DRAFT SIGNAL SYSTEM VISION

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Traffic signal improvement project

ON TO 2050 recommends establishing a program to modernize the region's traffic signals. The overarching Traffic Signal Improvement Project begins implementing that recommendation. This document describes the Vision a program should achieve.

2050 Vision

A modern traffic signal network providing for a well-integrated, multimodal transportation system that seamlessly moves people and goods within and through metropolitan Chicago safely and reliably with minimized delay.

> *"We cannot stand still, deferring important decisions that will shape the system for decades to come. In fact, while continuing to deal with past choices made or often deferred, our region must take bold steps both to address today's problems and to anticipate opportunities for achieving a well-integrated, multimodal transportation system for seamless movement of people and goods within and through the seven counties of metropolitan Chicago."*[1]

[1] Chicago Metropolitan Agency for Planning, "Mobility," CMAP ON TO 2050, accessed December 11, 2018, https://www.cmap.illinois.gov/2050/mobility.

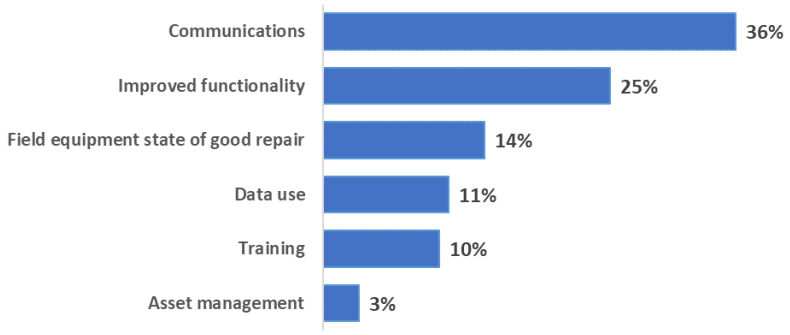
Vision Development

In October 2019, the Northeastern Illinois Regional Transportation Operations Coalition met at the Chicago Metropolitan Agency for Planning and discussed the future of the region's traffic signal system. The coalition represents years of experience, with signal experts from all parts of the region, including state, county and municipal signal engineers, along with technology consultants. Their expertise resulted in a Vision for traffic signals of the future. The vision does not depend on speculative technology or the invention of devices that don't already exist, rather it can be achieved using existing technology. However, bold steps in the signal arena are needed to address today's problems and anticipate opportunities for achieving a well-integrated, multimodal transportation system for seamless movement of people and goods within and through northeastern Illinois.

Overall goal areas

The experts provided twenty-eight essential elements of the effective traffic signal of the future. Figure one shows the result when each element was first ranked by participants, and then assigned to goal areas representing overall priority. Signal communications was identified as the most important component of the signal system of the future. Improving functionality over today's system and bringing all elements of the signal systems up to a state of good repair, which included modernizing outdated equipment.

Figure 1: Overall priorities



From the overall categories, three essential elements were identified as being most important to the signal system of the future. The ability to communicate with traffic signals in the field emerged as a top priority activity. **Communications** directly between a signal management center and the signal allows an agency to monitor signal activity. Once communication to a signal is established, it provides the opportunity to share information about signal operations between agencies, identify conflicting signal plans and allowing coordination between different agency signal systems, even if other aspects of the traffic signal are not fully modern. Communications infrastructure is the foundation required to take advantage of future opportunities in central control, system coordination, and connected vehicles.

The next priority, highly dependent on established communications, was the most important element of improved functionality. The region must develop traffic signals that are **Automated Traffic Signal Performance Measure (ATSPM) capable,** a real time performance measurement system, or are **fully**

adaptive, monitoring traffic conditions and responding in real time. Performance monitoring systems for traffic signals:

- measure traffic volumes,
- measure how well signals serve traffic and allocate time to movements,
- measure how well the signal coordination is working,
- measure queue lengths, and
- use that information to identify signals that need changes to timing or equipment.

ATSPM allows agencies to be aware of any signal that isn't performing as it should and to optimize signals without resorting to expensive and time consuming field data collection. Along with communications, ATSPM or fully adaptive signals require sufficient detection to collect the traffic data and a modern controller that can generate high quality data to be analyzed. Today our knowledge of how the traffic signal system is performing is very nearly non-existent, and the cost and time associated with reviewing performance is prohibitive.

