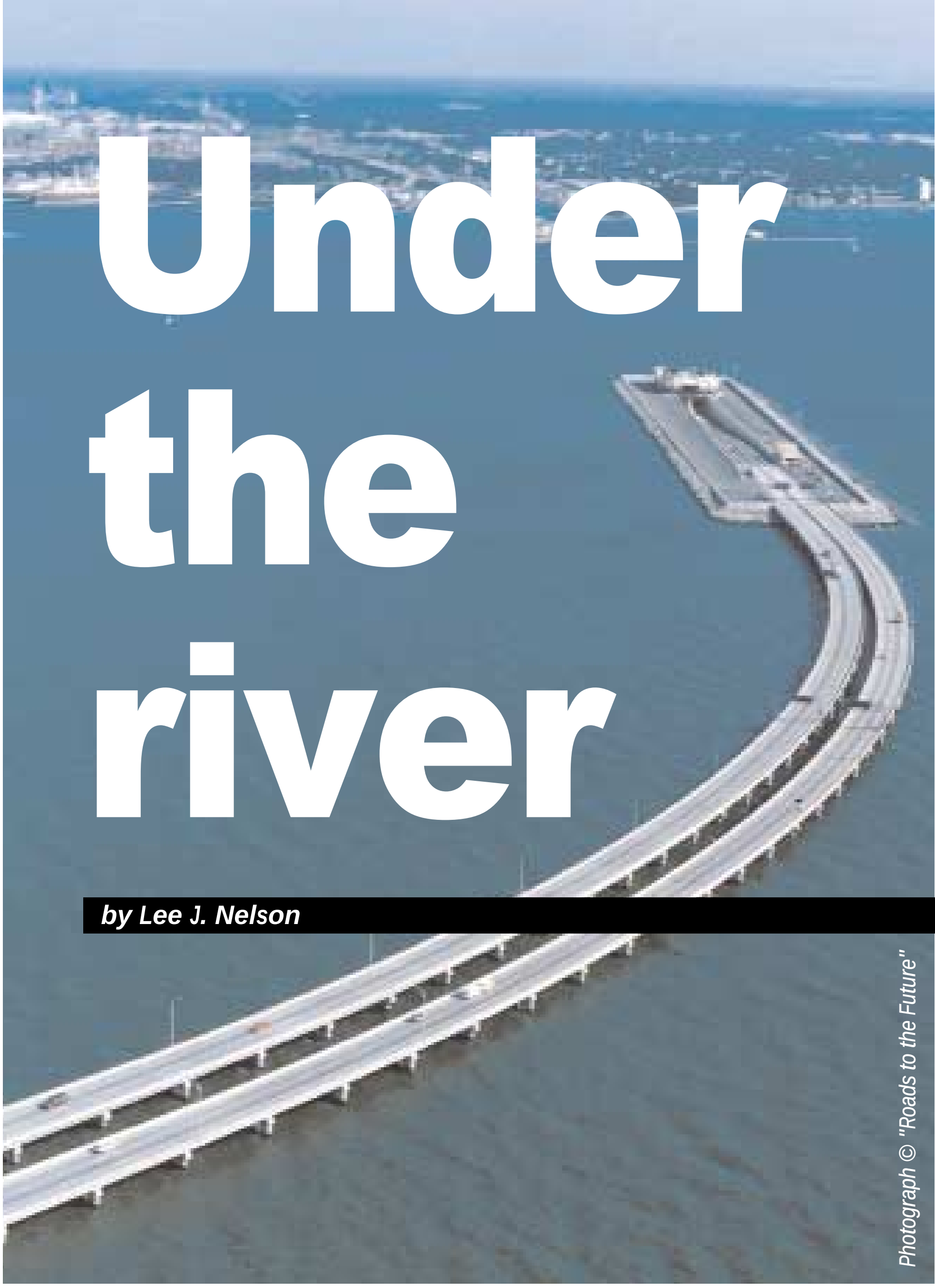
Under the river



Photograph © "Roads to the Future"

