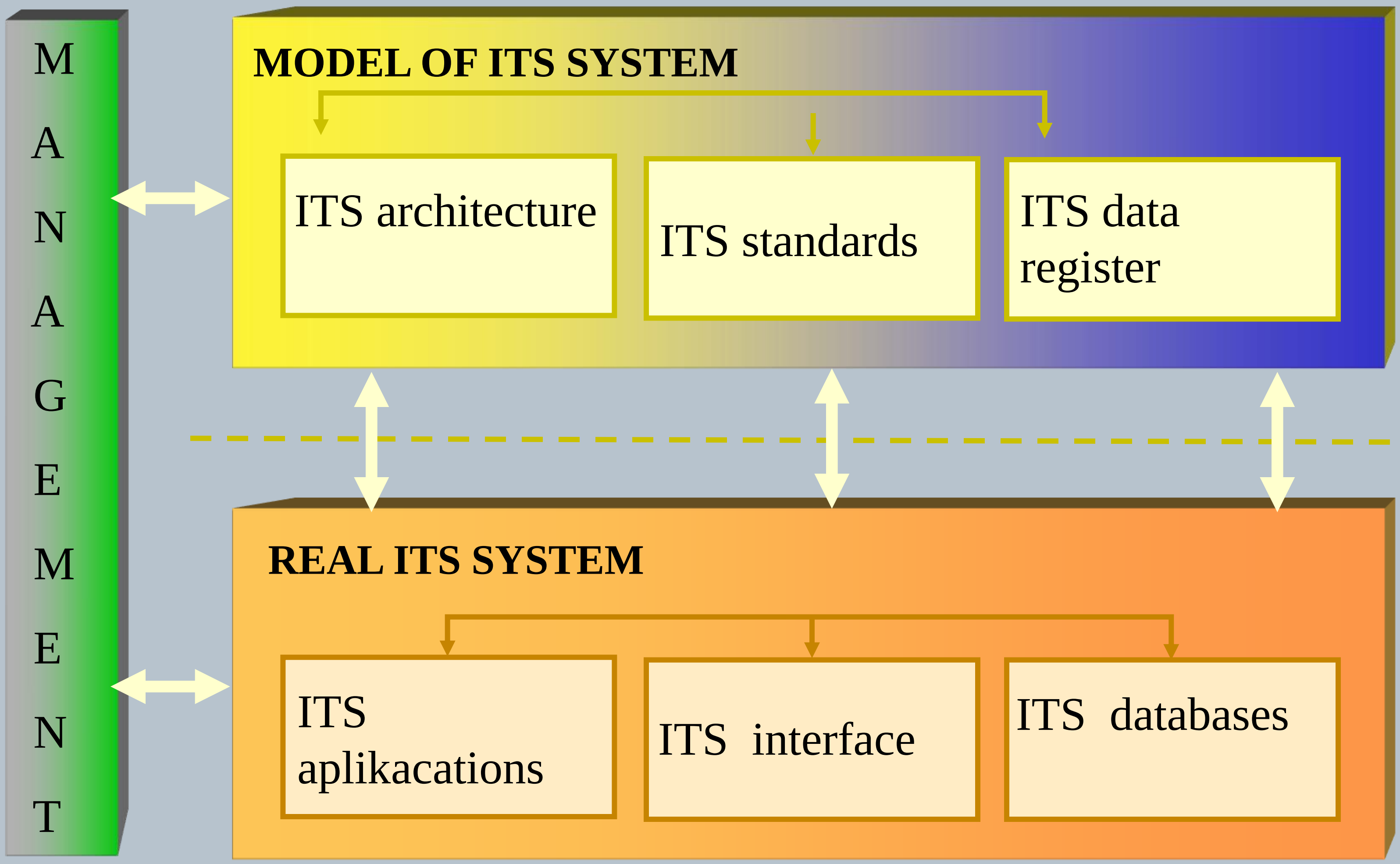
LECTURE

3

ITS ARCHITECTURE - European FRAME architecture

Zuzana Bělinová
Faculty of Transportation Sciences, Czech Technical University in Prague

Management of ITS systems - model and reality



Methodology of ITS system design

- System parameters assigned to each strong process and its decomposition into individual components
- The table of different performance parameters dedicated to each individual component
- Definition of optimisation criteria for performance parameters integration (the selection of most exacting criteria of all representative processes, weighted average of all the most exacting criteria)

Main parameters

- **Safety** (risk analysis, risk classification, risk tolerability matrix, etc.)
- **Reliability** (the ability to perform required function under given conditions for a given time interval)
- **Availability** (the ability to perform required function at the initialisation of the intended operation)
- **Integrity** (the ability to provide timely and valid alerts to the user when a system must not be used for the intended operation)
- **Continuity** (the ability to perform required function without non-scheduled interruption during the intended operation)
- **Accuracy** (the degree of conformance between a platform's true parameter and its estimated value)

ITS architecture

ITS architecture

- ITS architecture is based on
  - Experiences
  - Recommendations
- Goal is
  - Ensuring compatibility
  - Ensuring synchronization
- Notice: the term „architecture“ is a little misleading

Benefits of ITS architectures

- ITS architectures help to ensure that the resulting ITS deployment:
  - can be planned in a logical manner;
  - integrates successfully with other systems;
  - meets the desired performance levels;
  - has the desired behaviour;
  - is easy to manage;
  - is easy to maintain;
  - is easy to extend;
  - satisfies the expectations of the users.

Types of ITS Architecture

Three types

- Framework Architecture (e.g. FRAME Architecture)
  - User Needs
  - Functional Viewpoint
- Defined Architecture (e.g. US National Architecture)
  - User Needs
  - Function Viewpoint
  - Physical Viewpoint
  - Communication Viewpoint
  - Etc…
- Specific ITS Architecture (e.g. for public transport)
  - Physical Viewpoint of a particular ITS Deployment

ITS architecture

- ITS Architectures can be created at level of
  - International (European)
  - National
  - Regional
  - City
  - or relate to specific sectors or services.
- By complying with the European ITS Framework Architecture, not only will applications work together, but they can be made **inter-operable** at a European level, a feature of growing importance.
- Inter-operability encompasses the technical, operational and organisational aspects, and implies the harmonious and complementary functioning of the overall system.

