# ADVANCED ITS APPLICATIONS

## Building, Deploying and Integrating Cost-effective, Efficient ITS systems With a Higher Return on Investment

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**ABSTRACT**

It is clear that the transportation industry has accepted that intelligent transportation systems (ITS) and the associated technology are an important and necessary part of an efficient transportation system. The challenge now is how to deploy this technology in a cost effective manner that produces the highest possible return on investment. The following paper discusses how recent developments in field hardware solutions like the Universal ITS Field Hardware Platform can provide multiple sensor data points from one physical location, reducing the costs of building, installing and maintaining unnecessary infrastructure. Additionally, by retrieving multiple data points from one physical location opportunities are also created to reduce the power consumption and its associated costs as well as third-party communication costs to retrieve the sensor data. Advancements in ITS field hardware, like the Universal ITS Platform discussed here, provide the transportation industry with cost-effective solutions that will prove to be extremely valuable today and in the future as we try to find new and efficient ways to deploy ITS technology with greater returns on investments.

## INTRODUCTION

For years now federal, state, and local authorities have continued to increase the amount of Intelligent Transportation equipment and integrated solutions in their systems as part of their transportation management strategies. They have added more road weather information stations (RWIS) to gain localized road condition information, traffic sensors to gain access to traffic volume data, video cameras to monitor driver behavior and traffic patterns, even complete ATMS systems to tie all of this data together. The information gained from these systems has proven to be invaluable; providing accurate, cost-effective solutions to making decisions on whether to de-ice the roads, dispatch salt and sand trucks, determine the needs for slower or faster speed zones, and even dispatch necessary personnel given the current conditions sensed. The agencies and their engineers who have deployed this technology have even demonstrated their own creativity in developing and integrating additional applications using this data including providing travel-time to commuters, warning motorists about conditions of a work zone, and modifying safe driving speeds and behaviors dynamically based on the ITS sensed conditions on the road.

Historically, the biggest challenge with respect to investing in ITS for many agencies is the ability to demonstrate their return on investment. Often these agencies use studies that illustrate the number of lives saved, or the speed with which commerce moves along the roads. Most of these studies are subjective in nature and true experimental tests are difficult to apply. Clearly there is an advantage to using ITS to make the existing transportation system more efficient; it is just difficult to quantify.

We have discovered that the best way to bring the cost of investing in ITS systems in line with return on investment is to make their deployment and integration as cost effective as possible. The sensors and equipment used are most likely at their lowest cost available regardless of manufacturer, so the next solution is to develop more efficient ways to deploy these systems. One way to do this is to retrieve several ITS data points from one location. For example, if you deploy a permanent count loop station on an interstate, the basic steps you would take would be to install the loops in the pavement, pour a concrete pad, install a NEMA enclosure, run AC power to the control site, and run some type of communications (i.e. fiber, telephone line, or wireless data modem) so the data can be retrieved. Then ¼ of a mile down the road you may want to install an RWIS station to measure the conditions of the pavement: ice, water, freezing point, etc. You would repeat the same infrastructure chores you did with your permanent count station, thus duplicating your cost. One of the most recent engineering achievements in ITS is the development of advanced universal ITS platforms. These platforms provide the capability of retrieving multiple types of data regardless of manufacturer from one location. This data can be RWIS, Traffic Sensors (Radar based, Vehicle Magnetic Imaging based, video based, etc.), and/or environmental air quality data. Using NTCIP as a standard protocol, virtually any sensor can be integrated into these systems. By installing one ITS platform for multiple applications it is possible to reduce the infrastructure cost significantly. When applied to the simple example provided above the

cost to deploy a weather station and a permanent count station is cut in half and the recurring power and communication costs for those systems would be halved as well.

This paper will provide a detailed understanding of how universal platforms and similar technology can be utilized to reduce the cost of deploying ITS equipment and bring its costs very much in line with the return on investment we seek to demonstrate in the short-term and in the long-term.

