) Contains current information on a trip. Used in the SIS process data service.
RealBlock (IstUmlauf)	(optional, multiple) Contains up-to-date real-time (estimated) information about a block
ProtectedConnection (GesAnschluss):	(optional, multiple) Contains information about a planned connection in the sub-element 'ConnectionPlan' or the actual connection status in the sub-element 'ConnectionStatus'

With a route-based subscription the information in the *LineSchedule* reply structure is route-specific and for a block-based subscription it is packaged in the *DatedBlock* reply structure.

5.1.3 Route-based Schedule Data Transmission *(LineSchedule (Linienfahrplan))*

A *SISMessage* element can contain several *LineSchedule* elements:

Definition of *LineSchedule (LinienFahrplan)*	
LineID (LinienID):	The LineID (LinienID) is used to match the AVLC route with the route of the long-term schedule specified in the schedule information system (see 4.3).

Definition of *LineSchedule (LinienFahrplan)*	
DirectionID (RichtungsID):	This value is a meta datum (see chapter 4.3). It typically identifies the outbound and inbound journey of a route.
ScheduleVersionID (FahrplanVersionID):	(optional) Transmitted data relates to the specified version of the seasonal schedule. No specification: Schedule version unknown
ScheduleTrip (Soll-Fahrt):	(0 to multiple) Structure with details on the trip.
ProductID (ProduktID):	(optional) Product that is used on this route. Can be adjusted for each individual trip. The ProductID (ProduktID) belongs to the meta data (see chapter 4.3). The product is used to classify the mode of transport. This allows sub-division into fare groups, transfer times, logos, etc. No specification: The product is derived from the annual schedule.
LineText (LinienText):	(optional) Route text if different from published schedule. Can be overwritten per 'ScheduleTrip (SollFahrt)'. No specification: The route text is derived from the annual schedule.
DirectionText (Rich-tungsText):	(optional) Text of the terminal stop (vehicle signage), if different to the published schedule. Can be overwritten per 'ScheduleTrip (Soll-Fahrt)'. No specification: The direction text is derived from the annual schedule (per LineID and DirectionID).
FromDirectionText (VonRichtungsText):	(optional) Text of the start stop or the direction from which the trip is coming. Can be overwritten per 'ScheduleTrip (SollFahrt)'. No specification: The text from the annual schedule (per LineID (LinienID) and DirectionID (RichtungsID)) is used.
TransportModeText (VerkehrsmittelText):	(optional) Description of the mode of transport used by the operation or transport authority, e.g. 'tram'. Can be adjusted for each individual trip. No specification: The mode of transport text is derived from the an-nual schedule.
PredictionPossible (PrognoseMoeglich):	(optional) Indicates whether all trips of this route are subject to con-trol by the AVLC. No specification: Prognosis is possible.
CyclesPermitted (Fahrradmitnahme):	(optional) It is generally possible to take cycles on this route. Can be adjusted for each individual trip. No specification: Information from the published timetable remains valid.
InfoText (Hinweis-Text):	(optional, multiple) Information on the route. No specification: No information available for this route.

5.1.3.1 Single Trip Data (*ScheduleTrip (SollFahrt)*)

In every *LineSchedule* or *DatedBlock* structure there are none, one or several *ScheduleTrip* structures with the following content:

Definition of *ScheduleTrip (SollFahrt)*

TripID (FahrtID):	The TripID (FahrtID) is used to match the real-time messages from the SIS service with the planned schedule.
ScheduleStop (SollHalt)	(optional, multiple) Structure with details on the stops in the pattern.
BlockID (UmlaufID):	(optional) BlockID (UmlaufID) is used to identify the block.
LineText (LinienText):	(optional) Route text if different from published schedule. No specification: LineText taken from 'LineSchedule'.
ProductID (ProduktID):	(optional) Product that is used for this trip. No specification: ProductID taken from 'LineSchedule'.
DirectionText (Rich-tungsText):	(optional) Text of the terminal stop (vehicle signage), if different to the published schedule. Can be overwritten section by section by the entry in the "Stop" structure. No specification: DirectionText taken from 'LineSchedule'.
FromDirectionText (VonRichtungText):	(optional) Text of the start stop or the direction from which the trip is coming. Overwrites the FromDirectionText (VonRichtungText) from 'LineSchedule (Linienfahrplan)'. No specification: FromDirectionText taken from 'LineSchedule'.
InfoText (Hinweis-Text):	(optional, multiple) Information on the trip. No specification: No information on this trip.
TrainName (Zugname):	(optional, for train services) Train name, e.g. "West Coast Express". No specification: No train name
TransportModeText (VerkehrsmittelText):	(optional) Name of the mode of transport, e.g. 'tram'. No specification: TransportModeText taken from 'LineSchedule'.
PredictionPossible (PrognoseMoeglich):	(optional) Indicates whether this trip is controlled by the AVLC . No specification: PredictionPossible taken from 'LineSchedule'.
ExtraTrip (Zusatz-fahrt):	(optional) Indicates that this trip is transmitted as an addition to the planning data (can only be used when both communication partners recognise the same schedule version). No specification: The trip does not represent an addition with regard to the common planning data.
Deleted (FaelltAus):	(optional) Indicates that this trip has been deleted, contrary to the planning data (can only be used when both communication partners recognise the same schedule version). No specification: Trip not represented as 'deleted'.
CyclesPermitted (Fahrradmitnahme):	(optional) It is possible to take cycles on this trip. No specification: CyclesPermitted taken from 'LineSchedule'.
VehicleTypeID (FahrzeugTypID):	(optional) Transport vehicle type, for information on disabled access; meta datum (see chapter 4.3). No specification: Vehicle type is unknown
ServiceAttribute (Ser-viceAttribut):	(sub-element, optional, multiple) Structure that contains a description of the vehicle or trip attributes.

Implementation notes:

ScheduleTrip can be used without *ScheduleStop* to change the trip parameters if the trip has been made known previously.

5.1.3.2 Information on the Trip Service (*ServiceAttribute*)

The *ServiceAttribute* structure denotes the service attributes for the corresponding trip:

Definition of *ServiceAttribute (ServiceAttribut)*	
Name (Name):	Describes the service attribute of the trip or the vehicle, e.g. low-floor vehicle.
Value (Wert):	Specifies whether the attribute is provided (value = 1) or not (value = 0).

5.1.3.3 Information on the Stop *(ScheduleStop)*

The *ScheduleStop (SollHalt)* structure can occur more than once within a ScheduleTrip.

Definition of *ScheduleStop (SollHalt)*	
StopID (HaltID):	The StopID is used to match the AVLC stop with the stop in the schedule information system (see chapter 4.3).
StopName (Haltestel-lenName):	(optional) Name of the stop (used for schedule information systems without separate data import)
DepartureTime (Ab-fahrtszeit):	(optional) This can be omitted for the terminal stop.
ArrivalTime (An-kunftszeit):	(optional) Can be omitted if equal to the departure time or at the start stop.
DeparturePlatformTe xt (AbfahrtssteigText):	(optional) Bay or platform name.
ArrivalPlatformText (AnkunftssteigText):	(optional) Bay or platform name. Can be omitted if equal to Depar-turePlatformText (AbfahrtssteigText).
NoBoarding (Einstei-geverbot):	(optional) Vehicle only stops for alighting. No specification: No boarding restrictions.
NoAlighting (Aussteigeverbot):	(optional) Vehicle only stops for boarding. No specification: No alighting restrictions.
Passage (Durchfahrt):	(optional) Vehicle does not stop here. No specification: Vehicle does stop here.
DirectionText (Rich-tungsText):	(optional) Text of the end stop (vehicle signage), if different to the DirectionText for the full trip in ScheduleTrip. No specification: DirectionText taken from 'ScheduleTrip'.

Definition of *ScheduleStop (SollHalt)*	
FromDirectionText (VonRichtungText):	(optional) Text of the start stop or the direction from which the trip originates, if different to the FromDirectionText (RichtungsText) of the full trip in ScheduleTrip (SollFahrt). No specification: FromDirectionText (VonRichtungText) taken from 'ScheduleTrip (SollFahrt)'.
InfoText (Hinweis-Text):	(optional, multiple) Information on the trip that only applies at this stop. No specification: No special information for this stop.
PlannedConnection (SollAnschluss):	(optional, multiple) Information on planned connections. No specification: No connections.

5.1.3.4 Planned Connections (*PlannedConnection)*

Information concerning which connections are possible through the course of the operational day under normal conditions is of great interest to the schedule information system. For this reason, these trip pairs, along with the associated planning data, should be transferred to the schedule information system. The schedule information system represents these transfers to the customer with texts such as "connection expected".

The planned connections are transmitted in the *PlannedConnection* structure:

Definition of the *PlannedConnection (SollAnschluss)*	
TripID (FahrtID):	References the receiver trip
StopID (HaltID):	(optional) Stop where the receiver trip departs. No specification: The receiver trip stop is the same as the feeder trip stop (ScheduleStop).
ChangeoverTime (Umsteigewegezeit):	In seconds.
StaySeated: (Sitzen-bleiben)	(optional) Flag to denote block linking. No specification: The passenger must change vehicles for this con-nection.

The *PlannedConnection* structure can occur (possibly more than once) as a sub-element of the *ScheduleStop* structure. The details in *ScheduleStop* specify the feeder data of the con-nection whilst the data relating to the receiver trip is provided in *PlannedConnection*.

Implementation notes:

If both planning and real-time data are transmitted for the connection information, then the *ConnectionPlan* (for the planning data) and *ConnectionStatus* (for the process data) ele-ments should be used exclusively (see section 6.3).

With the exclusive transmission of planning information, the *PlannedConnection* element can continue to be used.