ITS architecture on the European level

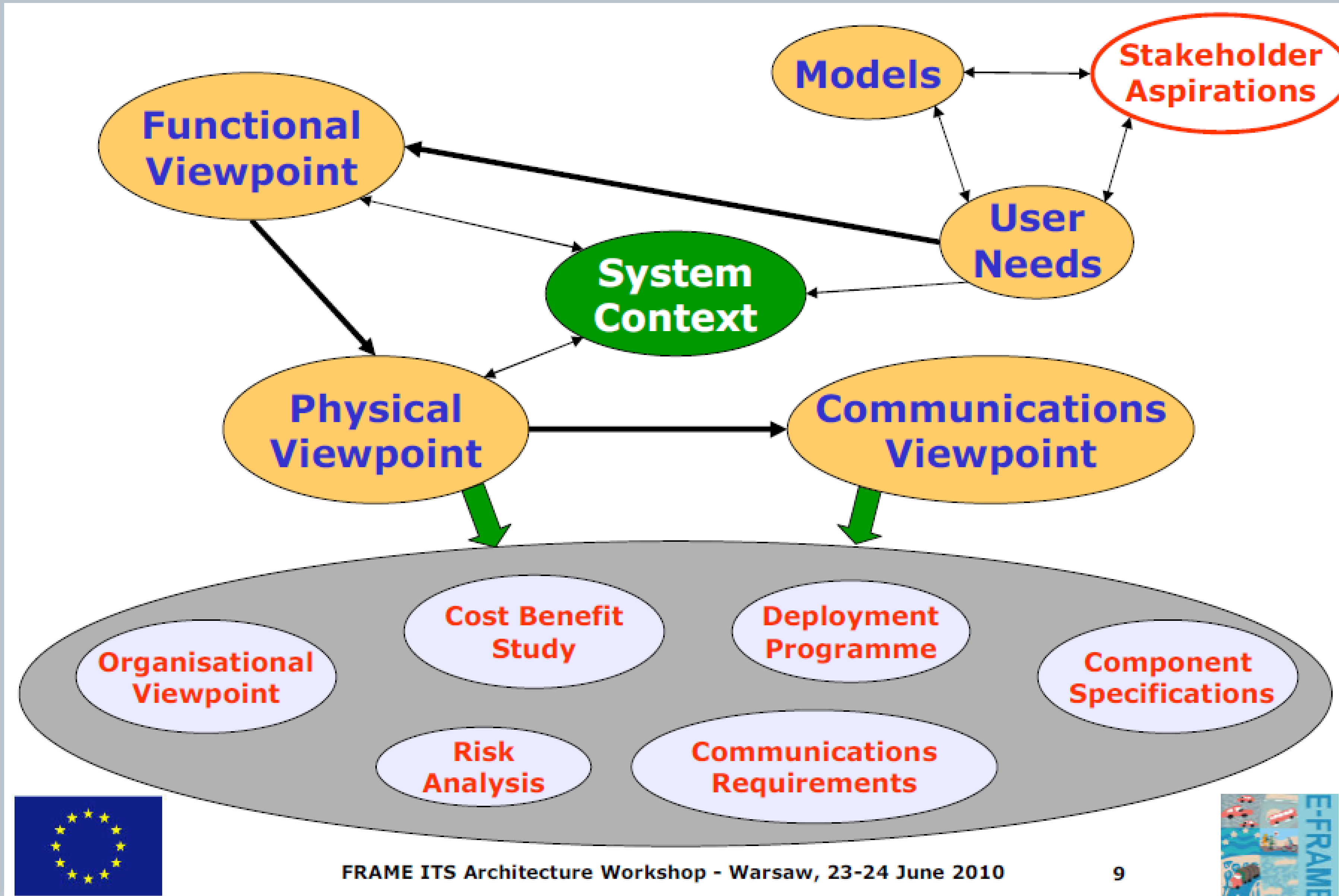
- Created from the 90s (together with development of ITS)
- It is framework architecture – enabling creation of national architectures
- Firstly named KAREN, now known under the name FRAME (FRamework Architecture Made for Europe)

- *Note: further description of ITS architecture will be based on the FRAME architecture*

European ITS framework architecture FRAME

- FRAME architecture designed to provide a flexible high level ‘framework’ that individual countries can tailor to their own requirements.
- National ITS Architecture projects based on the European ITS Framework Architecture have a common approach and methodology
- National ITS architecture can at the same time focus on the aspects of local importance and develop them in more detail.
- Outside Europe, other nations, including Japan, China, Chile and Australia, have taken similar initiatives. Despite differences in the approaches adopted around the world there is a growing desire to exchange experience and explore the possibility of co-operation at a global level on key issues.

ITS Architecture - structure



Content of ITS architecture

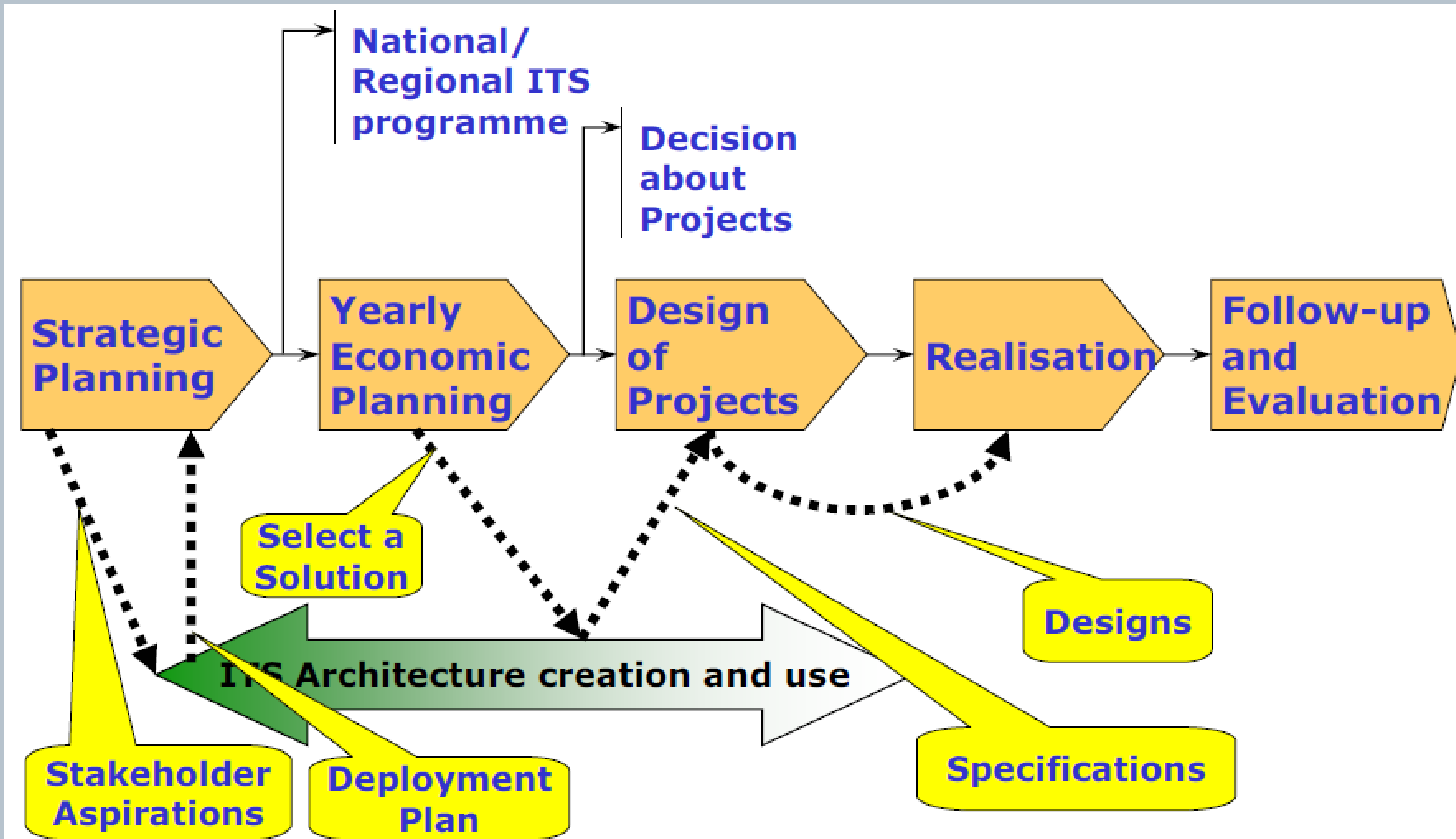
- ITS Architecture normally includes:
  - an **Overview or (Conceptual Model)** – a top-level diagram that shows the whole system and explains how it works.
  - a **Functional (or Logical) Architecture (or Viewpoint) – a** series of diagrams and specifications that show the functions or processes needed in order to satisfy the User Needs.
  - a **Physical Architecture (or Viewpoint) – a series of diagrams** and specifications for the physical components and their locations for a particular deployment.
  - a **Communications Architecture (or Viewpoint) – an analysis** of the communications requirements of the links needed between the locations shown in the Physical Architecture.
- Other Viewpoints that might be included are
  - **Organisational or Enterprise Viewpoint,** which describes the business relationships between organisations,
  - **Information Viewpoint to provide** models for key sets of data.

