Approaches to Develop an ITS Architecture and Integrated ITS

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VGU/VGTRC Symposium 2014

Intelligent Transport Systems – Applications and Architectures
Department of Transport Ho Chi Minh City, Vietnam
Recent Research on ITS Architectures at TU Darmstadt*

(1) International and national guidelines for telematics and ITS architectures in road traffic

Reports of the German Federal Highway Research Institute (BASt), Vol. F79 (2011)
⇒ http://bast.opus.hbz-nrw.de/frontdoor.php?source_opus=585&la=de

(2) Report on existing and planned ITS in Germany **

Basis of German ITS Initial Report (BMVBS 2011), Referred to: 17(1), Directive 2010/40/EU

(3) Identification and analysis of measures for the German National ITS Action Plan**

Basis of the German ITS Action Plan (BMVBS 2012)
⇒ http://www.bmvbs.de/SharedDocs/DE/Artikel/LA/ivs-im-strassenverkehr.html
* Basis for Doctoral Thesis of Philip Krueger (2013)
** Cooperation with TU Munich: Prof. Dr.-Ing. Fritz Busch
### Status of National ITS Architectures

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>History of National ITS Architectures</th>
<th>Status 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>1999 KAREN, FRAME 2000 Systemarchitektur 2004 ARKTRANS</td>
<td>Version 4.1</td>
</tr>
<tr>
<td>Austria</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Close relation to FRAME</td>
</tr>
<tr>
<td>France</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Version 5 of the model</td>
</tr>
<tr>
<td>Italy</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Regular updated</td>
</tr>
<tr>
<td>Norway</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Currently updated</td>
</tr>
<tr>
<td>Finland</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Update planned in 2013</td>
</tr>
<tr>
<td>Hungary</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Version 1.0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Regular updated</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Not updated</td>
</tr>
<tr>
<td>Germany</td>
<td>1999 Systemarchitektur 2000 ACTIF 2004 ARTIST</td>
<td>Development planned in 2013</td>
</tr>
</tbody>
</table>

**Caption**

- **F**: Basis FRAME
- **N**: Basis NITSA

**Legend**

- **Publication**
- **Development/Pre-studies**
Highlights of the Analysis Results

- Superordinate role of NITSA and FRAME as the basis of national ITS architectures.

- Most national ITS architectures focus on road transport, only.

- Worldwide, ITS architectures are addressing three levels:
  - Functional/logical aspects
  - Technical/physical aspects
  - Institutional/organisational aspects

- Between national ITS architectures notably differences exist, e.g.:
  Depth of contents, emphasis of included aspects, ...

- Two different types of modelling are used (according ISO 2010):
  - structured methods
  - object-orientated methods
FRAME: Functional Areas

1. Provide **Electronic Payment Facilities**
2. Provide **Safety and Emergency Facilities** – includes both in-vehicle and roadside "eCall" plus the management of the Emergency Services responses
3. **Manage Traffic** – includes urban and inter-urban traffic management, plus parking, incident and demand management
4. **Manage Public Transport Operations** – includes both regular and on-demand services, plus fare cards and vehicle sharing
5. Provide **Advanced Driving Assistance Systems** – includes support for in-vehicle services some of which are part of cooperative systems
6. Provide **Traveller Journey Assistance** – includes both pre- and on-trip planning, plus traveller information
7. Provide Support for **Law Enforcement**
8. **Manage Freight and Fleet Operations**
9. Provide Support for **Cooperative Systems** – includes support for cooperative systems not included elsewhere
FRAME: Functional Tree of Area 3.1 (Excerpt)
## Definitions – Overview

According to: (Boltze, Krueger, Reusswig 2011)

<table>
<thead>
<tr>
<th>National Guidelines / Standards</th>
<th>Implementations</th>
</tr>
</thead>
<tbody>
<tr>
<td>National ITS Vision</td>
<td>Operators/local ITS Vision</td>
</tr>
<tr>
<td>Framework Architecture</td>
<td>Overall Architecture</td>
</tr>
<tr>
<td>Reference Architecture</td>
<td>System (Architecture)</td>
</tr>
</tbody>
</table>
The **National ITS Vision** represents a high-level, long-term orientated and political strategy for the use of ITS. It should be a commitment for ITS which encompasses the aspirations of all stakeholders including the users. It also illustrates the aims as well as the expected benefits of using ITS. Furthermore, the National ITS Vision will be substantiated in a framework plan which comprises specifications regarding roles, responsibilities, as well as general specifications for measures and a timeline for the implementation.

When defining an ITS Vision on the level of a transport operator or local authority, the term “**Operators/Local ITS Vision**” is used. It correspondingly comprises the content of the National ITS Vision.

These Definitions have been developed with relation to:
National ITS Vision Recommendations

- A timeline as well as a funding concept for realising the ITS Vision should be developed.
- By defining the ITS vision, cost-benefit analyses should be applied to identify suitable measures.
The **Framework Architecture** is based on the national ITS Vision as well as on the framework plan. It is more concrete than the ITS Vision but still technology-independent. The Framework Architecture contains functional (equivalent: logical), physical, and organisational aspects, which aims to ensure interoperability on the level of the reference architecture, but also has to provide flexibility for the detailed implementation of ITS in specific projects.

