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Systems Engineering Management Plan

Dallas Integrated Corridor Management
(ICM) Demonstration Project

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Chapter 1. Program Overview

1.1 Introduction

The US-75 Integrated Corridor Management System Demonstration Project is a multi-agency, de-centralized operation which will utilize a set of regional systems to integrate the operations of the US-75 corridor. The purpose of the Dallas ICM System is to implement a multi-modal operations decision support tool enabled by real-time data pertaining to the operation of freeways, arterials, and public transit. The system will be shared between information systems and people involved in transportation operations and emergency response in the US-75 Corridor. The Dallas ICM System is intended to provide improved integration of operation procedures, including procedures that take advantage of the data sharing capabilities of the Dallas ICM System and facilitate improved emergency response, and traveler information.

A team headed by the Dallas Area Rapid Transit agency is providing technical and management services in support of the Dallas Integrated Corridor Management Demonstration Project.

1.2 Program Objectives

The proposed demonstration Integrated Corridor Management (ICM) system will operate as a multi-modal operations decision support tool with a cooperative network of agencies which will operate the corridor in a coordinated manner to reduce congestion of the transportation network, and improve the movement of people and goods within the corridor.

For the Demonstration Phase of the ICM Project, the Dallas team has reviewed the projects and systems which will be completed in the 24 month timeframe. We plan to have components of all the end stage systems deployed in the 24 month timeframe, and an ATIS and 511 public information systems will be deployed, along with the development of a Decision Support system, and improvements to the SmartNET/ SmartFusion product already deployed in Dallas.

1.3 Program Approach

The “ICMS” will operate as a multi-modal operations decision support tool with a cooperative network of agencies which will operate the corridor in a coordinated manner to reduce congestion of the network, and improve the movement of people and goods within the corridor. The ICM Demonstration System will consist of the following systems: a Decision Support subsystem; the Dallas SmartNET and SmartFusion subsystems; external to the ICMS the ICM program will deploy a 511 ATIS system, which includes an Interactive Voice Response (IVR) system, a 511 Web Site, and a Personalized Traveler System. In addition, several Infrastructure projects have been proposed to fill in data infrastructure gaps in the corridor.

The SmartFusion Database will store the data within the ICM System; this data will come from historical data possibly provided by the Regional Data Warehouse, current network data provided by the ICM Agencies in the corridor, and output data from the Decision Support subsystem including response plans and predictive conditions of the network. The Decision Support subsystem will be used as a tool for coordination of responses to events, evaluation of current network conditions, and prediction of network conditions in order to proactively manage the corridor. Lastly, the SmartNET subsystem will be a tool which will allow the viewing, reporting, and sending of information about Incidents, Construction, Special Events, and static ITS data (location of components, transit schedules, etc.) The SmartNET subsystem will provide a browser based interface for approved users to interact with the data, provide a response/request interface to the Decision Support System, and will provide a data feed of current network conditions to the 511 system.

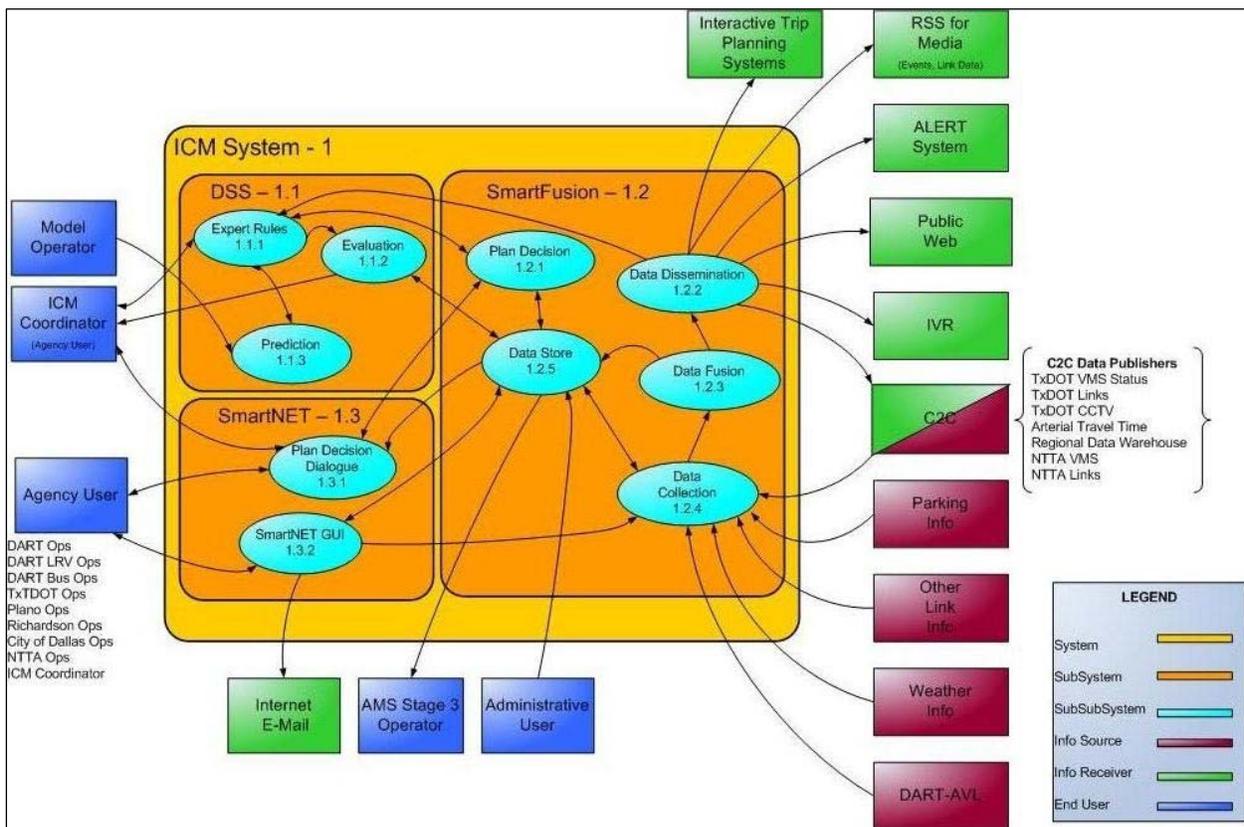


Figure 1-1. ICM Logical System Architecture

1.4 Program Assumptions and Constraints

Since the practice and concepts of ICM are relatively new, several program, technology, and institutional assumptions were made in the development of the high-level requirements. These assumptions may need adjustment once more is known, and ICM deployment is

under way. However, based on the information we currently have on ICM and the corridor, these are our best assumptions.

1.4.1 Program Assumptions for the Demonstration Project

- The Regional Center to Center information exchange system will be sufficient for the data exchange needs of the ICM
- The Regional Center to Center information exchange system will be deployed by some stakeholders
- The Regional Data Warehouse will be deployed
- The standards deployed as part of the Regional Center to Center will be sufficient in most cases for the data needed for the ICM System
- Data networking communication links between all US 75 stakeholders are incomplete
- Current deployed infrastructure and systems will be utilized as appropriate
- This is a research project, so some of the technology and systems deployed may need to be altered once operations have begun
- Utilize off-the-shelf solutions as much as possible
- Current and proposed infrastructure will be sufficient for the data requirements of the ICM, and the Decision Support subsystem

1.4.2 Technology Assumptions for the Demonstration Project

- Utilize the existing Regional Center to Center information exchange system
- Existing systems will sufficient for the needs of the system
- DART Network will be deployed under a separate project
- Regional Data and Video Sharing System may be deployed
- Regional Center to Center plug-in may be deployed for all stakeholders
- Current agency user authorization and authentication practices will be used
- Current agency information technology standards (hardware/ software) will be used
- Decision Support Subsystem will interface to the Dallas SmartNET subsystem for request and responses for implementation of Pre-approved Response Plans
- SmartNET and SmartFusion will utilize existing products with some modifications for interfaces and data
- ICMS will provide data to a Regional 511 system

1.4.3 Institutional Assumptions for the Demonstration Project

- An Operator at DalTrans will be the ICM Coordinator
- Funding will be available for ICM
- Agencies within the corridor will be willing to optimize the entire corridor, even if it impacts the transportation network under their control
- Regional Transportation Council and NCTCOG are supportive of the ICM and will provide funding, when needed.

1.4.4 System Constraints for the Demonstration Project

- The budget for the ICM is limited to the approved budget between DART and USDOT
- The design and deployment is limited to 20 months
- The ICMS is currently funded and approved to operate for an 18 month period
- The computer hardware and software will be deployed within the Daltrans facility, and must utilize the aesthetic standards for racks and cabling

1.5 Program Goals and Objectives

These Goals and Objectives are interrelated such that activities and strategies oriented towards attaining one of the Goals will likely impact the attainment of other Goals and Objectives.

Table 1-1. Goals and Objectives Relationship

Goals	Objectives
<p>Increase corridor throughput – The agencies within the corridor have done much to increase the throughput of their individual transportation networks both from a supply and operations point of view, and will continue to do so. The integrated corridor perspective builds on these network initiatives, managing delays on a corridor basis, utilizing any spare capacity within the corridor, and coordinating the junctions and interfaces between networks, in order to optimize the overall throughput of the corridor.</p>	<ul style="list-style-type: none"> • Increase transit ridership, with minimal increase in transit operating costs. • Maximize the efficient use of any spare corridor capacity, such that delays on other saturated networks may be reduced. • Facilitate intermodal transfers and route and mode shifts • Improve pre-planning (e.g., developing response plans) for incidents, events, and emergencies that have corridor and regional implications.
<p>Improve travel time reliability - The transportation agencies within the corridor have done much to increase the mobility and reliability of their individual networks, and will continue to</p>	<ul style="list-style-type: none"> • Reduce overall trip and person travel time through the corridor. • Improve travel predictability. • Maximize the efficient use of any spare

Goals	Objectives
do so. The integrated corridor perspective builds on these network initiatives, managing delays on a corridor basis, utilizing any spare capacity within the corridor, and coordinating the junctions and interfaces between networks, thereby providing a multi-modal transportation system that adequately meets customer expectations for travel time predictability.	corridor capacity, such that delays on other saturated networks may be reduced.
Improved incident management - Provide a corridor-wide and integrated approach to the management of incidents, events, and emergencies that occur within the corridor or that otherwise impact the operation of the corridor, including planning, detection and verification, response and information sharing, such that the corridor returns back to “normal.”	<ul style="list-style-type: none"> • Provide/expand means for communicating consistent and accurate information regarding incidents and events between corridor networks and public safety agencies. • Provide an integrated and coordinated response during major incidents and emergencies, including joint-use and sharing of response assets and resources among stakeholders, and development of a common policies and processes. • Continue comprehensive and on-going training program – involving all corridor transportation networks and public safety entities – for corridor event and incident management.
Enable intermodal travel decisions - Travelers must be provided with a holistic view of the corridor and its operation through the delivery of timely, accurate and reliable multimodal information, which then allows travelers to make informed choices regarding departure time, mode and route of travel. In some instances, the information will recommend travelers to utilize a specific mode or network. Advertising and marketing to travelers over time will allow a greater understanding of the modes available to them.	<ul style="list-style-type: none"> • Facilitate intermodal transfers and route and mode shifts • Increase transit ridership • Expand existing ATIS systems to include mode shifts as part of pre-planning • Expand coverage and availability of ATIS devices • Obtain accurate real-time status of the corridor network and cross-network connections

1.6 Program Performance Targets

Taking into account the vision, goals, and current conditions within the Corridor, the US-75 Steering Committee discussed “success” targets for several of the performance measures, their main concern was if the target was realistic, could be measured, and if enough data would be available. These “Performance Measures Success Thresholds,” listed in Table 1-2, provide an indication that the corridor goals have been achieved. The listed performance levels/thresholds are long-term targets that reflect the future vision of how the corridor will operate. Upon deployment of the ICM, any movement toward the thresholds will indicate

that ICM is having the desired effect. As data is collected in the next phase, and ICM model developed the targets will be validated and goals adjusted to ensure realistic and achievable targets are used.