Finally, field equipment **state of good repair** was cited as the third most important element. Modern traffic signal systems are combination computer system, communication system, and roadside infrastructure. In addition to basic maintenance of the physical elements such filters, fans, detectors and poles, "state of good repair" for a computer and communication system includes a commitment to computer upgrades to keep up with technology. A business process providing a critical service to the traveling public should not rely on computers that are no longer manufactured or supported, and do not provide needed capabilities.

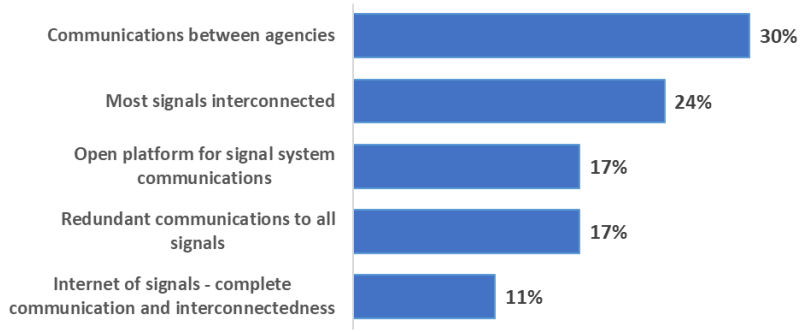
Communications

Communications is the foundation of the **well-integrated** 2050 system. It is the most important component of the future traffic signal system.

Figure two presents key objectives included in the communication goal area. Today, limited or no communication with traffic signals hinders progress towards efficient operation of the arterial system by preventing agencies from observing conditions in the field and responding to them. The objective is to develop a regional communication network with every signal in the region attached, thereby allowing agencies with jurisdiction to monitor and operate their signals, and other agencies to view them. Operators can identify conflicting signal plans and improve coordination between different agency signal systems as well as between their own signals. ON TO 2050 recommends coordinating traffic operations region wide, an activity that will require communications to signals. ON TO 2050 also recommends identifying public investments that could catalyze emerging technologies. The ability to support, encourage, and take advantage of emerging technologies, especially connected vehicles, will be dependent on expanded communications capabilities.

As the region expands advanced signal capabilities and use of connected vehicle information requiring communication from a central system, it becomes more important to protect against lost communication by providing for redundant communications pathways and developing materials and installation methods that are more resistant to damage.

Figure 2: Communication priorities



Improved functionality

Improved functionality incorporates **seamless movement and multimodality** into the 2050 signal system. The goal area of improved functionality represents the future as the traffic signal becomes a new operations tool to accomplish regional goals. Figure 3 shows the objectives cited within the goal area of improved functionality. Improved functionality manifests the ON TO 2050 recommendation to harness technology to improve travel and anticipate future impacts.

The most important objective is that all traffic signals would be fully adaptive or Automated Traffic Signal Performance Measure (ATSPM) able. These two abilities allow signals to benefit from real time awareness of traffic conditions and signal performance, plus more dynamic control of signal plans. Both technologies require sufficient vehicle detection, modern signal controllers, and for ATSPM, communications to a performance monitoring system to evaluate signal performance. ATSPM allows operators to optimize signals without resorting to expensive and time consuming field data collection and to measure the effects of new timing immediately. These systems also generate large amounts of data that can be used to plan for severe weather, special events, road incidents, and emergency situations.

ON TO 2050 advocates making transit service more competitive and recommends that roadway agencies should prioritize improving transit service. Expanding transit signal priority improves bus on-time performance and increases speed. Even where transit signal priority is not in place, better arterial operations provide better operating conditions for bus service, and safer transit access for pedestrians and bicyclists.

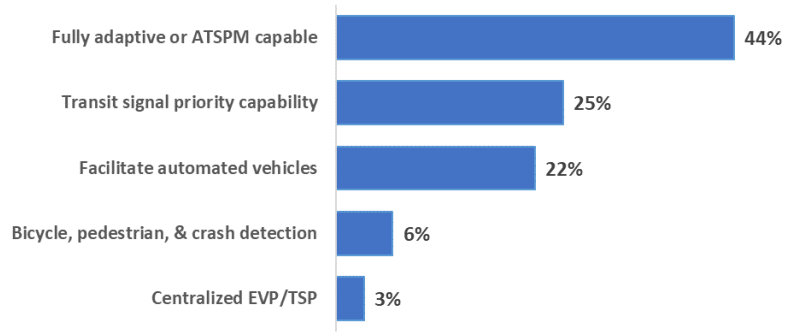
Many locations may benefit from bicycle and pedestrian detection to serve those users more safely. ON TO 2050 recommends investing in safe bike and pedestrian pathways to desired destinations and improving access to public rights of way for pedestrians, cyclists, and people with disabilities.

