On-Board Video Surveillance: A Look Ahead to Mobile Systems Integration

Outline:

A forward-looking presentation about the growing demands for on-board video surveillance, among transportations systems around the world. How can video systems be integrated with other on-board equipment, both OE and aftermarket? How can systems be integrated with agency communication systems, security systems, and operational systems? What new demands are being made of all video vendors by transit agencies?

Mobile systems integration is fast becoming the main topic of discussion for many equipment vendors and their transit customers. Increased technological capabilities and increased demands to leverage current agency systems and budgets are some of the main drivers. Agencies are seeking measurable and sustainable applications that will help them to protect passengers, operators, and property. These same agencies are also seeking new solutions to growing fuel costs, operational concerns, increasing litigation, ongoing vandalism and initiatives to counter the shadow of terrorism.

From an operations perspective digital video can be coupled with other on-board data to simplify the organization and retrieval of information and provide highly responsive decisions for operator management, special event management, and passenger safety. Integration on-board doesn't stop on the vehicle. Back office integration is another step. Active reporting systems that are integrated to provide one-stop access to real time information should be focused on the goal to reducing or eliminating wasted efforts/resources and improving passenger throughput. Can real time video access to vehicles help?

Additionally, stakeholders in protecting the public have a claim to mobile systems integration. Do they have access to these systems in the event of an emergency? Can they play a significant role in preventing crisis? What about passengers? Do they demand more from the same systems that agencies use? News, sports, weather, and route information are a basic staple of information.

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Are we able to increase ridership by enabling their PDAs, laptops and cellular phones? Do passengers value the ability to catch up on email after catching the bus?

On-board video surveillance has become one of the fastest sectors to evolve in a technology landscape of wireless/vehicle networking, security analytics, and increasing demands to integrate with other common telematics platforms. This presentation will review the state of the technology today with a look at lessons learned from both rail and bus perspectives, from the London Underground to New Jersey Transit.

The Mobile Convergence Continuum:

There has been much discussion in the security and technology sectors about 'convergence' and how it will manifest itself into business and our daily lives. At one time, the basic definition of convergence was that many processes and communications lines would be merged into single trunks or main highways of data communication using networking technologies.

Convergence continues to reach out and connect more and more disparate systems and find connecting points to stakeholders and their key processes.

The transportation industry is not immune to this convergence continuum. In fact, there are additional streams of communication converging to transportation stakeholders like public safety, operations, risk management and maintenance. Many of these stakeholders are discovering that they share common interest into many information parts that they own and have not previously shared. Route logs, passenger fare data, equipment/vehicle maintenance information, driver report cards, and claims report all related to the overall agency performance. Technology improvement and convergence will continue to aid a transit agencies two ongoing challenges – access to information and communication.

Much of the information that managers need to make informed decisions is generated on the 'front line' with the drivers, passengers and vehicles. To access this data the operations control center needs to find new technology connections.

The exponential growth of technology forces many transit organizations to be aware of emerging security applications:[1]

- Ubiquitous Computing: Intelligence is being incorporated into all kinds of everyday objects and appliances. With cheap, powerful and embedded processors, security systems functionality is likely to be "built-in" to fixed and rolling assets acquired by transit systems
- Networked Sensors: Sensors will allow detection not only of chemical, biological and radiological agents, but also (privacy concerns notwithstanding) of individuals as they traverse a space
- Wireless Connectivity: Wireless communications can be combined with ever-present computing and networked sensors to build an intelligent sensor net that continuously monitors a vehicle or a spatial area.
- Autonomous Applications: Video applications are being developed that no longer require security personnel to monitor video images in real time; these applications include facial recognition and detection of unusual events (such as placement of a suspicious parcel on a station platform).
- Global Positioning: GPS will be applied to all vehicles and many individuals; combining GPS with wireless technology and network connectivity will extend GPS capability to enclosed spaces.

As transit agencies become more aware of emerging technologies and related funding they drive specifications with vehicle manufacturers to accommodate these equipment installations at vehicle delivery. Pre-wiring, increased network capacity/connectivity, additional power ports, and mounting allowances are becoming more commonplace. Bus and rail operators are very aware of the costs involved to 'pull wire' through a vehicle or related maintenance issues to 'punch new holes' in the roof for antennas. If equipment is not installed as part of vehicle production the vehicles are produced with the capability to add equipment later. This reduces installation cost debate about warranty issues on vehicles.