Table 1-2. Corridor Performance Measure Targets – Demonstration Project

Performance Measure	Performance Measure Success Threshold
Travel Time Index	Reduce Index by 2% per year
Corridor Throughput	Increase overall throughput – increase person/trips per hour by 2% per year
Clearance time for an Incident (based on Jurisdiction and Corridor)	Emergency Responder Training - 75% of agencies trained on Incident Management response.
Response time	Response to Incidents - target is a consistent response time between jurisdictions (within 5 minutes)
Parking Lot Volume at Transit locations	Parking Lot Capacity – 90% utilization
Ridership per vehicle (Transit)	Increase of ridership – 2% (year to year increase)
Provide ATIS information to public on incident	Information to Regional 511 System – Incident available to the public within 10 minutes of Incident entered into SmartNET
Public Perception	Public Perception – Awareness of ICM and perceived benefits (survey based)
ICM Response Plan deployment	ICM Response Plan activated - 95% of plans were deployed correctly

The performance measures and targets discussed above focus on assessing the overall effectiveness of the ICM and corridor operations for purposes of needs identification and improvement selections. Such parameters, however, are not conducive to day-to-day assessments of alternatives by travelers and are not sensitive to quickly changing conditions within the corridor.

Data collection for the performance measures (i.e., overall assessment) and operations measures will be identical, using the information collected by each of the individual network systems. However, their respective processing may be different.

1.7 Purpose

The purpose of the Systems Engineering Management Plan is to assist the Dallas ICM Team by defining a procedural framework for management and control of the systems engineering components provided in the US-75 Integrated Corridor Management

Demonstration Project contract. The Project Management Plan serves as a reference for information regarding project structure and procedures throughout the project life cycle. As such both are living documents and will be reviewed at least twice in each year of the contract and updated as appropriate.

Chapter 2. References

- Final Concept of Operations for the US-75 Integrated Corridor in Dallas, Texas, October 2010
- Final Systems Requirements Specification for the US-75 Integrated Corridor in Dallas, Texas, October 2010
- System Engineering Handbook: A Guide for System Life Cycle Processes and Activities, version 3.2, January 2010, International Council on Systems Engineering
- System Engineering Handbook: A Guide for System Life Cycle Processes and Activities, version 2a, June 2004, International Council on Systems Engineering
- Systems Engineering Guidebook for ITS, FHWA CA Division/ Caltrans, version 3.0, January 2010
- ISO/IEC 15288:2008, Systems and Software Engineering – System life cycle processes, Geneva, International Organization for Standardization, issued 1 February 2008
- “Just Enough Structural Analysis”, rev 051406, May 2006, Ed Yourdon
- Dallas Fort-Worth Regional ITS Architecture, <http://www.nortex-its.org/Library.htm>
- “Systems Engineering Guidebook for ITS,” California Department of Transportation, Division of Research & Innovation, Version 1.1, February 14, 2005.
- FHWA Rule 940, Federal Register/ Vol. 66, No. 5/Monday, January 8, 2001/Rules and Regulations, Department of Transportation, Federal Highway Administration 23 CFR Parts 655 and 940, [FHWA Docket No. FHWA–99–5899] RIN 2125–AE65 Intelligent Transportation System Architecture and Standards.
- Florida’s Statewide Systems Engineering Management Plan, version 2, Florida Department of Transportation, 2005
- IEEE Guide to Developing System Requirements Specifications, Institute of Electrical and Electronics Engineers, 1998

Chapter 3. The Systems Engineering Process

This SEP ensures that the mission, goals, and objectives of the Dallas ICM stakeholders are met by ensuring that the ICM demonstration project is deployed in a fully integrated, seamless, and coordinated multimodal system.

3.1 Overview of the Systems Engineering Process

The purpose of this chapter is to provide an overview of the standard systems engineering process (SEP) that is implemented in the Dallas ICM Demonstration project; to provide the background for the SEP; and to cite applicable standards and references to support the standard selected. The INCOSE Systems Engineering Handbook v.3.2, based upon ISO/IEC 15288:2008, was used as a reference in the development of this SEP. Key processes that will be used are:

- Creation of high-level requirements
- Creation of detailed requirements
- Trade-off studies, gap analyses, or technology assessments
- Technical reviews
- Risk identification, assessment, and mitigation
- Creation of the requirements traceability verification matrix (RTVM)
- Creation of performance measure metrics
- System test, integration, and acceptance planning

3.2 Dallas ICM Systems Engineering Process

The Dallas ICM Team's approach is consistent with the system engineering process which is proven to greatly improve the chances of a successful system deployment by reducing the risk of unnecessary or unrealistic requirements, while validating that user needs (functional, political and budgetary) are met by the system.

We will build upon the Stage 1 and Stage 2 artifacts, to complete the remaining activities in the systems engineering process. In Stage 1 we developed our Concept of Operations and High-Level Requirements. As we begin the Stage 3 Demonstration phase, we will work with the US DOT to refine our High Level Requirements to complete the Detail Requirements, High Level and Detailed Design; once these are completed we will begin implementation of our ICM Demonstration. Since this project is a Design, Build, Operate and Maintain type of contract – some of the implementation may utilize an iterative methodology. Since some of the systems and concepts of the ICM are new, we are approaching those from multiple directions in order to reduce risk, and to deliver a working system.

3.2.1 Application of the Systems Engineering Process

The Dallas Integrated Corridor Management Demonstration Project will utilize a systems engineering process that ensures that the Integrator develops and closely adheres to a design process that is acceptable. The System Engineering process includes engineering for the design, software development, integration testing, documentation development, and installation and deployment of the ICM Demonstration project. DART will utilize the services of consultants to ensure that this process is followed. Presented below are the four areas of engineering analysis that will be implemented:

1. System Requirements Analysis – As described previously, the Dallas Integrated Corridor Management Concept of Operations document has been developed and approved by DART and the ICM stakeholders. The information presented in the Concept of Operations document was used during the development of the Dallas Integrated Corridor Management Systems Requirements, which are functional in nature.
2. Sub-System Functional Analysis – As part of the system requirements development process, Telvent will expand on the system requirements to the sub-system level. Telvent will ensure there are no conflicts between the system and the sub-system related requirements. It is expected that the various external interfaces will be identified at this point in the requirements development process.
3. Design Synthesis – Telvent will then use the various system and sub-system related functional requirements as the basis for designing the Dallas Integrated Corridor Management Demonstration project. The Dallas team will closely oversee the Telvent's design process and will conduct several rounds of testing to ensure that all identified requirements are being met. It is envisioned that Telvent will utilize the comprehensive requirements trace matrix, which will be developed, as the guide to ensure that the Dallas Team is designing the Dallas Integrated Corridor Management Demonstration project correctly.
4. System Analysis – During the design process, the Dallas team will monitor this activity to quickly identify possible technical problems with proposed equipment, commercial off-the-shelf (COTS) hardware or software, and customized application software. If technical trade-offs need to be implemented, the Integrator shall follow these procedures. The Program Manager will be required to approve the requested technical trade-off as proposed by Telvent.

Telvent has developed and implemented an internal document and drawing review and approval process that will be applied to the systems engineering process of the Dallas Integrated Corridor Management Demonstration project through system acceptance. The Dallas ICM Program Manager will have the contractual and legal authority to sign off on all system engineering related aspects of the Project. The typical approval process will be as described below:

1. Telvent will be required to provide a particular document and/or drawing within a certain timeframe.

2. The Dallas Team and US DOT will carefully review and provide comments and/or suggested modifications on the document or drawing. Telvent will then compile all of the comments into a single document.
3. Telvent will provide a recommendation to the Dallas ICM Program Manager, which might be to approve the document/drawing or ask to make changes and re-submit the document for a second round of review.
4. The Dallas ICM Program Manager and USDOT will then make the decision whether or not to officially approve the document/drawing and will inform, in writing, the Telvent Project Manager of that decision.
5. If the document or drawing is approved, it will become a configuration item and any further changes will require a change request.

To enhance the ability for the Dallas team to closely track the Telvent's system engineering process, Telvent will be required to provide a document management tool, ProjectSolve. This program will support the storage and retrieval of all types of project documents, including correspondence and e-mail messages. The program will also have the capability to segregate documents from general project documentation that can be accessed exclusively by DART and Telvent staff. This system is browser based to allow the users to access the documents and files remotely to better facilitate the oversight of the work.

3.3 Systems Engineering Description

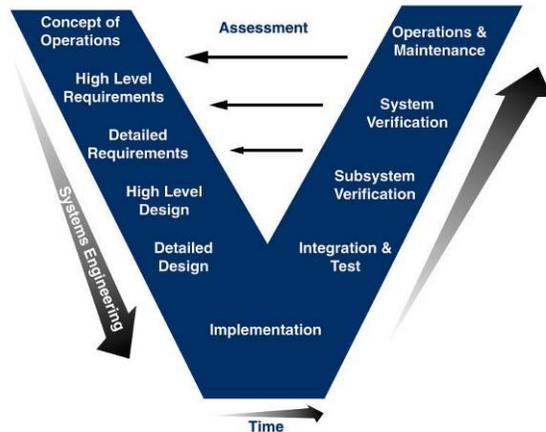
Systems engineering is a perspective, a process, and a profession, as illustrated by these three representative definitions.

1. Systems engineering is a discipline that concentrates on the design and application of the whole (system) as distinct from the parts. It involves looking at a problem in its entirety, taking into account all the facets and all the variables and relating the social to the technical aspect.
2. Systems engineering is an iterative process of top down synthesis, development, and operation of a real-world system that satisfies, in a near optimal manner, the full range of requirements for the system.
3. Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. SE considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.

The role of the systems engineer encompasses the entire life cycle for the system-of-interest. Systems engineers orchestrate the development of a solution from requirements determination through operations and system retirement by assuring that domain experts are properly involved, that all advantageous opportunities are pursued, and that all

significant risks are identified and mitigated. The systems engineer works closely with the project manager in tailoring the generic life cycle, including key decision gates, to meet the needs of their specific project. Per ISO/IEC 15288:2008:

5.2.2 – Life cycles vary according to the nature, purpose, use and prevailing circumstances of the system. Each stage has a distinct purpose and contribution to the whole life cycle and is conserved when planning and executing the system life cycle. ... The stages thus provide organizations with a framework within which organization management has high-level visibility and control of project and Technical Processes.