Emergency vehicle pre-emption (EVP), transit signal priority (TSP), and other priority requests can interfere with signal timing plans and disrupt signal coordination. Central signal control can serve these requests in more efficient ways that reduce traffic disruption.

While the focus so far has been on existing technologies, emerging technologies will result in new ways to improve arterial travel and collect data to support operations and maintenance decisions.

Establishing the functionalities needed to serve and take advantage of information communicated between infrastructure and vehicles (V2I) is likely to be one of the first new functionalities desired.

Figure 3: Functionality priorities



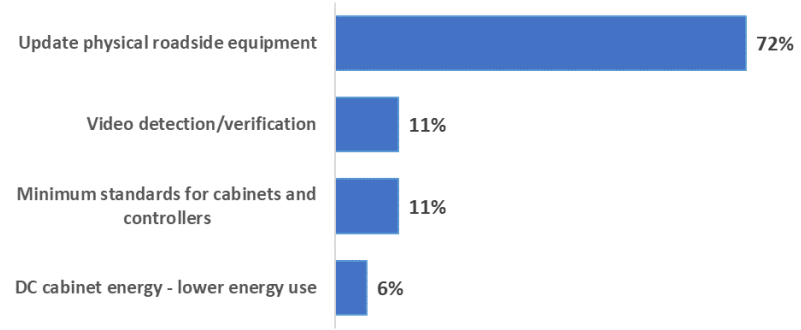
Field equipment state of good repair

Well maintained equipment promotes system **reliability**. Old and outdated equipment will fail more often, becoming less effective or even interrupting the flow of traffic. ON TO 2050 recommends planning for system modernization while making progress towards a state of good repair.

The least technically-complicated elements of the signal systems, such as poles and foundations are decaying and infrequently replaced. The region has cabinets too old to house modern controllers, and controllers that are no longer manufactured or supported and should be replaced. Detection may be working incorrectly which causes the traffic signal to perform inefficiently. There is no system in place to identify this malfunction short of receiving a complaint, visiting the location, and observing the situation.

Reduced safety and mobility results from power to a signal being lost and the signal going dark. Backup power can keep the lights working but is not a feature of all traffic signals. Opportunities to reduce electricity use should be explored, such as DC cabinets and signal equipment that may reduce power and battery costs and allow the signal to operate on backup power for a longer time during a power outage. Addressing these issues supports the ON TO 2050 recommendation to improve resilience of the transportation network to weather events and climate change.

Figure 4: State of good repair priorities



Data use

Data use allows operators to quantify **safety, delay, and reliability**, measuring how well the 2050 signal vision is achieved. ON TO 2050 recommends making the collection, sharing, and analysis of public and private sector transportation data a regional priority. This recommendation encompasses a number of activities in relation to traffic signal management and operations. Operators can

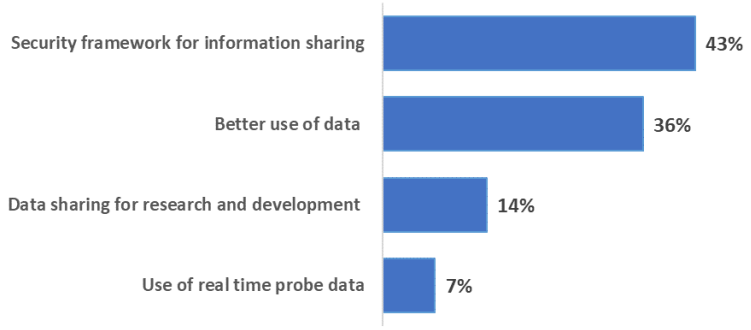
- collect and use their own data to support signal operations
- use data generated by other sources to support signal operations, such as probe data, transit data, or data generated by other highway operators,
- provide data to others for research and development purposes,
- broadcast data for connected vehicles to use, and
- collect and use data broadcast from connected vehicles.

