# Caught in the Middle:
# ATMS procurement options for mid-sized agencies

**John Kerenyi, R.E.E., R.T.E., PTOE**

City of Moreno Valley, California, USA

**Abstract**

The goal of Intelligent Transportation Systems (ITS) is to wring additional capacity by leveraging technology; that is, to optimize road performance. Yet, ITS investment itself can be optimized such that benefits are maximized at minimum cost. A model is proposed to illustrate how prototypical large and small agencies structure their programs to optimize ITS lifecycle costs. The model's applicability to mid-sized public agencies is analysed, and a general solution involving use of Advanced Traffic Controllers (ATC's), the National Transportation Communications for ITS Protocol (NTCIP), and open-source software is presented as a potential means to address the shortcomings of the large and small agency scenarios for mid-sized agencies. A strategy for funding the mid-sized agency Arterial Transportation Management Systems (ATMS) is proposed. The recommendations are directly applicable to any agency currently operating or planning to deploy Ethernet-based ATMS, and are extensible to the procurement of any NTCIP-compatible field device type.

**Scenario 1: Small Agency**

Small agencies, defined for the purpose of this model as any agency with less than approximately 60,000 population, typically have no dedicated traffic engineering/traffic signal operations staff, often contract out the traffic signal maintenance and operations function, and purchase small quantities of traffic signal control equipment as needed. Small agencies that choose to operate and maintain an ATMS typically seek to minimize the cost of software to do so, since the software cost is the majority of the ITS program budget in this scenario.

*Small Agency Hardware Considerations*

The modelled small agency would operate 60 signalized intersections or less (based on the rule of thumb of one signalized intersection per 1000 population), and can be expected to replace the equivalent of three signalized intersections per year assuming an equipment life of 20 years. The author's experience is that small agencies will sole-source traffic signal controllers and cabinets in order to gain the benefits of technical support from one manufacturer. The cost increment associated with sole-source procurement raises the unit cost of control equipment, but because quantities are small, the cost difference is unimportant; especially compared to software cost.

*Small Agency Software Considerations*

Small agencies that deploy ATMS typically contract with the vendor of their traffic signal control equipment for proprietary software. Historically, such software was often made available at no cost; although as the complexity of such systems has grown, some of the cost has been passed along to their clients. The author postulates that these proprietary systems are priced to be attractive to small agencies, and their features are tailored to their needs. Vendors internally allocate some of the hardware revenue to supporting the software base to make this model work.

**Scenario 2: Large Agency**

Large agencies in this model have at least 500,000 population and an installed base of 500 traffic signals or more. Assuming an average of 20 years of life for traffic signal equipment, such agencies are replacing the equivalent of 25 traffic signals a year; and undertaking new signalizations if their population is growing. Thus, the largest component of a large agency's ATMS program budget is the cost to supply traffic signal control equipment; and it is this cost that large agencies seek to minimize. This is done by commoditizing equipment purchases.

*Large Agency Hardware Considerations*

Large agencies generally have significant full-time, specialized traffic operations and maintenance staff and are able and willing to take on sophisticated and complex roles including maintaining equipment from multiple sources. Such agencies have often driven standardization of traffic control equipment in order to be able to buy traffic signal controllers from multiple manufacturers on a low-bid basis, thus optimizing hardware costs.

*Large Agency Software Considerations*

Large agencies often have complex traffic management needs such as sports stadiums, concert arenas, festivals, and large employment centers; as well as common disruptions in traffic capacity due to incidents and construction. The large agency thus demands greater functionality from its ATMS and is willing to invest to gain that functionality. The largest agencies have, at times, found bringing software development in-house (either central software or intersection control software; sometimes both) best suits their needs, by eliminating licensing fees and by easing the development of new functionality. The crucial feature that large agencies pay for is the ability to communicate with multiple traffic signal firmware (or their own firmware, or a paid-for agency-wide license to a firmware that can be run on commodity hardware), so they can purchase controllers from multiple manufacturers via low bid.

### Hardware Cost Model

The hardware cost model represents the higher unit costs paid by small agencies by assuming the unit cost is double what a large agency pays:

Small agency hardware cost = 2 * large agency hardware cost

The author believes this is a reasonable estimation, but the reader need only agree that small agencies typically pay higher unit costs than large agencies for the model to produce an informative result.

If the unit cost for commodity traffic signal controller and cabinet equipment is $10,000 and the large agency purchases 25 per annum, the annual budget for this equipment for a large agency would be $250,000.

