Course: ITS solutions for traffic and safety management

Topic 4. ITS architecture

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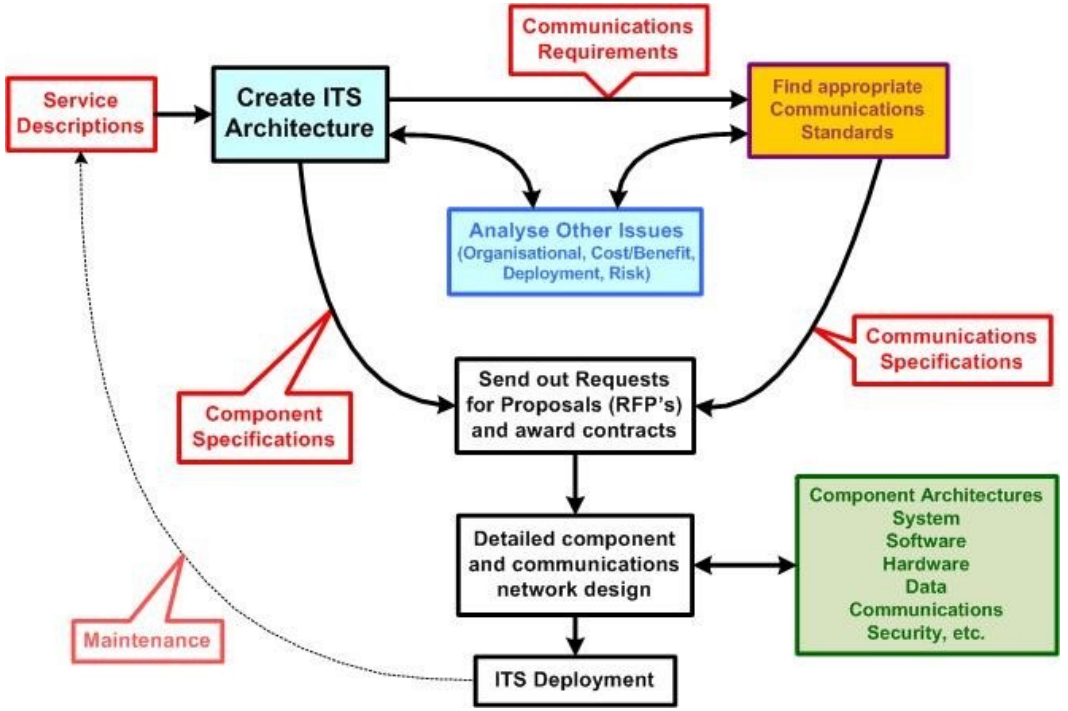
The use of ITS architectures in the ITS implementation process

An ITS Architecture is a conceptual framework (or structure) to guide the deployment of ITS. It is a formal specification of requirements that defines in detail:

- the functions to be performed by the ITS deployment (the user services – such as travel planning, traffic and emergency management, road pricing);
- the physical components needed to deliver these functions (such as roadside equipment, vehicle based control systems, control centre workstations);
- the interfaces and communications necessary to allow exchange of data and information between the physical components;
- stakeholders' roles and responsibilities in relation to the ITS deployment.



ITS architecture components

It is not possible to present a complex system in a way that can convey all the information about the system in an understandable manner. This is reflected in an ITS architecture, where multiple viewpoints, depicting different levels of detail and different types of information are used. These viewpoints might include:

- the logic (or functionality) of the system describing how various items of data should flow and be processed (the "**logical**" or "functional" viewpoint)
- how the ITS functionality will reside in the physical components of the system (the "**physical**" viewpoint)
- what communications are needed between the physical components – and between the outside world and the physical components (the "**communications**" viewpoint)
- how the system components, communications and responsibilities are to be assigned to providers and recipients of the ITS services (the "**organisational**" viewpoint)