Former types of ITS architecture

- Former division of ITS architectures:
  - reference – defining basic functional elements and specifying system goals
  - functional – defining functions of elements, modules, subsystems and relation among them
  - information – containing structure of information systems
  - physical – containing physical devices necessary for ensuring system functions
  - communication – describing information transmission among elements of physical architecture
  - organizational – describing functions and influences of human factor including financing and management

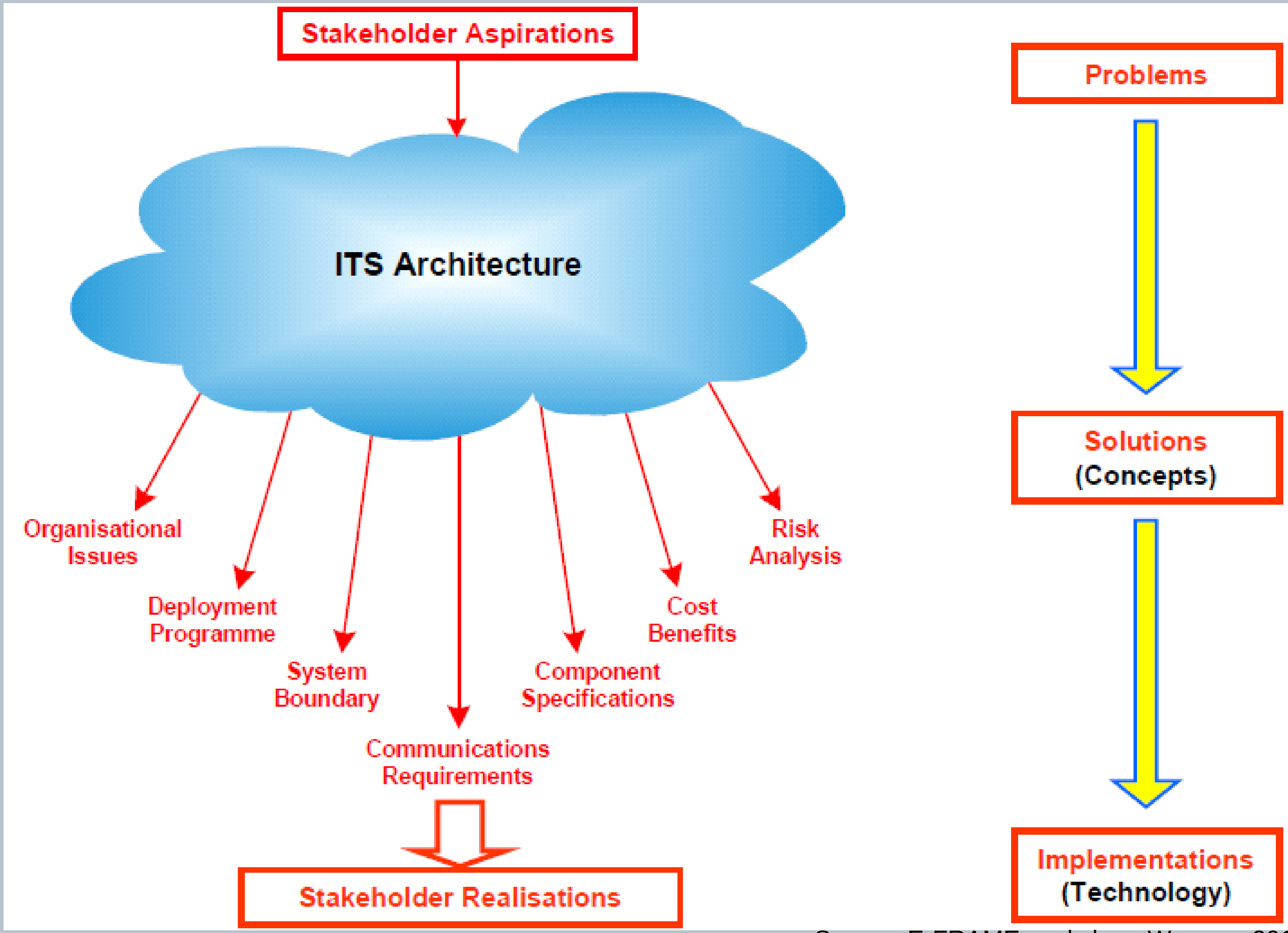
  - Functional and information used to be integrated into so called logical architecture and physical and communication under the term physical architecture
- Nowadays these are regarded as different view on the architecture

ITS architecture creation and use



Source: E-FRAME workshop, Warsaw, 2010

ITS architecture – creation and use



Source: E-FRAME workshop, Warsaw, 2010

ITS Architectures Inputs

Stakeholder Aspirations

- Must involve Stakeholder consultation
- Enable Stakeholders to define what they want from ITS deployment
- Crucial to the success of ITS Architecture and eventual deployment

ITS Architectures Outputs

System Boundary

- Defines the System Boundary
  - What is provided by the System and what is not
  - Shows the relationship between the System and the parts of its environment with which it interacts
- These “parts” are called Terminators:
  - Can be a person, organisation, or another system
  - Has a description stating what it is expected to do
  - Can be split into recognisable components (Actors)

ITS Architectures Outputs

Component Specifications and Communications Requirements

- Component : descriptions of each Sub-system & Module Used as input for:
  - Component procurement document creation
  - Component design requirements
- Communications : descriptions of each link between the Sub-systems & Modules
  - Used as input for communications network requirements