If the unit cost for sole-source traffic signal controller and cabinet equipment is $20,000 and the small agency purchases three per annum, the annual budget for this equipment would be $60,000.

The small agency's annual cost premium for purchasing sole-source equipment is modeled at $30,000. Since some of this premium goes to the manufacturer's software development program, it would be an oversimplification to label it profit. This premium generally buys good tech support, so the bargain is in the small agency's best interests.

### Software Cost Model

The software cost model postulates that small agencies pay a flat capital cost of $50,000 for software upon contracting with the vendor, followed by a support/maintenance cost of $10,000 annually. Large agencies are modelled as paying $500,000 up front and $50,000 annually. As with hardware costs, the operative feature is that large agencies are willing to shoulder a higher software cost than small agencies.

### Life-Cycle Costs

Given the parameters above, and a 20-year investment horizon, the total cost paid by agency type is tabulated on Table 1 (next page).

**Table 1. Derivation of Unit Costs for ITS Procurement for Small and Large Agencies**

| Agency Type | Software | | | Hardware | | Lifecycle Cost (20 Years) |
|---|---|---|---|---|---|---|
| | Initial | Annual | Total | Annual | Total | |
| Small | $50,000 | $10,000 | $250,000 | $60,000 | $1.2M | $1.45M |
| Large | $500,000 | $100,000 | $2.5M | $250,000 | $5M | $7.5M |

Other traffic signal hardware is not considered; either because they are normally commoditized by all agencies, or their procurement is subject to policy decisions not related to ATMS. Poles, indications, and wiring are examples of the former; and battery back-up systems are an example of the latter. Network communication equipment is not considered in the model, either, because its purchase is not always under the control of the Transportation Engineering function.

*Generalization of Agency Size*

The model can be abstracted to estimate life-cycle costs for any sized agency under the two procurement scenarios. This is done by correlating life cycle costs to population using the rule of thumb of one signalized intersection per one thousand constituents and assuming a 20-year life cycle. The following formulas estimate life-cycle cost as a function of population for the two agency types:

Software lifecycle costs = Initial cost + 20 * annual cost

Hardware lifecycle costs = 20 * annual equipment purchase budget

Since the annual equipment purchase budget was originally assumed to be the cost to replace all signal control equipment every 20 years, the lifecycle cost for hardware is simply the unit hardware cost multiplied by the number of signals that agency maintains; and the number of signals maintained by the agency is defined as the population divided by 1000.

Each procurement scenario's estimated lifecycle cost is the sum of the hardware cost and the software cost. Only the hardware cost has a population component, so the resulting formulas contain a fixed component and a variable component. These components will be revisited in the next section.

The two formulas are graphed in Figure 1 (next page).