Every system life cycle consists of the business aspect (business case), the budget aspect (funding), and the technical aspect (product). The systems engineer creates technical solutions that are consistent with the business case and the funding constraints. System integrity requires that these three aspects are in

balance and given equal emphasis at all decision gate reviews.

balance and given equal emphasis at all decision gate reviews.

The Vee model provides a useful illustration of the SE activities during the lifecycle stages. In the Vee model, time and system maturity proceed from left to right. The core of the Vee (i.e., those products that have been placed under configuration control) depicts the evolving baseline from user requirements agreement to identification of a system concept to definition of elements that will comprise the final system. With time moving to the right and with the system maturity shown vertically, the evolving baseline defines the left side of the core of the Vee. As entities are constructed, verified and integrated, the right side of the core of the Vee is executed. Since one can never go backward in time, all iterations in the Vee are performed on the vertical “time now” line. Upward iterations involve the stakeholders and are the in-process validation activities that ensure that the proposed baselines are acceptable. The downward vertical iterations are the essential off-core opportunity and risk management investigations and actions. In each stage of the system life cycle, the SE processes iterate to ensure that a concept or design is feasible and that the stakeholders remain supportive of the solution as it evolves.

For the Dallas ICM Demonstration project, an Incremental and Iterative Development process will be used. Incremental and iterative development (IID) methods have been in use since the 1960s. They represent a practical and useful approach that allows a project to provide an initial capability followed by successive deliveries to reach the desired system-of-interest. The goal is to provide rapid value and responsiveness. This approach is generally presented in opposition to the perceived burden associated with using any process.

3.3.1 Structured Analysis and Design Methodology

The requirements analysis and design will utilize a Structured Analysis and Design Methodology. Structured Analysis (SA) and its allied technique, Structured Design (SD), are methods for analyzing and converting business requirements into specifications and ultimately, computer programs, hardware configurations and related manual procedures.

Structured Analysis views a system from the perspective of the data flowing through it. The function of the system is described by processes that transform the data flows. Structured analysis takes advantage of information hiding through successive decomposition (or top down) analysis. This allows attention to be focused on pertinent details and avoids confusion from looking at many irrelevant details. As the level of detail increases, the breadth of information is reduced. The result of structured analysis is a set of related graphical diagrams, process descriptions, and data definitions. They describe the transformations that need to take place and the data required to meet a system's functional requirements.

The structured analyses approach develops perspectives on both process objects and data objects.

Our approach to structured analysis and design includes:

- Context diagram
- dataflow diagrams, and
- A data dictionary.

Hereby the Data flow diagrams (DFDs) are directed graphs. The arrows represent data, and the rounded rectangles represent processes that transform the data. A process can be further decomposed to a more detailed DFD which shows the sub processes and data flows within it. The sub processes can in turn be decomposed further with another set of DFDs until their functions can be easily understood. The DFDs model the structure of the system as a network of interconnected processes composed of functional primitives. The data dictionary is a set of entries (definitions) of data flows, data elements, files, and data bases. The data dictionary is partitioned in a top down manner. They can be referenced in other data dictionary entries and in data flow diagrams.

3.3.2 Context diagram

The Context diagrams are diagrams that represent the actors outside a system that could interact with that system. This diagram is the highest level view of a system, similar to Block Diagram, showing a, possibly software-based, system as a whole and its inputs and outputs from/to external actors.

This type of diagram pictures the system at the center, with no details of its interior structure, surrounded by all its interacting systems, environment and activities. The objective of a system context diagram is to focus attention on external actors and events that should be considered in developing a complete set of system requirements and constraints. System context diagrams are related to Data Flow Diagrams, and show the interactions between a

system and other actors with which the system is designed to face. System context diagrams can be helpful in understanding the context in which the system will be part of software engineering.

3.3.3 Data dictionary

A data dictionary or database dictionary is a file that defines the basic organization of a database. A database dictionary contains a list of all files in the database, the number of records in each file, and the names and types of each data field. Most database management systems keep the data dictionary hidden from users to prevent them from accidentally destroying its contents. Data dictionaries do not contain any actual data from the database, only book keeping information for managing it. Without a data dictionary, however, a database management system cannot access data from the database.

Database users and application developers can benefit from an authoritative data dictionary document that catalogs the organization, contents, and conventions of one or more databases. This typically includes the names and descriptions of various tables and fields in each database, plus additional details, like the type and length of each data element. There is no universal standard as to the level of detail in such a document, but it is primarily a distillation of metadata about database structure, not the data itself. A data dictionary document also may include further information describing how data elements are encoded. One of the advantages of well-designed data dictionary documentation is that it helps to establish consistency throughout a complex database, or across a large collection of federated databases.

3.3.4 Data Flow Diagrams

A Data Flow Diagram (DFD) is a graphical representation of the "flow" of data through an information system. It differs from the system flowchart as it shows the flow of data through processes instead of hardware.

It is common practice to draw a System Context Diagram first which shows the interaction between the system and outside entities. The subsequent DFDs are designed to show how a system is divided into smaller portions and to highlight the flow of data between those parts. This context-level Data flow diagram is then "exploded" to show more detail of the system being modeled.

The project stakeholders will be briefed and consulted throughout all stages of a system's evolution. With a dataflow diagram, stakeholders are able to visualize how the system will operate, what the system will accomplish, and how the system will be implemented. Dataflow diagrams can be used to provide the end user with a physical idea of where the data they input ultimately has an effect upon the structure of the whole system. How any system is developed can be determined through a dataflow diagram.

Gane Sarson DFDs

Data Flow Diagrams (DFDs) for the Dallas ICM project will utilize a Gane Sarson DFD diagramming standard. DFDs show the flow of data from external entities into the system, showed how the data moved from one process to another, as well as its logical storage. The figure below presents an example of a DFD using the Gane and Sarson notation.

There are only four symbols:

- Squares representing external entities, which are sources or destinations of data.
- Rounded rectangles representing processes, which take data as input, do something to it, and output it.
- Arrows representing the data flows, which can either be electronic data or physical items.
- Open-ended rectangles representing data stores, including electronic stores such as databases or XML files and physical stores such as or filing cabinets or stacks of paper.

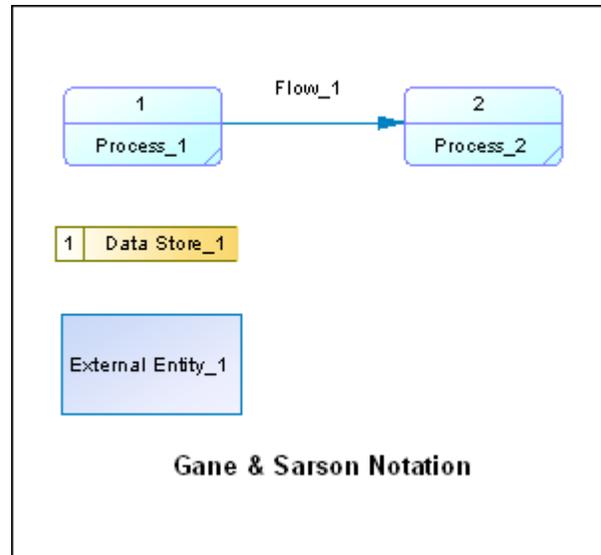
There are several common modeling rules that will be followed when creating DFDs:

1. All processes **must** have at least one data flow in and one data flow out.
2. All processes **should** modify the incoming data, producing new forms of outgoing data.
3. Each data store **must** be involved with at least one data flow.
4. Each external entity **must** be involved with at least one data flow.
5. A data flow **must** be attached to at least one process.
6. Data is conserved (neither created nor destroyed) within the DFDs

3.3.5 Structure Chart

A Structure Chart (SC) is a chart shows the breakdown of the configuration system to the lowest manageable levels. This chart is used in structured programming to arrange the program modules in a tree structure. Each module is represented by a box which contains the name of the modules. The tree structure visualizes the relationships between the modules.

In structured analysis, structure charts are used to specify the high-level design, or architecture, of a computer program. As a design tool, they aid the programmer in dividing



and conquering a large software problem, that is, recursively breaking a problem down into parts that are small enough to be understood by a human brain. The process is called top-down design, or functional decomposition. Programmers use a structure chart to build a program in a manner similar to how an architect uses a blueprint to build a house. In the design stage, the chart is drawn and used as a way for the client and the various software designers to communicate. During the actual building of the program (implementation), the chart is continually referred to as the master-plan.

3.3.6 Structured Design

Structured Design (SD) is concerned with the development of modules and the synthesis of these modules in a so called "module hierarchy". In order to design optimal module structure and interfaces two principles are crucial:

- Cohesion which is "concerned with the grouping of functionally related processes into a particular module", and
- Coupling relates to "the flow of information, or parameters, passed between modules. Optimal coupling reduces the interfaces of modules and the resulting complexity of the software".

The structure chart aims to "shows the module hierarchy or calling sequence relationship of modules. There is a module specification for each module shown on the structure chart. The module specifications can be composed of pseudo-code or a program design language. The data dictionary is like that of structured analysis. At this stage in the software development lifecycle, after analysis and design have been performed, it is possible to automatically generate data type declarations", and procedure or subroutine templates.

3.3.7 Requirements Analysis

Once the problem has been clearly stated as a set of stakeholder (user) needs, the next step is to define a solution or set of solutions, and pick the optimal ones. The project engineering team will perform requirements analysis for the purpose of establishing what the system will be capable of accomplishing; how well system products will operate; the human/system interface requirements; the physical/aesthetic characteristics; and constraints that affect design solutions. The User Needs, System Requirements, and constraints are derived from stakeholder expectation, project and enterprise constraints; external constraints, and high-level system requirements.

3.3.8 Relationship to the ITS Regional Architecture

The Regional Architecture and ITS Plan for the Dallas-Fort Worth was defined in 1999. The Regional Architecture was updated in 2004 and 2005 and posted to the regional ITS web site (<http://nortex-its.org/Architecture/ArchHome.htm>). The Dallas Area ITS Plan is currently being updated. The goals and strategies for the Regional ITS Architecture is very similar to the strategies and integration needed for the US-75 Integrated Corridor Management System.

The 1999 ITS Plan Regional Goals were defined as:

1. Enhance mobility of people and goods by reducing recurrent traffic congestion
2. Enhance mobility of people and goods by reducing traffic congestion caused by incidents
3. Enhance access and operation of high-occupancy modes of travel
4. Reduce drive-alone and peak period travel
5. Provide a safe transportation system
6. Provide increased opportunities for air quality and other environmental improvements

Similarly, the Goals for the US-75 ICM, as discussed in Section 4 below:

1. Increase corridor throughput
2. Improve travel time reliability
3. Improved incident management
4. Enable intermodal travel decisions

Market Packages

In addition, many of the strategies that the US-75 Steering Committee discussed are captured in many of the Market Packages described in the Dallas-Fort Worth Regional ITS Architecture. A sequence of projects is one of the required components of the regional ITS architecture. In order to meet this requirement, the Dallas-Fort Worth region has developed a sequence of market packages. Each market package priority was determined based on the regional ITS initiatives outlined in existing ITS documents and through consensus building of the Regional ITS Steering Committee. These initiatives include reducing the impacts of recurring and non-recurring congestion; improvements to the overall safety of the transportation system; enhance access and operation of high occupancy modes of travel; and the dependency of one market package on the deployment of another market package. Table 3-1 below summarizes the market package prioritization in the Dallas-Fort Worth region adopted in February 2005.