ITS Architectures Outputs

Organisational (Enterprise) Viewpoint

- Shows:
  - Who owns and operates:
    - Each of the Sub-systems & Modules
    - Each part of the Communications infrastructure
  - The links between each owner/operator
  - The enterprise model
- It can highlight potential conflicts between organisations and other organisational issues

ITS Architectures Outputs

Cost/Benefit Study

- Shows:
  - The costs for the deployment the System:
    - Each Sub-system and Module
    - Both Capital and Revenue Costs
  - Expected benefits from the ITS deployment
- Costs, used with Deployment Plan, to provide Funding Profile
- Benefits justify need for ITS

ITS Architectures Outputs

ITS Risk Analysis

- Identifies ITS deployment risks:
  - Severity of hazard
  - Probability of hazard
  - Mitigation Strategy for most severe risks
  - Risk and mitigation strategy ownership
- Use to manage planning and project risks

ITS Architectures Outputs

Deployment Programme

- Shows:
  - Plan for Sub-system, Module and Communications Infrastructure deployment
  - Shows what happens to existing systems and equipment
    - Defines migration strategy (replace/modify/retain as is)
    - May require use of "interim" communications and equipment
- Used with Costs to produce Funding Profile
  - May cause Deployment Plan to be modified
  - Can cause revision to Sub-systems and Modules

Functional viewpoint

ITS architecture principles

- One of the main elements of an ITS Architecture is the list of **Stakeholder Aspirations.**
- **These consist of the high-level objectives** and requirements of all those involved in the ITS deployment, i.e.
  - the users,
  - operators,
  - Regulators
  - providers,

  usually referred to collectively as the “**ITS Stakeholders”.**
- These Aspirations are then converted into simple statements often called the **User Needs**

Example of Stakeholder aspirations

An Example for Public Transport

- E.g.:

  The delivery of more secure, comfortable and easily usable public transport services through the provision of accurate, reliable and timely service information at stops, stations, all types of interchange points and inside public transport vehicles.

User Needs Groups

- 1 General
- 2 Management activities
- 3 Policing/Enforcing
- 4 Financial transactions
- 5 Emergency services
- 6 Travel information
- 7 Traffic management
- 8 In-vehicle systems
- 9 Freight and fleet operations
- 10 Public transport

Example of User Needs – public transport

- The system shall be able to inform travellers about public transport operations, e.g. travel times, delays, fares.
- The system shall be able to provide information about public transport services to the travellers either on-board the public transport vehicle, or before the journey.
- The system shall be able to provide an update of arrival/departure information in real-time and present it to travellers at public transport stops and/or on-board public transport vehicles.
- The system shall be able to provide general (dynamic) public transport information, personal safety information, as well as the arrival times of next vehicles, delays, etc. at mode interchanges, e.g. bus stops, in metro, railway or bus stations.
- The system shall be able to provide information that is relevant to travellers with special needs, e.g. obstacles, manually operated doors, manual payment systems, restrictions for guide dogs and/or push chairs.

Using the FRAME Architecture for creating architecture

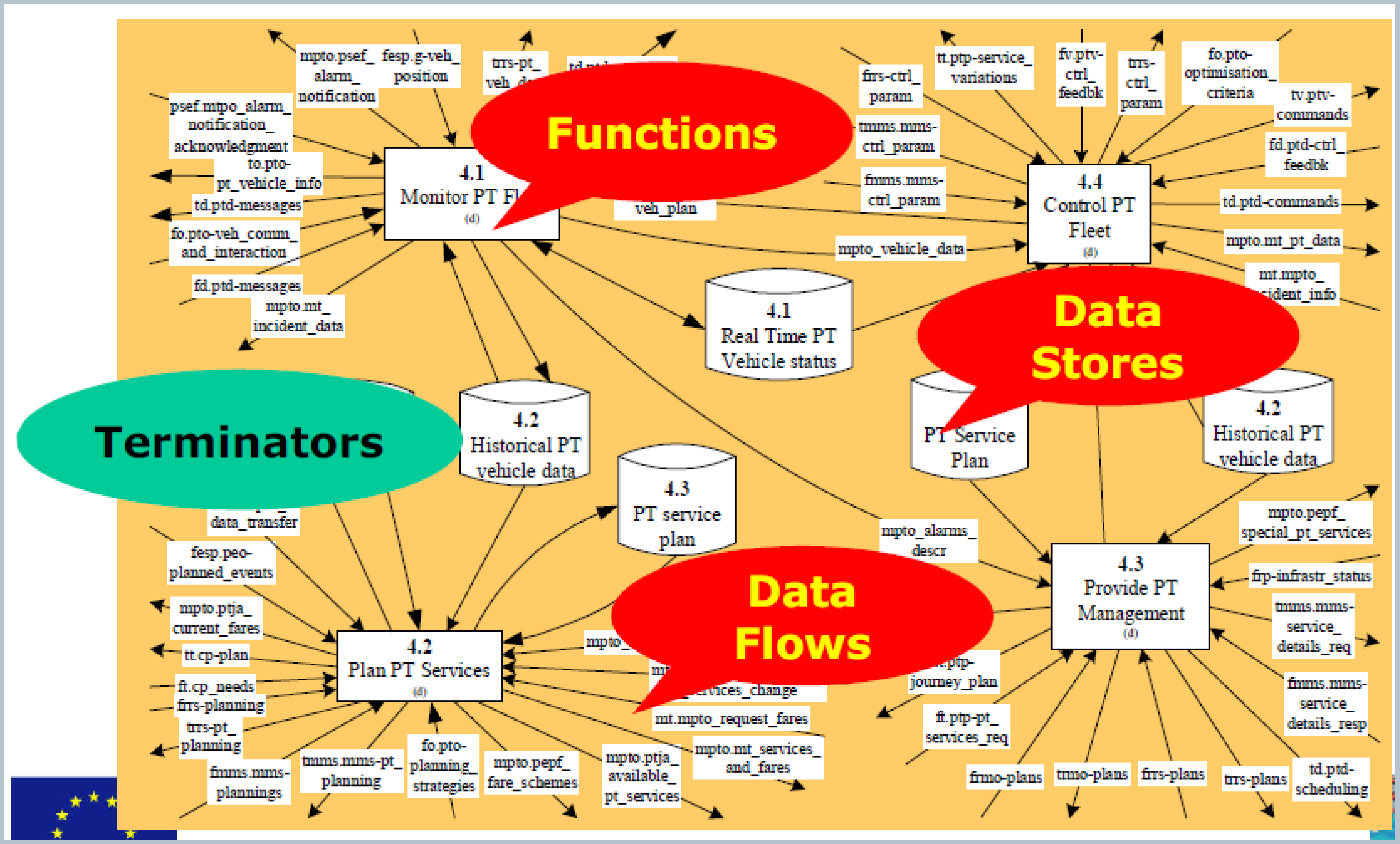
- Select User Needs
- Select Functions
  - From full list
- Select Data Flows
  - From list defined by selected Functions
- Select Data Stores
  - From list defined by selected Data Flows
- Select additional Data Flows
  - From list defined by selected Data Stores
- Select Terminator and Actors
  - From full list