As figure 5 shows, the development of a security framework for data sharing is viewed as the top objective of the data use goal area. Implementation of an internet of signals connected by Ethernet communications provides the channel to move data between signals, centers, vehicles and other data consumers, making it widely available. While Ethernet-enabled equipment allows for efficient communication, it can also introduce gateways for intrusion and security breaches. Existing signal communications systems are generally separated from other networks for security (and other) reasons, but the separation can impede the flow of data between consumers. Sharing data will require system operators to work together to develop a security framework to protect the system and safely share data.

Signal generated and other data isn't used as often as it should be for understanding signal performance and identifying opportunities to improve arterial operations. In the past, the information was unavailable for use. Today, the region is mostly unable take advantage of this resource due to widespread antiquated infrastructure and decision support systems. When private companies and universities can use signal data for research and development, signal operators can benefit from the development of new products that address unmet or badly met needs.

With the addition of video equipment, sharing video with other public or private partners becomes possible and allows the images to be used by others, such as emergency responders, for better arterial operations. In general, when data is shared with others, it opens the door for sharing the costs of infrastructure deployment and maintenance. ON TO 2050 recommends the strategic use of public-private partnerships.

Figure 5: Data use priorities



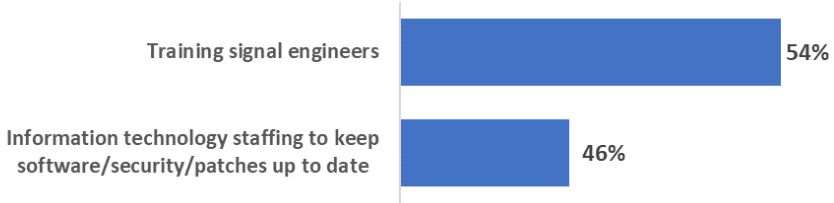
Training

Chicago Department of Transportation estimated that there are fewer than 200 traffic signal engineers in the region, and many of them are retiring. Meanwhile, new signal operating and decision support systems are highly technical, and a supply of individuals who understand how to use them is needed. Investing in the region's workforce may increase the number of workers with these important skills. Furthermore, new skills will be needed to operate the signal system. Modern signal systems and central signal are driven by computer hardware and software, requiring many skills more related to computers and information technology, than to traditional traffic operation engineering skills.

ON TO 2050 recommends marketing and building awareness about career pathways to equip our educators, career counselors, college advisors, and students themselves in strategizing for career and life choices, including transportation focused information technology, information security and traffic operations. In addition, there may be opportunities to develop sector-specific instructional models that reflect evidence-based research, local and regional goals, and skills demand in the labor market, another ON TO 2050 recommendation.

ON TO 2050 recommends sharing services when possible to reduce costs and promote efficiencies. If each agency maintains its own traffic signal management system, then software, software maintenance, and the hours spent maintaining and upgrading systems are duplicated. Shared software can make coordination between agencies easier and reduce costs and manpower needs.

Figure 6: Training priorities



Asset management

The asset management goal area identified two primary objectives, shown in Figure 7. ON TO 2050 supports implementing an asset management system for traffic signals, as it recommends performance-based programming and expanding asset management practices to the entire transportation system.

The asset management planning framework would detail infrastructure life cycle needs, regional planning and operations goals, and how the traffic signal system can support them. It might include priorities for targeting investments to locations, facilities, or technologies. For example, ON TO 2050 recommends leveraging the transportation network to promote inclusive growth, improve access to public rights of way for pedestrians, cyclists, and people with disabilities, improve transit service, and developing a unified regional approach for freight transportation issues. Each of these could be reflected in a planning framework.

Comprehensive information describing each element of the regional traffic signal system should be developed, including condition and information needed to understand the signal relationship to goals in the planning framework. Current road oriented asset management efforts focus on pavement and bridges, but traffic signals are critical to the system and should be included. With this information, agencies can apply prioritization methods arising from the asset management planning framework.

Individual operators keep their own signal inventories, but regional planning and investment would be improved and the cost of agency asset management software would be reduced under a shared asset management platform. ON TO 2050 recommends sharing services when possible to reduce costs and promote efficiencies.