Table 3-1. Summary of Market Package Priorities for the DFW Regional ITS Architecture

Area	Market Package	Priority 1	Priority 2	Priority 3
Traffic Management Systems	Network Surveillance	x		
	Probe Surveillance	x		
	Surface Street Control		x	
	Freeway Control	x		
	HOV Lane Management	x		

U.S. Department of Transportation, Research and Innovative Technology Administration
Intelligent Transportation System Joint Program Office

Area	Market Package	Priority 1	Priority 2	Priority 3
	Traffic Information Dissemination	x		
	Regional Traffic Control		x	
	Traffic Incident Management System	x		
	Electronic Toll Collection	x		
	Emissions Monitoring and Management			x
	Standard Railroad Grade Crossing	x		
	Railroad Operations Coordination		x	
	Parking Facility Management		x	
	Regional Parking Management			x
	Reversible Lane Management		x	
	Speed Monitoring	x		
	Roadway Closure Management	x		
Emergency Management	Emergency Call-Taking and Dispatch		x	
	Emergency Routing			x
	Mayday Support		x	
	Roadway Service Patrols	x		
	Transportation Infrastructure Protection			x
	Wide-Area Alert		x	
	Early Warning System			x
	Disaster Response and Recovery			x
	Evacuation and Reentry Management			x
	Disaster Traveler Information			x
Maintenance and Construction	Road Weather Data Collection		x	
	Weather Information Processing and Distribution			x
	Winter Maintenance			x
	Roadway Maintenance and Construction	x		
	Work Zone Management	x		
	Work Zone Safety Monitoring			x
	Maintenance and Construction Activity Coordination	x		

Area	Market Package	Priority 1	Priority 2	Priority 3
Public Transportation	Transit Vehicle Tracking	x		
	Transit Fixed-Route Operations		x	
	Demand Response Transit Operations			x
	Transit Passenger and Fare Management		x	
	Transit Security			x
	Transit Maintenance			x
	Multi-modal Coordination		x	
	Transit Traveler Information			x
Commercial Vehicle Operations	HAZMAT Management		x	
Traveler Information	Broadcast Traveler Information	x		
	Interactive Traveler Information		x	
Archived Data	ITS Data Mart		x	
	ITS Data Warehouse			x

Other Deployment Considerations

- Fill gaps in the existing ITS communications infrastructure by completing critical system linkages
- Leverage transportation resources by targeting investment, where possible, to facilities undergoing reconstruction
- Leverage transportation resources by creating or enhancing public/private partnerships which will provide communications infrastructure for regional ITS
- Provides transportation service or transportation data that is regional in scope.

3.3.9 User Needs and Functional Breakdown

The first step in the development of detailed requirements for the ICM Demonstration is to identify the needs and goals and potential solutions that could be implemented under the constraints of the Demonstration Project. The constraints of the project include the high-level requirements developed and agreed by the US DOT as part of our proposal, the schedule (24 months for design, development, integration), and the project budget approved for the demonstration project. The User Needs were developed during the Concept of Operations (ConOps) phase of the ICM program, and have been updated and verified with

the project stakeholders. The User needs were further broken down into high-level requirements, and further broken into functional requirements.

3.3.10 Interface Standards

The engineering team will define the functional and design interfaces to external and/or high-level and interacting systems, platforms, humans, and/or products in quantitative terms. Mechanical, electrical, thermal, data, communication-procedural, human-machine, and other interfaces are included. The Dallas ICM demonstration architecture includes information that allows the engineering team to identify information flows between the project functions and subsystems. These will be defined as data flows for this project.

Data Flows – Data flows represent data flowing between processes within a system, or between a system subsystem and an external interface or between subsystems. As discussed in 3.3.4 above, Gane Sarson DFDs will be utilized by the engineering team to visualize the data flows between processes, between sub subsystems, between subsystems, and between subsystems and external interfaces.

In the analysis process, the data flows are aggregated depending on the level of system decomposition. For example, data flows between subsystems and external systems will be shown on the Level 0 diagrams, data flows between subsystems will be shown on the Level 1 diagrams, and data flows between functions will be shown on the Level 2 diagrams. Further decomposition, if necessary, will further break down the functions into data elements and functions. As discussed above as part of the Structured Analysis process, a data dictionary will be maintained that maps and defines all the data names to their aggregate data flows.

3.3.11 Concept of Operations

The concept of operations (ConOps) developed during Stage 1 of the ICM program, will be made available to the engineering team during the system requirements, design, and implementation phases. The role of the ConOps in the SEP is to describe how the delivered system will work in terms that stakeholders understand. The Concept of Operations will assist the engineering team in better understanding the User Needs of the stakeholders and the envisioned system.

3.4 Tracking Project Requirements and the Use of a Database

A key characteristic of the SEP is the traceability of all requirements back to the User Needs. Further, requirements must be defined in a hierarchical manner. As discussed below, a Requirement Tracking database is utilized by the engineering team to track requirements from user needs through implementation.

3.4.1 Functional Design Hierarchy

The systems considered in ISO/IEC 15288:2008 are man-made, created and utilized to provide products and/or services in defined environments for the benefit of users and other stakeholders. These systems may be configured with one or more of the following system elements: hardware, software, data, humans, procedures, facilities, materials and naturally occurring entities. In practice, they are thought of as products or services.

The perception and definition of a particular system, its architecture and its system elements depend on an observer's interests and responsibilities. One person's system of interest can be viewed as a system element (subsystem) in another person's system of interest. Furthermore, a system of interest can be viewed as being part of the environment operation for another person's system of interest.

Hierarchies are system or organizational representations of a partitioning relationship where the entity (or system) is separated into smaller more manageable entities. The hierarchy is balanced with appropriate fan out and span of control. Appropriate fan out and span of control refers to the number of elements subordinate to each element in the hierarchy.

For the Dallas ICM Demonstration project, a hierarchy has been defined as follows:

System → Subsystem → SubSubSystem → Functions → Elements

This generic system hierarchy ties: the system architecture; specification and drawing trees; work breakdown structure; technical reviews; and configuration baselines together. Many pieces within the system hierarchy can be considered a "system" by the classical definition, but actually represent subsystems within the system hierarchy. Note that the "ICMS" is the one system for this project; however, within the "system" the Decision Support Subsystem, SmartNET Subsystem, and SmartFusion subsystem could be considered "systems" from some stakeholders points of view.

Each subsystem may be composed of many functions, and elements. The focus of this SEP is to specify the system by its functional requirements. The functional requirements are developed in a hierarchal manner by defining the system level requirements, and then taking each requirement and decomposing it to the next lower level of functional decomposition. Requirements will be maintained and tracked throughout the project to ultimately prove that the system that is delivered and installed meets all the requirements. The Requirements will be maintained in a database and identified in a logical way to uniquely identify all requirements.

3.4.2 Design Verification

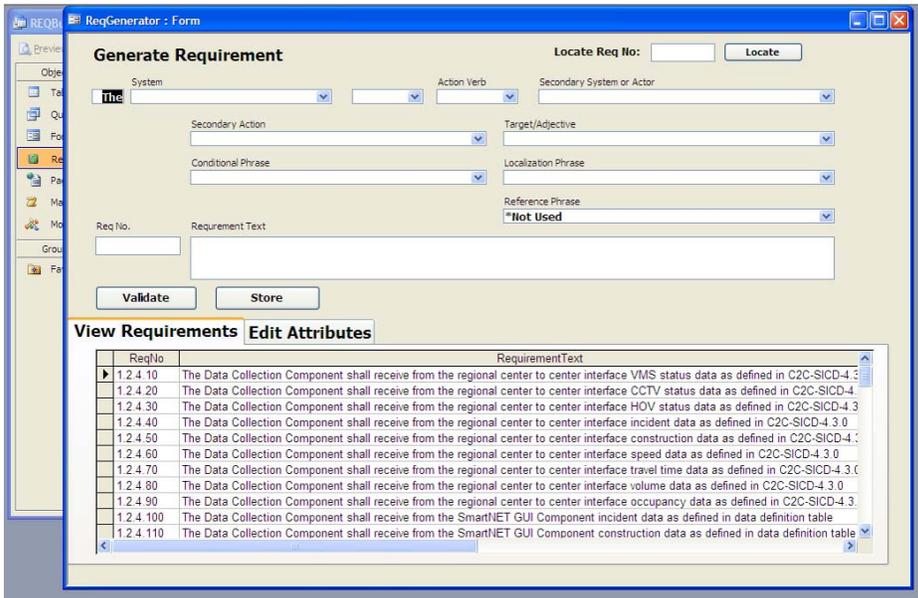
The Systems Engineering lead will be responsible for performing design verification to ensure that the design architecture's lowest level requirements, including derived

requirements, are traceable to the verified functional architecture, and that the design architecture satisfies the validated requirements baseline.

At the design verification stage, the physical architecture is examined to determine if it satisfies all the requirements and constraints of the project. As discussed below, a Requirements Database and Tracking tool will be utilized to support the manual mapping of the requirements hierarchy to the stakeholder needs.

3.4.3 Requirements Database and Tracking Tool

A Microsoft Access database has been developed to track all requirements from User needs through implementation, as shown in Figures 2 and 3 below; the identification of requirements follows the rules provided below.



Types of Requirements

- F = Functional
- I = Interface (interface between ICMS and external systems)
- D = Data (internal storage, exchange of data within the ICMS)
- C = Constraint
- P = Performance
- H = Hardware

Verification Method

- Analysis = Analysis (Analysis is the use of established technical or mathematical models or simulations, algorithms, or other scientific principles and procedures to provide evidence that the item meets its stated requirements.)
- Inspect = Inspection (Inspection is observation using one or more of the five senses, simple physical manipulation, and mechanical and electrical gauging and measurement to verify that the item conforms to its specified requirements.)
- Demo = Demonstrate (Demonstration is the actual operation of an item to provide evidence that it accomplishes the required functions under specific scenarios.)
- Test = Test (Test is the application of scientific principles and procedures to determine the properties or functional capabilities of items.)

Requirement Criticality

- H = High
- M = Medium
- L = Low

Atomic Requirement Rules

The system requirements will follow the principles provided by US DOT for writing well-written requirements, which are well-formed, unambiguous, feasible, and verifiable.

In addition, atomic requirement rules will be used. Every requirement should be a single requirement. If we can say “Half of this requirement is implemented” then this needs to be two or more requirements. If a requirement read “Sales reps can manage their client list and generate custom reports” it expresses two atomic ideas (list management and report generation). Those ideas need to be separated.

Rule 1: If you want to describe an action that has to be performed by the system alone, use:

- Autonomous system action requirement ::= The system <must | should | can> <verb> <object(s)>[, <if | as soon as> <all of | exactly one of | at least one of> the following conditions are true: <condition1>[, <condition2>]*]>
- Notes:
 - System action requirements define the solution space from the inside, i.e. they describe the area of valid solutions in positive terms.
 - You indicate priority and/or obligation by choosing the respective auxiliary verb.
 - You need to clearly define your strong verbs in a glossary. Usually you end up with 10-20 verbs you need throughout the spec.
 - Logical conditions should be indicated by the keyword 'if', time conditions by 'as soon as'.
 - Avoid 'when', because it is ambiguous.
 - Conditions, especially if there are many, should be put at the end of the requirement, to establish a context first. You can put it in front of the action only if there's a single, simple condition.
 - If there are complex conditions, do not hesitate to use some form of logical expressions. Just make sure you explain their use in the requirements management plan.