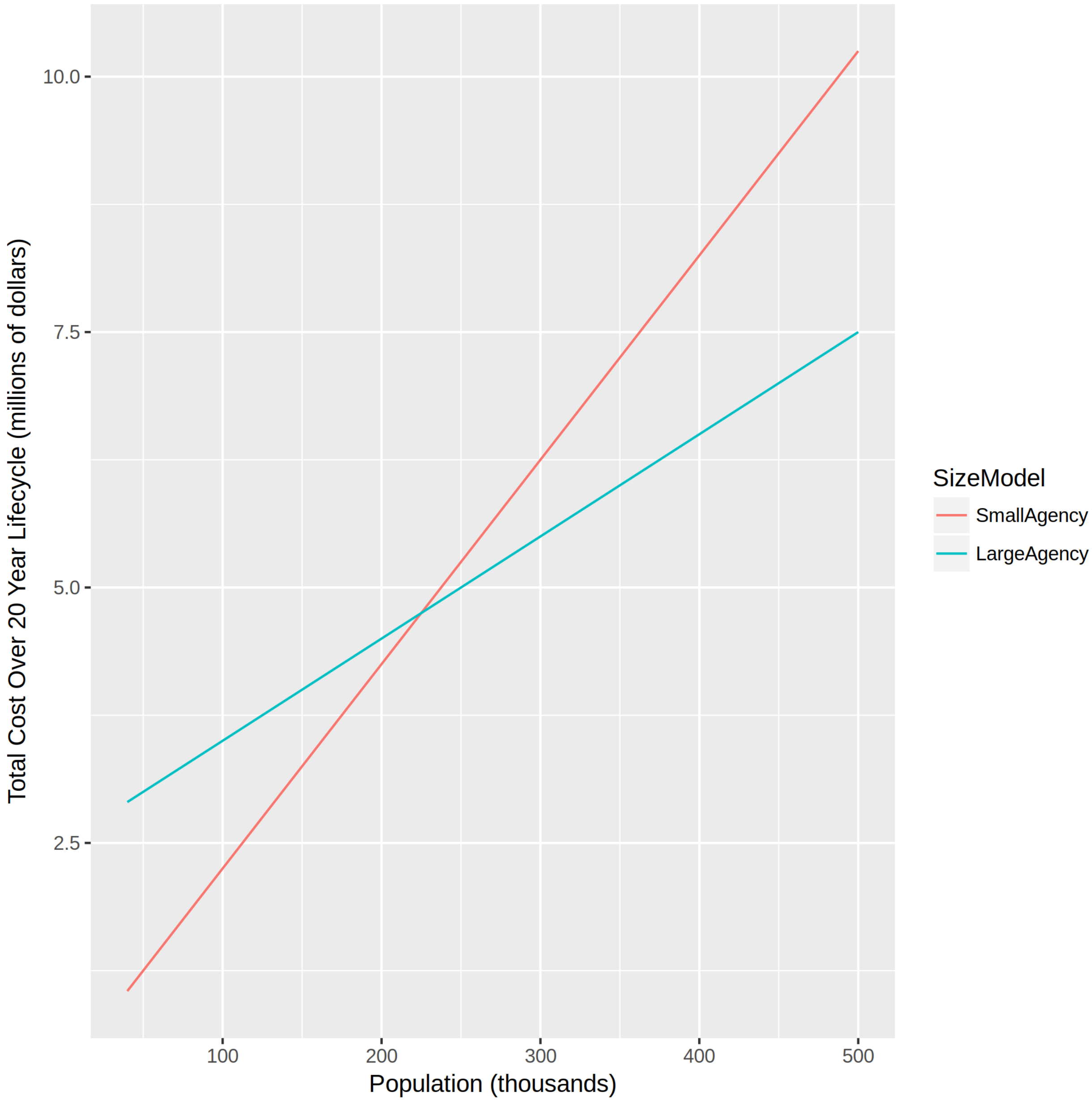


**Figure 1. Small-Agency and Large-Agency Procurement Scenarios by Population**

As expected, the model shows that large agencies optimize life-cycle costs by commoditizing hardware purchases while investing in software, whereas small agencies optimize life-cycle costs by doing the opposite (purchasing traffic control equipment from one source in order to minimize software costs). To do otherwise would be to substantially over-pay.

The population at which the two procurement scenarios predict identical life-cycle costs occurs at 225,000. At this population, either procurement method is equally applicable; but also, the procurement approaches are equally inefficient: The mid-sized agency that applies one will either over-pay for equipment, or over-pay for software; compared to large and small agencies, respectively.

## Ramifications for Mid-Sized Agencies

Mid-sized agencies often face a dilemma when considering ATMS: How to provide advanced traffic management capabilities with a shoestring budget. Oftentimes, the small-agency procurement model is applied because the capital funds are not available to fund the software needed to support commodity equipment purchases; then (unless the agency has the foresight to lock in a fixed price for future traffic control equipment purchases), the unit costs for proprietary control equipment will inevitably rise.

This paper proposes a general approach for mid-sized agencies to commoditize traffic control equipment purchases without paying large-agency software costs. It involves the use of Advanced Traffic Controllers (ATC's) as commodity equipment, open-source software for the ATMS, NTCIP communication between them, and staff time in lieu of software initial and recurring cost. The author's agency is presented as a model deployment.

### *Advanced Traffic Controllers*

The defining characteristics of ATC's, for the purpose of this paper, is that they natively support the NTCIP and Ethernet communication. Any agreement to procure ATC's should include a clause requiring the vendor's Management Information Base (MIB) to be supplied prior to award of a procurement contract or purchase order. Then, the procuring agency is assured that the controller can be integrated into the ATMS. Integration is performed once per vendor/firmware type.

Control equipment purchases are made by awarding to the lowest bid for ATC controllers, including firmware/intersection control software. If the agency requires new traffic signal controller cabinets, they should also be awarded on the basis of low bid and generally should be sourced from the same company as the ATC's to allow for ease of warranty service. If possible, purchases should be grouped into batches to obtain quantity discounts. In this manner, the hardware cost is minimized over the long term.