The spectacular Monitor-Merrimac Memorial Bridge Tunnel in Virginia carries 45,000 vehicles a day. This volume of traffic requires an ITS infrastructure able to cope with the complexities of such an unusual environment. TTi regular Lee J. Nelson tells the story of how the system has been upgraded

by Lee J. Nelson

As motorists, most of us tend to take our highway systems for granted. We drive where we want, when we want, and pay little attention to the complex network of roads, bridges, and tunnels at our disposal. A case in point is Interstate 664 – a 33.8km (21-mile) expressway between Newport News and Suffolk (Virginia, USA) that includes the Monitor-Merrimac Memorial Bridge Tunnel (MMMBT).

Completed in April 1992, at a cost of US$400 million (Euro425 million), the MMMBT includes dual, man-made portal islands. A 5.6km (3.5-mile) twin-bridge trestle holds four reversible traffic lanes plus two full-width emergency shoulders. The tunnel portion, measuring 1,463m (4,800ft) portal-to-portal comprises 15 prefabricated submarine segments.

Each and every day, without fail, nearly 45,000 vehicles navigate MMMBT as it spans the James River. Managing that volume of traffic falls to the Virginia Department of Transportation's Smart Traffic Center and the MMMBT traffic control system, dubbed TOMAC (tunnel operation maintenance and control). Although TOMAC is underpinned by a sophisticated supervisory control and data acquisition (SCADA) architecture, the decades-old computer technology was showing its age. Furthermore, since TOMAC's inauguration, traffic control applications have evolved into true traffic management systems, embracing: bi-directional communications networks for commanding, polling, re-commanding, and confirming the status of numerous 'control' points; collecting data from incident detectors, video cameras, and facilities monitors; and, handling event-specific responses.

Control system modernization

Earlier in 2001, the Virginia Department of Transportation (VDOT) released a pair of requests for proposal (RFPs), calling for the upgrade and modernization of TOMAC and MMMBT's variable message sign controller. For most contracting endeavors of such magnitude, VDOT publishes a request for quotation (RFQ) that specifies what a system should do, and how. RFQs routinely mandate certain engineering approaches. By contrast, an RFP stipulates a framework for the contemplated effort, but leaves conceptual and implementation details to competitive bidders. Lead computer systems engineer at VDOT's Traffic Management systems engineering group, Pete Pearson, told *Traffic Technology International*: "This time we departed from convention, relying on an RFP, and put the onus on the contractor. In so doing, we invited creative, cost-effective designs and avoided forcing the supplier to deliver a pre-ordained solution." In recognition of the successes enjoyed by the RFP model, the Commissioner's Award of Excellence was recently bestowed on Pearson and his supervisor, Alton Yates.

"Nowadays, people are traveling at a much higher speed, and much closer together than they should be for safety's sake." Adds Pearson. "When we have traffic as dense as that, any one incident can precipitate others. We need to make sure there is enough signage and warnings to keep traffic flowing even when problems arise." There's also the legal aspect: if a collision should occur, the system must record the scenario for possible future court action. Along MMMBT, therefore, it's not surprising to find thousands of discrete points under computer control. Those include detectors for traffic volume and average velocity, vehicle classification and overheight sensors, visibility (fog and illumination) monitors, variable message warning signs, variable message speed limit signs and lane directionality and lane-use signal lights as well as real-time CCTV cameras (with zoom, pan, and tilt capacity). Plus, equally important to safe traffic flow through the tunnel, there are ventilation (fresh air and carbon monoxide) and water level detectors.