[1] James A. Lewis, "Security and Surveillance", Center for Strategic and International Studies, June 2002

Benefits of On-Board System Integration

From a fleet management perspective the main benefits for on-board system integration area:

a) Increased security for the vehicle operator and passengers
b) Proper fleet utilization to improve vehicle in-service productivity
c) Increased passenger throughput
d) Improving service disruption response time

Benefits of On-Board __Security__ System Integration[2]

Reduced Maintenance Costs

Respondents at agencies with multiple systems performing the same function in different locations report that the costs of training personnel to maintain diverse systems exceed a desirable level. More uniformity in devices and communications architecture will ease the agency's ability to maintain the security system.

Integrated Future System Enhancements

With the development of new transit facilities, such as a new transit line, a transit property with multiple security system architectures must evaluate how each of these system architectures will be integrated with the new system. If there has been a more uniform implementation for all of the project architectures, the evaluation of integrating new systems architectures is likely to be more straightforward.

Enhanced Cost Distribution Across Functions

Security consultants and studies emphasize the benefits of multipurpose systems. One such study, completed by the National Research Council (NRC), calls for "security methods and techniques that are dual-use, adaptable, and opportunistic." These methods "mesh security with other operational tasks and objectives, such as curbing crime, dispatching and tracking vehicles, monitoring

[2] USDOT – Transit Security Considerations Final Report 2004

the condition of infrastructure and assuring safe operations."[3] A major benefit is the ability to distribute costs among different cost centers. For example, one transit agency uses the same smart card technology for fare collection and facility access control; thus, distributing the costs of acquiring and maintaining this technology across functions.

Inter-organizational Coordination

From debriefings of transit and transportation agency response in New York, New Jersey, and Connecticut on September 11, 2001, it is clear that inter-organizational and interpersonal relationships developed prior to that date were instrumental to the impressive system response, even in the face of the failure of many communications channels. Early and continuing stakeholder input over many projects increases the ability of system personnel to mount a robust response to major incidents.

Economies of Scale

Related to the reduction of maintenance costs, total system development life cycle costs can be reduced by increased system integration and the replication of security system elements throughout a transit network. In the past, piecemeal solutions have been implemented by transit agencies because resources could not be obtained to acquire system-wide solutions. Nevertheless, the case can be made that the total cost of ownership of an integrated system will be less than the sum of the costs of ownership of multiple non-integrated systems.

Fast Delivery of Information

A respondent described the ideal video surveillance system as delivering images to the operations, police, and safety units. Another respondent stressed that images produced by video systems installed in transit vehicles must be viewed in real-time by the transit police, so that law enforcers can respond as quickly as possible with as much information as possible. Integrated systems have the potential to increase the ability to quickly deliver information to the parties that need it when they need it.

[3] National Research Council, op. cit., p. 220.

Leveraged Specialized Expertise

Systems integration is a function of the convergence of communications, information, and electronic technologies with transportation system elements. Specialized expertise is needed to implement these systems. Regardless of whether this expertise is in-house or outsourced, increased systems integration means that the level of expertise can be leveraged across individual projects. If heterogeneous systems are installed, the opportunity to build the expert capability can be lost.

Visibility of Security Issues

In conversations with transit officials, the perceived relevance of transit security systems for countering terrorism is low (except in the case of the largest systems in cities assumed to be terrorist targets). One respondent even called security “an afterthought.” Transit agencies remain focused on everyday concerns, such as crime prevention. An integrated approach that treats security issues along with crime prevention, safety, and other concerns will help keep security on the table as a function of new access control, video surveillance, and other systems being planned.

Continuous Technology Improvements

The systems engineering approach takes into account future developments in technology, enhancing the ability to integrate future enhancements. A known architecture built of elements based on standards presents an upgrade path that is not possible with heterogeneous systems or with manyproprietary systems. A standards-based architecture allows for upgrades using industry-wide procedures and is not dependent on the continued support of a single vendor.

