Charlotte ITS Deployments
A Success Story in Systems Engineering

Debbie Self, P.E.
Traffic Safety, ITS, and Special Projects Section Manager
Charlotte Department of Transportation
600 E. 4th Street, Charlotte, NC 28202
(704) 336-3935
drself@charlottenc.gov

Mark Dunzo, P.E.
Senior Vice President
Kimley-Horn and Associates, Inc.
P.O. Box 33068, Raleigh, NC 27636-3068
(919) 677-2056
Mark.Dunzo@kimley-horn.com

Cole Dagerhardt, E.I.
Engineering Analyst
Kimley-Horn and Associates, Inc.
P.O. Box 33068, Raleigh, NC 27636-3068
(919) 677-2056
Cole.Dagerhardt@kimley-horn.com

Kelly Nicholas, E.I.
Engineering Analyst
Kimley-Horn and Associates, Inc.
P.O. Box 33068, Raleigh, NC 27636-3068
(919) 677-2109
Kelly.Nicholas@kimley-horn.com

ABSTRACT
Over the past couple years the City of Charlotte has been working with Kimley-Horn to implement a number of technologically advanced aspects proposed in the City’s Intelligent Transportation Systems (ITS) Master Plan. The two main aspects are a conversion to IP/Ethernet communications and a migration to a digital video system. From its conception, this project has followed the recommended guidance for system engineering documents established by the Federal Highway Administration (FHWA). The Systems Engineering for Intelligent Transportation “V-diagram” establishes checkpoints to ensure that from design to deployment, the project proceeds as intended. You are invited to travel along this “V-diagram” in the following pages as the project progress is described each step of the way.

As shown in Figure 4, the Systems Engineering “V” Diagram suggests an interdisciplinary approach to developing systems and through checkpoints ensures that what is designed and deployed meets the project intent. The Systems Engineering process is tailored to defining stakeholder needs and required functionality early in development. The requirements will be documented prior to proceeding with design and then ultimately system validation.
Beginning in the late 1990’s and the early 2000’s the City of Charlotte began investing in ITS technology as a means of improving the footprint and efficiency of their transportation systems. Due to a surge of ITS deployments, they quickly realized a need for an overall plan for implementation of a citywide system. This began with the *City of Charlotte ITS Communication Master Plan (2004)*. This plan determined the existing inventory and bandwidth demand as well as evaluated the future needs based on the City of Charlotte’s expected ITS growth.

However, technology was quickly changing and the City’s deployments of ITS equipment continued to increase, which lead to the *City of Charlotte ITS Communication Master Plan Update (2008)*. In this update a transition path matrix was provided to serve as a template when updating and expanding the City’s existing ITS infrastructure.

The Master Plan Update included a plan for Ethernet technology and architectures which would support digital video devices as well as accommodate further expansion of the City’s CCTV coverage of its transportation network. Ultimately, the plan specified an IP/Ethernet system with a ring/mesh topology as seen in Figure 3.
The proposed architecture in the plan identified a digital video system as a priority to accommodate the city’s future network demands while upgrading to the latest in video technology.

In 2009, the Charlotte Department of Transportation (CDOT) was able to use the Master Plan to position them to receive Federal Funding for the U-5133 Intelligent Transportation System (ITS) Projects. Project U-5133 Part A began to implement various elements of the Master Plan. The project included two main tasks:

- Migration of the City’s ITS communications system to an IP/Ethernet architecture
- Migration from an analog video system to a digital video system

Figure 4: Systems Engineering “V” Diagram

Concept of Operations

The development of the Concept of Operations brings all the stakeholders together to ensure a common understanding of the project before commencing with design. As with any project involving multiple agency participants, this invokes collaboration and insights that are unlikely to be gained through individual departmental meetings. Stakeholders invited to the U-5133 Part A workshops included the City and State Departments of Transportation, City Information Technology Services, Charlotte Area Transit System, Charlotte-Mecklenburg Police Department (CMPD) and the Charlotte Fire Department (CFD).

Several workshops were held to determine an appropriate concept of operations for both the IP/Ethernet System and the related digital video system. The workshops were exceedingly successful as CMPD and CFD were looking to move forward with a new video surveillance system as well. Ultimately, this collaboration would allow several City departments to pool resources to implement an extremely robust digital video system that stretches across the city. This system currently supports over 300 closed circuit television cameras and is expected to support over 500 cameras within the next 5 years.
In addition, conversion of the existing serial-based network to a fault tolerant IP/Ethernet architecture would provide a network foundation capable of supporting existing and future ITS subsystems, including the digital video system.
Digital Video Requirements and Detailed Design

The requirements process, much like the concept of operations, involved several workshops where stakeholders provided insights and questions that were molded into system requirement documents. The functional requirements defined in these documents are intended to facilitate implementation of the goals and objectives into the final system and to help define more specific needs of the stakeholders. Functional requirements are statements of what the system should do, but not how to do it. They can be statements of expected functions, outcomes, interfaces or performance objectives.

Overall, the requirements documents provided a baseline for development of detailed requirements and criteria for hardware and software procured under a series of request for proposals released under the U-5133 Part A Project.
With the successful bidders under contract, collaboration to ensure each of the design elements worked well together was imperative. A test lab was set up to demonstrate the network topology’s ability to reroute data along a backup link when necessary. Full capability of the proposed digital video system also was demonstrated. The extensive planning, design, and test phases of the U-5133 Part A Project allowed for seamless implementation of the IP/Ethernet architecture simultaneously with deployment of a digital video system.

Overall, several agencies, vendors, and consultants worked together to implement one of the most sophisticated intelligent transportation and surveillance systems in the southeast.
Project Verification and Validation

The procurement, requirements, detailed design, and concept of operations documents provided clear insight as to how each phase of the project would proceed. The partnering agencies were able to use these documents as a roadmap for implementation. Constant comparison of the procurement and design documents during integration resulted in a solid foundation upon which the IP/Ethernet network architecture and digital video systems were built. Overall the system correlated directly with the high level designs envisioned during project planning.

Overall, close adherence to the FHWA systems engineering process facilitated development of a collaborative, robust intelligent transportation and surveillance system shared by multiple agencies within the Charlotte-Mecklenburg region of North Carolina.

Conclusion

The above described “V-diagram” is a tool to aide in the successful project tracking from design to deployment. When used as a guide to step you through each checkpoint, this method will ensure the project intent is met with the final deliverable. For the City of Charlotte and Kimley-Horn, following this process provided a clear framework for how to proceed at each juncture. Laying the ground-work with a master plan; involving stakeholders early; clearly defining needs, requirements, and end results; testing the concept; implementing as designed; and verifying along the way helped make the project final deliverable true to its original intent.