Rule 2: If you want to describe a capability the system has to provide for some user, use:

- User interaction requirement ::= The system <shall> provide <whom> the capability to <verb> <object(s)>[, <if | as soon as> <all of | exactly one of | at least one of> the following condition(s) are true: <condition1>[, <condition2>]*]
- Notes:
 - See notes of Rule 1.
 - Interaction requirements also define the solution space from the inside, i.e. they describe the area of valid solutions in positive terms.
 - It's not valid to avoid the passive voice by making the object the subject in the above sentence structure (e.g. „The user must do X“), because the spec must describe what is required from the system, not from the user.

Rule 3: If you want to describe a constraint, something the system mustn't do or allow, use ...

- Constraint requirement ::= The system mustn't [<allow whom> to] <verb> [<object(s)>]
- Notes:
 - Constraint requirements limit solution space from the outside, i.e. they describe the area of valid solutions in negative terms.
 - This negative character makes constraints hard to test, as you cannot see the absence of things in a system. In essence, you check whether the constraint

(for example a legal constraint) is violated by the system or can be violated by a user using the system.

3.4.4 Requirement Assumptions and Dependencies

- All Design, Development and Deployment needs to be done by December 2011
- The Regional Center to Center information exchange system will be sufficient for the data exchange needs of the ICM
- The Regional Center to Center information exchange system will be partially deployed
- The Regional Data Warehouse will be utilized as appropriate
- Communication links between all US 75 stakeholders are incomplete
- Current deployed infrastructure and systems will be utilized
- This is a research project, so some of the technology and systems deployed may need to be altered once operations has begun
- Current and proposed infrastructure will be sufficient for the data requirements of the ICM, and the real-time Decision Support Subsystem
- Utilize the existing Regional Center to Center system
- Existing systems will sufficient for the needs of the system
- DART Network will be deployed under a separate project
- Regional Center to Center plug-in will be deployed for some partners
- Current agency specifications for equipment will be utilized
- Current agency user authorization and authentication practices will be used
- Current agency information technology standards (hardware/ software) will be used
- Decision Support Subsystem will include a web interface for agency's to utilize
- An Operator at DalTrans will be the corridor coordinator
- Funding will be available for ICM
- Agencies within the corridor will be willing to optimize the entire corridor, even if it impacts their individual network
- Regional Transportation Council and NCTCOG are supportive of the ICM and will provide funding, when needed

3.4.5 Analysis of Alternate Designs and Technologies

Once the problem has been clearly stated, as a set of User Needs and the Functional Requirements have been developed, the next step is to define a solution or set of solutions, and pick the optimal one for the budget available. The engineering team will perform requirement analysis for the purpose of establishing what the system shall be capable of accomplishing; how well the system shall perform in quantitative, measurable terms; the environments in which system products will operate; the human/system interface requirements; the physical/aesthetic characteristics; and constraints that affect the design solutions.

As stated in ISO/IEC 15288:2008: The purpose of the Architectural Design Process is to synthesize a solution that satisfies system requirements. This process encapsulates and defines areas of solutions, expressed as a set of separate problems of manageable complexity and explores one or more implementation strategies at a level of detail consistent with the system's technical and commercial requirements and risks. From this, an architectural design solution is defined in terms of the requirements for the set of system elements from which the system is configured. The specified design requirements resulting from this process are the basis for verifying the realized system and for devising an assembly verification process.

The Design process includes the following activities:

- Define the Architecture
 - Define a consistent logical architecture – capture the logical sequencing and interaction of system functions or logical elements
 - Partition system requirements and allocate them to system elements with associated performance requirements – Evaluate COTS solutions that already exist.
 - Identify interfaces and interactions between system elements (including human elements of the system) and with external and enabling systems
 - Define verification and validation criteria for the system elements.
- Analyze and Evaluate the Architecture
 - Evaluate COTS elements for compatibility with the design
 - Evaluate alternative design solutions using the selection criteria established
 - Support definition of the system integration strategy and plan
- Document and Maintain the Architecture
 - Document and maintain the architectural design and relevant decisions made to reach agreement on the baseline design
 - Establish and maintain the traceability between requirements and system elements.

Selection Criteria

Selection criteria are the quantifiable consequences of system implementation and operation. They are derived from the system requirements, ConOps, and functional architecture, and from programmatic considerations, such as available resources, acceptable risks, political considerations, and the updated business case for the system. This activity is conducted by the engineering team led by the Technical Lead, TBD, with involvement from specialists, as necessary, to support the definition of selection criteria and the analysis used to make the selection. Selection criteria include:

- Measures of the system's ability to fulfill its mission as defined by the requirements
- Ability to operate within resource constraints
- Accommodation of interfaces
- Ability to adapt to projected future needs and interoperating systems (i.e., system robustness)
- Costs (economic and otherwise) of implementing and operating the system over its entire life cycle
- Side effects, both positive and adverse, associated with particular architecture options
- Measures of risk
- Measures of quality factors
- Measures of subjective factors that make the system more or less acceptable to customers, users, or clients (e.g., aesthetic characteristics)

Analyze and Select Preferred System Architecture/ Element Solution

The objective of this activity is to select or evolve the preferred System Architecture from the set of System Architecture options in the previous activities. The selection of the preferred System Architecture is essentially a tradeoff among the various architecture options, using the tradeoff process.

3.4.6 Implementation Options

For the majority of the ICM demonstration project, existing COTS products are being utilized. For the implementation, as discussed above, the engineering team will select the optimal option for the various subsystem elements in order to meet the requirements and the selection criteria established by the stakeholders.

3.4.7 Functional Verification

As stated in ISO/IEC 15288:2008: The purpose of the Verification Process is to confirm that the specified design requirements are fulfilled by the system. This process provides the

information required to effect the remedial actions that correct non-conformances in the realized system or the processes that act on it.

The Verification Process confirms that the system of interest and all its elements perform their intended functions and meet the performance requirements allocated to them. Verification methods include inspection, analysis, demonstration, and testing.

Verification Activities

The Verification Processes include the following activities:

- Plan Verification
 - Schedule
 - Confirm
 - Install verification enabling systems, if needed
- Perform Verification
 - Develop verification procedures
 - Conduct verification activities, per established procedures, to demonstrate compliance with requirements
 - Document verification results and enter data into the Requirements Tracking Database

3.4.8 Transition Phase

As stated in ISO/IEC 15288:2008: The purpose of the Transition Process is to establish a capability to provide services specified by stakeholder requirements in the operational environment. This process installs a verified system, together with relevant enabling systems (e.g., operating system, support system, operator training system.) This process used at each level in the system structure and in each stage to complete the criteria established for exiting the stage. It includes preparing applicable storage, handling, and shipping enabling systems.

Ultimately, the Transition Process transfers custody of the system and responsibility for system support from one organizational entity to another. This includes, but is not limited to, transfer of custody from the development team to the organizations that will subsequently operate and support the system. Successful conclusion of the Transition Process typically marks the beginning of the Utilization Stage of the system of interest.

Transition Activities

The Transition Process includes the following activities:

- Plan the Transition
 - Prepare a transition strategy, including operator training, logistics support, delivery strategy, and problem rectification/ resolution strategy.
 - Develop installations procedures

- Perform the Transition
 - Prepare the installation site and Install system per established procedure
 - Train the users in the proper use of the system and affirm users have the knowledge and skill levels necessary to perform Operation and Maintenance activities. This includes a complete review and handoff of operator and maintenance manuals, as applicable.
 - Receive final confirmation that the system as operated and maintained by the intended users meets their needs. This process typically ends with a formal, written acknowledgement that the system has been properly installed and verified, that all issues and action items have been resolved, and that all agreements pertaining to development and delivery of a fully supportable system have been fully satisfied or adjudicated.
 - Post implementation problems are documented and may lead to corrective actions or changes to the requirements.

3.4.9 Validation Phase

As stated in ISO/IEC 15288:2008: The purpose of the Validation Process is to provide objective evidence that the services provided by a system when in use comply with stakeholders' requirements, achieving its intended use in its intended operational environment. This process performs a comparative assessment and confirms that the stakeholders' requirements are correctly defined. Where variances are identified, these are recorded and guide corrective actions. System validation is ratified by stakeholders.

This process is invoked during the Stakeholders Requirements Definition Process to confirm that the requirements properly reflect the stakeholder needs and to establish validation criteria (i.e., that the right system has been built). This process is also invoked during the Transition Process to handle the acceptance activities. For the Dallas ICM Demonstration Phase, this phase is also known as the System Acceptance Test.

Validation Activities

The Validation Process includes the following activities:

- Plan Validation
 - Develop a validation strategy
- Perform Validation
 - Develop validation procedures that demonstrate that the system is fit for its purpose and satisfies the stakeholders' requirements
 - Ensure readiness to conduct validation – system, enabling systems, and trained operators
 - Support in process validation throughout system development
 - Conduct validation to demonstrate conformance to stakeholder requirements
 - If anomalies are detected, analyze for corrective actions and detect trends in failure to find threats to the system and evidence of design errors
 - Recommend corrective actions and obtain stakeholder acceptance of validation results

- Document validation results and enter data into the Requirements Tracking Database

3.4.10 Operation and Maintenance Phase

As stated in ISO/IEC 15288:2008:

The purpose of the Operation Process is to use the system in order to deliver its services. This process assigns personnel to operate the system, and monitors the services and operator system performance. In order to sustain services it identifies and analyzes operational problems in relation to agreements, stakeholder requirements and organizational constraints.

The purpose of the Maintenance Process is to sustain the capability of the system to provide a service. This process monitors the system's capability to deliver services, records problems for analysis, takes corrective, adaptive, perfective and preventive actions and confirms restored capability.

Operation Activities

The Operation Process includes the following activities:

- Prepare for Operation
- Perform Operational Activation and Check out
 - Provide operator training and maintain qualified staff
- Use System for Operations
 - Execute ConOps for the system of interest
 - Track system performance and account for operational availability
 - Perform operational analysis
- Perform Operational Problem Resolution
 - Manage operational support logistics
 - Document system status and actions taken
 - Report malfunctions and make recommendations for improvement
- Support the Customer.

Maintenance Activities

The Maintenance Process includes the following activities:

- Plan Maintenance
 - Establish a maintenance strategy
 - Define maintenance constraints on the system requirements
 - Obtain the enabling systems, system elements, and other services used for maintenance of the system
 - Monitor replenishment levels of spare parts
 - Manage the skills and availability of trained maintenance personnel

- Perform Maintenance
 - Implement maintenance and problem resolution procedures, including scheduled replacement of system elements prior to failure (i.e., preventive maintenance)
 - Maintain a history of failures, actions taken, and other trends to inform operations and maintenance personnel and other projects creating or utilizing similar system elements
 - Monitor customer satisfaction with system and maintenance support.