Functional Viewpoint

- The Functions that, together, provide the services specified by the User Needs
  - What, not how
    - **Technology independent**
- The data that flows between the Functions
- The “things” that interact with the Functions
  - E.g. travellers, operators, traffic
- The data that is stored for later use
  - Temporarily or permanently

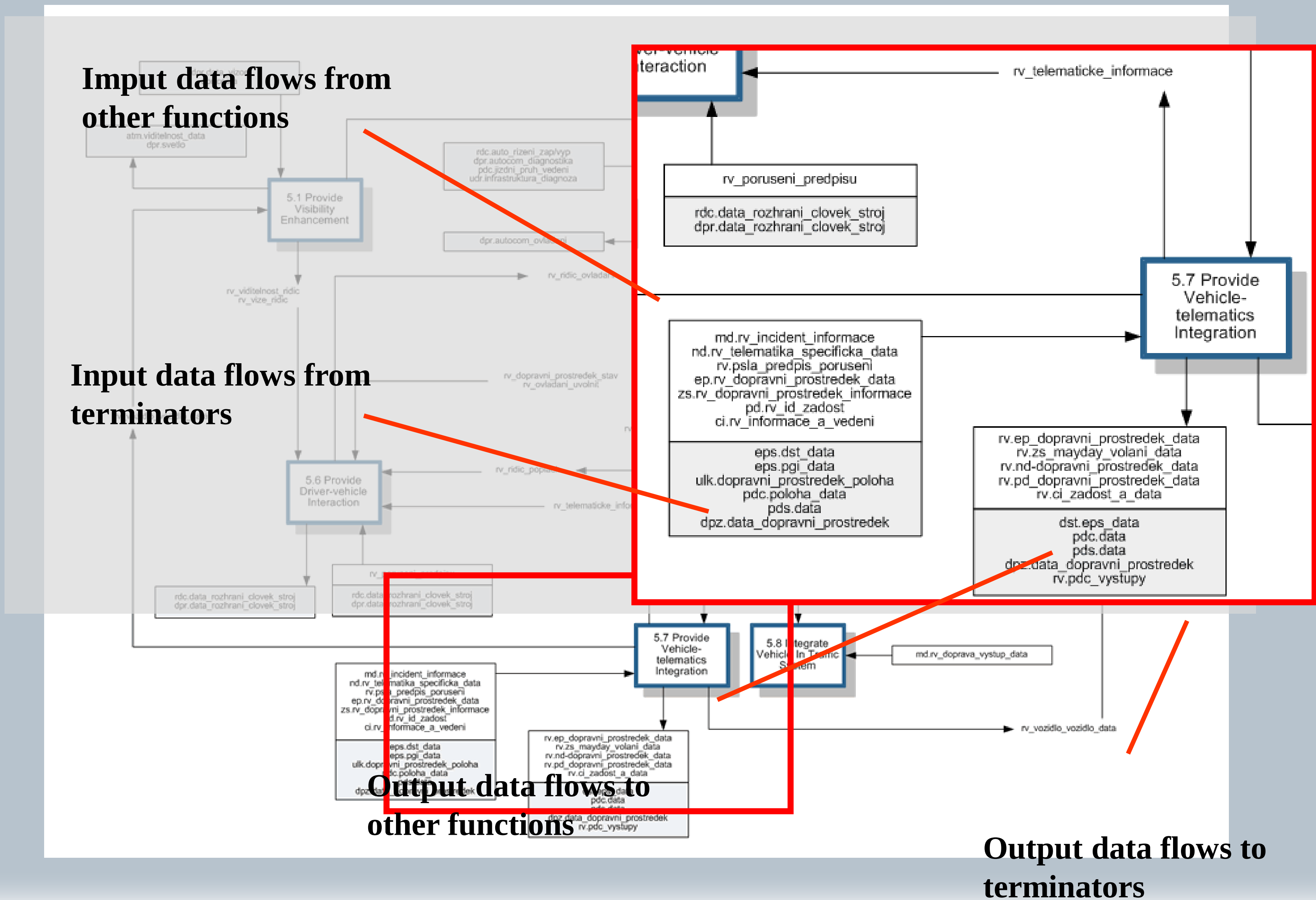
Functional viewpoint

- A Functional Viewpoint defines and describes the functionality needed to fulfil a set of User Needs



Source: E-FRAME workshop, Warsaw, 2010

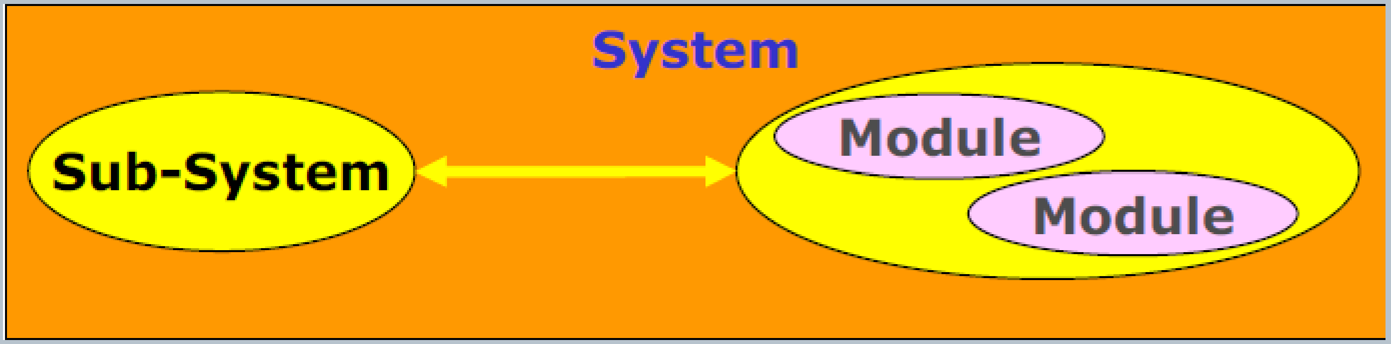
ITS architecture – Information data flow



Physical viewpoint

Physical Viewpoint

- A description of how (a sub-set of) the Functional Viewpoint will be deployed in a given situation
- Functions are allocated to Physical locations (Sub-Systems), sometimes to Modules within the Sub-Systems
- This process will define the data that need to pass between the sub-systems



Physical realization of ITS components (subsystems)

- Definition of all parameters used in component (subsystem) together with its atributes (sample freguency, acuracy, representation, etc.)
- Definition of unified SW modules available for all proceses (functions, databases and conditions)
- Definition of management taking into account all system parameters (safety, priority, etc.)
- Definition of processes/ applications using unified functions, databases and conditions (development kit)

Communication viewpoint

Communications Viewpoint

- An Analysis of the Physical Data Flows to identify the characteristics of the physical links that will carry the data, e.g.
  - The types of data to be transferred
  - The physical mode of data transfer
  - Any security requirements
  - The data transfer capacity required

Communication viewpoint

Types of Data to be Transferred

Examples

- Raw Data
  - Numbers, characters, XML, EDIFACT
- Smart card data
- Image
  - Digital picture
  - Video motion
- Human machine interaction
  - Voice, audio, display
- Physical
  - Movement
  - State : e.g. weather, road surface, person

Communication viewpoint

Mode of Data Transfer

Examples

- **Sound**
  - Pedestrian signals
- **Vision**
  - Computer display screen
  - LCD, LED
- **Tactile**
  - Buttons
  - Touch screens
- **Hard Copy**
  - Timetable...
- **Physical**
  - Tokens
  - Insertion of smart cards...
- **Sensor/transducer**
  - Loop Detector
  - IR presence indicator...
- **Wire Line**
  - Ethernet
  - Dial-up POTS/ISDN...
- **Wire Less**
  - FM Radio, DAB
  - Cellular
  - Microwave transmission...