The following example shows the planned schedule for route 10, consisting of one trip only with six stopping points and a planned connection at the second stopping point.

```
<AUSNachricht AboID = "25>
      <Linienfahrplan>
            <LinienID>10</LinienID>
            <RichtungsID>HIN</RichtungsID>
            <SollFahrt>
                  <FahrtID>
                        <FahrtBezeichner>2210</FahrtBezeichner>
                        <Betriebstag>2001-07-21</Betriebstag>
                  </FahrtID>
                  <SollHalt>
                        <HaltID>235</HaltID>
                        <Abfahrtszeit>2001-07-21T09:30:00</Abfahrtszeit>
                  </SollHalt>
                  <SollHalt>
                        <HaltID>236</HaltID>
                        <Ankunftszeit>2001-07-21T09:35:00</Ankunftszeit>
                        <Abfahrtszeit>2001-07-21T09:36:00</Abfahrtszeit>
                        <AbfahrtssteigText>2A</AbfahrtssteigText>
                        <SollAnschluss>
                        <FahrtID>
                              <FahrtBezeichner>3330</FahrtBezeichner>
                              <Betriebstag>2001-07-21</Betriebstag>
                        </FahrtID>
                        </SollAnschluss>
                  </SollHalt>
                  <SollHalt>
                        <HaltID>237</HaltID>
                        <Ankunftszeit>2001-07-21T09:50:00</Ankunftszeit>
                        <Abfahrtszeit>2001-07-21T09:51:00</Abfahrtszeit>
                        <AnkunftssteigText>5B</AnkunftssteigText>
                  </SollHalt>
                  <SollHalt>
                        <HaltID>238</HaltID>
                        <Ankunftszeit>2001-07-21T09:55:00</Ankunftszeit>
                        <Abfahrtszeit>2001-07-21T09:56:00</Abfahrtszeit>
                  </SollHalt>
                  <SollHalt>
                        <HaltID>239</HaltID>
                        <Ankunftszeit>2001-07-21T09:57:00</Ankunftszeit>
                        <Abfahrtszeit>2001-07-21T09:58:00</Abfahrtszeit>
                  </SollHalt>
                  <SollHalt>
                        <HaltID>240</HaltID>
                        <Ankunftszeit>2001-07-21T09:59:00</Ankunftszeit>
                  </SollHalt>
            </SollFahrt>
            <PrognoseMoeglich>true</PrognoseMoeglich>
            <FahrradMitnahme>true</FahrradMitnahme>
      </Linienfahrplan>
</AUSNachricht>
```

5.1.4 Block-specific Schedule Data Transmission (*DatedBlock*)

For a block oriented transfer of data, the *SISMessage* (AUSNachricht) element can contain one or more elements of the type *DatedBlock* (SollUmlauf):

Definition of *DatedBlock (SollUmlauf)*	
BlockID (UmlaufID):	BlockID (UmlaufID) is used to identify the block.
ScheduleTrip (Soll-Fahrt):	(alternative, multiple) Structure with details on the trip.
DatedBlockTrip (SollUmlaufFahrt):	(structure, alternative, multiple) The DatedBlockTrip uniquely identifies the trips within a block on the basis of the long-term schedule.

5.1.4.1 DatedBlock - Single Trip (*DatedBlockTrip*)

A *DatedBlock* can comprise several *DatedBlockTrip* individual trips.

Definition of *DatedBlockTrip (SollUmlaufFahrt)*	
LineID (LinienID):	The LineID is used to match the AVLC route with the route of the long-term schedule known within the schedule information system.
ScheduleTrip (Soll-Fahrt):	Structure with details on the trip

Implementation notes:

The *ScheduleTrip* element in DatedBlock is retained for reasons of compatibility, however only *DatedBlockTrip* should be used for new implementations.

5.2 SIS Real-time Data Service

With this service the AVLC informs the schedule information system of the current status of all known trips. This enables the schedule information system to provide up-to-the-minute information for short-term journey planning.

As with the reference data service, the AVLC must only transmit the productive trips to the schedule information system, i.e. the trips that carry passengers.

5.2.1 Request for Real-time Data *(SISSubscription)*

With the *SISSubscription* request, the schedule information system requests real-time data from the AVLC for all or a selection of routes.

SISSubscription (AboAUS) contains the following elements:

Definition of *SISSubscription (AboAUS)*

SubscriptionID (AboID):	(attribute) The SubscriptionID (AboID) references the subscription for real-time data.
ValidUntilTimeStamp (VerfallZst):	(attribute) Specifies the time to which the real-time data is to be transmitted.
LineFilter (LinienFilter):	(optional, multiple) Filter stating which route real-time data is to be transmitted for. No specification: Real-time data reported for all routes
BlockID (UmlaufID):	(optional, multiple) Defines in a block-oriented manner the data to be transferred.
Hysteresis (Hysterese):	Threshold value in seconds after which the deviations from the planned schedule or the last message are to be transmitted (see chapter 7.1.7). The deviation must be greater than or equal to the specified value before deviations are transferred.
PreviewTime (Vorschauzeit):	Maximum preview time in minutes requested by the schedule information system (see chapter 7.1.6).
WithProtectedConnection (MitGesAnschluss):	(optional) Specifies whether the transfer information, for which transfer protection is active, is also to be transmitted. No specification: Transmission without connection information

If neither *LineFilter* nor a *BlockID* is specified as a subscription filter, this implicitly implies transmission of data for all routes in the AVLC. In other words, the AVLC can decide which routes it wants to report.

The following example depicts such a request:

```
<AboAnfrage Sender="hha" Zst="2001-09-20T09:30:47">
      <AboAUS AboID="25" VerfallZst="2001-09-22T09:30:47">
            <Linienfilter>
                  <LinienID>10</LinienID>
            </Linienfilter>
            <Hysterese>120</Hysterese>
            <Vorschauzeit>20</Vorschauzeit>
      </AboAUS>
</AboAnfrage>
```

5.2.2 Transferring Real-time Data

With a route-specific subscription the real-time data is packaged in the *RealTrip* reply structure according to route and with a block-specific subscription in the *RealBlock* reply structure. These elements are embedded within a *SISMessage* element, which combines all replies of the schedule information service (see 6.1.2).

At the start of the subscription, the AVLC is responsible for transmitting the current full status to the schedule information system, i.e. it transmits all real-time data that deviates from the planned schedule at the start of the subscription.

Messages relating to the real-time data status can contain the following content:

- Schedule deviations with predictions for future route sections,
- Failure of a trip,
- Change to the vehicle capacity (passenger load),
- Change to mode of transport / vehicle equipment,
- Platform change,
- Stop obstruction,
- Path changes.

In short: Every change with regard to the transmitted planned schedule can be represented and made known to the schedule information system.

5.2.2.1 Real-time Data of a Trip *(RealTrip)*

A change message is communicated in the *RealTrip (IstFahrt)* structure within *SISMessage (AUSNachricht)*. It is possible to specify several trips.

Definition of *RealTrip (IstFahrt)*

LineID (LinienID):	The LineID (LinienID) is used to match the AVLC route with the route of the long-term schedule specified in the schedule information system (see 4.3).
DirectionID (RichtungsID):	This value is a meta datum (see chapter 4.3). It typically identifies the outbound and inbound journey of a route.
TripRef (FahrtRef):	(sub-element) The TripRef (FahrtRef) can be used to reference the real-time messages from the SIS service within the planned schedule.
CompleteTrip (Komplettfahrt):	Indicates whether - as a result of dispatch actions - all stops are transmitted in the RealStop (IstHalt) structure (see chapter 7.1.5).
BlockID (UmlaufID):	(optional) BlockID (UmlaufID) is used to identify the block (see 4.3).
RealStop (IstHalt):	(sub-element, optional, multiple) Structure with details on the stops in the pattern. Can be omitted if all transmitted information is independent of path.
LineText (LinienText):	(optional) Route text if different from published schedule. No specification: No change with regard to the planned schedule or last message.
ProductID (ProduktID):	(optional) Product used for this trip; meta datum (see chapter 4.3). No specification: No change with regard to the planned schedule or the last message.

Definition of *RealTrip (IstFahrt)*

DirectionText (RichtungsText):	(optional) Text of the terminal stop (vehicle signage), if different to the published schedule. Can be overwritten section by section by the entry in the “Stop” structure. No specification: No change with regard to the planned schedule or last message.
FromDirectionText (VonRichtungText):	(optional) Text of the start stop or the direction from which the trip is coming. Overwrites the FromDirectionText (VonRichtungText) from 'ScheduleTrip (SollFahrt)'. No specification: FromDirectionText taken from 'ScheduleTrip'.
InfoText (HinweisText):	(optional, possibly multiple) Information on the trip. No specification: No change with regard to the planned schedule or last message.
TrainName (Zugname):	(optional, for train services) Train name, e.g. 'West Coast Express'. No specification: No change with regard to the planned schedule or last message.
TransportModeText (VerkehrsmittelText):	(optional) Name of the mode of transport, e.g. 'tram'. No specification: No change with regard to the planned schedule or last message.
PredictionPossible (PrognoseMoeglich):	(optional) Indicates whether the trip is controlled by the AVLC (possibly different to the field of the same name in the higher-order LineSchedule (Linienfahrplan) structure). No specification: No change with regard to the planned schedule or last message.
PredictionInaccurate (PrognoseUngenau):	(optional) Quality status of the prediction. (see chapter 7.1.8) No specification: Vehicle is not in a traffic jam.
ExtraTrip (Zusatzfahrt):	(optional) Indicates that this trip is transmitted as an addition to the planning data already sent. No specification: Not an additional trip. Note: It is only in the case of CompleteTrip messages (which are compulsory as the first message for extra trips) that the absence of the 'ExtraTrip' attribute is interpreted as 'ExtraTrip=false'. With updates however, a missing 'ExtraTrip' attribute does not trigger a change.
Deleted (FaelltAus):	(optional) Indicates that this trip is deleted. No specification: This is not a trip that has been deleted.
CongestionInfo (StoerungsInfo):	(sub-element, optional) Explains the reason for the deletion of the trip or other error.
CyclesPermitted (Fahrradmitnahme):	(optional) It is possible to take cycles on this trip. No specification: No change with regard to the planned schedule or the last message.
VehicleTypeID (FahrzeugTypID):	(optional) Transport vehicle type, for information on disabled access; meta datum (see chapter 4.3). No specification: No change with regard to the planned schedule or last message.
PassengerLoad (Besetzgrad):	(optional) Possible values: “Light load”, “Heavy load”, “Overloaded”. No specification: Passenger load is unknown.

Definition of *RealTrip (IstFahrt)*	
ServiceAttribute (ServiceAttribut):	(sub-element, optional, multiple) Structure that contains a description of the vehicle or trip attributes.
TimeStamp (Zst):	(attribute) Time stamp of the creation of the request (optional).

Implementation notes: The mid section of a trip is prolonged with a dispatch action, which results in overlapping planned times at the entry stop. How should the complete RealTrip now be transmitted?

• If the alternative path takes longer than the original path, the travel time for this section is artificially streamlined to ensure that chronologically increasing values are consistently transmitted to the schedule information system.

5.2.2.2 Referencing the Trip Data *(TripRef)*

To allow the real-time data messages in the schedule information system to be matched to the planned schedule, it is possible to use the *TripID (FahrtID)* of the *LineSchedule (Linienfahrplan)* structure from chapter 6.1.2 to identify the trip within a route when setting up the REF-SIS reference data service.

For installations in which there is no exchange of planning data using the REF-SIS service, the key details of the trip, i.e. the start and end stops and scheduled times at these stops, can be used in order to create a reference to the planned schedule. This means that use of the REF-SIS is not obligatory.

This information is combined in the *TripRef* structure:

Definition of *TripRef (FahrtRef)*	
TripID (FahrtID):	(optional, if provided) Unique reference to the trip.
TripStartEnd (FahrtStartEnde):	(sub-element, optional) Defining data of the planned trip: First and last stop.

Both elements are optional, one of the two however must be specified, either *TripID* or *TripStartEnd*.