3.4.11 Use of Standard Practices and Tools

There are several COTS tools used for the Dallas ICM Demonstration project to support the System Engineering activities described in the above sections in support of the INCOSE Systems Engineering Handbook methodology. These tools include:

- Microsoft Access – used for the Requirements Tracking Database
- Microsoft Visio – using the Gane Sarson template for DFD and architectural diagrams
- Microsoft Word – used for document authoring and editing
- Adobe Acrobat – used for document publishing
- EMC Documentum – used by the ProjectSolve website for document storage and version control
- Synergy - Synergy is a revision control system controlling hierarchical directories each containing revision controlled files. Synergy will be used for all application source code and related files.

Chapter 4. Management with the Systems Engineering Process

4.1 Life-Cycle Management Using the Systems Engineering Process

This SEP defines the interdisciplinary tasks required throughout the system's life cycle to transform user needs, requirements, and constraints into a system solution. The Project Management Plan is developed in concert and provides the plan, controls and processes to manage the overall life cycle of the project.

4.1.1 Project Management Planning

The engineering team will work with the Project Management organization to ensure that all system related activities are planned and coordinated with the Project Management activities of the project. This includes coordinating controls and processes, such as change management, and risk management processes for the project. The SEP activities map to the project management plan and coordination between the technical lead and project manager is down through project communication and control.

4.1.2 Organization Structure

As defined in the Project Management Plan, the staffing for the project will be broken into the following elements:

1. Program Management
2. Design
3. Systems Development and Delivery
4. Operations and Maintenance

The project is organized as defined in the proposal submission and as shown in Figure 4-1, with further description of roles and responsibilities provided in Table 4-1.

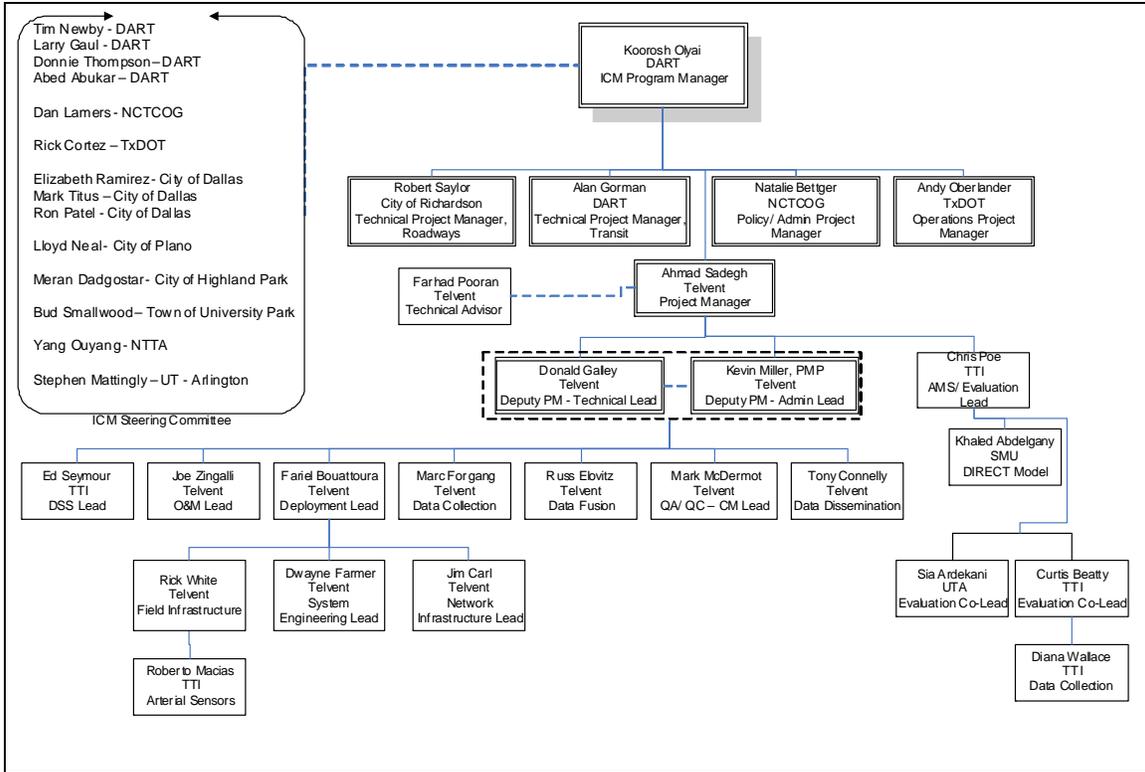


Figure 4-1. Project Organization

Program Management

Responsibilities for the project have been assigned to individual project staff which is accountable for the project products as shown in Table 4-1.

Table 4-1. Project Roles and Contact Information

Staff	Role	Responsibility
DART		
Koorosh Olyai	Program Manager	Overall oversight of the Dallas ICM Program
Alan Gorman	Technical PM - Transit	Oversight of the Transit Components of the ICM Program
Stakeholder Agencies		
Natalie Bettger	Technical PM - Policy	Oversight of the Institutional Issues and Policy of the ICM Program
Robert Saylor	Technical PM - Roadways	Oversight of the Arterial Roadway Components of the ICM Program
Andy Oberlander	Technical PM - Operations	Oversight of the Freeway and Operations Components of the ICM Program
Contractors		
Ahmad Sadegh	Telvent Project Manager	Overall project responsibility

Staff	Role	Responsibility
TBD	Telvent Deputy PM – Technical	Overall Technical Development and Deployment responsibility
Kevin Miller	Telvent Deputy PM - Admin	Overall project coordination - tracking of scope, schedule and budget
Scot Love	Telvent – Regional Vice President	Corporate responsibility for project performance, ensure resources are available to execute project and resolve issues.
Fariel Bouattoura	System Deployment Team Lead	Responsible for deployment activities for computer and software systems
Jim Carl	Network Integration Lead	Responsible for issues regarding computer and communications system hardware
Marc Forgang	Data Interface Lead	Responsible for data collection system implementation
Russ Elovitz	Data Fusion Lead	Responsible for data fusion system implementation
Tony Connelly	Data Dissemination Lead	Responsible for data dissemination implementation
Farhad Pooran	Technical Advisor	Responsible for oversight of Telvent's Systems and Infrastructure implementation
Roberto Macias	Field Infrastructure Lead	Responsible for field infrastructure implementation
Ed Seymour	DSS Lead	Responsible for Decision Support System implementation
Chris Poe	AMS Lead	Responsible for the Analysis, Modeling, and Simulation (AMS) and Evaluation activities
Mark McDermott	QA Lead	Responsible for the Quality Assurance and Quality Control and Configuration Management activities

Systems Delivery Lead Responsibility

Responsibilities for system deliverables have been assigned to individual project staff which is accountable for their project products as shown in Table 4-2.

Table 4-2. Project Deliverables and Responsibilities

Section / Task ID & Deliverable	Task Lead
Task 1 - Project Management	
Quarterly Progress Report	Kevin Miller
Annual Progress Report	Kevin Miller/ DART
Final Report	Kevin Miller/ DART
Task 2 - Refinement of Systems Requirements	
System Requirement Specifications (SyRS)	Kevin Miller
Concept of Operations	Kevin Miller
Task 3 – System Design	
Preliminary Design Document(40% Design)	TBD

Section / Task ID & Deliverable	Task Lead
PDR - walkthrough	TBD
Critical Design Document (90% Design)	TBD
CDR - Walkthrough	TBD
Final Systems Design Document	TBD
Task 4 – System Build	
Operations Manuals	Fariel Bouattoura
As-Built Diagrams	Fariel Bouattoura
Task 5 – System Test Planning and Execution	
System Test Plan	Mark McDermott
System Acceptance Test Plan and Scripts	Mark McDermott
System Test Readiness Review (TRR)	TBD
Test Results Reports	Mark McDermott
Task 6 - Training	
Training Plan	Fariel Bouattoura
Training Manuals	Fariel Bouattoura
Task 7 - Operations & Maintenance	
Operations & Maintenance Plan	Fariel Bouattoura
Task 8 - Participation in the AMS	
Pre-deployment AMS Plan	Chris Poe
Pre-deployment Data Collection Plan	Chris Poe
Data Collection – Pre-deployment	Chris Poe
Post-deployment AMS Plan	Chris Poe
Post-deployment Data Collection Plan	Chris Poe
Data Collection – Post-deployment	Chris Poe
AMS Transition Plan	Chris Poe
Task 9 - Participation in the Evaluation of the System	
Evaluation Report Assistance (on-going)	Chris Poe
Data Collection – Pre-deployment	Chris Poe
Data Collection – Post-deployment	Chris Poe
Task 10 - Participation in Outreach Programs	
Marketing Plan	Koorosh Olyai
Three briefings per year on the Demonstration System to National audiences.	Koorosh Olyai
Participation in the final National ICM Conference	Koorosh Olyai
Subsystems – ICM Project	
SmartNET	Fariel Bouattoura
Interactive Voice Response subsystem	Russ Elovitz
511 Website	Fariel Bouattoura
511 Alert System	Russ Elovitz
Decision Support System	Ed Seymour
Arterial Street Monitoring System	Roberto Macias
Parking Management System	Kevin Miller

Section / Task ID & Deliverable	Task Lead
Transit Signal Priority	Kyle Irvin
Weather Information System	Fariel Bouattoura
IT Hardware/ Communications	Jim Carl

4.1.3 Work Breakdown Structure

The Work Breakdown Structure (WBS) is a means of organizing system development activities based on system and product decompositions. The systems engineering process described in earlier sections produces system and product descriptions. These product architectures, together with associated services (e.g., program management, systems engineering, etc.) are organized and depicted in a hierarchical tree-like structure that is the WBS.

The physical and system architectures are used to prepare the WBS. The architectures should be reviewed to ensure that all necessary products and services are identified, and that the top-down structure provides a continuity of flow down for all tasks. Enough levels must be provided to identify work packages for cost/schedule control purposes. If too few levels are identified, then management visibility and integration of work packages may suffer. If too many levels are identified, then program review and control actions may become excessively time-consuming.

The first three WBS Levels are organized as:

- Level 1 – Overall System
- Level 2 – Major Element
- Level 3 – Subordinate Components

The WBS and WBS Dictionary are included in and maintained as part of the Project Management plan.

4.1.4 Schedule

The schedule is included in and maintained as part of the Project Management plan.

4.1.5 Risk Management

The technical risk management process includes the approach, methods, procedures, and criteria for risk identification, quantification sensitivity assessment, handling, and risk impact integration into decision processes. The process describes the risks associated with the development, test, and evaluation requirements. The process identifies critical risk areas, plans to minimize the technical risk (e.g., additional prototyping, technology and integration verification, back up development), and describes the method of relating the Technical Performance to cost and schedule performance measurement and the relationship to the Work Breakdown Structure.

During the development of the Risk Assessment Table, as defined in the Project Management Plan, the risk control and monitoring measures including special verifications, technical performance measurement parameters, and critical milestones were developed.

4.1.6 Subcontractor Management

Because subcontractors may be involved in software development efforts for the Dallas Integrated Corridor Management Demonstration project, Telvent quality management policies dictate that process area procedures outline the involvement of Telvent in working with subcontractor-provided products. Subcontractors for the project are identified in this section along with information necessary to manage activities, shown in Table 4-3 and 4-4, and dependencies between Telvent and the subcontractor.