Figure 7: Asset management priorities

Ahead

With the Vision established, the cornerstone of the northeastern Illinois Signal Improvement plan is laid. To understand what actions are need to build the desired traffic signal system, the state of the current signal system must be understood. The existing conditions section describes the current system and was produced based on data collected for the northeastern Illinois regional Highway Traffic Signal Inventory, interviews with state, county, and municipal signal engineers, and interviews with the primary traffic signal maintenance contractors.

Appendix

Ranking of desired characteristics

Characteristic	Description or Purpose	Votes
Communications between agencies	Identify conflicting signal plans and allow coordination between different agency signal systems.	14
Fully adaptive or ATSPM capable	Optimize signals without resorting to expensive and time consuming field data collection.	14
Update physical roadside equipment (mast arms, etc)	The least technically-complicated elements of the signal systems are decaying and infrequently replaced.	13
Most signals interconnected	Improve traffic flow by aligning signal plans.	11
Open platform for signal system communications	Allows easier integrations and communication between different agency signal systems and different signal manufactures and signal ages.	8
Redundant communications to all signals	As the region gets more dependent on advanced signal capabilities that require communication from a central system, it becomes more harmful for communication to be lost.	8
Transit signal priority capability	Improves bus on-time performance and increases speed	8
Facilitate automated vehicles	Communication between signals and vehicles	7
Training of personnel	Signal engineers are retiring. New signal systems and decision support systems are highly technical.	7
Information technology staffing to keep software/security/patches up to date	Modern signal systems and central signal are driven by computer hardware and software. These are different skills than traffic operations engineers.	6
Security framework for information sharing	Ethernet-enabled equipment allows for better communication, but also opens avenues for intrusion and security breech.	6
Better use of data	Probe data and signal generated data isn't used as much as it should be for understanding signal performance and identifying opportunities to improve arterial operations.	5
Internet of signals - complete communication and interconnectedness	Every signal system is connected to a "signal internet" where different agencies can view them and owning agencies can operate them.	5
Asset Inventory	All aspects of the signal system should be inventoried and include condition information.	2
Detection of bikes, peds, and crashes in an intersection	Some locations can benefit from bicycle and pedestrian detection.	2
Minimum standards for cabinets and controllers regionwide (to accommodate	The region has cabinets and controllers that are so old they cannot support modern technology and operations. There should be a requirement to replace them.	2

new equipment and capabilities)		
Data sharing/open data for research and development	Private companies and universities can use signal data for research and development, signal operators will benefit by having new products developed that address unmet or badly met needs.	2
Video detection/verification	Information arriving from the signal system in the field to a central location may be incorrect and there is no way to verify it except through visual inspection.	2
Information and planning framework to support asset management (data and priorities)	Development of prioritization methods to guide investments based on signal performance and the planning data (traffic, traffic mix, crashes, expected traffic growth etc) to support them.	2
Use of real time probe data	Arterial speeds have traditionally been difficult to estimate. New probe data provides new ways to evaluate arterial performance. It can be incorporated into signal support systems.	1
DC cabinet energy - lower energy use	DC cabinet and signal equipment reduces power needs at the signal, reducing costs and allowing the signal to run on backup power for a longer time if there is a power outtage.	1
Centralized EVP/TSP that reduces upsetting signal timing when possible	EVP, TSP and other priority requests can interfere with signal timing plans. A central system can quickly review the request and cycle, and sometimes grant the request within the current cycle.	1
Hands off adaptive signal (no human intervention)	Adaptive signal systems promised better performance, but often required operators to review and actively implement changes. This reduces the value of the system.	0
Shared inventory platform	Individual agencies keep their own inventories with different attributes and qualities. Regional planning and investment, would be improved and the cost of agency asset management software would be reduced if the platform were shared. Standard data would be collected.	0
Back up power	It is unsafe and reduces mobility when power to a signal goes out and the signal goes dark. Backup power can keep the lights working.	0
Move systems to software as a service	Each agency maintains their own system of managing traffic signals, which duplicates software, software maintenance, and the hours spent maintaining and upgrading it. Shared software could make coordination between agencies easier and reduce costs.	0

Video sharing	Sharing video with other public or private partners allows the images to be used for better arterial operations (emergency responder use) and opens the door for additional funding opportunities for cost sharing of equipment.	0
Backwards compatible equipment	Older equipment is going to be on the street for a long time. New hardware and software should be backwards compatible to accommodate old systems.	0
Total votes		127