### *Open-Source ATMS*

The NTCIP uses the Simple Network Management Protocol (SNMP) for communicating between field devices and the Transportation Management Center. Software libraries for using SNMP are available for all commonly used programming languages and can be straightforwardly configured for communicating meaningfully with ATC's.

### *Substitution of Staff Time for Software Cost*

Inspecting Table 1, a goal of the mid-sized agency's ITS procurement policy should be to find a way to pay large agency hardware costs while paying small agency software costs. The following table summarizes life cycle costs for the mid-sized agency (population 225,000) under three scenarios: Small agency, large agency, and optimized (e.g. commoditized hardware and low-cost software). The agency is assumed to operate and maintain 225 signalized intersections, consistent with the previously made assumption of one signalized intersection per thousand population.

**Table 2. Applicability of Scenarios to Hypothetical Mid-Sized Agency (225,000 Population)**

| Scenario | Hardware | Software | Total |
|---|---|---|---|
| Small Agency Method | $4.5 million | $250,000 | $4.75 million |
| Large Agency Method | $2.25 million | $2.5 million | $4.75 million |
| Mid-Sized Agency Optimized | $2.25 million | $250,000 | $2.5 million |

Table 2 shows, as expected, that the small agency and large agency procurement models result in identical life-cycle costs at this population. It also quantifies the benefits of developing an approach tailored to mid-sized agencies, in the form of an optimized scenario. This scenario hinges on deployment of software that allows hardware to be commoditized (that is, purchased from multiple sources). The cost savings of this scenario is $2.25 million over 20 years, or $112,500 per year. This savings can be applied to staff salaries to support development, deployment, and maintenance of an ATMS that costs nothing to license because it is open-source. Said staff would be specialized in operating the ATMS, which means continuously fine-tuning system performance and implementing special timing plans for incidents, construction, and special events. In this manner, the mid-sized agency can affordably move into the advanced traffic management domain of larger agencies: Dedicated staff, modern traffic controllers, and full-featured central traffic control software.

### Moreno Valley's Open-Source ATMS

The City of Moreno Valley currently utilizes an ATMS built on open-source software libraries. It has the following characteristics:

- Ability to communicate with any ATC, so long as the MIB's are provided by the vendor.
- Polls all intersections on a regular basis and sends notifications to configurable email addresses for adverse events (e.g. intersection in flash, communication failure).
- Provides a client interface in a Web browser (no client software to maintain) which consists of a real-time status map and the ability to manipulate intersections individually or in groups.
- Stores poll information in a database for future reference.
- Utilizes the University of Utah's ATSPM (Automated Traffic Signal Performance Measures) project for performance metrics *(in progress).*

This software project has allowed Moreno Valley to gain the benefits of competitive traffic controller procurement without the upfront cost of commercial ATMS software. The project is in active development with new features being added regularly. Readers are invited to contact the author if interested in collaborating on the project.

This open-source project results in software cost below even the small-agency scenario, which provides additional justification for investing staff time.

**Applicability/Conclusions**

The ITS procurement model presented herein establishes a framework to explain the author's observation that small agencies tend to sole-source traffic control hardware and pay little for central software, whereas large agencies do the opposite. The model also shows why mid-sized agencies tend to develop individualized approaches to ITS procurement: They are seeking a better optimum than the small-agency and large-agency models provide. Finally, the model explains that mid-sized agencies that are budget-constrained (which tends to be most agencies) may choose adopt the small-agency procurement model when deploying ATMS because it offers low up-front cost, accepting higher equipment costs down the line; because not doing so may mean not being able to deliver the mobility benefits of an ITS program at all.

The paper suggests an alternative approach to deploying ATMS for mid-sized agencies that are so inclined, which consists of purchasing ATC control equipment from multiple sources and deploying open-source software to manage them. If some of the following characteristics apply, the approach may be worth further consideration:

- Annual traffic control equipment purchase budget greater than approximately $200,000.
- Currently purchasing traffic control equipment from a single source or considering upgrading to ATC.
- Requires advanced traffic management capability but does not have funding to deploy commercial software that provides advanced functions.
- Employs, or is willing to employ, full-time traffic operations staff who can invest the time to get an open-source ATMS up and running.
- Has deployed, or is willing to deploy, Ethernet communication to all traffic signal controllers to be managed by the ATMS.