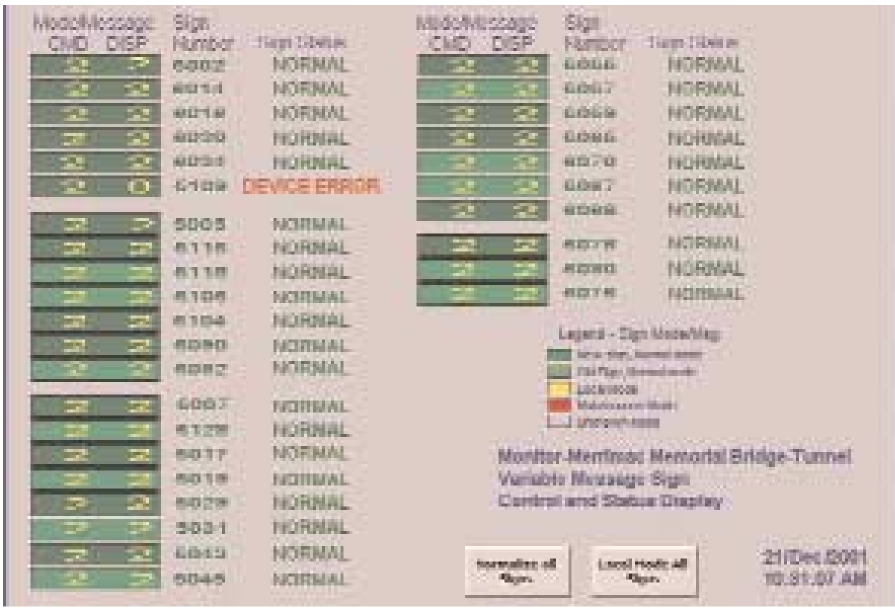
Variable message sign controller

A winning bid for the initial upgrade was tendered by the traffic management/process control specialists, Advanced Traffic Control, Inc of Coral Springs, Florida, USA. Twenty-six of MMMBT's 34 variable message signs were replaced; resulting in a mixture of products from Lake Technologies, Inc (formerly of Culver City, California, US) and Ledstar Inc (Concord, Ontario, Canada).

With the SCADA-based toolkit and Microsoft's Visual Basic, Advanced Traffic Control developed VMS controller software to support multiple, simultaneous protocols. Its consummate design interfaced both Lake Technologies' and Ledstar's signs over a single, multidrop, 2,400baud serial line. "It was quite a challenge," remarks Frank Roark, president of Advanced Traffic Control. "The legacy sign technology is not well-documented. Plus, newer signs embed text messaging as part of the communications protocol itself." Testing and maintenance capabilities, similarly, now are incorporated into the controller.

A graphical user interface, supplanting the previous command line-driven

Opposite view of the MMMBT



Monitor-Merrimac Memorial Bridge Tunnel VMS control and status display

Tunnel entrance

"In today's litigious society, technology at MMMBT is helping confirm precise system operation"

mode, employs terminology already familiar to operators. By using recognizable labeling, the new system's learning curve is minimized; key to meeting VDOT's aggressive timeline for installing and placing the VMS controller on-line.

Behind the scenes, the system continuously populates a time-stamped event database with every command and each control point's status. Advanced Traffic Control utilizes CodeBase, a high-performance rDBMS engine (Sequiter Software Inc., Edmonton, Alberta, Canada). CodeBase offers an easily integrated application programming interface, while extending memory-sparing methodology that is revision-independent.

Detecting, handling, displaying and managing the status of all signage on outgoing and return pathways is of paramount importance because VDOT can be liable if a communications fault occurs. (Some unscrupulous drivers allege ambiguous signage as the causes of collisions.)