Levels of ITS architecture

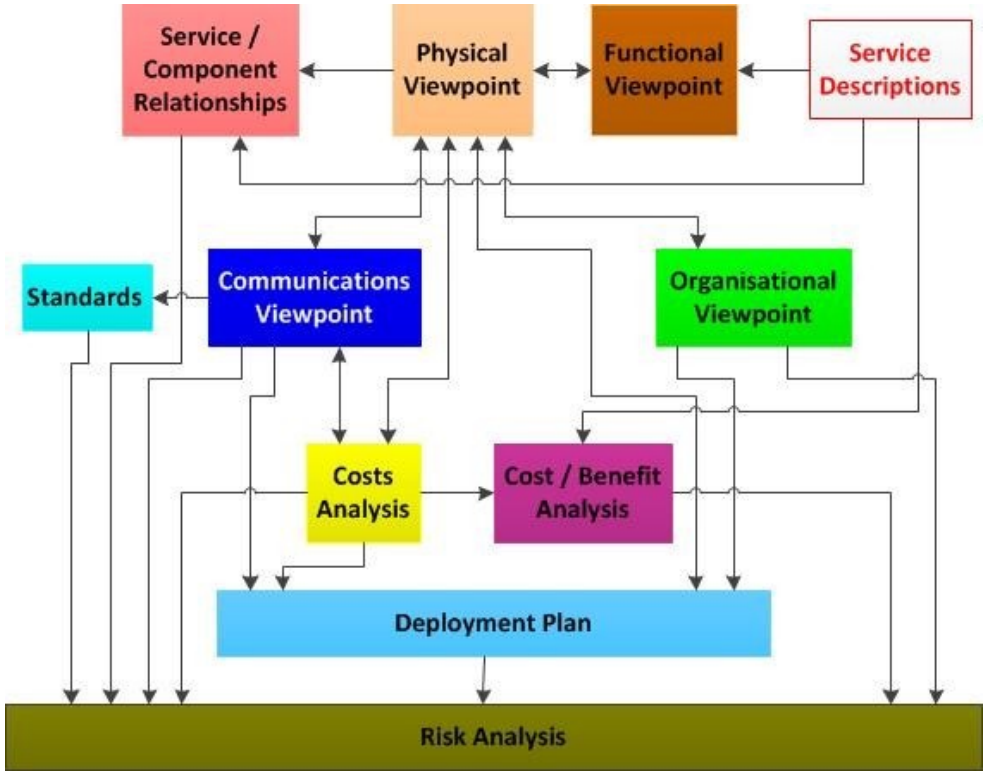
1. **Low-level (or component) architectures**, by contrast, contain the actual designs for hardware, software, data exchange and communications. They define more narrowly the technologies required including the use of ITS standards. A low-level architecture could be developed by the commissioning body, if they have the expertise, but it is more common for design specifications to be developed from a high-level architecture by the systems integrator or system supplier.

2. **High level ITS architectures** are developed to ensure that component systems can be successfully integrated and that the ITS deployment satisfies certain objectives – namely it:
   - is planned in a logical manner
   - meets the desired performance levels
   - is easy to manage, maintain and extend
   - delivers the desired performance and satisfies user expectations

Relationships between different ITS architecture viewpoints and other aspects of ITS deployment

The creation of a high level ITS architecture with optimal system configuration requires the analysis of a number of different – but crucial – aspects of the proposed deployment, as follows:

- a logical (or functional) viewpoint – what functionality is needed to deliver the services that the ITS architecture supports?
- a physical viewpoint – what system components are needed to deliver the required functionality, and how can these components be grouped together and co-located?
- a communications viewpoint – how does the choice and distribution of functionality in system components and component locations impact on the overall communications requirements?
- an organisational viewpoint – what organisational structure is needed to manage and operate the ITS implementation and how does this fit in with what already exists?
- a deployment plan – how are components and communications to be deployed, taking account of how many existing system components can be re-used?
- a cost/benefit analysis – to estimate the cost of supply and installation of components and communications, offset against the value of benefits from the deployment of ITS;
- a risk analysis – to evaluate the areas of risk associated with the deployment, and who will be responsible for their mitigation.