5.2.2.2.1 Alternative referencing information (*TripStartEnd*)

The defining data of a trip - first and last stops of the trip with the planned times at these stops - is combined in the *TripStartEnd* structure:

Definition of *TripStartEnd (FahrtStartEnde)*	
StartStopID (StartHaltID)	Start stop
StartTime (Startzeit)	Departure time at the start stop
EndStopID (EndHaltID)	Terminal stop
EndTime (Endzeit):	Arrival time at the end stop

5.2.2.3 Information on the Stop *(RealStop, (IstHalt))*

The *RealStop* structure comprises possible changes with regard to the planned *ScheduleStop*:

Definition of *StopID (IstHalt)*	
StopID (HaltID):	The StopID is used to match the AVLC stop with the stop in the schedule information system (see chapter 4.3).
StopName (Haltestel-lenName):	(optional) Name of the stop (used for schedule information systems without separate data import)
DepartureTime (Ab-fahrtszeit):	(optional) Planned departure time. Not entered or omitted for the terminal (end) stop.
ArrivalTime (An-kunftszeit):	(optional) Planned arrival time. (Can be omitted if identical to the departure time. Obligatory at the terminal stop.)
RealDeparturePrediction (IstAbfahrtPrognose):	(optional) Prognosis for the departure time. No specification: Planned departure time
RealArrivalPrediction (IstAnkunftPrognose):	(optional) Prognosis for the arrival time. No specification: Planned arrival time
RealArrivalPrediction Quality (IstAnkunftPrognose Qualitaet)	(optional) Specification of a prediction quality level for the *RealArrivalPrediction (IstAnkunftPrognose)*
RealDeparturePredictionQuality (IstAbfahrtprognoseQualitaet)	(optional) Specification of a prediction quality level for the *RealDeparturePrediction (IstAbfahrtPrognose)*
RealDepartureDispatch (IstAbfahrtDisposition):	(optional) Predicted departure time on the basis of an active dispatch action that differs from the scheduled departure time

Definition of *StopID (IstHalt)*	
RealArrivalDispatch (IstAnkunftDisposition):	(optional) Predicted arrival time on the basis of an active dispatch action that differs from the scheduled arrival time
PredictionInaccurate (PrognoseUngenau):	(optional) Quality status of the prediction. (see chapter 7.1.8) No specification: Vehicle is not in a traffic jam.
DeparturePlatformText (AbfahrtssteigText):	(optional) Bay or platform name. No specification: No change with regard to the planned schedule or the last message.
ArrivalPlatformText (AnkunftssteigText):	(optional) Bay or platform name. Can be omitted if equal to DeparturePlatformText (AbfahrtssteigText). No specification: DeparturePlatformText (AbfahrtssteigText).
NoBoarding (Einsteigeverbot):	(optional) Vehicle only stops for alighting. No specification: No change with regard to the planned schedule or the last message.
NoAlighting (Aussteigeverbot):	(optional) Vehicle only stops for boarding. No specification: No change with regard to the planned schedule or the last message.
PassThru (Durchfahrt):	(optional) Vehicle does not stop here, travels straight through. No specification: No change with regard to the planned schedule or the last message.
ExtraStop (Zusatzhalt):	(optional) This stop is additional and unplanned. No specification: Stop is planned.
DirectionText (RichtungsText):	(optional) Text of the terminal stop (vehicle signage), if different to the DirectionText of the full trip in RealTrip (IstFahrt). No specification: DirectionText taken from 'RealTrip'.
FromDirectionText (VonRichtungText):	(optional) Text of the start stop or the direction from which the trip is coming. Overwrites the FromDirectionText (VonRichtungText) from 'RealTrip' (IstFahrt). No specification: FromDirectionText from RealTrip is valid.
InfoText (HinweisText):	(optional, multiple) Information on the trip that only applies at this stop. No specification: No change with regard to the planned schedule or the last message.
CongestionInfo (StoerungsInfo):	(sub-element, optional) Explains the reason for the deviation from schedule, e.g. vehicle waiting for a connection.
PassengerLoad (Besetzgrad):	(optional) Possible values: 'Light load', 'Heavy load', 'Overloaded'. No specification: Passenger load is unknown.

If the *PassengerLoad* field in the *RealStop* structure is filled, this represents a predicted passenger load. If the corresponding field of *RealTrip* is completed, this overwrites the last current passenger load message.

Note: VDV Paper 454 is to be interpreted such that transmission of the planned departure time is always compulsory, unless dealing with a terminal stop. From this specification it is possible to derive the sequence of stopping points.

The transmission of the planned arrival times can be omitted if equal to the planned departure times. Transmission of the planned arrival times is compulsory at the terminal stops.

Depending on technical factors it is not easy to represent this rule in the associated XSD schema.

5.2.2.4 Additional Information (*CongestionInfo*)

The *CongestionInfo* structure offers various possibilities for transferring additional information, e.g. concerning the cause of an error.

This information can be transmitted in the form of free texts as well as coded information, which can then be further processed automatically.

Definition of *CongestionInfo (StoerungsInfo)*

Cause (Ursache):	(optional) Explains the reason for the deviation from schedule, e.g. vehicle waiting for a connection.
TpegReasonGroup (TpegReasonGroup):	(optional) Facilitates the classification of the cause of error in accordance with the TPEG standards, see also SIRI Situation Exchange Service.
SituationBaseIdentity Group (SituationBaseIdentity Group):	(optional) References a situation in the SIRI SX service.

TpegReasonGroup and *SituationBaseIdentityGroup* are elements, which are specified in the SIRI Situation Exchange Service or which make reference to a message of the SIRI Situation Exchange Service.

Tip: This structure is only included in the 'with SIRI' version of the XML schema definition.

5.2.2.5 Prediction quality (*RealArrivalPredictionQuality (IstAnkunftPrognoseQualitaet)* and *RealDeparturePredictionQuality (IstAbfahrtprognoseQualitaet)*): (*TimeQuality (ZeitQualitaet))*

Definition of *TimeQuality*	
PredictionLevel (PrognoseVerlaesslichkeit):	Data type *PredictionLevelType (VerlaesslichkeitType)*, values 1 to 5 (see 10.
LowerTimeLimit (ZeitMin):	(optional) Defines the start point of the time frame in which the prediction can vary in maximum.
HigherTimeLimit (ZeitMax):	(optional) Defines the end point of the time frame in which the prediction can vary in maximum.

5.2.3 Block-oriented Real-time Data Transmission (*RealBlock*)

As an alternative to the transmission of trip related information, real-time block-related information can also be transmitted with the *SISMessage* element. The *RealBlock* element is based on the *RealBlockTrip* element, which contains the *RealTrip* and associated *LineID*.

Definition of *RealBlock (IstUmlauf)*	
BlockID (UmlaufID):	BlockID (UmlaufID) is used to identify the block.
RealTrip (IstFahrt):	(alternative, multiple) Structure with details on the trip.
RealBlockTrip (IstUmlaufFahrt):	(structure, alternative, multiple) The DatedBlockTrip uniquely identifies the trips within a block on the basis of the long-term schedule.

5.2.3.1 RealBlock - Individual Trip (RealBlockTrip)

A *RealBlock* can comprise several *RealBlockTrip* individual trips.

Definition of *RealBlockTrip (IstUmlaufFahrt)*	
LineID (LinienID):	The LineID is used to match the AVLC route with the route of the long-term schedule known within the schedule information system.
RealTrip (IstFahrt):	Structure with details on the trip

Implementation notes:

The *RealTrip* element in *RealBlock* is retained for reasons of compatibility, however only *RealBlockTrip* should be used for new implementations.

As with the trip related transfer of information more then one *RealBlock* element can be embedded in *SISMessage*.

5.3 Protected Connection Relationships

5.3.1 Transferring Connection Data (*ProtectedConnection*)

If both planning and real-time data is to be transmitted for the connection relationships, this is achieved with the *ProtectedConnection* structure. This structure either transmits the planning data (*ConnectionPlan*) or the real-time data (*ConnectionStatus*) for a connection relationship.

Definition of *ProtectedConnection (GesAnschluss)*

ConnectionPlan (AnschlussPlan):	(optional, alternative) Structure with the planning data of a connection relationship to be protected.
ConnectionStatus (AnschlussStatus):	(optional, alternative) Structure with the real-time data of a previously planned connection relationship to be protected.

5.3.2 Planning Data of a Connection Relationship (*ConnectionPlan*)

The *ConnectionPlan* element is used to transmit the information for a planned transfer relationship to be included in the transfer protection. This provides the schedule information system with advance information on which feeder-receiver pairs are to be monitored by the transfer protection.

Definition of *ConnectionPlan (AnschlussPlan)*

ConnectionID (AnschlussID):	(attribute) The ConnectionID identifies the connection.
Feeder (Zubringer):	Structure that specifies the feeder trip of a connection relationship.
StopIDFeeder (HaltIDZubringer):	Element that denotes the stopping point of the feeder in the connection area.
Receiver (Abbringer):	Structure that specifies the receiver trip of a connection relationship.
StopIDReceiver (HaltIDAbbringer):	Element that denotes the stopping point of the receiver in the connection area.
ChangeoverTime (Umsteigewegezeit):	(optional) Specifies the time normally required (in seconds) to get from the feeder stopping point to the receiver stopping point.
MaxAutoDelay (MaxAutoVerzoegerung):	(optional) Specifies the maximum delay that can be imposed automatically by the control system (in seconds) on the receiver vehicle if the feeder is delayed. If this time period is exceeded a dispatcher decision becomes necessary.
Priority (Prioritaet):	(optional) This element can be used to classify the priority / importance of an individual connection relationship. Value range: 1 to 3 where 1 is the highest value

5.3.2.1 Feeder and Receiver Trip Information (*Feeder, Receiver*)

The *feeder* and *receiver* elements use the *TripIDGlobal* element, which contains all information on the relevant trips inclusive of the *ControlCentreID*. This means it is also possible to uniquely identify the trips across several control systems.

Definition of *TripIDGlobal (TripID, structure of elements feeder + receiver)*	
TripIDExt (FahrtIDExt):	Structure for the unique identification of the feeder or receiver trip
LineID (LinienID):	(optional) Route identificator of the feeder or receiver trip
ControlCentreID (LeitstellenID):	(optional) Code for the identification of the respective control centre in the case of an inter-agency connection relationship.

5.3.3 Status Data of a Connection Relationship (*ConnectionStatus*)

The *ConnectionStatus* structure is used to transmit the information concerning the current status of a previously planned connection relationship designated for protection. This means that the planning data is updated in the schedule information system in advance.

Definition of *ConnectionStatus (AnschlussStatus)*	
ConnectionID (AnschlussID):	(attribute) The ConnectionID identifies the connection.
WaitInfo (WarteInfo):	Structure that provides information about the current status of the connection relationship (NotWaiting or HoldBackUntil).
DepTimeReceiverProg (AbfahrtszeitAbbringerPrognose):	(optional) Gives a prediction of the new departure time taking into consideration all feeders and transfer times.
ProtectionOff (SicherungAufgehoben):	(optional) Indicates that a planned or an active transfer protection that has already begun, has been cancelled. It is not possible to make a statement about the success of a corresponding connection relationship.

5.3.3.1 Information on holding back the receiver vehicle (*WaitInfo*)

The *WaitInfo* structure specifies the status of the instructions to the receiver vehicle. It is used to transmit the information concerning the current status of a previously planned connection relationship designated for protection.