Communication viewpoint

Security Level

- None
  - Public information
- Low
  - No unauthorised changing of data
    - Identification required before use
- High
  - No unauthorised reading of data
    - Use of encryption

Quantity of data in each item

- Bits, Kb, Mb

Waiting time permitted

- Time between data creation and data use

Time interval between transmissions

- Time before a new value is required

Communication viewpoint example

- Example

Physical data flow	Data type	Max bytes/ message	Max delay (sec)	Messate Interval (sec)	Security level	Transfer mode
Mpto_vehicle_data	Raw data	250	0,1	10	None	wireless
trmo_plans	Raw data	80	0,5	30	Low	Wired line

Organisation viewpoint

Organisational (Enterprise Viewpoint)

- Shows:
  - Who owns and operates:
    - Each of the Sub-systems & Modules
    - Each part of the Communications infrastructure
  - The links between each owner/operator
  - The enterprise model
- It can highlight potential conflicts between organisations and other organisational issues

Organisational (Enterprise Viewpoint)

- Each service is used by somebody, or organisation
  - Services are comprised of Sub-systems and Modules
- Each Sub-system/Module must be owned by somebody, or organisation
- Each Sub-system/Module must be managed by somebody, or organisation
- A Sub-system/Module may provide data for another
  - Incorrect data transfer will raise organisational issues
- An ITS Architecture can provide the basis for planning the organisational structure of services

Organisational (Enterprise Viewpoint)

Control Relationships between Organisations

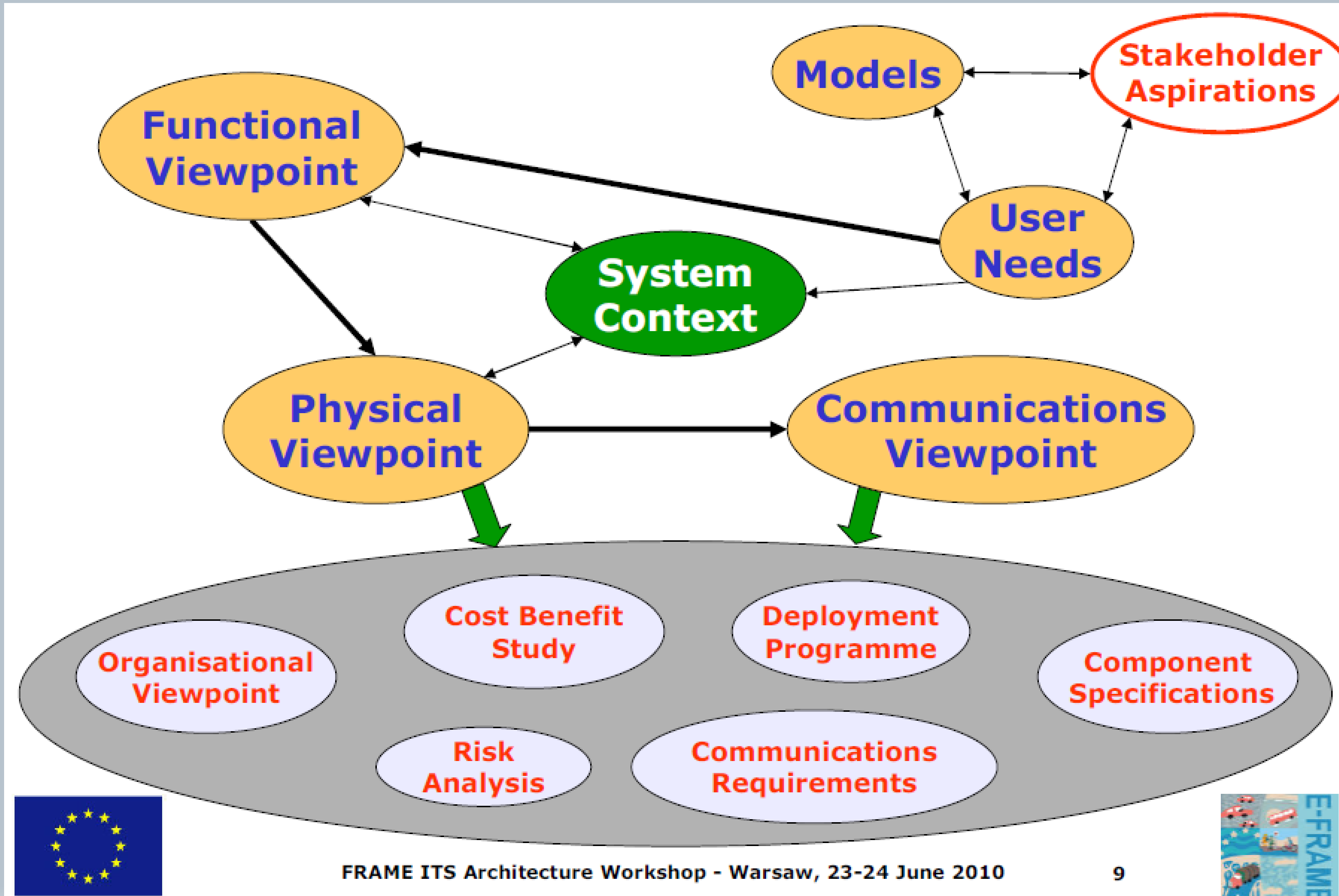
- Directional
  - One (part of an) organisation has the power to direct, or manage, what another (part of an) organisation does and, possibly how it is done
    - e.g. Traffic Management “controls” PT Management
- Long Term Contractual
- – One organisation is required to perform a defined service for, or on behalf of, another organisation
    - e.g. Provide communications
- Short Term Contractual
  - One organisation, or individual, pays another organisation for a well defined service
    - e.g. Traveller on pubic transport

Component and Communication Specifications

- **Define what is to be provided through acquisition and deployment**
- Must provide:
  - Unambiguous descriptions
    - What component must do
    - Itemised and testable
- Other Requirements
  - Expected Price
  - Delivery Schedule
- *Example*
  - *Physical size, colour and other characteristics*
  - *Location and any constraints*
  - *Data Transfer Rate (min and/or max)*
  - *Frequency of use (min and/or max)*
  - *Type of data, e.g. voice, data*
  - *Required Security*