Applications to Other Systems

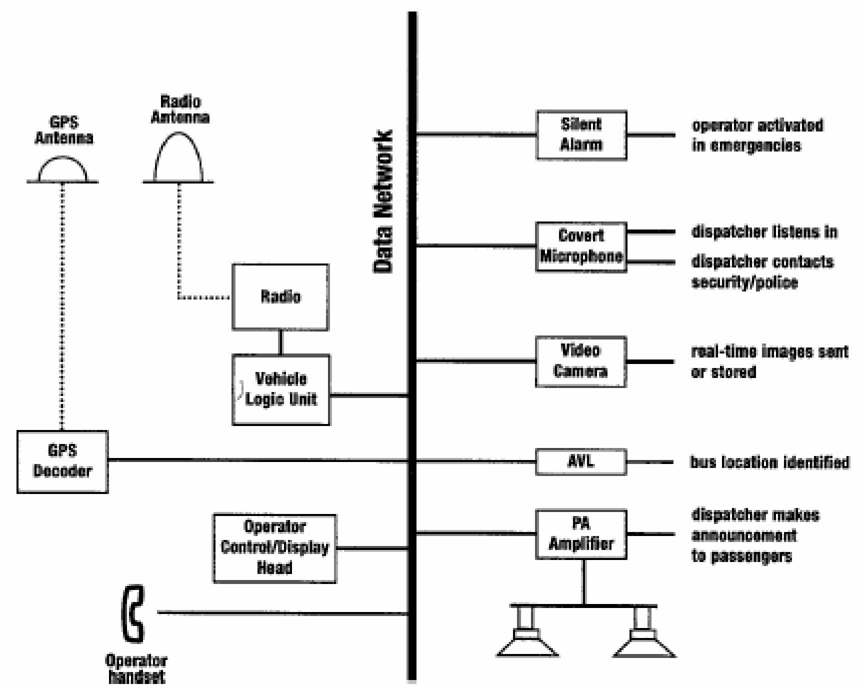
The systems integration processes applied to transit security systems can be used for other transit related systems using convergent technologies. As with other benefits of systems integration listed in this subsection, the process and technical expertise acquired by the transit agency can be applied to other agency development projects that incorporate increasing levels of digital and communications technology. A prime area of convergence are the technologies used in ITS.

Avoidance of Installation Failures

Agencies have a greater chance of avoiding system failures in implementing transit security systems, if they use the systems engineering process and focus on building systems integration into the system.

For example, the defective installation of properly specified equipment can be avoided if the systems engineering process institutes quality assurance controls and if the agency recognizes that the specifications for installing the device were as important as the specifications for the device itself.

Integration of AVL to Video System



Components integrated to improve on-board security.

Figure 1 - Diagram source: TCRP Report 43

Integrating AVL (Automatic Vehicle Location) with advanced on-board communications systems has the potential to enhance operator and passenger security in several ways. Silent alarms, triggered by the operator, combined with bus location information can decrease the response time of security personnel. Activated by the operator in time of crisis, the silent alarm allows the dispatcher to instantaneously determine the bus location. Cover microphones, that become active only when the alarm is tripped, let the dispatcher listen in on conversations and determine the severity of the incident and respond accordingly. [4]

[4] Transportation Research Board – TCRP Report 43 "Understanding and Applying Advanced On-Board Bus Electronics".

If on-board surveillance cameras are integrated with the radio system, real-time images can be sent (with adequate radio capacity) to the control center to obtain a better indication of the incident. If not sent in real-time, images can be stored to identify the perpetrator(s) when the bus returns from service. On-board cameras can also be used to identify vandals, or assist agencies to determine the cause of slip-and-fall accidents. Figure 1 shows the integration of specific components needed to improve on-board security. [5]

On-Board Video Surveillance "A Look Back"

Passenger and driver surveillance and monitoring evolved a long way from the dash mounted camcorder. In the very earliest versions of mobile CCTV there was simply a tape based analog camera recording inside the vehicle acting as a silent witness for events that typically were debated in the court of 'he said, she said'.

Operators considered these types of camera systems to offset to wage costs of people acting as vehicle marshals and monitors on critical routes where they have received many complaints or problems. In many cases both passengers and drivers were caught on tape when there was violence or bad behavior. Agencies found this tool helpful in resolving many situations including passenger claims and complaints. However, the early days of mobile surveillance were not without issues.

There were equipment problems that showed that these analog systems were not hardened enough against the mobile environment. Hot, cold, electrical, vibration and moisture plagued many of these early day systems and rendered them useless. In fact, many operators would anxiously go to their vehicles to retrieve tapes of an incident and come back empty handed because of equipment failure.

[5] Transportation Research Board – TCRP Report 43 "Understanding and Applying Advanced On-Board Bus Electronics".