Definition of *WaitInfo (WarteInfo)*	
NotWaiting	(optional, alternative) This element denotes that the receiver has not

(WartetNicht):	received an instruction to wait beyond the scheduled departure time.
HoldBackUntil (ZurueckhaltungBis):	(optional, alternative) This denotes that the receiver vehicle will wait for the arrival of the feeder up to a maximum defined by the given time. The *HoldBackUntil* element contains an optional *VehicleAcknowl-edgement* element, which indicates that the wait instruction has been acknowledged by the receiver vehicle (see section 7.2.5).

6 Handling of the SIS Real-time Data Service

6.1 Implementation Notes and Regulations

Having dealt with the structure of the interfaces for the REF-SIS and SIS services in the previous chapter, this section covers important rules for their implementation and handling. Chapter 7.1.1 deals with the authority of the AVLC for establishing predictions. The exceptions are listed in the form of supplementary rules for the schedule information system in section 7.1.2.

The following sections then specify the time-based reporting behaviour for subscribed trips. This begins with the necessity of an active first message of all trips that fall within a prediction horizon (chapter 7.1.6). Then in chapter 7.1.7 we describe the regular reporting behaviour in accordance with the hysteresis functionality. The remaining chapters are concerned with special situations following a traffic jam or an unscheduled log-off.

After that the document outlines the handling of deleted and additional trips as well as the implementation for applications in the train field with different referencing.

6.1.1 Prediction Ability of the AVLC

In accordance with the approach of this interface, the authority to predict arrival and departure times lies completely with the automatic vehicle location and control system (AVLC). This has access to all the latest operating data and dispatch actions. At the operational management level, local know-how is available ensuring higher quality predictions, which take into account a variety of influencing factors and which build on existing statistical material.

As a consequence, this means that the schedule information system – disregarding error checks and exceptions – is unable to independently correct the transmitted arrival and departure times. The specific ability of the schedule information system lies in the combination of knowledge. The schedule information system combines current individual trips to form complete connections with, under certain conditions, transfer times that are adapted to the current operational situation. With this comprehensive and up-to-date network knowledge, it is able to advise the passenger accordingly. This means that the schedule information system is interested in as much departure time and arrival time information as possible concerning pending mid-term trips (see chapter 7.1.6).

Example: 'Delay Predictions'

The following example indicates the transmission of a delay prediction of a vehicle of route 10 corresponding to the example in section 6.1.3.4. The vehicle leaves the start stop with a delay and is located between the first and second stop with a delay of 2 minutes. On the basis of the long running time between stops 2 and 3, the prediction algorithm of the AVLC detects the potential to make up one minute. The prediction profile is as follows.

Stop	Scheduled arrival	Predicted arrival	Scheduled departure	Predicted departure	Delay
235	-	-	09:30	Passed	2
236	9.35	09:37	09:36	09:38	2
237	09:50	09:51	09:51	09:52	1
238	09:55	09:56	09:56	09:57	1
239	09:57	09:58	09:58	09:59	1
240	09:59	10:00	-	-	1

Transmission of the delay profile

The AVLC must not only provide the schedule information system with data concerning the departure and arrival times at one or more stops of a trip, but it must also report the predicted times (departure/arrival) for all future stops of a trip. It must inform the schedule information system of the entire stop-time function, the so-called **delay profile** of a trip.

6.1.2 Supplementary Rule for the Delay Profile

To prevent unnecessary data traffic, measures are introduced to avoid the transmission of redundant information. These represent exceptions to the agreed rules, which allow the schedule information system to independently supplement the transmitted data. This is of particular importance to the delay information.

To reduce the transmitted data volume, the AVLC only completes the stops at which the delay has changed (extrapolation rule). The schedule information system assigns the last reported delay to all stops along the pattern until the next reported delay is received.

This supplementary rule also applies to schedule deviations in which the vehicles are running early.

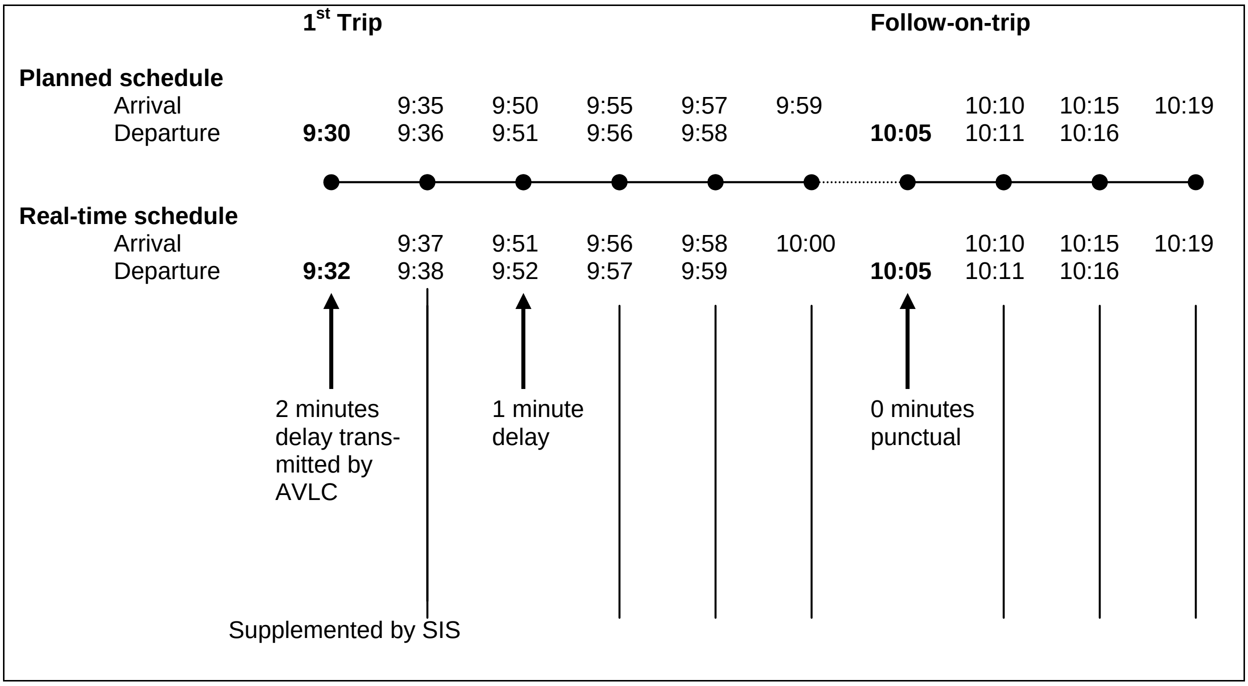

Fig. 4: Supplementary rule for delay extrapolation

If the AVLC establishes that there are waiting times at subsequent stops along the trip, which are able to compensate for a delay, it can use its prediction capacity. The schedule information system receives a message for these stops by means of multiple RealStop structures (in 1 message). For the stops in between, the schedule information system must extrapolate the current real-time status. This means that the responsibility of the delay predictions remains wholly with the AVLC. There is no infringement of the generic approach. Using this rule, the schedule information system can then complete the remaining fields from a single message without additional information from subsequent or previous messages – there is neither need nor authorization for independent interpretation.

In the RealTrip structure it is therefore only necessary to specify the stops at which a delay prognosis changes. These are stops 236 (first point) and 237 (change from 2 minutes to 1 minute).

```
<AUSNachricht AboID="25">
      <IstFahrt>
            <LinienID>10</LinienID>
            <RichtungsID>HIN</RichtungsID>
            <FahrtRef>
                  <FahrtID>
                        <FahrtBezeichner>2210</FahrtBezeichner>
                        <Betriebstag>21/07/2001</Betriebstag>
                  </FahrtID>
                  <FahrtStartEnde>
                        <StartHaltID>235</StartHaltID>
                        <Startzeit>2001-07-21T09:30:00</Startzeit>
                        <EndHaltID>240</EndHaltID>
                        <Endzeit>2001-07-21T9:59:00</Endzeit>
                  </FahrtStartEnde>
            </FahrtRef>
            <Komplettfahrt>false</Komplettfahrt>
```

```
            <IstHalt>
                  <HaltID>236</HaltID>
                  <Abfahrtszeit>
                        2001-07-21T09:36:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:35:00
                  </Ankunftszeit>
                  <RealDeparturePrediction>
                        2001-07-21T09:38:00
                  </IstAbfahrtPrognose>
                  <IstAnkunftPrognose>
                        2001-07-21T09:37:00
                  </IstAnkunftPrognose>
            </IstHalt>
            <IstHalt>
                  <HaltID>237</HaltID>
                  <Abfahrtszeit>
                        2001-07-21T09:51:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:50:00
                  </Ankunftszeit>
                  <IstAbfahrtPrognose>
                        2001-07-21T09:52:00
                  </IstAbfahrtPrognose>
                  <IstAnkunftPrognose>
                        2001-07-21T09:51:00
                  </IstAnkunftPrognose>
            </IstHalt>
      </IstFahrt>
</AUSNachricht>
```

Other supplementary rules

Extrapolation rules must be agreed for each project. The use of the extrapolation rule is only recommended for the transmission of delays or early times.

On the basis of the first practical experiences with inter-operational AVLC interfaces, further rules should be exactly specified for the independent supplementation of transmitted data in order to avoid any confusion in interpretation. The AVLC control computer must know the stops for which the schedule information system carries out extrapolation and the stops for which the predictions need to be sent.

6.1.3 Example: 'Passage Through a Stop' (Attribute Change)

Changes to stop-related attributes such as no boarding/no alighting, provision for bicycles, info texts or passage must be sent as special information in the RealStop structure for each relevant stop. The delay extrapolation rule cannot be applied in these situations.

In the following example, the vehicle passes through the third stop and indicates 'no boarding' at the last two stops.

```
<AUSNachricht AboID="25">
      <IstFahrt>
            <LinienID>10</LinienID>
            <RichtungsID>HIN</RichtungsID>
            <FahrtRef>
                  <FahrtID>
                        <FahrtBezeichner>2210</FahrtBezeichner>
                        <Betriebstag>2001-07-21</Betriebstag>
                  </FahrtID>
                  <FahrtStartEnde>
                        <StartHaltID>235</StartHaltID>
                        <Startzeit>2001-07-21T09:30:00</Startzeit>
                        <EndHaltID>240</EndHaltID>
                        <Endzeit>2001-07-21T9:59:00</Endzeit>
                  </FahrtStartEnde>
            </FahrtRef>
            <Komplettfahrt>false</Komplettfahrt>
            <IstHalt>
                  <HaltID>237</HaltID>
                  <Abfahrtszeit>
                        2001-07-21T09:51:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:50:00
                  </Ankunftszeit>
                  <Durchfahrt>true</Durchfahrt>
            </IstHalt>
            <IstHalt>
                  <HaltID>239</HaltID>
                  <Abfahrtszeit>
                        2001-07-21T09:58:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:57:00
                  </Ankunftszeit>
                  <Einsteigeverbot>true</Einsteigeverbot>
            </IstHalt>
            <IstHalt>
                  <HaltID>240</HaltID>
                  <Ankunftszeit>
                        2001-07-21T09:59:00
                  </Ankunftszeit>
                  <Einsteigeverbot>true</Einsteigeverbot>
            </IstHalt>
      </IstFahrt>
</AUSNachricht>
```

Changes to the vehicle type are transmitted for the route.