Summary

ITS Architecture - structure



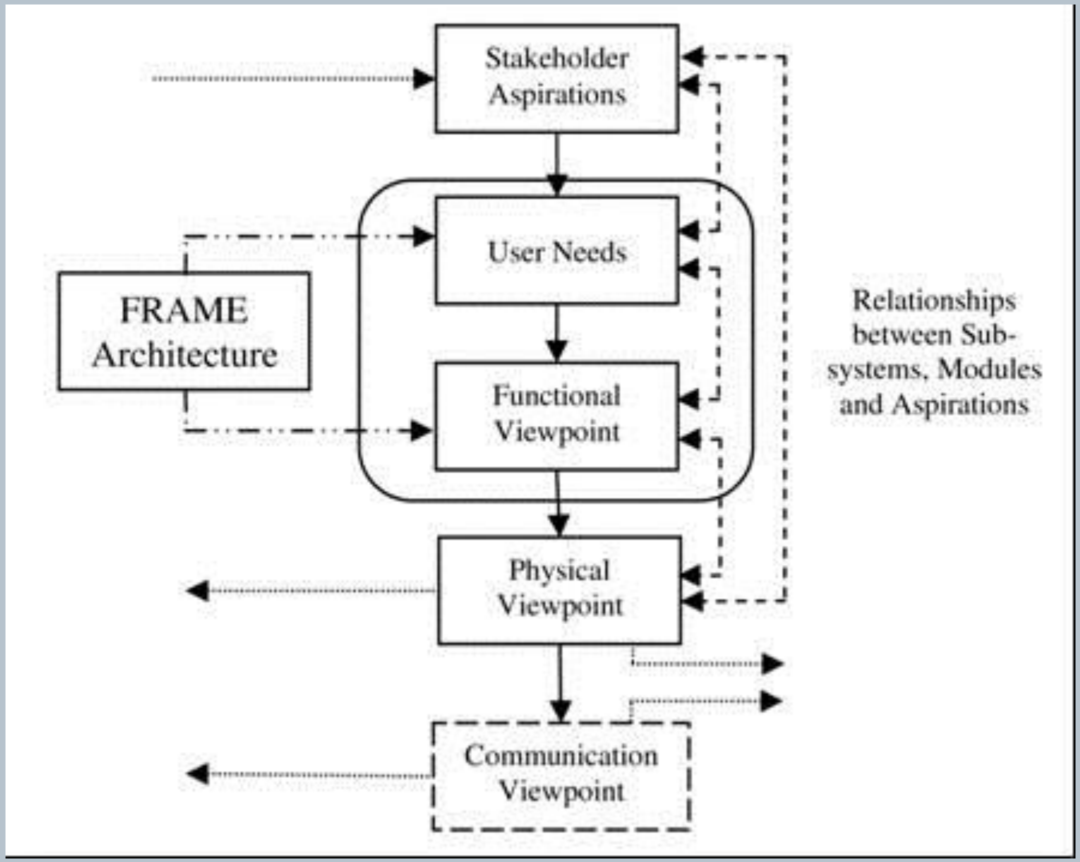
Creation of ITS architecture - summary

- Identify the various people and institutions to be involved. They include: the team responsible for creating the ITS Architecture, a review team, and all the ITS stakeholders.
- The next task is to draw up the list of Stakeholder Aspirations. These need to be agreed and endorsed by everyone, and can then be published.
- A survey of existing ITS applications may also be done at this stage.
- Turn the Stakeholder Aspirations into formal User Needs, for which functionality can be developed;
- split the functionality into components that can be produced;
- draw up the outline specifications of these components;
- submit these specifications to a review team;
- compare ‘where you are’ with ‘where you want to be’;
- draw up deployment plans.