Many organizations also had to set up elaborate video filing rooms and organization to maintain adequate storage of tapes in the event that a complaint would be made in the future. Camcorders and their cousins the mobile VCR (Video Cassette Recorders) had limited recording duration and would at best provide only a few days of route coverage.

There were also issues of poor image quality. Recording systems did not provide good cabin coverage, or there was poor image quality, low frame rates, or lighting conditions were not adequate for cameras.

The early days of mobile surveillance set the stage for some basic requirements for this type of equipment. These included:

1. Resistance to transient voltage and power surges
2. Automatic power up and recording upon triggering
3. Video recycling
4. Resistance to vibration and shock
5. Infra-red illuminated
6. On-board triggering
7. Other data collected: Audio, Time, Date, Speed. Brakes, Turn Signals
8. Image quality
9. Camera coverage

Analog systems set the stage for developments of the first generation of digital video recorders and their peripherals. In many of these deployments video systems acted as a visual event recorder that provided recorded information for ‘post-incident’ investigations. In essence, an unbiased report of what happened.

On-Board Video Surveillance “A Look Ahead”

In the wake of recent transportation crisis like those in Mumbai, Madrid and London transportation agencies have become sensitive to terrorism vulnerabilities. This new ‘security psyche’ is now meshed with the day-to-day operational issues of responding to passenger and vehicular claims, driver training, vehicle maintenance, vehicle procurement, passenger comfort and route management. Federal funding initiatives have promoted that agencies conduct risk assessments and seek out smarter and more encompassing security solutions.

Amidst the heightened security awareness of transit agencies emerges the new generation of digital video recording systems. These new systems are improved in core competencies of image quality, storage capacity and media transportability. But also have increased security integration, networkability, and interoperability.

Cameras are now capable of capturing images in all types of lighting scenarios and with higher resolution and higher frame rates. Standard frame rates now are from 15 to 30 FPS (Frames Per Second) per camera. Camera housings now allow for infra-red illumination, microphones and more flexible mounting.

Recording systems can allow for up to 16 camera inputs giving operators full cabin coverage and additional cameras for monitoring outside the vehicle through the windshield, wheelchair lifts, bus exits and accident prone vehicle areas. This provides more information for slip and fall claims and vehicular claims.

Systems now provide advanced video compression and on-board storage of a terabyte or more giving ample response time to claims management and operations on late reported incidents and claims. In some cases up to 90 days of recorded video and data is stored on-board before being recycled.

Video viewing software has also become easier to use providing users to have increased ability to quickly find information and allow multiple camera review and data display on the same desktop. Investigators are able to search video by GPS data, bus/route, driver, stations, vehicle door openings, crash sensors, or other available on-board triggers or equipment data points.

Network data storage has replaced video tape collections and for easier cataloguing and sharing. The digital format also provides more ability to transport using various digital media like portable hard drives, CDs ,etc.

An important aspect of new video recording systems has become their ability to interoperate with other on-board systems through vehicle area networks and wireless networks. This increased capacity to integrate with other systems has provided some additional security benefits that allow agencies to be more responsive and in some cases prevent operational or security incidents.

Integration with OCC (Operations Control Center) systems is also an area of agency improvement widely being sought. For example, video archives could be linked with vehicle logs to allow review of data and video on the same computer desktop. These OCC integrations provide video confirmation of passenger and personnel activity, vehicle performance, crowd densities, route blockages and vehicle downtime.

Where Are the Connecting Points?

Vehicle manufacturers and aftermarket equipment manufacturers recognize the ‘mobile convergence continuum’ being driven by transportation organizations that are now more educated and articulated about how they see on-board systems working together. In the constant search for improvements that will increase vehicle uptime and improve passenger throughput transportation departments are now creating access points to get data that will aid their day-to-day decision making.

There has been some evolvement of wireless and wireline access paths to and from the vehicles over the last decade.

Multiplexing has replaced traditional electrical systems and delivers cost saving on installation, engineering and testing. There is also a reduction in the number of relays, connectors and weight for components. One of the main benefits of multiplexing is making electrical system changes without running new wires. In many cases, there need only be software changes.

On bus vehicles, the utilization of the J1708/VAN (Vehicle Area Network) and J1939/Drivetrain data networks can allow connected devices on network the ability to communicate with each other or to on-board storage or relay via RF (Radio Frequency) signal to an off-board data storage location for later review and analysis.

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This data can include route information, passenger counts, faremeter data, geographic information, equipment health status, and audio/video. This same wireless connectivity can download to the vehicle component updates, upgrades, configurations and equipment commands.