6.1.4 Example: 'Serving a Request Stop'

Stops that are only served as a result of a previous request are viewed in the planned schedule as demand response stops and specified as 'false' for the 'pass through' element.

If there is no stop request within the registration time for the respective stop, there is a correction in RealStop with PassThru = true. Afterwards, these stops are no longer displayed in the schedule information system and the vehicle can either pass through, or in the case of branch trips for example, miss out these stops.

6.1.5 Example: 'Path Change'

In the case of major dispatch actions, it is necessary to re-transmit **one-off** information for the **entire trip**, including new scheduled and predicted times. This is the case for any additional trips, not included in the planning data, as well as any path changes. The CompleteTrip field in RealTrip must be set to 'true' to inform the schedule information system that an entire trip is being transferred. In this situation, the old trip is deleted and replaced by the new information.

It should also be noted that all attributes need specifying, as there is no possibility of any reference to existing data. The schedule information system must be able to deal with this so that predictions are sent for all stops of the relevant trip after dispatch actions.

If a path change involves the omission of stops when compared with the original status, they no longer appear in the message. If new stops are inserted, the ExtraStop field must be set to 'true'.

The following example shows the RealTrip structure for the situation in which a different path is followed between the start and destination stops. The new stops are marked with the ExtraStop attribute.

```
<AUSNachricht AboID="25">
      <IstFahrt>
            <LinienID>10</LinienID>
            <RichtungsID>HIN</RichtungsID>
            <FahrtRef>
                  <FahrtID>
                        <FahrtBezeichner>2210</FahrtBezeichner>
                        <Betriebstag>2001-07-21</Betriebstag>
                  </FahrtID>
                  <FahrtStartEnde>
                        <StartHaltID>235</StartHaltID>
                        <Startzeit>2001-07-21T09:30:00</Startzeit>
                        <EndHaltID>240</EndHaltID>
                        <Endzeit>2001-07-21T10:02:00</Endzeit>
                  </FahrtStartEnde>
            </FahrtRef>
            <Komplettfahrt>true</Komplettfahrt>
            <IstHalt>
                  <HaltID>253</HaltID>
                  <Abfahrtszeit>
                        2001-07-21T09:36:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:35:00
                  </Ankunftszeit>
                  <IstAnkunftPrognose>
                        2001-07-21T09:37:00
                  </IstAnkunftPrognose>
                  <IstAbfahrtPrognose>
                        2001-07-21T09:38:00
                  </IstAbfahrtPrognose>
                  <Zusatzhalt>true</Zusatzhalt>
            </IstHalt>
            <IstHalt>
                  <HaltID>254</HaltID>
                  <Abfahrtszeit>
```

```
                        2001-07-21T09:44:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:43:00
                  </Ankunftszeit>
                  <IstAnkunftPrognose>
                        2001-07-21T09:45:00
                  </IstAnkunftPrognose>
                  <IstAbfahrtPrognose>
                        2001-07-21T09:46:00
                  </IstAbfahrtPrognose>
                  <Zusatzhalt>true</Zusatzhalt>
            </IstHalt>
            <IstHalt>
                  <HaltID>255</HaltID>
                  <Abfahrtszeit>
                        2001-07-21T09:54:00
                  </Abfahrtszeit>
                  <Ankunftszeit>
                        2001-07-21T09:53:00
                  </Ankunftszeit>
                  <IstAnkunftPrognose>
                        2001-07-21T09:54:00
                  </IstAnkunftPrognose>
                  <IstAbfahrtPrognose>
                        2001-07-21T09:55:00
                  </IstAbfahrtPrognose>
                  <Zusatzhalt>true</Zusatzhalt>
            </IstHalt>
            <IstHalt>
                  <HaltID>240</HaltID>
                  <Ankunftszeit>
                        2001-07-21T09:59:00
                  </Ankunftszeit>
                  <IstAnkunftPrognose>
                        2001-07-21T10:02:00
                  </IstAnkunftPrognose>
            </IstHalt>
      </IstFahrt>
</AUSNachricht>
```

If an additional trip is to be transmitted and not just a path change to a known trip, then the ExtraTrip attribute in the RealTrip (IstFahrt) structure must be set to 'true'. This eliminates the marking of additional stops.

6.1.6 First Message and Preview Time

First message (Erstmeldung)

With the help of the SIS service the schedule information system can, for example, mark trips as 'delayed x min', 'punctual' or 'cancelled'. The customer therefore expects, irrespective of the marketing strategy of the operator, trip information that is of a higher quality than the planned schedules with regard to actuality, accuracy and reliability.

The basic problem for the schedule information system when it comes to reliability is that in the case of trips for which it has not yet received any real-time messages, it is unable to decide whether it has no significant delay or whether the AVLC is unable to generate messages for this vehicle, if for example, it has no radio equipment. In the first case the trip should be marked as punctual in the schedule information system and in the latter case as having unknown accuracy.

In order to support highly reliable information when constructing the interface, the handling of the interface has been agreed so that the schedule information system bases its trip information on concrete message events and not on conclusions regarding non-events.

PreviewTime (Vorschauzeit)

The further one reaches into the future with a prognosis on the basis of scientific methods, the more unclear the influencing factors, which in turn increases the inaccuracy. This finding also corresponds to intuitive expectation.

It also applies to the prediction of traffic situations. Basically speaking, predictions are only reliable for near future trips. To avoid the danger of the misrepresentation of apparent prognosis accuracy, every automatic vehicle location and control system (AVLC) has a restricted preview time. The preview time is specific to each project and lies in the region of 20-60 min. This means it is impossible to make predictions about the punctuality of trips that lie too far in the future.

From the other point of view, the passenger does not expect an exact long-term prognosis. It makes little sense then within a schedule information system, in response to a morning enquiry to mark the evening's trips as punctual.

When setting up an SIS subscription, the schedule information system requests a desired preview time from the AVLC.

Reporting rules (Melderegeln)

The AVLC must report every trip for which there are predictions at least once.

The AVLC only transmits the predictions for the trips that start within the preview time. A future trip lies within the preview time if the departure time of the trip at the start stop lies in the time window from the current time given by the preview time.

The message should be generated as soon as possible within the preview time, as soon as the AVLC can give a prediction for the start of the trip. If this is not possible, a message is generated for the trip after the first planned/real-time comparison (after logon, after first radio contact, before/at/after the start stop).

As soon as a follow-on trip falls into the preview time, this too should be reported with the entire delay profile as soon as possible (i.e. with the prediction for the start stop and all subsequent stops).

For every transmitted trip, its predicted delay profile is reported (see chapter 0) up to the end of the trip, even if the trip finishes after the prediction horizon.

A trip that has been reported once must continue to be reported to its end or until predictions become impossible.

The schedule information system can therefore assume a trip to be punctual if it has received an initial message from the AVLC and PredictionPossible has not been set to false. Without the active transmission of this information via the interface, the schedule information system switches to the backup level of planning data.

If a vehicle is not under AVLC control, the first message is missing and it can only offer the customer pre-planned schedule information.

This procedure guarantees that the schedule information system only marks trips as punctual when they are actually monitored by the AVLC and have been transmitted without error.

The disadvantage is the slightly greater volume of data that needs to be transmitted. The **re-initialisation of a real-time data subscription** (e.g. after a restart) in particular would generate a new message to the schedule information system from every vehicle affected by the subscription currently in operation.

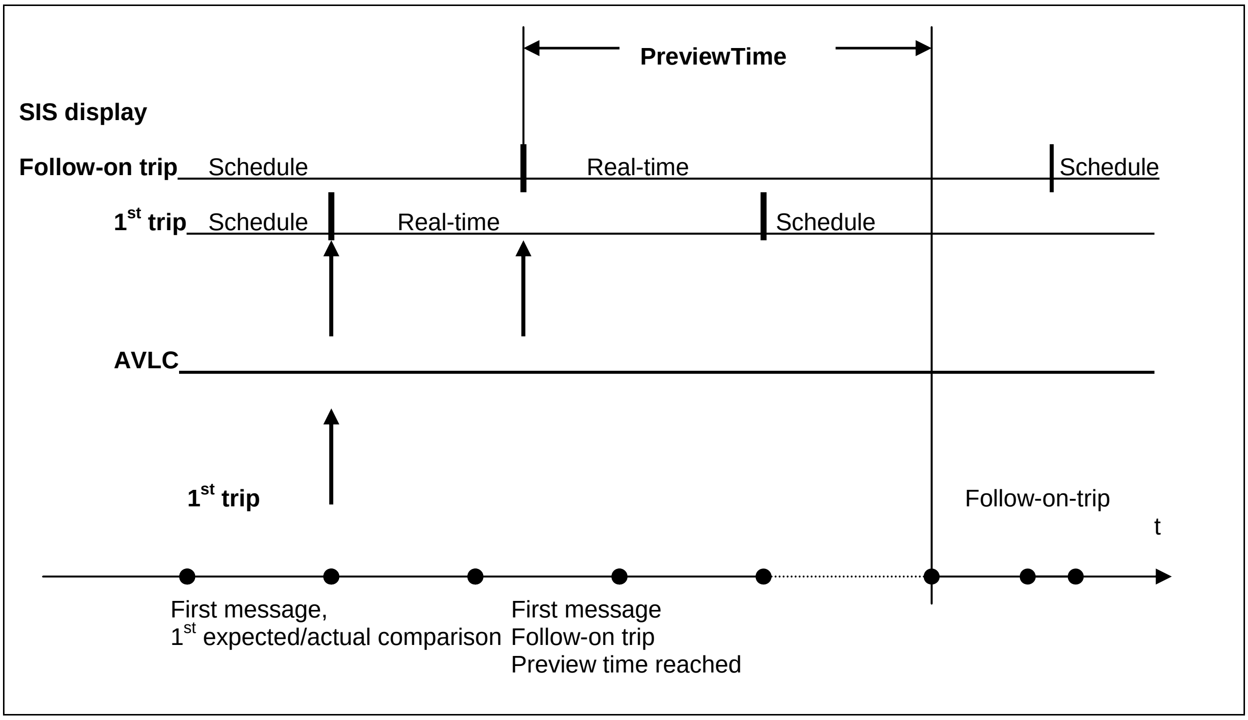

Fig. 5: Prediction period and active first message

6.1.7 Temporal Reporting Behaviour - Hysteresis

The SIS service reports the current absolute arrival and departure times. The content of the delay message therefore does not represent information that is relevant to the preceding message, e.g. '+5 min', or to the pre-defined planned schedule. Every individual SIS message can be interpreted on its own. It can be made available in the schedule information system if there is a corresponding reference to the planned data.