When defining a Framework Architecture on the level of operators or local authorities the term **Overall Architecture** is used which correspondingly comprises the content of the Framework Architecture.
The ITS framework architecture should be designed to include all modes of transport.

The ITS framework architecture should comprise functional (logical), physical, and organizational aspects.
Reference Architectures Definition

The Reference Architecture specifies the framework architecture for one ITS-related function, e.g. traffic signal control systems, and the Reference Architecture is used as a blueprint for implementing this function. The Reference Architecture comprises all specifications and, if necessary, also standards to ensure integrated ITS implementations.

When defining a Reference Architecture on the level of operators or local authorities, the term System Architecture is used which correspondingly comprises the content of the Reference Architecture.

The Reference Architecture generally includes specifications
• of the related function,
• for implementing components of the related function,
• of interfaces as well as for the communication between components,
• of data protocols,
• of roles and responsibilities for the involved stakeholders.
As a part of reference architectures, standards should be comprised to ensure interoperability of ITS services. In particular, existing established standards should be considered for this purpose.

It should be elaborated whether the development of specific modules is appropriate, such as service packages in the USA.
Leadership and responsibility regarding ITS architecture should be held by the respective ministry of transport. If necessary, additional ministries should be also involved.

The responsibility for the development of the national ITS architecture should be assigned by the leading ministry to a suitable institution.

All relevant stakeholders should be involved (including provinces, cities, scientific bodies, private companies).

As part of the development of a national ITS architecture the exchange with other countries should be encouraged.

Compatibility to ITS architectures of neighbouring countries should be achieved.
Recommendations related to the Process for the Development, Maintenance and Updating of a National ITS Architecture (2)

- It should be analyzed which models of existing ITS architectures can be used or modified to serve as a starting point for the development of the National ITS architecture.
- The ITS architectures content should be continuously maintained and updated. The ITS architecture should be flexible and allow to adopt new services or functions.
- The development and maintenance of the national ITS architecture should be financed by public authorities.
- The use of the ITS architecture should be mandatory to ensure its dissemination. Therefore, public funding should be linked with the use of the ITS architecture.
- Suitable aids and tools, e.g. software tools, manuals, guidelines, training courses, workshops, website, etc. should be developed.
## NITSA: Service Areas

<table>
<thead>
<tr>
<th>User Service Bundle</th>
<th>User Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel and Traffic Management</td>
<td>Pre-Trip Travel Information</td>
</tr>
<tr>
<td></td>
<td>En-Route Driver Information</td>
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<tr>
<td></td>
<td>Route Guidance</td>
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<td></td>
<td>Ride Matching and Reservation</td>
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<td></td>
<td>Traveler Services Information</td>
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<tr>
<td></td>
<td>Traffic Control</td>
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<tr>
<td></td>
<td>Incident Management</td>
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<tr>
<td></td>
<td>Travel Demand Management</td>
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<tr>
<td></td>
<td>Emissions Testing and Mitigation</td>
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<tr>
<td></td>
<td>Highway-Rail Intersection</td>
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<tr>
<td>Public Transportation Management</td>
<td>Public Transportation Management</td>
</tr>
<tr>
<td></td>
<td>En-Route Transit Information</td>
</tr>
<tr>
<td></td>
<td>Personalized Public Transit</td>
</tr>
<tr>
<td></td>
<td>Public Travel Security</td>
</tr>
<tr>
<td>Electronic Payment</td>
<td>Electronic Payment Services</td>
</tr>
<tr>
<td>Commercial Vehicle Operations</td>
<td>Commercial Vehicle Electronic Clearance</td>
</tr>
<tr>
<td></td>
<td>Automated Roadside Safety Inspection</td>
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<tr>
<td></td>
<td>On-Board Safety and Security Monitoring</td>
</tr>
<tr>
<td></td>
<td>Commercial Vehicle Administrative Processes</td>
</tr>
<tr>
<td></td>
<td>Hazardous Material Security and Incident Response</td>
</tr>
<tr>
<td></td>
<td>Freight Mobility</td>
</tr>
<tr>
<td>Emergency Management</td>
<td>Emergency Notification and Personal Security</td>
</tr>
<tr>
<td></td>
<td>Emergency Vehicle Management</td>
</tr>
<tr>
<td></td>
<td>Disaster Response and Evacuation</td>
</tr>
<tr>
<td>Advanced Vehicle Safety Systems</td>
<td>Longitudinal Collision Avoidance</td>
</tr>
<tr>
<td></td>
<td>Lateral Collision Avoidance</td>
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<tr>
<td></td>
<td>Intersection Collision Avoidance</td>
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<tr>
<td></td>
<td>Vision Enhancement for Crash Avoidance</td>
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<tr>
<td></td>
<td>Safety Readiness</td>
</tr>
<tr>
<td></td>
<td>Pre-Crash Restraint Deployment</td>
</tr>
<tr>
<td></td>
<td>Automated Vehicle Operation</td>
</tr>
<tr>
<td>Information Management</td>
<td>Archived Data Function</td>
</tr>
<tr>
<td>Maintenance and Construction Management</td>
<td>Maintenance and Construction Operations</td>
</tr>
</tbody>
</table>
NITSA: Subsystems and Communications