**** NOTE: CURRENTLY THERE ARE NO SUBCONTRACTORS ON THIS PROJECT – ONCE SUBCONTRACTORS ARE IDENTIFIED AND CONTRACTED, THESE SECTIONS WILL BE UPDATED ***

Table 4-3. Subcontractor Software Configuration Management Identification and Contacts

Subcontractor Name	Contact Info	SW Lead/SSM Manager	Notes

Table 4-4. Configuration Management (CM) Subcontractor-Related Activities

Activity	Subcontractor(s)	Description	Notes
CM Review of Policies and Procedures	All		
CMP Review	All		
Update Project Plan/CMP critical commitments and dependencies	All		
Audits and Reviews of subcontractor Software Baseline	All		
Technical CM meetings	All		

Subcontractor SCM Schedules

Schedules for subcontractors will be developed once subcontractor use and scopes are defined.

4.1.7 Project Status Review

As discussed in the Project Management Plan, monthly project status reviews will be held. During these reviews, any System Engineering and technical issues will be discussed and the Technical Lead will facilitate any actions necessary for the engineering team.

4.1.8 Configuration Management

Configuration management (CM) can be defined as “A management process for establishing and maintaining consistency of a product’s performance, functional, and physical attributes with its requirements, design and operational information throughout its life.” (From ANSI/EIA 649-1998)

Establishing the system baseline, or configuration, and managing change to that baseline, is key processes for ensuring that system integrity is maintained throughout the life of the system.

The configuration management process consists of five major activities:

- Configuration management planning – Planning for what needs to be controlled to completely define the configuration of the system, how you change a controlled configuration, how you keep track of those changes, and how you verify that the CM processes are working;
- Configuration identification – Identifying the functional and physical characteristics of a configuration item;
- Configuration change management – Controlling change to those characteristics;
- Configuration status accounting – Keeping track of the status of changes to the configuration items (e.g., proposed, approved, or implemented);
- Configuration auditing – Verifying that CM procedures are being followed as well as the consistency of documentation against the configuration item.

For this project, all software development related configuration items will be stored in the Telvent tool: Synergy. For documents, and project deliverables the ProjectSolve website will be used to manage configuration and version control of all project documents. A variety of different tools, provided in Table 4-5 below, are used by software development and CM staff in the production and maintenance of software. Some key items are listed below.

Table 4-5. Configuration Management Tools

Tool	SCM Description
Synergy	Synergy is a revision control system controlling hierarchical directories each containing revision controlled files. Synergy will be used for all application source code and related files. Documents and libraries will also be placed in Synergy as appropriate.
Change Synergy	Change Request (CR) (requirements and bug fixes) repository. All CRs are tracked from entry to resolution and closing.
Perl	A scripting language used by QA to automate CM actions in and around Synergy and build processes.
Developer Studio	Software development environment/Tools.
Install Master	Build the automated installation procedure.
ProjectSolve (EMC Documentum)	Version control of all documents for the project, including all plans, and document deliverables.

Configuration Management Planning

Configuration management comprises four interrelated efforts:

- Identification;
- Control;
- Status Accounting; and
- Audits.

Also directly associated with configuration management are data management and interface management. Any configuration management planning effort must consider all six elements.

Configuration Identification

Each configuration item is assigned a unique identifier. Standard naming practices are used for file types. Naming conventions for project-unique configuration items are set by the Task Lead in coordination with Telvent. Each software product is identified by the configuration item title. Telvent-CM and the Task Lead will manage the controlled item. Items include documents, source files, and database configurations, install scripts, and selected COTS applications. Stamps and other unique identifiers can be viewed through the Synergy software tool by software development staff, Telvent-CM and QA/QC staff. Some or all of these configuration items, shown in Table 4-6 below, may be subject to baseline management procedures as designated in the following section.

Table 4-6. Configuration Managed Items

	Name of Work Product	Description	Responsible Org
1.	System Requirements Allocated to Software (SRAS)	Defined before or during Project Initiation and used for planning	Task Lead and PM
2.	Project Plan	Planning documents	PM
3.	Software Design Descriptions	Design documents reviewed and approved by the CCB	Software Development project team(s)
4.	Source code	Program Source Code	Software Development project team(s)
5.	Map Data, Infrastructure Data	Project base map and layer data, facility information	Software Development project team(s)
6.	Voice files	For 511 IVR systems recorded voice files may be placed under CM during the development phase.	Software Development project team(s)
7.	Application configuration Data	Configuration file(s) / script(s) for project	Software Development project team(s)
8.	Database installation and creation scripts	Used to create the DBMS schema for testing and production	Task Lead and Telvent-CM
9.	Systems Test Scripts	The collection of scripts used to verify the software	Internal Test Group (ITG)
10.	User and System Administration Manuals	Developed for the project by Documentation and Training.	Documentation and Training
11.	Online Help file	PDF file for on-line help	Documentation and Training
12.	Training materials	Materials for training on project	Documentation and Training
13.	Concept of Operations	Final baselined concept of operations document approved by the stakeholders.	PM
14.	System Requirements Specification	Final baselined system requirements specification approved by the stakeholders.	PM
15.	System Design Document	Final baselined system design document approved by the stakeholders	PM

Configuration Change Management

Telvent may periodically conduct audits of the product and the processes used to create the products as appropriate. These audits may include:

- Check-in audits to verify that software reviews were conducted and CR(s) are appropriately referenced;
- Baseline audits to verify that the software products are at the appropriate point in the process for base lining; and

- Physical Configuration audits to verify that all of the associated work products are developed and checked in for a software project.

Configuration Status Accounting

Software developers are required by policy to submit code to Synergy periodically and follow the workflow model as defined in this Plan. Developers are additionally required to identify the CR for which a change is made, the functions, objects, modules, classes or segments of code changed when the code is checked into Synergy. The Task Lead is responsible for overall management of the code under development for that subsystem of the project for which they are responsible and managing the code through the workflow states throughout the life of the project. These actions combined with other procedures regarding the use of Synergy comprise the basic information necessary for conducting audits and providing status reporting to affected development teams regarding the state and status of code under development. Telvent makes these reports available via Synergy and generates reports for the development team at various stages of the project. Table 4-7 below provides information for the standard reports provided to the project by the SCM group.

Table 4-7. Software Configuration Management Reports

Report	Purpose/When Applicable	Recipient
Build Report	This report shows which code files have changed from one build to another. It is generated by Telvent-CM during a Systems Test build and is placed in the project's '.\process\CM\Build Reports' directory	Task Lead and project integrator and other developers on the project.
Code Development Status Report	This report details which files are at particular Workflow States in the development path. It also shows which files are currently undergoing change for the project. It is generated by Telvent-CM and delivered to Task Leads and/or designee weekly.	Emailed to Task leads and whomever they request as a recipient
Code Check-in Report	This report details overall developer activity checking files into Synergy	Integrated in the Biweekly QA report review. Project Manager's meetings

Engineering Change Proposal (ECP)

An ECP is documentation that describes and suggests a change to a configuration baseline. Separate ECPs are submitted for each change that has a distinct objective.

ECPs are identified as Class I or Class II. Class I changes require client approval before changing the configuration. These changes can result from problems with the baseline requirement, safety, interfaces, operating/servicing capability, preset adjustments, human interface including skill level, or training. Class I changes can also be used to upgrade

already delivered systems to the new configuration through use of retrofit, mod kits, and the like. Class I ECPs are also used to change contractual provisions that do not directly impact the configuration baseline; for example, changes affecting cost, warranties, deliveries, or data requirements. Class I ECPs require the Program Manager's approval, which will be handled through a formal Configuration Control Board, chaired by DART Program Manager, Koorosh Olyai.

Class II changes correct minor conflicts, typos, and other "housekeeping" changes that basically correct the documentation to reflect the current configuration. Class II applies only if the configuration is not changed when the documentation is changed.

Any member of the stakeholder or contractor team can submit an ECP to the CCB secretary for review and consideration by the CCB. The Secretary reviews the ECP, classifies the ECP (Class I or Class II), and catalogs and collects the ECP for CCB reviews. The CCB will meet formally once a month to review and decide on Class I ECPs. Class II ECPs will be distributed via e-mail by the Secretary, and reviewed and decided upon by CCB members on an ad-hoc basis.

Configuration Control Board

For the Dallas Integrated Corridor Management Demonstration project Requirements and Design issues identified prior to Production will be coordinated between DART Project Management and Telvent Project Management. After the initial Production implementation a project Configuration Control Board (CCB) will be established to decide on any system Requirements and software changes. The CCB is formed to review Class I ECPs for approval, and make a recommendation to approve or not approve the proposed change. The CCB chair, Koorosh Olyai, makes the final decision. Members advise and recommend, but the authority for the decision rests with the chair. CCB membership represents the stakeholder Project Managers, Telvent Project Manager, Telvent Deputy Project Manager – Technical, Configuration Accounting Manager, the Telvent Deputy Project Manager – Admin will serve as the secretary of the CCB. The CCB Chair makes all final decisions, with input from CCB members.

CCB Documentation

Once the CCB makes a decision concerning an ECP, the CCB issues a Configuration Control Board Directive that distributes the decision and identifies key information relating to the implementation of the change:

- Implementation plan (who does what when);
- Contracts affected (prime and secondary);
- Dates of incorporation into contracts;
- Documentation affected (drawings, specifications, technical manuals, etc.), associated cost, and schedule completion date; and
- Identification of any orders or directives needed to be drafted and issued.

4.1.9 Data Management

A relational database management system (RDBMS) is used to support components of the ICM System. Database artifacts including SQL scripts containing database permissions, structures, stored procedures, and functions are stored in configuration management and are tracked in change control.

In addition, as part of operations and maintenance, data is archived on a weekly basis at a minimum. Backup and archiving of data is defined in the operations and maintenance plan.

4.1.10 Technical Performance Measurement

Technical performance measurement (TPM) is a project control tool. For the Dallas ICM Demonstration Project, we will utilize an Earned Value Methodology to track the technical performance of the project as related to the schedule and budget. The earned value compares the cumulative value of the budgeted cost of work performed (earned) at the original allocated budget amount to both the budgeted cost of the work scheduled (planned) and to the actual cost of the work performed (actual). This technique is especially useful for cost control, resource management, and production.

Since we are utilizing an earned value process, percent complete of in-progress schedule activities can also be tracked and reported to project stakeholders to demonstrate the amount of work completed, budget expended, and cost to complete. Earned Value will be used to manage and report on major sub-projects and the overall project.

4.1.11 Technical Reviews

Technical reviews are essential to insure that the system being developed will meet requirements, and that the requirements are understood by the development team. For the Dallas ICM Demonstration Project, several formal and informal technical reviews will be performed, utilizing IEEE STD 1028-1997 IEEE Standard for Software Reviews:

- Requirements Walkthroughs;
- Preliminary Design Review (PDR);
- Critical Design Review (CDR);
- Software Development Review (SDR);
- System Readiness Review (SRR).

Requirements Walkthrough

The Dallas ICM team will conduct a requirements walkthrough with the US DOT and its representatives to ensure that both have a common understanding of what will be built and what capabilities the proposed system will actually be deployed. As agreed, a second walkthrough with the US DOT and its representatives will occur once the Detailed Requirements document and SEP are submitted.