The temporal reporting behaviour in the case of trip delays however is relative to the last message, and takes the form of a hysteresis function: As soon as a delay prediction for a stop exceeds the last transmitted value by a specific threshold (either negatively or positively), the AVLC triggers a real-time message to the schedule information system which overwrites the old value.

It is recommended that a single hysteresis value be globally defined for the entire real-time data subscription in the range of 1-2 min. Defining the threshold values per route or even per trip or interval cannot be recommended due to the resulting complexity. Instead, the significance of the global hysteresis value should be interpreted as indicating that the schedule information system does not wish to receive any messages that lie below this threshold value. (The deviation must therefore be greater than or equal to the specified value before deviations are transferred.) In the opposite direction however, the AVLC reserves the right to suppress messages that lie above the threshold as it is able to determine the meaningfulness of transmission. For example, the messages could be suppressed when the headways are short, i.e. the vehicles run in rapid succession. In this way, the AVLC retains the possibility of dynamically deciding on meaningful threshold values.

6.1.8 The PredictionInaccurate Element

If the AVLC detects that it is not able to make a reliable prediction, it can activate the PredictionInaccurate field in the RealTrip structure for the relevant trip and transmit a reason. At the same time, the hysteresis mechanism described above is suspended, i.e. the AVLC refrains from sending any more messages as long as PredictionInaccurate (PrognoseUngenau) is active. This limits the rapidly increasing exchange of messages as the delay increases. The system avoids sending delay messages, when it must be assumed they will only increase further after another 2 minutes.

PredictionInaccurate can have the following values:

- 'Vehicle in jam' (Fahrzeug im Stau) means that the vehicle is proceeding slowly or not at all.
- 'Technical problem' (technisches Problem) states that there is a problem with transmitting the vehicle data, which means there is no current, up-to-date information.
- 'Dispatch action' (dispositive Massnahme) indicates that manual interaction has taken place, for example to protect a transfer, which means that accurate predictions are not possible.
- 'Missing update' (fehlende Aktualisierung) means that although a prediction exists, communication errors have prevented any updates.

Implementation notes:

In the case of a missing update, the control centre system must send the last available prediction together with the above-mentioned 'missing update' information.

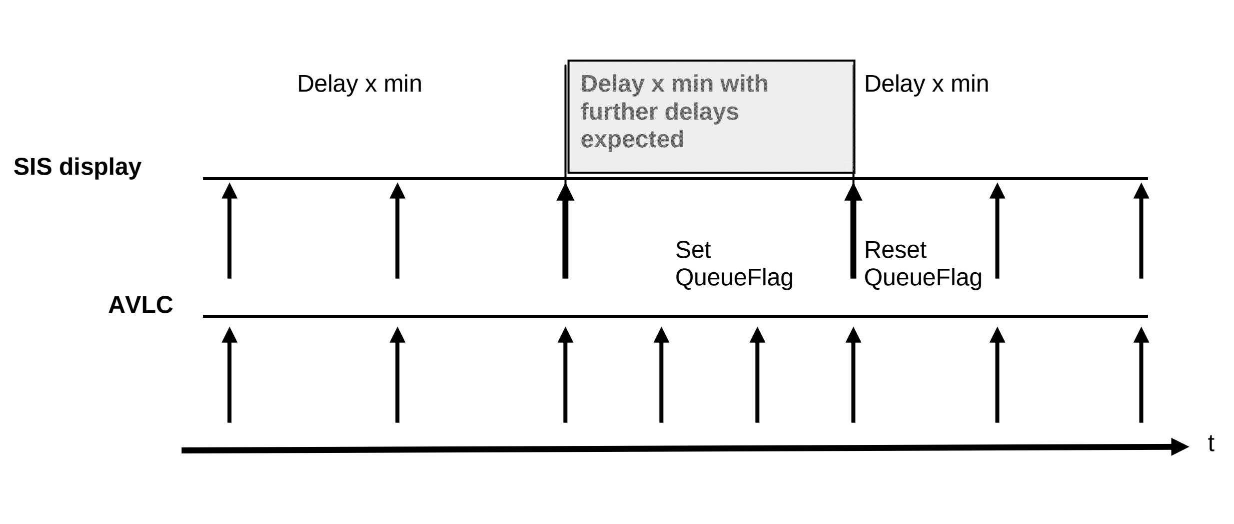

Figure 6: Reporting behaviour in the case of PredictionInaccurate

With the transmission of a new up-to-date prediction, the AVLC lifts the PredictionInaccurate (PrognoseUngenau) status and signals that the hysteresis is running again.

The schedule information system can react in a special way to the PredictionInaccurate (PrognoseUngenau) message. Contrary to a breakdown in communication, the schedule information system does not revert to the backup level of planned data but is able to trigger messages such as '20 min delay, more delays expected'.

Note:

On the basis of the new prediction quality (see 10 Appendix: Transmission of the Prediction Quality) PredictionInaccurate should no longer be used (for new implementations). It is listed here for reasons of compatibility with earlier versions. Special care should be taken to ensure it is not used in conjunction with the new methods.

6.1.9 Unscheduled Log-off

If a vehicle logs off from its block, or becomes unattainable via radio, the AVLC must have the possibility to revoke a previously reported prediction. In this case, the AVLC must send the schedule information system a schedule deviation message with the PredictionPossible = false attribute for every trip already reported. With that, the schedule information system is aware of the inaccurate status of these trips and can pass on this information to the customers. After a message with the PredictionPossible = false attribute, the trip has the same status as if it had not been reported at all.

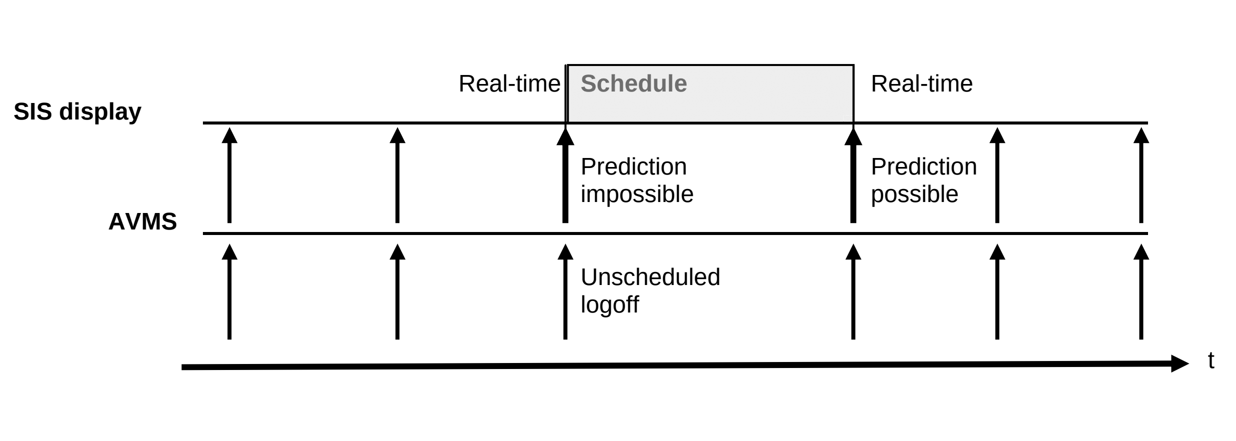

Fig. 7: Unscheduled log-off

6.1.10 Missing Trips

There are two different starting situations for an AVLC message regarding missing trips:

a) The data sender and the schedule information system know the same schedule version, however, in the control centre and in contrast to the planning status, a trip is cancelled before transmission of the planned schedules in the REF-SIS service.

b) After completion of the REF-SIS transmission, a trip is deleted in the control centre.

In case a) the trip to be deleted is communicated in the *ScheduleTrip* structure in *Line-Schedule* and denoted by the *Deleted* attribute.

In case b) the trip to be deleted is communicated in the *RealTrip* structure in *LineSchedule* and denoted by the *Deleted* attribute.

In both cases, at least the start and destination stops of the trip must be transmitted in the *ScheduleTrip* or *RealTrip* structure, as these identify the trip.

6.1.11 Additional Trips

There are also two different starting situations for an AVLC message regarding extra trips:

a) The data sender and the schedule information system know the same schedule version, however, in the control centre and in contrast to the planning status, an additional trip is added before transmission of the planned schedules in the REF-SIS service.

b) After completion of the REF-SIS transmission, an additional trip is added by the dis-patcher.

In case a) the additional trip is communicated in the *ScheduleTrip* structure in *LineSchedule* and denoted by the *ExtraTrip* attribute.

In case b) the additional trip is communicated in the *RealTrip* structure and denoted by the *ExtraTrip* attribute.

If the additional trip follows a path that deviates from the other paths of the route, it must be guaranteed that this path has been previously supplied in the planning system. Otherwise, it may not be possible to represent the additional trip within the network topology of the schedule information system. In the case of an unknown path, there must be a suitable reaction in the schedule information system.

6.1.12 Implementation for Rail Applications

With train travel, it is often not possible to apply the regular route modelling as used in local public transport. However, in order to be able to apply the same data model for the train schedules, it is recommended that one uses the timetable links for a corresponding route definition. In this case, the TripID would be the (unique) train number and the LineText would be composed of train type and train number (e.g. IC 18). This allows a train journey to be broken down into several 'routes' on the basis of the timetable links.

6.2 Connection Information

6.2.1 The Situation

Passengers using public transport are often reliant on connections with other routes. Within information systems, the term 'connection' has a broader meaning than within an AVLC system. For a schedule information system, a connection exists between two trips when a passenger can sensibly transfer between them in order to continue a meaningful journey.

Connections at important junctions are planned by the transport authority in advance in order to guarantee the most comfortable journey for the passenger. Connections should not be too tight in order to ensure they can still be protected even in the case of a minor delay. However, the wait for the connecting vehicle should not be so great as to be considered annoying by the passengers.

As the operational process is prone to disturbances and delays, the transport authority often applies the transfer protection function. In this context, the AVLC exchanges messages with the participating feeder and receiver vehicles in order to allow a sensible wait decision to be made regarding the receiver vehicle for the given connection. Wait decisions during the transfer protection procedure should also be made available to the schedule information system in order to publish this information for the passenger and to keep those travelling fully up-to-date of the current situation, for example, by means of a central schedule information system.

6.2.2 Applications

The applications for passenger information and interaction are as follows (see Fig. 8):

Pre-trip connection information:

The pre-trip connection information provides advance information about all connections that are to be protected within the operation. This information has additional benefits for the passenger as connections that are to be protected are generally more reliable that those that are not actively monitored. With the availability of this information an electronic schedule information system is able to calculate connections with a higher level of reliability.

Collective on-trip connection information:

With the collective on-trip connection information a passenger can get information about all the connection possibilities of his current trip. In this context the most current data can be derived from the transfer protection procedures. The collective information does not know the travel plans of individuals so does not take this into account.

Personalised on-trip connection information:

As a travelling companion service, the personalised on-trip information monitors the travel plans of the registered passengers and actively informs them when the connections become endangered.

