City of Columbus
Traffic Signal System

Improvements Update
October 25, 2016
Columbus Regional Signal System

Identifying need for system upgrade

- Existing proprietary systems that had surpassed their design life
- Limited signal coordination and traffic monitoring ability
- Older character based interface was less intuitive for system users
- Inability to integrate coordination of signals across jurisdictional boundaries
- Increasing population growth and traffic projected for region
## Signal System Improvement Highlights

### CTSS Improvements by Phase

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>Project Phase</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Future *</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In Service</td>
<td>Design/Construction</td>
<td>Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backbone FOC (288 strand)</td>
<td>87</td>
<td>5</td>
<td>8</td>
<td>18</td>
<td>15</td>
<td>9</td>
<td>143</td>
</tr>
<tr>
<td>Trunk FOC (144 strand)</td>
<td>96</td>
<td>111</td>
<td>114</td>
<td>112</td>
<td>95</td>
<td></td>
<td>528</td>
</tr>
</tbody>
</table>

### Total Fiber Optic Cable (miles) 671

| Traffic Signals               | 318           | 240              | 265              | 250              | 150              |          | 1223  |
| Data Node sites               | 19            | 8                | 12               | 10               | 11               | 5        | 65    |
| Radio Links                   | 70            | 9                | 6                | 20               | 10               | 115      |       |
| CCTV sites                    | 38            | 19               | 12               | 10               | 15               |          | 133   |

**Total Network Access Sites 1651**

*preliminary estimate of regional infrastructure
Impacts to Regional Motorists

- Enhanced signal operation and coordination options – optimized traffic flow
- Additional traffic flow monitors – better incident congestion mitigation
- Ability to provide seamless signal coordination across jurisdictional boundaries
- Adaptive coordination capability
- Vast increase of bandwidth for City and regional agency data sharing

**Interagency connection capability by phase**

<table>
<thead>
<tr>
<th></th>
<th>In Service</th>
<th>In Design or Construction</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Map showing interagency connections with different symbols for each phase.
CTSS Phase A

• Fiber optic backbone along freeways
• Communications node sites installed at arterial routes for future connections
• Routed IP network equipment installed to form basis of communications network

Typical CTSS Communications Node Site with Power Distribution Cabinet
CTSS Phase A

- Approximate 85 miles of fiber optic interconnect cable installed
- Columbus Department of Technology shared installation costs to double capacity
- Fibers were designated for use by various regional agencies.
- Construction of new Traffic Management Center

**CTSS Backbone Fiber Optic Network Allocation**

<table>
<thead>
<tr>
<th>Reserved for:</th>
<th># Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbus Traffic Signal System</td>
<td>24</td>
</tr>
<tr>
<td>Central Ohio Transit Authority Operations</td>
<td>12</td>
</tr>
<tr>
<td>ODOT Freeway Management System</td>
<td>12</td>
</tr>
<tr>
<td>ODOT Division of Information Technology</td>
<td>12</td>
</tr>
<tr>
<td>Other Agencies</td>
<td>24</td>
</tr>
<tr>
<td>Columbus Department of Technology</td>
<td>144</td>
</tr>
<tr>
<td>Future Use</td>
<td>60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>288</strong></td>
</tr>
</tbody>
</table>

Operator Console at Columbus Traffic Management Center
CTSS Phase B

- Upgraded equipment and connected to 318 traffic signals
- Installed approximately 100 miles of fiber optic interconnect cable connecting arterial corridor signals to communication nodes.
- Designed relied heavily on making use of or rehabbing existing coaxial network infrastructure
- Approximately 70 wireless ethernet links established, primarily in CBD
- 38 CCTV sites were upgraded and/or installed

### CTSS Trunk Fiber Optic Network Allocation

<table>
<thead>
<tr>
<th>Reserved for</th>
<th># Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbus Traffic Signal System</td>
<td>24</td>
</tr>
<tr>
<td>Central Ohio Transit Authority Operations</td>
<td>12</td>
</tr>
<tr>
<td>ODOT Freeway Management System</td>
<td>6</td>
</tr>
<tr>
<td>Other Agencies</td>
<td>6</td>
</tr>
<tr>
<td>Columbus Department of Technology</td>
<td>72</td>
</tr>
<tr>
<td>Future Use</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>144</strong></td>
</tr>
</tbody>
</table>
CTSS Phase B

- Responsible for the testing and evaluation of new central signal control system software
- First phase to integrate signals to new system
- Tested software and device compatibility to retain existing equipment when possible

Operator View of Traffic Signal Central Control Software

- Upgraded CCTV video control software
- 38 CCTV sites were upgraded and/or installed, including several high rise mounted sites downtown
- Software enables CTSS to share traffic signal and video data with ODOT and other regional agencies
CTSS Phase B