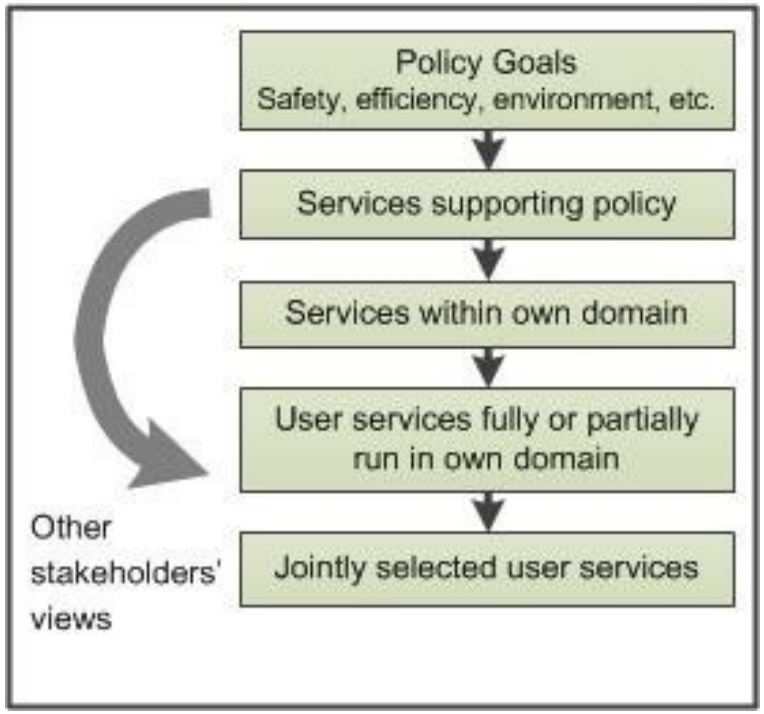
Framework ITS architectures

Framework ITS architectures have the following advantages:

- it makes it possible to achieve the harmonious integration of systems by defining where common standards, norms and practices can be used
- it prompts the resolution of important issues - such as stakeholder relationships and responsibilities for communications infrastructure provision
- they can be easily developed and adapted to provide a framework ITS architecture in different national contexts
- users can expand a framework ITS architecture to support additional services
- they can be used to develop low-level ITS (or component) architectures that are adapted for particular ITS implementations – giving users the freedom to create their own component configurations and specify the associated communications networks
- they can be used to explore alternative component configurations and associated communications networks - making it possible to investigate the options leading to an optimum ITS architecture for a particular deployment

Why create an ITS architecture?

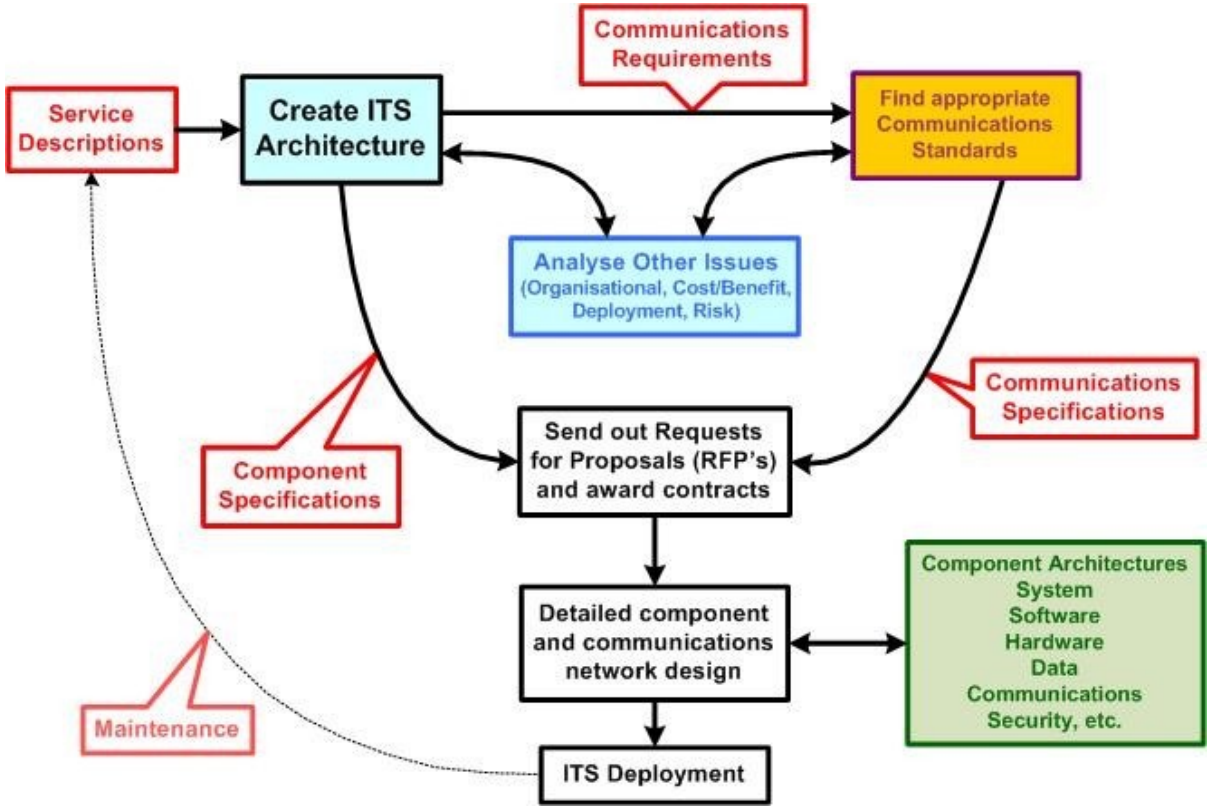
Within any single country or region, there are likely to be large differences between the set of ITS services useful for big cities and for rural areas. Many ITS applications (such as navigation and location based services) are market driven. In road network operations there are always key stakeholder groups, public authorities and private sector organisations with a part to play. Each has different organisational areas of competence or responsibility. Each has its own policy goals. Alongside there are the wider community objectives of improving road safety, transport efficiency and environmental quality. The process of stakeholder consultation is intended to take account of the bigger picture – to identify what ITS services are viable and how they should be implemented. This is outlined in the diagram, which shows that the first step is to define the policy goals, and then identify the services that will support these goals. Stakeholders nominate the ITS services that will run either fully or partially within their own domains. These are then amalgamated to provide a set of services that have been jointly selected by all stakeholders.