# NITSA: Application Areas and Service Packages

| ATMS – Advanced Traffic Management Systems | APTS01 | Transit Vehicle Tracking |
| APTS – Advanced Public Transportation Systems | APTS02 | Transit Fixed-Route Operations |
| ATIS – Advanced Traveler Information Systems | APTS03 | Demand Response Transit Operations |
| CVO – Commercial Vehicle Operations | APTS04 | Transit Fare Collection Management |
| EM – Emergency Management | APTS05 | Transit Security |
| AD – Archived Data | APTS06 | Transit Fleet Management |
| MCO – Maintenance and Construction Management | APTS07 | Multi-modal Coordination |
| AVSS – Advanced Vehicle Safety Systems | APTS08 | Transit Traveler Information |
|  | APTS09 | Transit Signal Priority |
|  | APTS10 | Transit Passenger Counting |

NITSA: Service Package APTS01
Transit Vehicle Tracking

*Note: Graphic shows key service package elements. Some elements are omitted for clarity.

NITSA: Service Package APTS03
Demand Response Transit Operations

Traffic Management
- road network conditions
- incident information
- traffic images

Information Service Provider
- demand responsive transit request
- demand responsive transit plan
- selected routes
- transit and fare schedules
- transit schedule adherence information

Transit Operations Personnel
- transit operations personnel inputs
- transit operations status

Transit Management
- transit vehicle operator information
- demand response passenger and use data

Transit Vehicle
- on-board Paratransit Operations
- transit vehicle operator display
- transit vehicle operator inputs

Transit Vehicle Operator
- transit vehicle operator availability
- route assignment
- current asset restrictions
- roadway maintenance status
- work zone information

NITSA: Service Package APTS09
Transit Signal Priority

Traffic Management
  TMC Multimodal Coordination
  TMC Signal Control

Roadway
  signal control commands
  right-of-way request notification
  signal control status
  signal fault data
  Roadway Signal Priority

Transit Management
  traffic control priority status
  traffic control priority request
  transit schedule information
  transit vehicle schedule performance
  Transit Center Signal Priority

Transit Vehicle
  local signal priority request
  transit vehicle operator display
  transit vehicle operator inputs
  On-board Transit Signal Priority

NITSA: Equipment Packages

Example „Transit Center Vehicle Tracking“

This equipment package monitors transit vehicle location. The location information is collected via a data communication link between the transit vehicles and the transit center. The location information is presented to the transit operator ………

Functional Requirements
The center shall monitor the locations of all transit vehicles within its network.
The center shall determine adherence of transit vehicles to their assigned schedule.
The center shall support an interface with a map update provider, or other appropriate data sources, through which updates of digitized map data can be obtained and used as a background for transit tracking and dispatch.
The center shall provide transit operational data to traveler information service providers.
The center shall provide collected transit probe data to traffic management centers and traveler information service providers for use in measuring current traffic conditions.

Pspects:
4.1.5- Provide Transit Vehicle Status and Probe Information
4.1.6- Manage Transit Vehicle Operations
4.2.3.9- Update Transit Map Data

### NITSA: Equipment Packages

**Example „Transit Center Vehicle Tracking“**

#### Inputs/Outputs (Included Architecture Flows)

<table>
<thead>
<tr>
<th>Source</th>
<th>Architecture Flow</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map Update Provider</td>
<td>map updates</td>
<td>Transit Management</td>
</tr>
<tr>
<td>Transit Management</td>
<td>transit probe data</td>
<td>Information Service Provider</td>
</tr>
</tbody>
</table>
| Transit Management                 | transit schedule adherence information  
[Standards](#)             | Information Service Provider                   |
| Transit Management                 | map update request                                     | Map Update Provider                   |
| Transit Management                 | transit probe data                                     | Traffic Management                    |
| Transit Vehicle                    | transit vehicle location data  
[Standards](#)             | Transit Management                               |
| Transit Vehicle                    | transit vehicle schedule performance  
[Standards](#)             | Transit Management                               |

[Standards](#)

This icon indicates that the associated architecture flow either has been or will be addressed by ITS Standards. Select the architecture flow for more information on relevant standards activities.

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For all „Architecture Flow“ more detailed advice is available, Including cross-references with relevant standards.

Source: http://www.iteris.com/itsarch/index.htm
Conclusion and Proposal for Next Steps

Define a **National ITS Vision** and a Framework Plan. Include a Strategy for the use of ITS. Define functional of ITS application and fix them with a time line.

Customize / develop a **Framework Architecture** and include functions, physical elements and organisational issues.

Customize / develop **Reference Architectures** and detail functions, physical elements and organisational issues.
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