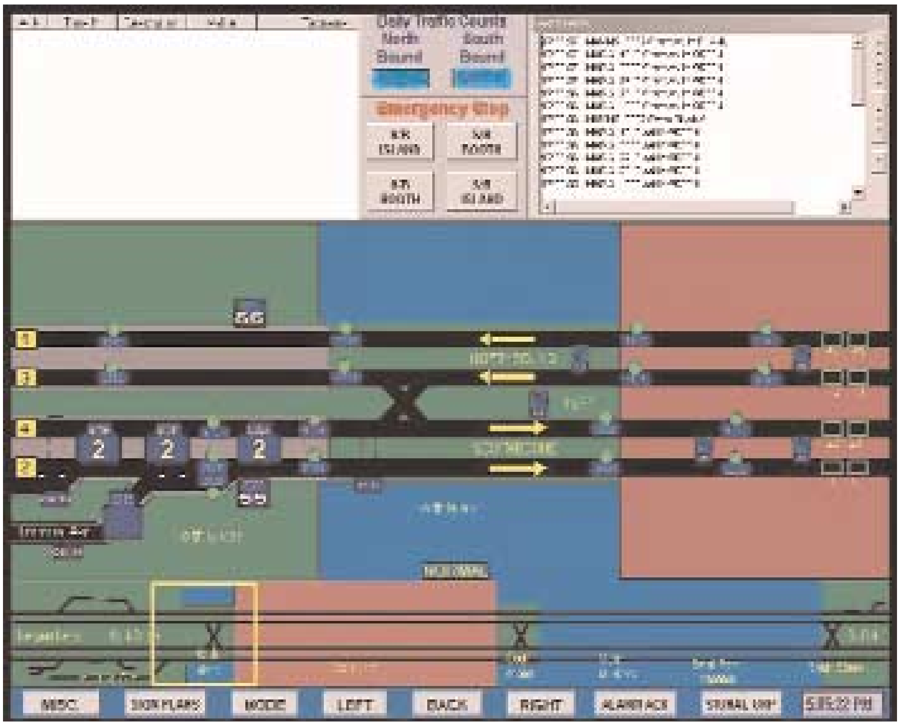
The VMS controller is required to prompt a database entry if a field communications controller either fails to respond or the reply data stream is unintelligible. The error is considered resolved only when the offending device 'passes' a set of consecutive cycles that meets or exceeds VDOT's reliability definition. In today's litigious society, technology at MMMBT is helping confirm precise system operation. Database entries, as well as archival video footage, are admissible evidence in the Commonwealth of Virginia's courts.

Off-the-shelf customization

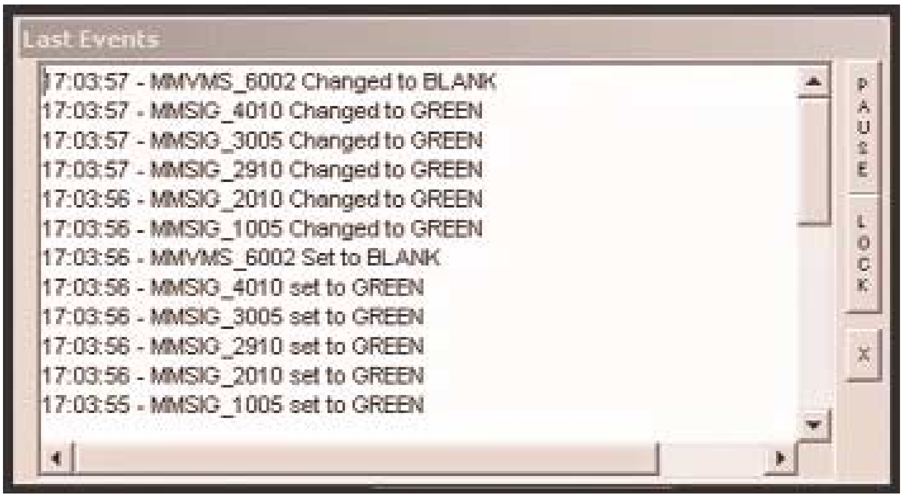
To address VDOT's custom requirements, Advanced Traffic Control draws upon a cadre of well-known and respected commercial, off-the-shelf components. Not doing so opens the door to what Roark terms "Orphan software … proprietary code that was developed by a business which is defunct or no longer offers support for the commodity.

"Without sourcecode and requisite expertise, users have no way to safeguard or enhance their investment. Often, that forces entire replacement when relatively simple fixes could preserve a serviceable solution." Take, for example, SCADA software, which is considered by many to be a de facto standard. With over 100,000 worldwide licenses, its maintainability is effectively ensured. And, since Advanced Traffic Control furnishes sourcecode (licensed only for maintenance) for all the software it authors, customers are never left with a potentially non-functional product.