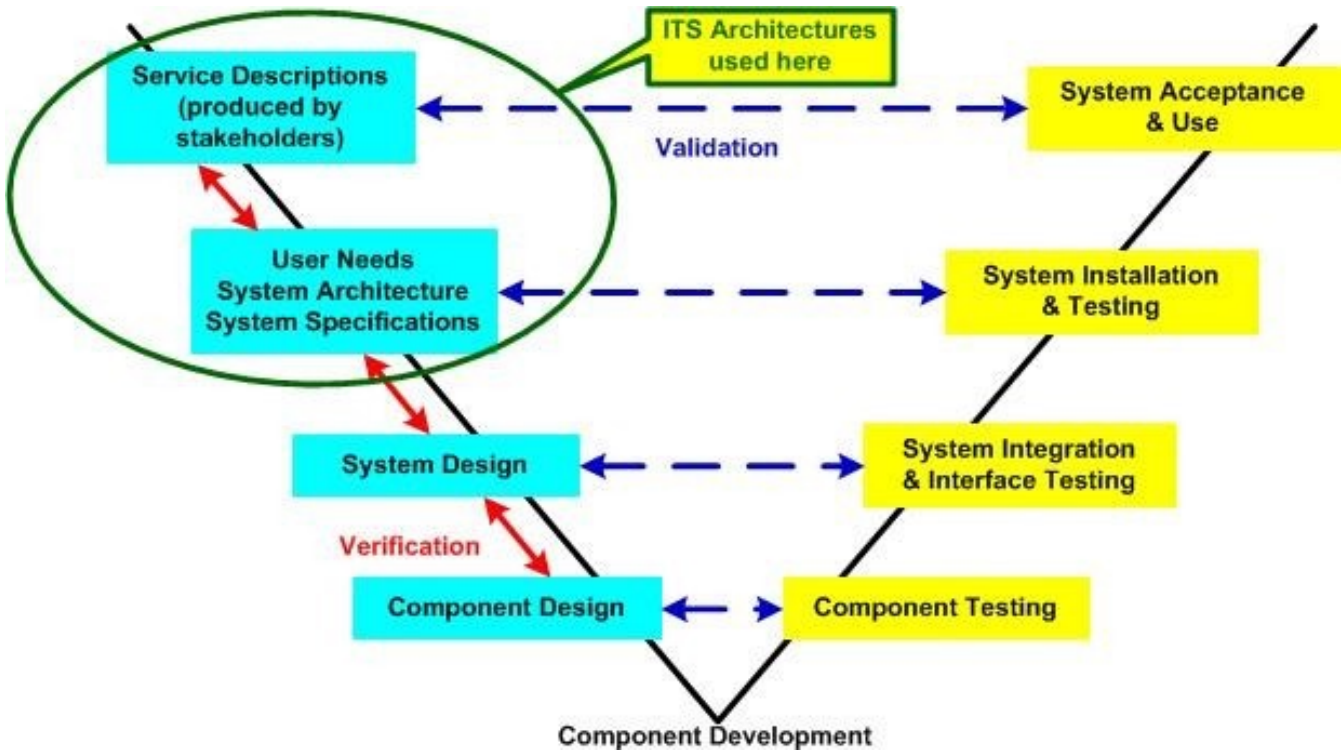
Expression of Policy Goals in ITS Service Selection