## PROBLEM AND SOLUTION

Many engineers would like to deploy more sensors and expand their ITS systems. The problem lies in finding a cost effective way to do this. The costs of sensors themselves are not the majority of the costs. Table #1 illustrates the typical costs to deploy a standard RWIS station used to collect localized weather and pavement conditions. It demonstrates that the bulk of the costs are in the installation and commissioning of the system. The sensors themselves constitute only 41% of the total cost of deployment and 59% of the costs are in the installation of the basic infrastructure for the ITS site.

| Equipment/Service | Avg. Cost |
|---|---|
| RWIS Station | $ 5,500 |
| Pavement Sensor | $ 1,500 |
| Wind Sensor | $ 1,200 |
| Air temperature/Humidity | $ 600 |
| Visibility Sensor | $ 7,800 |
| ***Total Equipment Cost*** | ***$ 16,600*** |
| | |
| Installation of Power/Communication | $ 6,400 |
| Installation of Base, Enclosure and Tower | $ 11,400 |
| Commissioning of System | $ 2,600 |
| Traffic Control | $ 3,800 |
| ***Total Services Cost*** | ***$ 24,200*** |
| ***Total Cost of RWIS site*** | ***$ 40,800*** |
| % equipment costs | 41% |
| % installation/infrastructure cost | 59% |

Table# 1 – Costs Associated with a Typical RWIS site Installation

Table #2 illustrates the typical costs associated with the installation of a permanent count station (PCS) that uses a non-intrusive radar based count system. In this case the actual sensor hardware is only 21% of the total cost and the installation is 79% of the cost. Inductive loop systems have an even lower cost associated with the hardware making the installation percentage even higher.

| Equipment/Service | Avg. Cost |
|---|---|
| Non-Intrusive Traffic Analyzer | $ 4,800 |
| Sensor Cables | $ 280 |
| ***Total Equipment Cost*** | ***$ 5,080*** |
| | |
| Installation of Power/Communication | $ 6,400 |
| Installation of Base and Tower | $ 8,210 |
| Commissioning of System | $ 1,200 |
| Traffic Control | $ 3,800 |
| ***Total Services Cost*** | ***$ 19,610*** |
| | |
| ***Total Cost of RWIS site*** | ***$ 24,690*** |
| % equipment costs | 21% |
| % installation/infrastructre cost | 79% |

Table# 2 – Avg. Costs associated Typical PCS site Installation

Historically, one approach to reducing the cost of deploying ITS equipment was to convince the sensor manufacturers to produce lower cost sensor solutions. This has resulted in two things happening: Sensor manufacturers have consolidated and merged to reduce production therefore creating an influx of inferior sensors in the marketplace that go unchecked for quality, often having to be replaced before they provide an equal return on investment.

Many engineers are now demanding high quality sensors with longer life spans to capitalize on their investments. This has in turn stabilized the sensor manufacturing market bringing sensor pricing in line with the costs to manufacture and significantly reducing the ability to lower the price of the sensors any further.

With the cost of sensors stabilizing, cost savings can really only be gained by reducing the costs associated with installation, infrastructure, and maintenance of these systems. This is where the deployment of Advanced Universal ITS hardware platforms provide the unique ability to cut the costs of installation, maintenance, and infrastructure in half at a minimum by using the same infrastructure for multiple sensor points.

| Equipment/Service | Avg. Cost |
|---|---|
| Non-Intrusive Traffic Analyzer | $ 4,800 |
| Sensor Cables | $ 280 |
| RWIS Station | $ 5,500 |
| Pavement Sensor | $ 1,500 |
| Wind Sensor | $ 1,200 |
| Air temperature/Humidity | $ 600 |
| Visibility Sensor | $ 7,800 |
| | |
| ***Total Equipment Cost*** | ***$ 21,680*** |
| | |
| Installation of Power/Communication | $ 6,400 |
| Installation of Base and Tower | $ 11,400 |
| Commissioning of System | $ 4,500 |
| Traffic Control | $ 3,800 |
| ***Total Services Cost*** | ***$ 26,100*** |
| | |
| ***Total Cost of RWIS site*** | ***$ 47,780*** |
| % equipment costs | 45% |
| % installation/infrastructre cost | 55% |

Table# 3 – Avg. Costs associated a Universal ITS platform with Traffic Sensors and Weather Sensors.

Using the examples above, if you installed the same RWIS system and Permanent Count Station (PCS) using a Universal ITS platform your costs would be reduced by 27%. Table 3 illustrates the cost of deploying a PCS system and RWIS system together. The combined cost of installing two separate systems is $65,490. When the same set of sensor technology is deployed using the Universal ITS platform your cost is $47,780. This is a savings of $17,710. The ITS system platform allows you to install a permanent count station and RWIS station at 73% of normal costs without sacrificing sensor and data quality. This example uses just two sets of data, but the system could include a video camera site and/or air pollution sensing site all in one location, as well to achieve even greater savings. These savings result in a higher return on investment for ITS infrastructure.