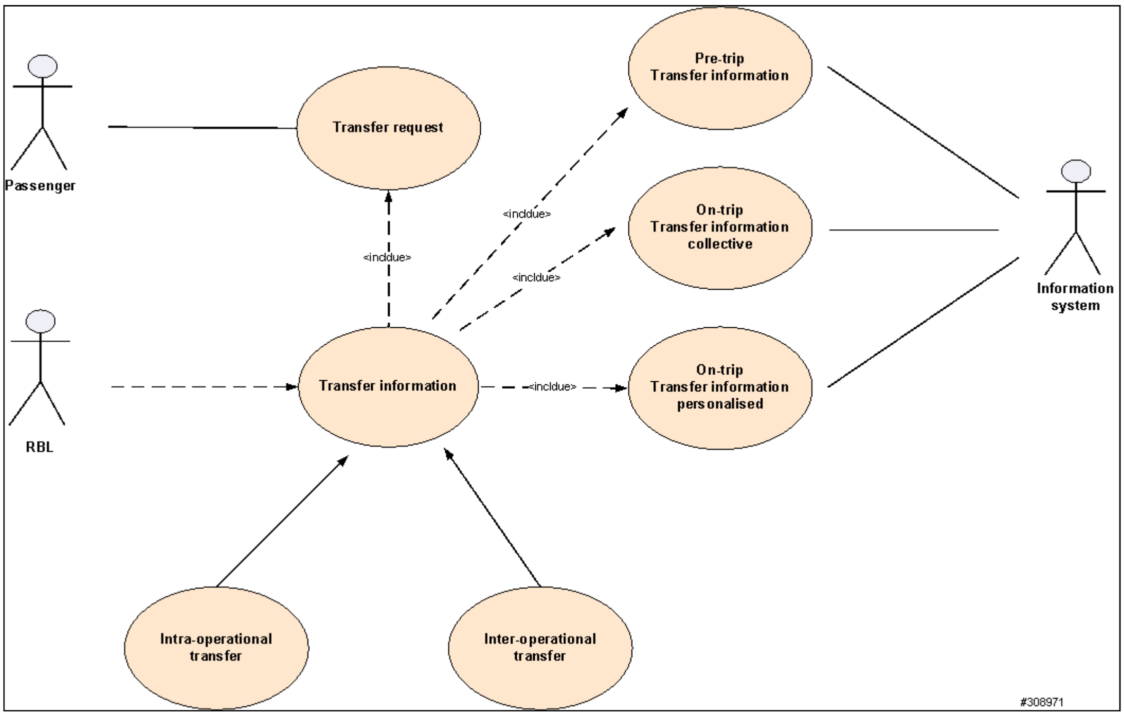

Fig. 8: Application cases of the connection information

A transfer protection action can either be initiated within a specific transport authority or as an inter-operational action. In the first situation only one AVLC system is involved and in the second messages are exchanged between two AVLC systems.

6.2.3 Connection Information in the Schedule Information System

In order to have access to advance information on planned connections, they must be transmitted as feeder-receiver trip pairs to a schedule information system. These trip pairs are made known to the schedule information system within the context of the planning data transmission (see sections 6.1.3.3 and 6.3.2)

When a feeder nears a connection point during operation, the receiver system is informed of the predicted arrival time of the feeder, on the basis of information exchanged between the participant AVLC systems, allowing it to decide whether the receiver should wait in case of delay. Corresponding information must then be transmitted from the receiver AVLC to the schedule information system within the context of real-time data transmission (see section 6.3.3).

6.2.4 Message Content

Identifiers must be used for the transmission of the planned transfer protection data, which can be understood globally by all participant systems. The information relating to a connection to be protected comprises the following data elements:

- ID of the connection
- TripID of the feeder
- Feeder StopID at the connection location
- TripID of the receiver
- Receiver StopID at the connection location
- Control centre code of the feeder (agency code)
- (The control centre code of the receiver is implicit when the receiver is reporting the data)
- Necessary transfer time
- Max. delay automatically

The necessary transfer time describes the time that is typically required by a passenger to change from the feeder into the receiver vehicle.

The maximum automatic delay denotes the time period for which the receiver vehicle can be automatically held back by its control centre if the feeder is delayed. A decision by the dispatcher in the receiver AVLC system is only requested when this delay value is exceeded.

In order to keep the message volume to a minimum during operation, a schedule information system can evaluate a protected connection as viable as long as the feeder delay remains below the threshold value of the maximum automatic delay. For larger delays, the connection is considered cancelled unless a message is received from the receiver AVLC system indicating that the dispatcher has authorised a longer wait for the receiver vehicle. The dispatcher can of course also initiate the transfer failure below the maximum automatic delay threshold.

The receiver AVLC sends messages in the following situations:

- Transfer failure,
- In case of wait decisions that exceed the maximum automatic delay,
- In the case of new, dynamically created connection pairs and
- Upon surrender of the transfer protection (transfer protection has been withdrawn but there is no statement regarding the realization of this transfer).

6.2.5 Quality Statements

It is essential to be able to assess the reliability of the predictions in order to be able to provide the passenger with reliable and meaningful statements. It would be fatal to recommend an alternative to the passenger if his originally planned connection proved successful. On the one hand, it is important to be able to inform the passengers about critical connections and possible alternatives in good time, but on the other the quality and reliability of the predictions increase the closer the feeder is to the connection point.

It is necessary to find quality features that resolve this dilemma.

In accordance with the information status, which is implicit (for the first three stages) and explicit (with acknowledgement) within the schedule information system, it is possible to differentiate between the following quality levels when providing the passenger with connection information:

- Planning level
- Prediction level
- Dispatcher level
- Vehicle acknowledgement level

The 'planning' level is the preliminary stage for dynamic schedule information. Here the protected connections are only considered on the basis of the planning data.

In the 'prediction' level the predicted arrival times received from the AVLC are used to determine whether a connection will take place. This is the lowest quality level when using dynamic data.

In the 'dispatcher' level there is a dispatcher decision and instruction to the receiver vehicle. This level can be regarded as very reliable.

In the 'vehicle acknowledgement' level there is also confirmation from the receiver vehicle, so that one can be certain that the connection decision has arrived in the receiver vehicle. This level represents the highest degree of reliability.

6.2.6 Stay-seated connection

The situation where the passengers remain seated, the so-called 'stay seated' connection, represents a special case. This represents a virtual connection in the same vehicle. This situation arises when the vehicle in question transfers to a different route at the end of the current trip, where it begins a new trip (route reassignment within a block). For the passenger, the change between these two individual trips represents a connection. However, the passenger can remain seated in the same vehicle (assuming this is permitted). In this situation, the information that he need not get off the vehicle is very useful.

7 Glossary

Term	Description
Actual timetable	Timetable generated from the planned timetable, which is supplemented with up-to-date information.
AVLC	Automatic vehicle location and control system
Connection planning	Determination of the connections to be monitored (on the basis of the daily schedule).
Control centre	Set-up to control and regulate the traffic-based and operational processes of a transport authority.
CP	Connection protection: Service for the operational exchange of transfer protection data
Delay	Positive deviation from the planned schedule
Dispatch	Operative management for controlling the traffic and the operation
DPI sign	Dynamic passenger information: Service for the operational exchange of passenger information data.
Early time	Negative deviation from the planned schedule
GMS	General message service: Service for the exchange of operational messages between two control centres
HTML	Hyper Text Markup Language
http	Hyper Text Transfer Protocol
Meta data	The definitions and stipulations agreed between two transport authorities as a basis for data exchange.
OperationalType (Betriebstag)	Time frame for the validity of schedules within an AVLC (can be different in different AVLC systems).
Planned timetable	The scheduled timetable.
Process data exchange	Exchange of real-time information between the AVLC and schedule information system
Reference data exchange	Exchange of planned schedules between the AVLC and schedule information system
REF-SIS (REF-AUS)	Schedule information system planning (reference) data service for the days planned schedules for mid-term information
Route trip	Trip on a route
Seasonal timetable	Timetable that is valid for a defined period of time (schedule season) and which is published in various media (timetable booklet, electronic schedule information).
SIS	Real-time schedule information system service, real-time data from the operational procedure for short-term enquiries
Stay-seated connection	Virtual connection in the same vehicle (see section 7.2.6)
Subscription method	Communication method in the interface for the purpose of data exchange.
Timetable prediction	Preview of the actual timetable of a subsequent time section
Transfer time	Time required to change between vehicles at a connection point.

Term	Description
Validity time frame of timetables	Fixed time frame for which a timetable is valid, e.g. a timetable period. Different transport authorities do not generally have matching validity time frames for timetables.
VIS	Visualisation: Service for exchanging process data for visualising third-party vehicles in a control centre
XML	Extended Markup Language

8 English Aliases

The following tables contain the German names of the elements used in the XML-file (XSD), the English translation used in this recommendation and the name used in the CEN-standard 'SIRI'.

Please refer to the SIRI documentation for the equivalents of the additional elements.

8.1 Services

VDV 454		**SIRI Equivalent**	
Full name	Abbr.	Full name	Abbr.
Timetable Information Reference Data Service	REF-SIS (REF-AUS)	Production Timetable Service	PT
Timetable Information Process Data Service	SIS	Estimated Timetable Service	ET

8.2 Root Elements and Complex Sub-elements

VDV 454 term	**SIRI equivalent**
LineSchedule (LinienFahrplan)	DatedTimetableVersionFrame
PlannedConnection (SollAnschluss)	TargetedInterchange
RealStop (IstHalt)	EstimatedCall
RealTrip (IstFahrt)	EstimatedTimetableVersionFrame with EstimatedVehicleJourney
ScheduleStop (SollHalt)	DatedCall
ScheduleTrip (SollFahrt)	DatedVehicleJourney
SISMessage (AUSNachricht)	ProductionTimetableDelivery (PT Service) EstimatedTimetableDelivery (ET-Service)
SISRefSubscription (AboAUSRef)	ProductionTimetableSubscriptionRequest with ProductionTimetableRequest
SISSubscription (AboAUS)	EstimatedTimetableSubscriptionRequest with EstimatedTimetableRequest
TimeWindow (Zeitfenster)	ValidityPeriod
TripStartEnd (FahrtStartEnde)	DatedVehicleJourneyIndirectRef

8.3 Additional Elements

The following table contains other English aliases which are used for the SIRI implementation.