The use of ITS architectures in the ITS implementation process

The use of ITS architectures in the ITS implementation process comes before any of the components or communications have been purchased or designed. This is because they do not contain any reference to technologies. In fact the component specifications and communications requirements produced from ITS architectures can be used as input to the procurement process. This is illustrated by the diagram.

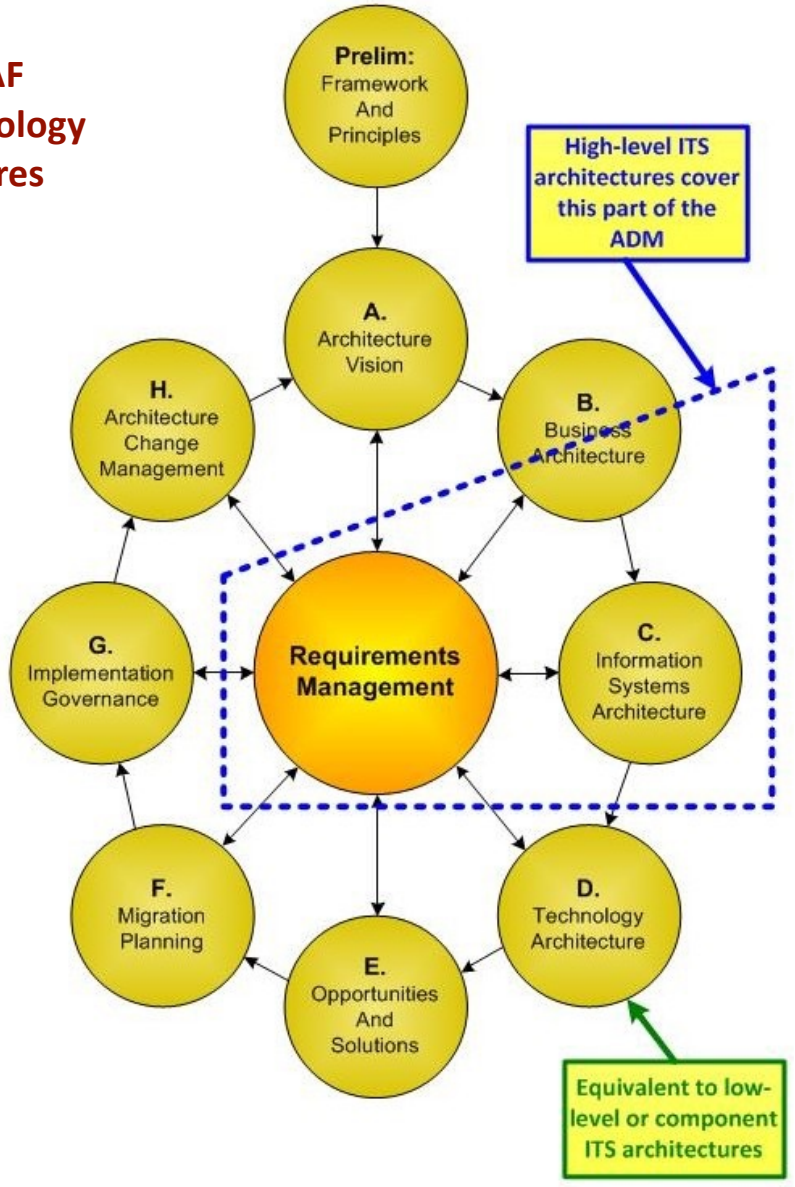


Model of ITS architecture development in the Systems Engineering



Relationship between the TOGAF Architecture Development Methodology (ADM) and typical ITS Architectures

Another methodology that can be used for ITS implementation is TOGAF (The Open Group Architecture Framework). It is robust and used in many parts of the world, backed by a strong user community that offers professional certification for those that use it (TOGAF practitioners). TOGAF Architecture Development Methodology (ADM) divides architecture creation and use into several phases as shown in the figure. The phases are similar to the steps shown in the figure on ITS architecture in the Systems Engineering "V" Model.