As discussed with the US DOT, a 2nd Requirements Walkthrough will be scheduled once the System Requirements document has been updated and reviewed.

Preliminary Design Review

At the completion of the 40% Design a Preliminary Design Review (PDR) will be conducted to obtain verification/ approval of the system architecture design. The goals of the PDR are to:

- Verify the technical content of the architectural design document and its interfaces are complete and traceable;
- Ensure the selected design methodology has been followed in producing the architectural design;
- Obtain approval from the DART Program Manager to proceed into detailed design.

Critical Design Review

After completion of approximately 90% of the detailed design and prior to system build, a Critical Design Review (CDR) will be conducted to ensure the design fulfils the requirements. The CDR will serve as a baseline for all deliverables, and there will be no deviation from the final CDR without change requests being approved by the Change Control Board. The goals of the CDR are to:

- Verify the technical content of the System Design Document are complete and its functions traceable to requirements;
- Ensure the selected design methodology has been followed in producing the detailed design;
- Obtain approval from the DART Project Manager; the team will proceed into the implementation phase.

System Readiness Reviews (SRR)

The Dallas ICM team will hold Test Readiness Reviews prior to each major testing milestone, including sub-system testing, integration testing, and system acceptance testing. The Test Readiness Review process is an extract of the overall Quality Assurance process, the purpose of the Test Readiness Review is to provide the Stakeholders with the assurance that the software has undergone a thorough test process and is ready for turnover to the next test phase. The scope of the Test Readiness Review is to inspect the test products and test results from the completed test phase for completeness and accuracy, and to verify that the test cases, test scenarios, test scripts, environment, and test data have been prepared for the next test phase. Each of the sub-systems contributing to the overall ICM System will hold Test Readiness Reviews for their sub-system.

There are three (3) levels of Test Readiness Reviews at the sub-system level as defined below:

- Development Test Readiness Review – informal test readiness review conducted following successful completion of unit / module testing of a given sub-system
- Functional Test Readiness Review – formal test readiness review conducted following successful completion of the Integration Test of a given sub-system.
- Integration Test Readiness Review – formal test readiness review conducted following successful completion of functional test of a given sub-system.

There is one level of Test Readiness Review conducted at the Enterprise level, and an Implementation Readiness Review following Enterprise testing as defined below:

- Acceptance Test Readiness Review – formal test readiness review conducted following successful completion of the Integration Test and Performance Test of each release.
- Go-Live Readiness Review – formal review conducted following successful completion of the System Acceptance Test and assessment of the system to go operational.

4.1.12 Requirements Traceability

Each system requirement derived from user needs must be managed from design through system deployment. This is done by developing a requirements traceability matrix (RTM), a living artifact which must be managed to ensure requirements are met, adjusted as requirements change, and acknowledged as associated system components are deployed.

Telvent tracks all requirements to ensure that all associated work products are developed, tested as necessary, deployed, accepted and signed off by the project team. By developing a matrix, the Telvent management, software and system engineering teams are able to develop a work breakdown, budget and schedule of work items based on a common project artifact.

The RTM, which is a byproduct of a relational database containing user needs, requirements and subsystems, will be adjusted as required and utilized to manage change across all areas of the ICM project.

Chapter 5. Engineering Specialty Integration

Incorporating engineering specialties within the Dallas ICM Demonstration project is necessary to verify that all products within the WBS are designed and fabricated to the specified requirements. Systems engineering ensures that the various engineering specialties perform their tasks efficiently, and that they are integrated into a project from concept design through system installation and support.

5.1 Engineering Specialty Integration Introduction

For the Dallas ICM project, a project organization is in place to support the goals of the project. The team includes members from the lead agency, members from all stakeholder agencies and a team of consultants led by Telvent.

The consulting team is led by a project manager. He is responsible for accomplishing the project goals. He coordinates the sub consultants and deputy project managers that report to him. The structure below the sub consultants and deputies include integrated product teams that are in place to accomplish their parts of the project. The teams are: the decision Support team, the technical team, the administration and coordination team and the analysis, modeling and simulation team. A description of each team follows:

5.2 Engineering Specialties – Integrated Product Teams

5.2.1 Decision Support Team

The decision support team is headed by Texas Transportation Institute reporting to Telvent. The team is responsible for building the decision support system. This team meets with the system implementation team as needed to verify the two systems communicate correctly.

The technical team is led by the deputy PM – technical lead. The teams under the technical lead are: the team responsible for implementing the system: Data Collection; Data Fusion and Data Dissemination; and the team responsible for deployment and the operations and maintenance of the system.

5.2.2 System Implementation Team

Three teams make up the system implementation team. The data collection team is responsible for all of the data interfaces used to collect data from the various sources. The collection team's job is to interface with the data providers and gather raw data from them. Once the raw data is gathered it is converted and translated into the common format used by the ICM system, and finally stored and made available to other internal consumers of the information. The data fusion team is responsible for making the data collected by the collection team fit the particular needs of the data disseminators. This includes

compensating for missing, unavailable data. Data dissemination is responsible for providing information to the information consumers of the ICM system. These consumers include the public advanced traveler information system users and other downstream consumers of ICM information. These three teams work together and with external data providers and consumers to insure that information flows correctly through the system. The implementation team leads and most of its members communicate daily.

5.2.3 System Deployment Team

The system deployment team is responsible for integrating all of the pieces of the system together. This team includes the field infrastructure team; the system engineering lead; and the network infrastructure lead. The field infrastructure lead is responsible for design and implementation of the arterial travel time information gathering system. This team will work with the data collection team to insure that information from the arterial system is correct and complete is providing the real-time performance of the arterial roadways in the ICM corridor. The system deployment team is responsible for configuring the computing equipment used to operate the system. This team works with the system implementation team and the network infrastructure lead to ensure an environment is produced that realizes the system goals. The network infrastructure lead is responsible for designing an internal network that allows all of different components of the ICM system to communicate with each other in an efficient, safe, and secure manner. In addition the network infrastructure lead is responsible for insuring that connections to networks outside of the ICM system are sized properly and secure.

5.2.4 Operations and Maintenance Team

The operations and maintenance team is responsible for daily operation of the system and maintaining it to ensure it is up-to-date in every sense of the word. The O & M team consults with the network infrastructure lead and the system deployment team as needed.

5.2.5 Administration and Coordination Team

The administration and coordination team is responsible for tracking the project's progress in terms of schedule and budget. This team will keep the project manager aware of the financial condition of the project so that any issues with resources or schedule can be addressed before they become a problem.

5.2.6 Analysis, Modeling and Simulation Team

The TTI led AMS team continues the analysis modeling and simulation work that was begun under Stage 2 of the ICM Program. The AMS system interfaces only with the decision support system.

5.3 Engineering Specialty Selection

This section identifies and describes the engineering specialties that are applicable to the Dallas ICM Demonstration project. These areas of engineering specialties include:

- Data management engineering
- Software Engineering
- Test Engineering
- Hardware Engineering
- Communication Engineering
- Operations Engineering

Similar to the Integrated Product Teams, and as described in the Project Management Plan, each specialty engineering discipline will utilize stakeholder and contractor experts to provide the engineering specialty during the appropriate phases of the project. For example, during the design phase the Data Management Engineering specialty will utilize the data integration engineers of Telvent to work with the stakeholders in understanding and designing any interfaces for the data sources necessary for the project. Each specialty will be used during the requirement, design, and implementation phases to assist the stakeholder committees with decisions by providing the technical expertise and recommendations to make the project successful.

5.3.1 Data Management Engineering

The data management engineering specialty addresses the overall data management requirements included in a specific subsystem to provide the necessary management and control of the identified operational, management, financial, administrative, or technical data items. Data is essentially anything other than hardware and software, and includes, but is not limited to, drawings, documentation, and source code listings.

The prime functions of data management include such items as:

- Administration of contract deliverables and records
- Infrastructure Definition Data
- Real-time Performance Data
- Data quality and copy control
- Data storage and retrieval systems
- Maintenance and control of supplier-developed and purchased/ furnished information
- Planning, scheduling, and delivery of data

5.3.2 Software Engineering

The software engineering defines the activities, objectives to be used for system software components during the development life cycle. For this project, a Software Development Plan will be required for new software products, or major enhancements to existing COTS products are identified. As part of the alternatives analysis, software products (whether COTS or custom code) will be identified, and a Software Development Plan (SDP) will be developed to identify and establish the software management, policies, etc.

5.3.3 Test Engineering

The test engineering specialty provides a systematic approach for implementing a process to verify that all requirements have been met. The test engineering specialty establishes a philosophy and strategy for qualifying the system, and includes the identification of any special tests and special test equipment that may be needed.

5.3.4 Hardware Engineering

The hardware engineering specialty defines the activities, objectives, and schedules for system hardware components during the development life cycle. The hardware engineering specialty works closely with the software engineering specialty to ensure that the hardware and hosting facilities will support the software being purchased and/or developed for the project.

5.3.5 Communication Engineering

The communication engineering specialty provides the necessary communication services needed for the project. This includes communication between field devices and the central system, computer network communication requirements, and Internet communication requirements for the project.

5.3.6 Configuration Management/ Quality Control Engineering

The CM/QC engineering specialty addresses the requirements for management of drawings, documentation, and application source codes. This specialty also ensures that all drawings, documentation, and application source codes are complete and prepared according to standards.

5.3.7 Operations and Maintenance Engineering

The Operations engineering specialty addresses the operation (and maintenance) of the system once the Operations and Maintenance phase of the project has begun. The operations engineering specialty is involved during the entire life cycle to ensure that operational considerations are understood and addressed during the requirements, design, and implementation phases of the project.

5.4 Other Considerations

The following SE and Specialty Engineering areas, as discussed in the INCOSE Systems Engineering Handbook, were considered by Dallas ICM stakeholders, and determined to not be a high risk impact for this project:

- Survivability, including nuclear, biological, and chemical attacks
- Electromagnetic Compatibility, radio frequency management, and electrostatic discharge
- Human Engineering and Human Systems Integration – new GUIs are not planned and existing command and control systems will be used.
- Safety, health hazards, and environmental impact
- System Security – the existing security standards of the agencies will be followed, e.g. the TxDOT Daltrans Physical Security standards and processes.
- Transportability

Chapter 6. Acronyms

AMS	Analysis, Modeling, and Simulation
ASMS	Arterial Street Monitoring System
ATIS	Advanced Traveler Information
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
CCB	Configuration Control Board
CCTV	Closed Circuit Television
CDR	Critical Design Review
COTS	Commercial Off The Shelf
DalTrans	Dallas Transportation Management Center
DART	Dallas Area Rapid Transit
DMS	Dynamic Message Sign
DSS	Decision Support System
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GDP	Gross Domestic Product
GPS	Global Position System
HAR	Highway Advisory Radio
ICD	Interface Control Document
ICM	Integrated Corridor Management
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
NCTCOG	North Central Texas Council of Governments
NTTA	North Texas Tollway Authority
PDR	Preliminary Design Review
RCU	Roadside Communications Devices
RITA	Research and Innovative Technologies Administration
RFP	Request for Proposals

RTM	Requirements Traceability Matrix
SDR	Software Development Review
SRR	System Readiness Review
TIS	Travel Information System
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TSP	Transit Signal Priority
TxDOT	Texas Department of Transportation

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