VDV 454 term	SIRI equivalent
ArrivalPlatformText (AnkunftssteigText)	ArrivalPlatformName
ArrivalTime (Ankunftszeit)	AimedArrivalTime
ChangeoverTime (Umsteigewegezeit)	InterchangeDuration
CompleteTrip (Komplettfahrt)	IsCompleteStopSequence
CyclesPermitted (Fahrradmitnahme)	(VehicleFeatureRef)
Deleted (FaelltAus)	Cancellation
Departure time (Abfahrtszeit)	AimedDepartureTime
DeparturePlatformText (AbfahrtssteigText)	DeparturePlatformName
DirectionID (RichtungsID)	DirectionRef
DirectionText (RichtungsText)	DestinationName
EndStopID (EndHaltID)	DestinationRef
EndTime (Endzeit)	AimedArrivalTime
ExtraStop (Zusatzhalt)	ExtraCall
ExtraTrip (Zusatzfahrt)	ExtraJourney
FromDirectionText (VonRichtungsText)	OriginName
Hysteresis (Hysterese)	ChangeBeforeUpdate
InfoText (HinweisText)	JourneyNote / LineNote
LineFilter (LinienFilter)	LineRef
LineID (LinienID)	LineRef
LineText (LinienText)	LineNote / PublishedLineName
NoAlighting (Aussteigeverbot)	(ArrivalBoardingActivity)
NoBoarding (Einsteigeverbot)	(DepartureBoardingActivity)
Passage(Durchfahrt)	(DepartureBoardingActivity) / (ArrivalBoardingActivity)
PassengerLoad (Besetzgrad)	Occupancy
PredictionInaccurate (PrognoseUngenau)	PredictionInaccurate
PredictionPossible (PrognoseMoeglich)	Monitored
PreviewTime (Vorschauzeit)	PreviewIntervall
Product ID (ProduktID)	ProductRef
RealArrivalDispatch (IstAnkunftDisposition)	ExpectedArrivalTime
RealArrivalPrediction (IstAnkunftPrognose)	AimedArrivalTime
RealDepartureDispatch (IstAbfahrtDisposition)	ExpectedDepartureTime
RealDeparturePrediction (IstAbfahrtPrognose)	AimedDepartureTime
ScheduleVersionID (FahrplanVersionsID)	VersionRef
ServiceAttribute (ServiceAttribut)	VehicleFeatureRef
StartStopID (StartHaltID)	OriginRef
StartTime (Startzeit)	AimedDepartureTime
StaySeated (Sitzenbleiben)	StaySeated
StopID (HaltID)	StopPointRef
StopName (HaltestellenName)	StopPointName

VDV 454 term	SIRI equivalent
StopSeqCounter (HstSeqZaehler)	VisitNumber
TimeWindow (Zeitfenster)	ValidityPeriod
TrainName (Zugname)	VehicleJourneyName
TransportModeText (VerkehrsmittelText)	VehicleMode
TripID (FahrtID)	DatedVehicleJourneyRef
TripRef (FahrtRef)	DatedVehicleJourneyRef
ValidUntilTimeStamp (VerfallZst)	InitialTerminationTime

9 Appendix: Transmission of the Prediction Quality

The following are extracts from the "Transmission of Prediction Quality using the VDV 453/454 Interfaces" document, the current version of which can be found at the VDV website under Technology – Projects – Real-time data interfaces (http://www.vdv.de/i-d-s-downloads.aspx).

9.1 Terms and Definitions

Prediction deviation	Difference between the actual and the predicted arrival or departure time.
Prediction period	The difference between the time of creation of the prediction and the time of the actual arrival or departure of the corresponding trip at the specified stopping point.
Prediction quality	This is a measurement provided by the source system together with the prediction value indicating the expected prediction error in accordance with the definition.
Prediction value	This is provided by the source system operator in the context of it's ownership of the predictions; it is the communicated predicted arrival or departure time (according to the definition) of a particular mode of transport at a particular stopping point; it can change several times during the course of the trip (with block-based predictions even before the trip starts).
Schedule deviation / punctuality	Difference between the planned and actual arrival, departure or passage times of a trip at a specific location; can only be calculated after the relevant real-time message has been received.
Source system	System that generates trip and prediction data and makes it available to external target systems via the VDV interfaces (e.g. AVLC, Regio-AVLC, ISTP/RIS, ...)
Target system	System that receives or processes trip and prediction data via the VDV interfaces (e.g. to create the journey chains) and passes it on to the end user (usually passengers) - for example via stationary DPI signs, schedule information on the web, mobile media platforms etc.

9.2 Level Definitions, Threshold Values

As limiting values for the confidence intervals of levels 1 - 4 we would suggest the following:

Prediction quality level	**Lower threshold value (earliest arrival / departure time)**	**Upper threshold value (latest arrival / departure time)**	**Interval width**
1: Very certain	- 1 min	+ 2 min	3 min
2: Quite certain	- 3 min	+ 6 min	9 min
3: Uncertain	- 8 min	+ 16 min	24 min
4: Very uncertain	- 20 min	+ 40 min	60 min

Prediction quality level	Lower threshold value (earliest arrival / departure time)	Upper threshold value (latest arrival / departure time)	Interval width
5: No prediction possible	Undetermined	Undetermined	> 60 min

Level 5 has no temporal limitation. This is always used if it is not possible to make a reliable statement about the prediction accuracy, i.e. the prediction stretches more than 60 minutes (-20/+40).

Transmission of a particular level means that from the point of view of the source system, the prediction errors are highly likely to lie within the specified interval. Although the source system is not offering a 'guarantee', it is subsequently possible using relatively simple statistical tests to establish which confidence level was actually achieved. In addition, this definition in the VDV interface allows the participating parties to agree different assured confidence levels depending on their respective constellations and technical possibilities, which can then be used accordingly by the target system. In an initial stage, the creation and use of these levels is also possible without such assurances (e.g. 95%).

In each case it is the responsibility of the target system operator to agree comparable quality assurances with the various supplier systems on the basis of this quality level definition, in order to ensure common usage of the data in the target system.

Prediction level 1 for example, is therefore defined so that the deviation from the predicted time P has a high probability to lie within the interval [P – 1 min - P + 2 min]. In the absence of any additionally supplied interval limits, the confidence interval limits are given by the above table in connection with the respective predicted value.

Furthermore, it is optionally possible to transmit specific interval limits which differ from those defined by the rules implied above.

If the supplying system still specifies a time interval for the quality level, then the level and the interval width must be consistent, i.e. it is not possible to specify a quality level whose interval width according to the above definition is smaller than the explicitly specified interval (for example, the explicitly defined interval [-5, +5] can only be supplied with quality level 3, 4 or 5 and not with level 1 or 2). If this condition is not upheld, the target system is free to select a correspondingly lower level for any further processing (in the example level 3).

An important consequence of this definition is that the prediction quality is not a property that relates to the entire trip (or the remaining part of the trip), instead it is only valid for a specific time and a specific event in the future (arrival/departure at a specific stop). Particularly in the case of long trips with large distances between stops, e.g. in the case of long-distance rail travel, the prediction quality can differ quite significantly at the various stops due to the varying prediction periods.

9.3 Projection Rule

It would seem sensible to define a projection rule for the prediction quality level, similar to that which is already used in VDV 454 to communicate the current timetable deviation of a trip. As long as there is no additional knowledge of further problems along the trip sequence, the level for the next stop should be used for all additional stops. If however due to congestion messages or existing disturbances it can be assumed that the vehicle will run into trouble further along the route, the situation will worsen from that point compared to the current level and possibly also the calculated limits. From this point therefore, the values should be projected along the remainder of the pattern.

The focus group found that it would be unrealistic to accurately project the prediction quality of future events. The purely theoretical possibility that a vehicle can remain stationary at any time does not mean that mobility in local public transport cannot be planned reliably. To the contrary, there are good empirical values for most types of traffic, where it is necessary to consider deviations from the scheduled operation. A prediction for a departure or an arrival that lies in the future, should not be classified within the quality levels as worse than the usual empirical value for the deviation of this type of traffic. If, for example, it is known that for a specific trip, the usual delay is no more than 2 minutes and there are currently no known problems, it is acceptable to assign this trip to quality level 1, even if the end of the trip is hours away.

These empirical values must be agreed between the schedule suppliers, the AVLC operators and the schedule information system operators. Their definition requires the knowledge and experience of the respective transport operator. This experience-based quality classification can occur at the level of transportation type, route, individual trip or weekday and time.

In the same way, it is also possible to classify the traffic, which is not subject to any monitoring by the AVLC, for example, as it is only executed on a day in the future as the necessary vehicle equipment is missing or it is not recorded by an AVLC system.

A further possibility - which is not included in this proposal - is for these empirical values for the reliability to be transmitted via a suitably extended VDV interface from the trip operator (en route via the corresponding AVLC) to the schedule information system. As this deals with values that refer to the planned schedules, an extension of the REF-SIS syntax would be conceivable, which would be analogous to the extension of the SIS syntax outlined here. The meaning of the values would no longer represent an assessment of the reliability of the supplied prediction values but an assessment of the reliability of the planned trips as described above. The data for the prediction qualities with punctual traffic supplies an initial, already very accurate, estimation of the reliability assessments. If necessary, they can be further refined into starting delays by an assessment of the historical data.

Example of the projection rule:

Stop sequence of a trip	Stop A	Stop B	Stop C	Stop D	Stop E
Planned schedu-le time	06:47	07:24	07:53	08:18	08:49
Prediction times and levels					
Example 1:		07:29 Level 1			
Example 2:		07:29 Level 3		08:23 Level 2	
Example 3:		07:24 Level 1	07:53 Level 2		

Table 1: Three examples for the transmission of prediction quality levels with the help of the projection rule, the missing values are projected by definition

Table 1 shows three examples of how to represent the prediction levels for the future stops of a trip with the help of the projection rule. The trip in the example travels along the five stops from A to E. The scheduled times are given in the first table row. The trip is currently located between A and B at 6:50 a.m.

In example 1, the predicted time for stop B is 7:29 a.m. This would indicate that the trip is currently running 5 minutes behind schedule. Prediction level 1 indicates that the expected fluctuation around the predicted value lies within the tolerance values of level 1. On the basis of the projection rule, it is possible in the same way to assume a delay of 5 minutes with prediction level 1 for the subsequent stops C, D and E.

In the second example there is also a predicted delay of 5 minutes for stop B. This time however there is a greater level of uncertainty. For this reason only prediction level 3 is assigned. As it can be assumed there is a certain travel time reserve in this situation between stops C and D, an improved prediction quality of level 2 is signalled for stop D (with an unchanged delay prediction of 5 minutes).

in the third example, a punctual departure with prediction level 1 is indicated for stop B. In this example it is assumed that the subsequent prediction for the trip after violation of a prediction period of more than one hour will comprise greater fluctuations. This means that worse prediction levels are indicated for the stops after 7:50 a.m. Due to the projection rule it is sufficient to transmit this exclusively for stop C (level 2).

The values that are implied implicitly by the projection rule, without the express need for transmission, are entered in grey in Table 2.

Stop sequence of a trip	Stop A	Stop B	Stop C	Stop D	Stop E
Planned schedule time	06:47	07:24	07:53	08:18	08:49
Prediction times and levels					
Example 1:		07:29 Level 1	07:58 Level 1	08:23 Level 1	08:54 Level 1
Example 2:		07:29 Level 3	07:58 Level 3	08:23 Level 2	08:54 Level 2
Example 3:		07:24 Level 1	07:53 Level 2	08:18 Level 2	08:49 Level 2

Table 2: The same table with the above examples. The values that are derived from the projection rule are shown in grey