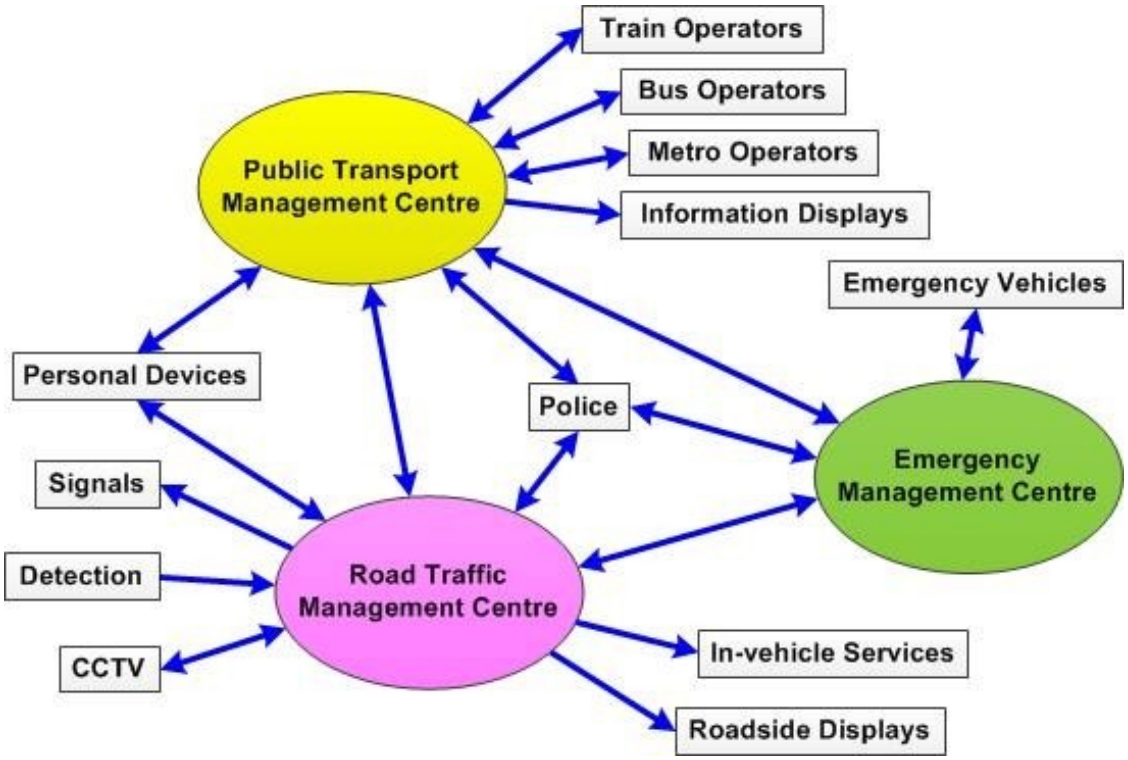


A typical high-level architectural sketch for Road Network Operations

For some ITS architecture practitioners the creation of a Concept of Operations (or ConOps) document is a key part of the ITS architecture creation process. Its usefulness depends on how the ITS architecture is going to be used and the content of both the functional and physical viewpoints.