Similar onboard networking exists for rail vehicles to allow device/passenger/driver communication through the train control network. There are challenges of limited network bandwidth and dynamic connectivity between rail cars over auto-couplers.

Although radio voice communication is a main ingredient for all transit operations there are other wireless communication developments to increase the number of channels of connectivity to the vehicle equipment networks…

- High bandwidth cellular (CDMA/EVDO)
- 4.9 GHZ frequencies licensed and unlicensed
- Data over voice radio networks

Agencies are requesting video event downloads, live camera views, and active control of video equipment. These wireless applications allow agencies the ability to review on-board incidents more rapidly and provide emergency first responders data/visual information prior to deploying.

Industry standardization and customer's communication requirements will continue to feed the networking demands on-board and drive manufacturing product road maps.

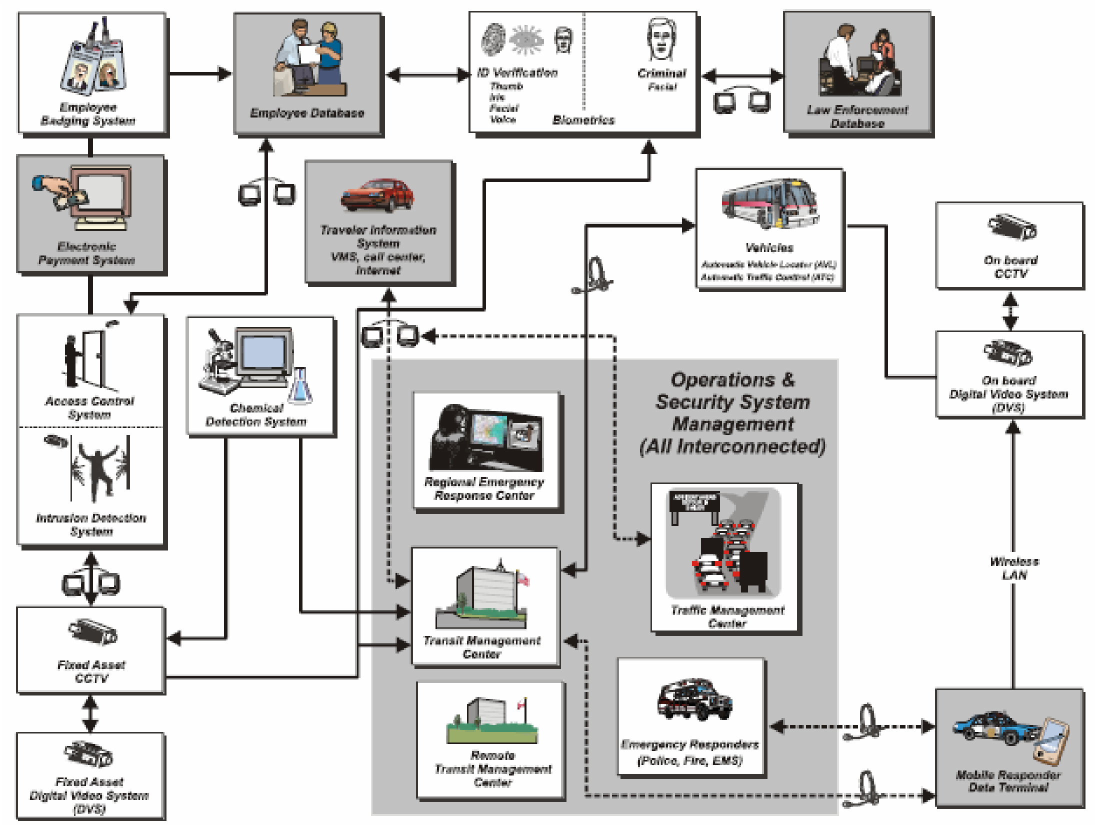

Figure 2 - Generic Transit Security System (source: USDOT Transit Security Design Consderations: Final Report 2004)

As the above illustration demonstrates there are many stakeholders to be consulted with in a transit security system integration. Although the agency is the primary holder of the information there are critical events that necessitate sharing of information to a number of agencies and in some events to adjoining agencies or federal agencies.