- Investigated interconnect technologies – wireless, fiber optic, ethernet over copper, etc...
- Developed design standards and specifications to be used through subsequent phases
- Established wireless radio benchmarks for data throughput and reliability

Existing Downtown Building Mounted CCTV Sites to be Upgraded

Screenshots of wireless radio testing
CTSS Phase B
Network Design Considerations

- Large amount of make ready utility coordination – expenses forced design revisions
- Aged infrastructure not always reliable – aged conduits fail and repairs not always properly performed
- City acquisition of Columbus Fiber Network - provided interconnect pathways also but required additional design and coordination
- Access to backbone network restricted due to ongoing innerbelt construction
- Maintaining redundancy, minimizing IP “hops”, and eliminating network loops not always straightforward

Available space through existing infrastructure was sometimes at a premium

Weathered and inaccessible existing infrastructure
CTSS Phase B
Ideal Downtown Network Structure
CTSS Phase B
Limited access due to other projects and unusable existing conduit
CTSS Phase B
Existing Columbus Fiber Net becomes available for CTSS use
CTSS Phase B
Wireless communication links proposed
CTSS Phase B
Downtown subnet structure
CTSS Phase B
Sub Network Development

- Non-routing network switches used at intersections due to substantially lower cost
- Some precautions required to overcome technology limitations

Spatial connectivity of sub-network
CTSS Phase B
Sub Network Development

• Rearranged nodes for working clarity
CTSS Phase B
Sub Network Development

- “data in/data out” sites removed from diagram to simplify network
- Connectivity “loops” identified – these loops can create “data storms”
CTSS Phase B
Sub Network Development

• Interconnect patching reconfigured, network ports disabled in order to remove network “loops”. Links can be reactivated in case other links fail
CTSS Phase C

- Upgraded equipment and connected to 240 traffic signals
- Installed approximately 120 miles of fiber optic interconnect cable
- 12 Communication node sites
- Approximately 10 wireless ethernet links
- 20 CCTV sites were upgraded and/or installed
- Most of system is online to date

Challenges

- Signal warrants
- Power services to remote sites
CTSS Phase D

- Upgraded equipment and connected to 265 traffic signals
- Installed approximately 135 miles of fiber optic interconnect cable
- 10 Communication node sites
- Approximately 10 wireless ethernet links
- 36 CCTV sites were upgraded and/or installed

Construction scheduled to begin Spring of 2017
CTSS Phase E

- Upgraded equipment and connected to 250 traffic signals
- Installed approximately 125 miles of fiber optic interconnect cable
- 12 Communication node sites
- Approximately 20 wireless ethernet links
- 25 CCTV sites were upgraded and/or installed

Preliminary design is currently underway
Network Security

Identified potential weaknesses

• Large IP network with numerous access points

• Wireless links

• Other connecting agencies

• Physical infrastructure
Network Security

Mitigated Potential Threats

• Large IP Network with numerous access points
  • Lock enclosures
  • Enable password protection and encryption
  • Disable unused network ports

• Wireless
  • Avoided commonly used public wireless frequencies and utilized point to point radio equipment
Network Security

Mitigated Potential Threats

• Outside connecting agencies
  • Discouraged use of inter IP-network links
  • Firewalled any links that had to be made

• Physical Infrastructure
  • Lock enclosures
  • Multiple redundant communication paths in the event of power outage, equipment failure, or cable break
Clarity of Plan Set Results in Improved Constructability

- Highly indexed plan set for ease of review and construction
Clarity of Plan Set Results in Improved Constructability

- Cable schematic diagram developed after Phase B project and continued through subsequent phases
Clarity of Plan Set Results in Improved Constructability

- Cable schematic diagram graphically simplifies installation process

Crowded Utility Paths, both Above and Below Ground

Cable Schematic

Not to Scale
Clarity of Plan Set Results in Improved Constructability

- Communication and fiber splicing diagrams revamped to more clearly illustrate proposed work

**Earlier Fiber Optic Splicing Diagram Format**

**Currently Used CTSS Fiber Optic Splicing Diagram Format**
Clarity of Plan Set Results in Improved Constructability

- Visually representative communication diagrams reduce confusion during construction and can be a beneficial tool for future maintenance efforts.
Future Implications

• Better regional signal coordination and adaptive capability resulting in less traffic congestion and increased system safety
• Standardization of regional signal system
• Robust regional communications network and ability to readily share interagency data
• High capacity fiber optic network equipment will serve as the communications base for the Columbus Connected Transportation Network which, through the ongoing Smart Columbus project, will implement pilot automated and connected vehicle programs, real time traffic and public transit conditions, and a multitude of new technologies and roadway system instrumentation to provide and truly interactive transportation network
Questions, Comments, Concerns...

Ryan J. Bollo, P.E.
Senior Project Manager
ITS/Technology Program

Matt Graf, P.E.
Project Manager
ITS/Traffic Planning