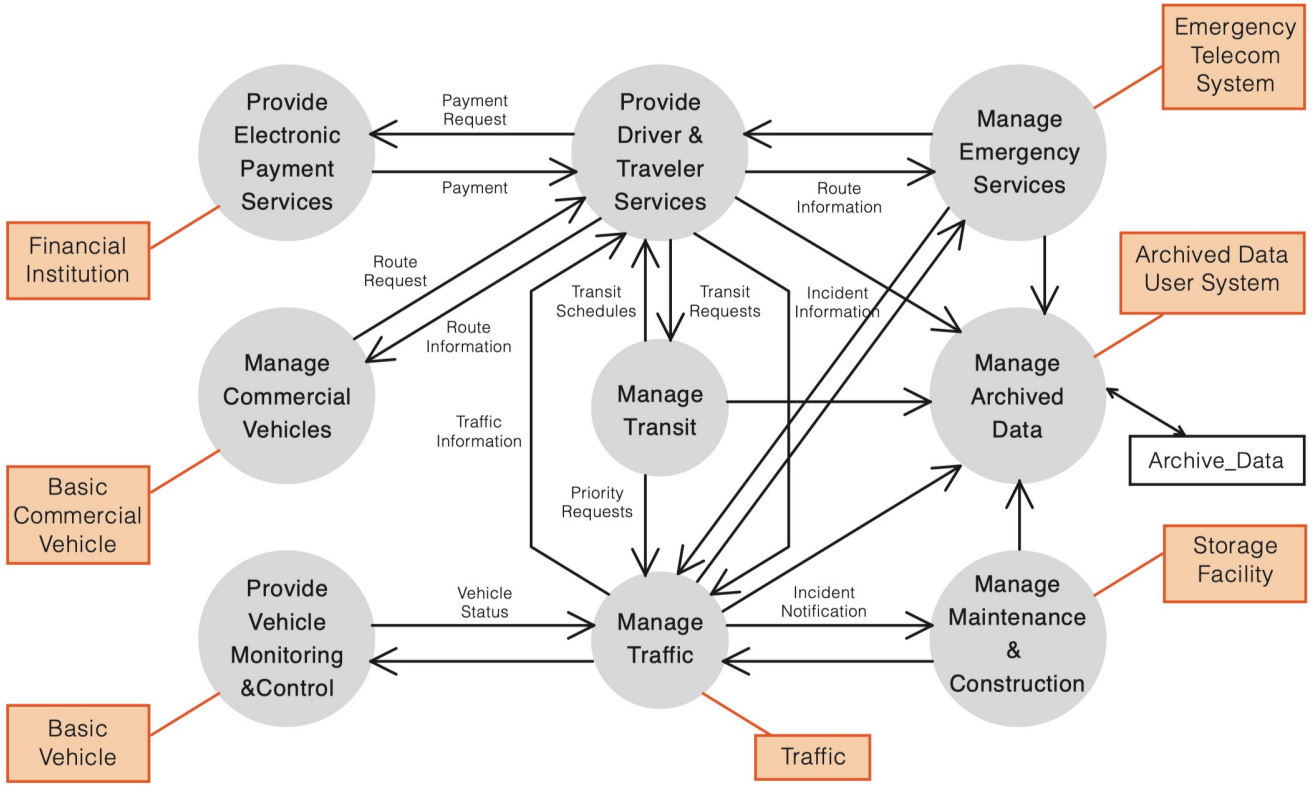
The ConOps document can be used to provide answers to stakeholders' questions about what is needed, how it works, who is involved and when it is needed. In order to produce this document, the starting point must be the service descriptions produced at the start of the ITS creation process.
Once the service descriptions have been produced and included in the ConOps document, it can be used to provide answers to the following questions:

- **What**: data/information is to be input/output and how is it obtained/provided
- **How**: the way that the inputs are processed to produce the outputs
- **Who**: the different levels and areas of responsibility of all those involved in delivering the services
- **When**: what will the end users get, where and when