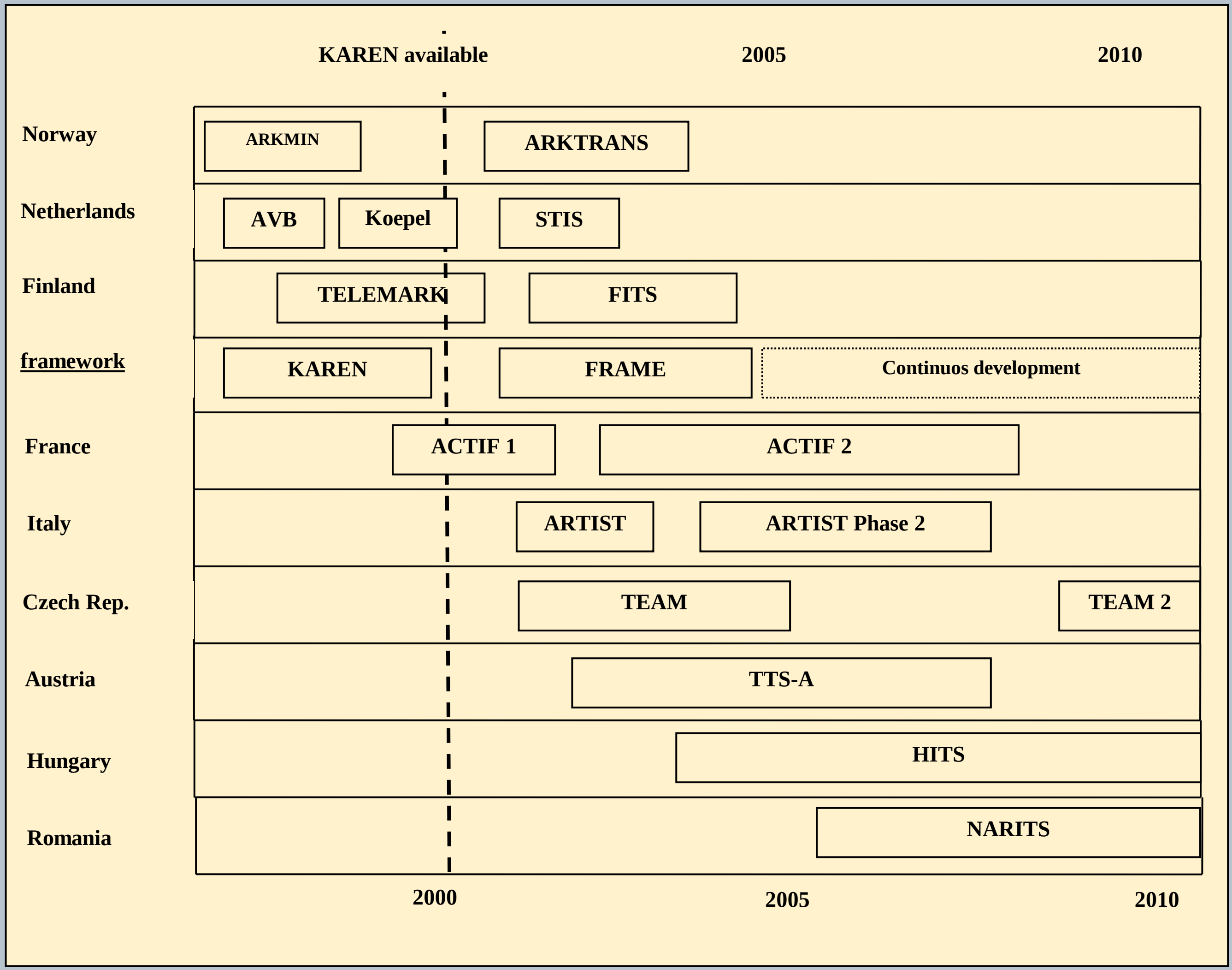
Usage of ITS architecture - summary

- a preliminary analysis of ***Costs & Benefits*** *identifying* e.g. savings from improved transport efficiency;
- a ***Risk Analysis*** *examining potential problems, e.g. reliability of* technologies, uncertainty about sources and volume of revenue, potential stakeholder conflicts;
- the starting point for producing the ***Component Specifications*** *for* the elements needed for the ITS deployment;
- a basis for the necessary ***Infrastructure Specifications***, *including* standards for the communication links
- the key milestones in the *Deployment Programme in the short,* medium and long term, specifying e.g. when existing component upgrades are needed, and when new components must be available;
- an *Organisational Issues document, which highlights aspects* affecting the organisation of the ITS deployment, e.g. relationships between the various stakeholders, revenue distribution, data ownership, procedures to ensure data privacy.

FRAME architecture principles - summary



Time schedule of national architecture developmnet in Europe



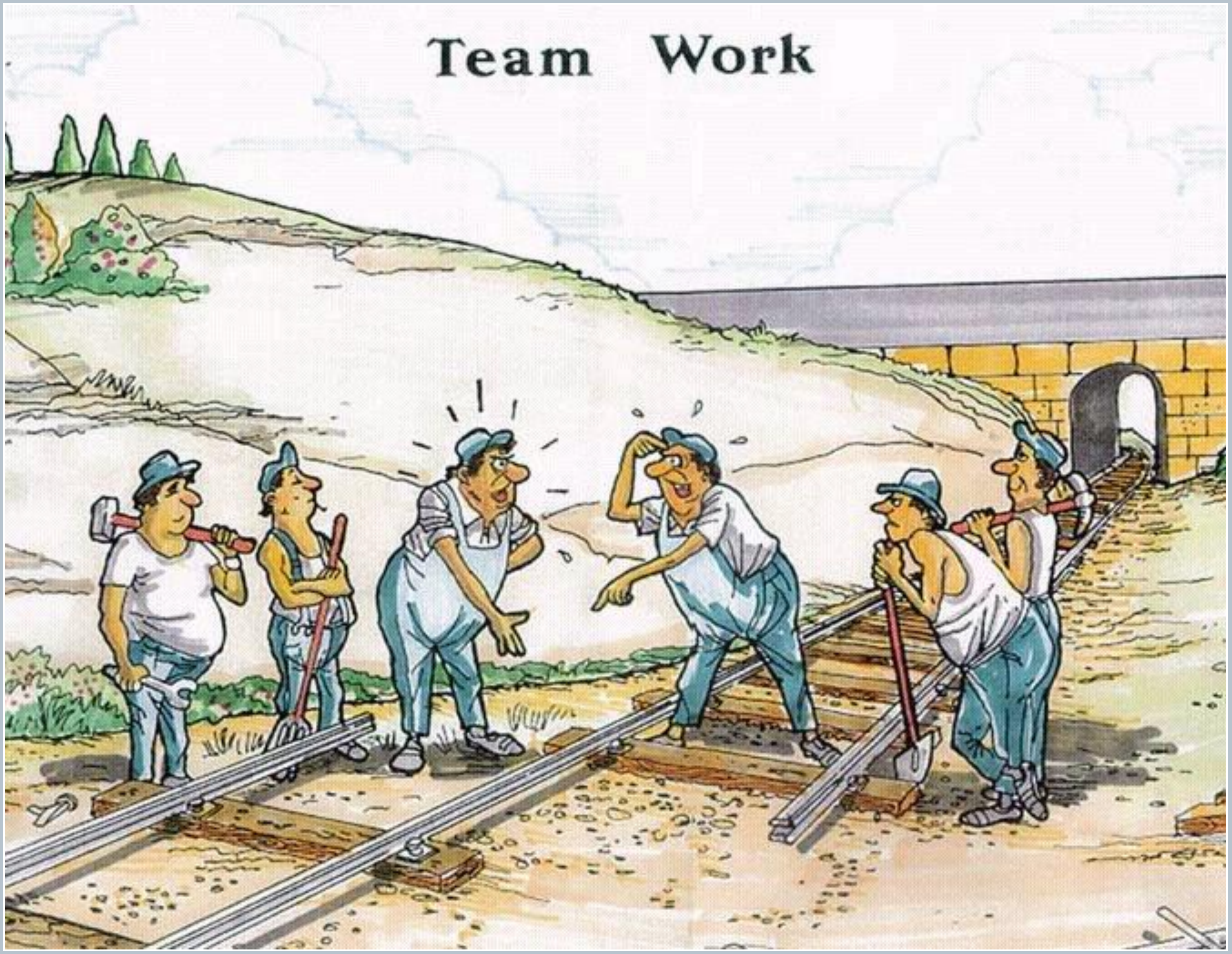
Ongoing development of FRAME architecture

- Architecture is never finished
- Need to react to nowadays trends
- For example European project E-FRAME (2008-2011) was upgrading the architecture and extending it with cooperative systems

E-FRAME project

- Project partners
  - **Peter Jesty Consulting Ltd (UK) (coordinator)**,
  - Siemens Traffic Controls (UK),
  - AustriaTech – Federal Agency forTechnological Measures (AT),
  - Rijkswaterstaat Dienst Verkeer en Scheepvaart (NL),
  - Czech Technical University in Prague (CZ),
  - Centre d’Etudes sur les Réseaux, les Transports, l’Urbanisme et les constructions publique (CERTU) (FR)
  - MIZAR Automatizione S.p.A. (IT)
- Czech Technical University was leader of Work Package Standards for Cooperative Systems

Thank you for your attention



References

- Peter H Jesty, Richard A P Bossom. E-FRAME workshop slides, Warsaw, 2010
- www.frame-online.net
- Peter H Jesty, Richard A P Bossom. Why do you need an ITS architecture – European and national perspectives
- Peter H Jesty, Richard A P Bossom. Planning a modern transport system – a guide to intelligent transport system architecture
- Peter H Jesty, Richard A P Bossom. Planning a Modern Transport System: A guide to ITS Architecture
- E-FRAME project factsheet
- E-FRAME Deliverable 16
- www.frame-online.net
- www.silmos.cz
- http://www.iso.org/iso/iso_technical_committee?commid=54706
- http://192.87.114.76/cen278/
- Action Plan for the Deployment of Intelligent Transport Systems in Europe http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0886:FIN:EN:PDF
- DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:207:0001:0013:EN:PDF
- Key Concepts of the National ITS Architecture http://www.iteris.com/itsarch/documents/keyconcepts/keyconcepts.pdf
- http://www.iteris.com/itsarch
- http://www.its.dot.gov/arch/