On-board Passenger Networks

Several electronic technologies can be integrated to provide passengers with helpful information. Equipment includes electronic information displays, public address systems, and automatic next-stop enunciators. In addition to enhancing passenger service and convenience, the equipment can be used to satisfy ADA requirements by provide audio and visual announcements of major stops and transfer points.[6]

Next-stop enunciators, either integrated with AVL or installed as a stand-alone system, provide automatic and pre-recorded voice announcements of bus stops. To supplement audio announcements, interior signage provides visual information for the hearing impaired. Audio and visual equipment can also be used for public service messages, news, weather and advertising.[6]

In some cases digital video recording equipment is multi-tasked to delivering audio and video messages to passengers. This allows operators the ability to leverage existing hardware already installed to enable increased passenger messaging and non-fare revenue opportunities.

For commuter travel or passenger long-haul wireless networks can be created to provide passengers with internet capabilities allowing them to access internet based applications for work or personal use. This network can also be provided by the transit agency and create another communication channel to passengers through their laptops or handheld devices.

Back Office Integration

Whether prompted by a critical incident or for strategic process improvement the internal departments of a transit agency are sharing more cross functional data. This may include all manner of information from vehicle maintenance and route logs to passenger claims and vehicle parts supply.

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[6] Transportation Research Board – TCRP Report 43 "Understanding and Applying Advanced On-Board Bus Electronics".

Assembling useful data from various points in the organization with purpose-built reporting systems for each department has in the past been a major undertaking. Having to pull various reports from each department and roll up into a comprehensive document.

Software and systems integration can also include pulling data from various systems to provide a detailed post event report. In fact, it's now possible to consider seeing real time views of information, monitor driver communication and view on-board cameras while vehicles are in service.

Centralization of data reporting and security monitoring will also increase an agency's responsiveness to critical events and service disruptions.

Mobile System Integration Process

Stakeholder Involvement

Involving relevant stakeholders that together have a vested interest into system integration and development is critical. Involvement at all stages including budgeting, planning, testing and development are also crucial for full recognition of strategic organizational results. These stakeholders may include:

a. Customer Service
b. IT Dept
c. Claims management
d. HR
e. Vehicle Maintenance/Repair
f. Route planning
g. Fleet Management
h. Facilities Management

Internal and External Organization Communication

This has become more apparent on the security side with increased communication with local, state/provincial and federal transportation and public safety agencies. Sharing of critical project initiatives, and related data are only one part.

In the event of an emergency having close contact with these counterparts may aid in keeping communication channel open for more effective incident response. These groups may include:

a) Emergency services
b) Regional and federal transport and public safety officials
c) Unions
d) Passenger advocates

Inter-Organizational Data Sharing

"Information without action is entertainment" as the saying goes. However in a transit agency useful data that can be acted upon and responded to is what drives a system integration. Sometimes a third party can be useful in helping stakeholders identify data points and the key results and responses the information prompts.

Construction and Installation

Once the equipment is identified and key results prioritized it's important that the equipment be properly procured, installed and maintained. This means that thorough project management and quality control is part of reducing the result of a negative result.

There are only three opportunities to insert mobile systems onto vehicles in the vehicle lifecycle.

a) At vehicle production
b) Major vehicle overhaul/retrofit
c) Minor vehicle overhaul/retrofit

Depending upon the amount of installation intrusiveness a project manager will have to plan appropriate timing to minimize vehicle downtime, maintain passenger service and achieve project results. There may also be time based delivery of the project over a period of time to partially outfit fleet or deploy equipment with scheduled replacement of vehicles.

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Systems Operations and Maintenance

To ensure continued delivery of desired results from a mobile systems integration it's not realistic to expect that equipment work in isolation from regular maintenance checks, equipment orientation and evaluation of key system results.

Appropriate diagnostics should be reviewed, equipment inspected and properly maintained and upgraded.

Key Building Blocks for Mobile Systems Integration

To achieve an ideal scenario for integration of available technologies makes the following assumptions: [7]

a) A data network is in place that ensures complete interoperability between devices, and allows them to be easily upgrade and expanded;
b) The functionality of each component and the results expected from them are clearly specified by the transit agency;
c) The equipment and software as delivered perform as promised by the vendor;
d) Agencies have the resources to operate and maintain the equipment properly , and can manage all of the data produced from it; and
e) Agencies have the capability to take full advantage of the technology, For example, AVL can inform a dispatcher that buses are bunched on a particular route. However, if steps are not taken to mobilize buses, that particular benefit lies dormant.

[7] Transportation Research Board – TCRP Report 43 "Understanding and Applying Advanced On-Board Bus Electronics".