ITS Logical Architecture

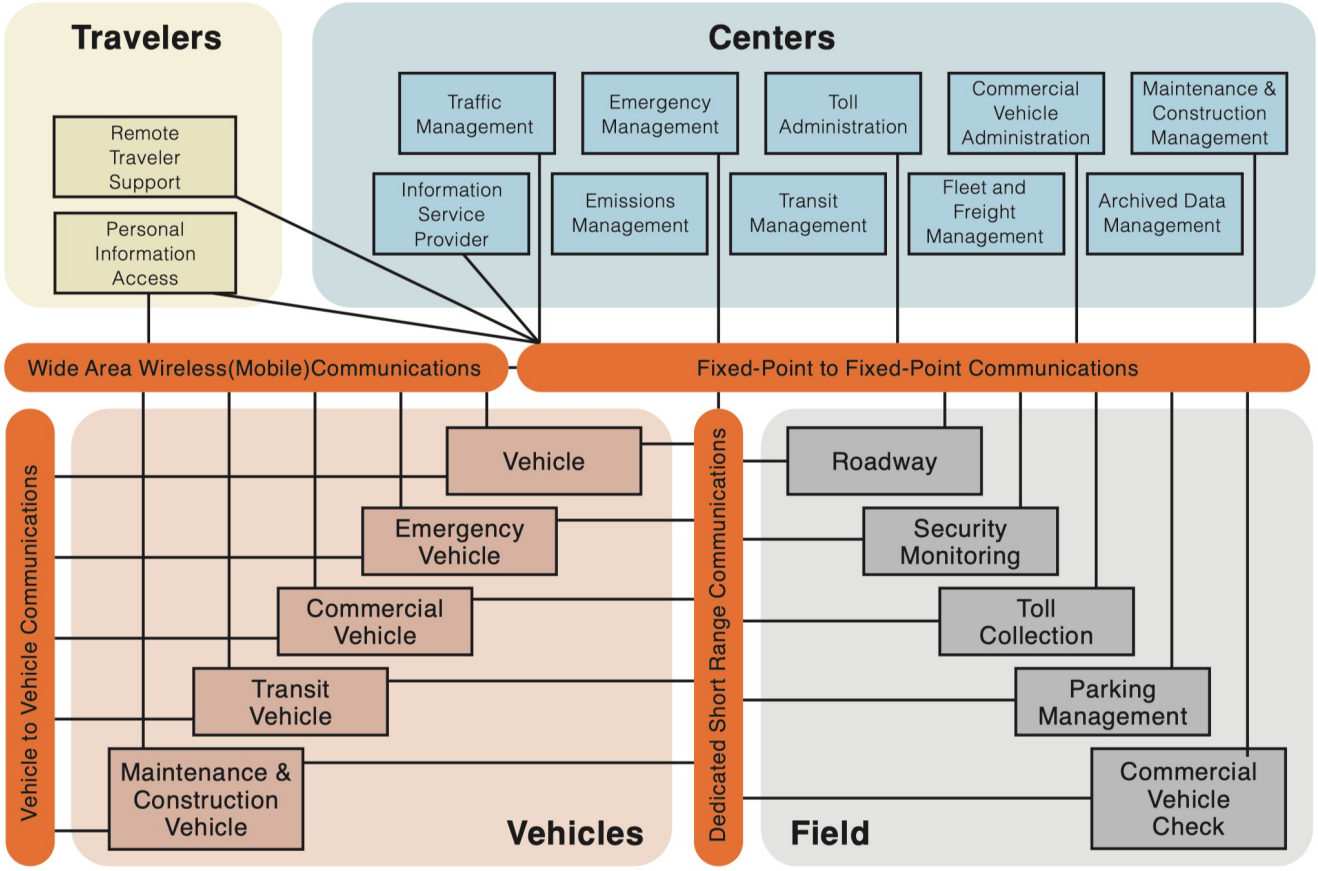
The logical architecture illustrates the ITS system architecture at many levels of detail. The logical architecture aims to explain the configuration of services, without worrying about how it will get done. The logical architecture takes the form of a series of data flow diagrams (DFDs) which depict logical processes (shown as circles), entities (rectangles), data flows (arrows), and data stores (logical data files, shown as a name between parallel lines). Figure shows the very highest level DFD for the US logical architecture. Each of the processes (circles) is then blown up into an entire DFD of its own, with additional lower level detail. This refinement continues for a number of levels.



http://www.iteris.com/itsarch/html/glossary/glossary.html entry on "Data Flow Diagrams"

Physical Architecture

The physical architecture is a physical representation of the important ITS interfaces and major system components. The principal elements in the physical architecture are entities and architecture flows that connect these entities into an overall structure. The physical architecture assigns processes from the logical architecture to subsystems, and groups data flows from the logical architecture into architecture flows. These flows and the corresponding communication requirements define the interfaces which are a main focus of ITS standards. Example of US national physical architecture is shown at the figure.



http://www.iteris.com/itsarch/html/entity/paents.html

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