## ADVANCED UNIVERSAL ITS PLATFORM DESCRIPTION

The Universal ITS platform (see illustration #1) provides the ability to interface with many different types of data from one physical location. The backbone of the system is a Remote Processing Unit (RPU) This RPU uses a state of the art low power consumption processor and a Linux based operating system. This flexible and open source operating system provides for the quick and easy integration of new sensor technology as it is developed. The advantage of this is that ITS platform never becomes obsolete as new technology is developed. It provides a platform that makes it easier and more cost effective to upgrade your sensor technology without having to deploy completely new systems. The system has expandable data storage memory so that as new sensors are added the memory requirements can be adjusted to accommodate.

In addition to the RPU this system has multiple expandable input ports that can host up to 16 different sensors. These sensors can be connected to the system using serial, analog, or digital input ports. The data is stored in memory on the RPU until it is retrieved by a third party database application. The data can be accessed through multiple communication methods via either the on-board Ethernet and/or serial rs232/485 output ports. These ports provide flexibility for communication using any wireless communication device, telephone modem, or Ethernet/fiber infrastructure desired to retrieve the data from the site.

Illustration #1 – Universal ITS Platform hardware.

In addition to merely managing the sensor data, storage of the data, and providing a universal platform for the retrieval of that data, the Universal ITS platform also can be programmed with logical decision making capabilities.


The system includes contact closures that can be controlled based on a programmable decision matrix. For example, when monitoring the visibility of a section of road using a visibility sensor you could set a threshold for the visibility and if the visibility dropped below that threshold the system would trigger and close the relay. This relay could then be used to turn on flashing beacons or a dynamic message board. This provides real-time condition information to the motorist in addition to providing the data to the agency.

## DATA COLLECTION

The most important aspect of and reason for deploying ITS equipment is the data that is obtained from the sensors. The data provides the various departments of transportation with the necessary information they need to make the proper decisions with respect to maintenance, resource allocation, and other functions of the department. Data can be collected from the Universal ITS platform using the National Transportation Communication for Intelligent Transportation Systems Protocol (NTCIP). The data retrieved can be any kind of sensor data that is connected to the RPU. While this RPU began with the integration of the NTCIP 1204, objects it now includes 1209 and 1203 object sets as well as the standard NTCIP object sets. It also contains some custom object sets for devices such as Highway Advisory Radio which don't yet have defined protocols. The universal ITS platform also has the capability of integrating sensors without NTCIP MIBS by interpreting their proprietary protocols and converting the data into NTCIP object sets for retrieval.

The Universal ITS platform is independent of any software required to poll the system for its sensor data. Any third party Automated Traffic Management System (ATMS) or database

structure that has the ability to communicate using NTCIP can retrieve all of the data from the Universal ITS Platform.

By using a universal ITS platform in the example ITS system defined above to deploy the sensors we utilized in our example, which include standard RWIS atmospheric sensors and a non-intrusive radar based traffic sensor, you could retrieve the following list of data points from one location:

| | |
|---|---|
| **Traffic Speed by Lane** | **Traffic Volume by Lane** |
| **Traffic Occupancy by Lane** | **Vehicle Classification** |
| **Visibility Distance** | **Ambient Air Temperature** |
| **Pavement Temperature** | **Pavement Freeze Point** |
| **Wind Speed** | **Wind Direction** |
| **Humidity** | **Precipitation Amount** |
| **Precipitation Type** | **Precipitation Rate** |
| **Water Depth** | **Video Images** |

While this is the type of data you could gain from the defined system in our example as you add sensors to the system, the amount of data can grow significantly. Other potential data points could include:

| | |
|---|---|
| **Ozone Detection** | **Travel Time Detection** |
| **Carbon Monoxide** | **License Plate Recognition** |
| **Radiation Detection** | **Weigh-in-Motion Sensors** |
| **OverHeight Detection** | **Soil Moisture Content** |
| **Chemical/Biological Detection** | **Streaming Video** |

Virtually anything that can be sensed can be compiled and retrieved from one location with one set of costs associated with basic infrastructure development. The biggest advantage this type of system provides is that as new technology is developed it can be easily and quickly integrated into the platform without having to install all new infrastructures.

## CONCLUSION

As the transportation industry begins to deploy more and more ITS systems and has to do so with budgets that have become smaller and smaller, there is a real need for cost-effective methods and technology. The universal ITS platform discussed in this paper provides a new strategy in deploying more ITS systems with fewer dollars. Consolidating multiple sensors into one physical location provides near limitless data points with less infrastructure cost. As different transportation departments - including traffic, weather, maintenance, and environmental protection - all begin to work together to develop and share critical related information they will need new technologies developed around finding cost-effective ways to deploy all the sensors providing that data. Building and maintaining the most advanced transportation system in the world will require more than the most advanced sensor technology, it will require efficient, cost-effective ways to deploy ITS throughout the system.