Two prior tunnel system upgrades completed on schedule and within budget established Advanced Traffic Control's reputation for integrity and dedication. Unsurprisingly, the company was also awarded the TOMAC modernization contract.



A section of the NewTON graphical user and control interface



Display box showing bi-directional, real-time traffic counts

Display box containing the real-time event log

New operating network

The replacement new tunnel operating network (NewTON) capitalizes on state-of-the-art technology for monitoring and controlling traffic, detecting and reporting incidents, responding to emergencies, channeling data to VDOT's browser-based Graphical Traffic Information System, providing an interactive environment to command dynamic signs and signals, and obtaining various effectiveness and status reports.

In addition to coding new software, Advanced Traffic Control is retrofitting display consoles, renovating VDOT's existing incandescent map indicator board, and integrating two government-furnished operator workstations and a training/simulation unit.

Switches between the TOMAC host and field device modems enable one or more communications pathways to be connected to NewTON. That allows engineers to validate and verify control points individually on each line with minimal impact to the motoring public. Installing, commissioning, and transitioning to NewTON is accomplished with negligible disruption of traffic nor inconvenience to operations center personnel.

Traffic management systems like NewTON must 'remain up' around-the-clock. Redundant CPUs, alone, cannot ensure system-wide fault-tolerance. The solution: fail-over clustering, where operating system (Microsoft Windows 2000) and application software unite to confer continuous system availability. If one machine in a clustered pair fails or registers a fatal error, a microcomputer-controlled 'heart-beat' monitor and smart serial switches toggle to a 'hot standby'.

During fail-over, the standby host, essentially a clone of the main processor, is granted access to the same event database, and all peripherals (terminals, drives, network, I/O channels) are seamlessly routed to the back-up system. The entire process operates transparently to users.

To make certain the fail-over mechanism keeps running indefinitely, Advanced Traffic Control delivers schematics, parts lists, and firmware sourcecode for any company-designed components.

Incident management

Any event that degrades motorist security or slows traffic, such as disabled vehicles, crashes, maintenance activities, adverse weather conditions, special circumstances, and roadway debris defines an 'incident.' Incident-related congestion (including secondary impacts) detrimentally affects the driving public, local economies, and the environment. Efficient incident resolution by the automatic, integrated response to highway traffic disruptions can yield significant benefits through reduced

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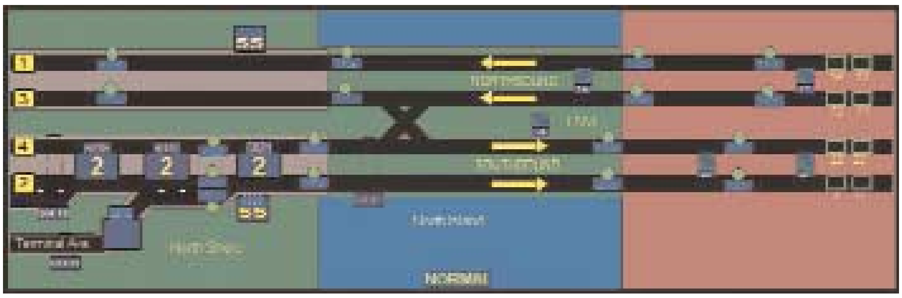

Location and status of all 'points', including CCTV cameras, under computer control

Overview of MMMBT's entire NewTON control complex

Soft-keys for user-controlled NewTON display features

“Thresholds are adjustable and can be revised to compensate for traffic dynamics on an hourly basis”

delays and improved security. Those savings, and the consequent return to nominal travel speeds, help diminish vehicle emissions.

Detection is the means by which an incident is identified. Seventy-two in-ground loop controllers are queried at a rate of 40Hz and summary data are input to NewTON once per second. From traffic count signals returned by sets of operational loops, a detection algorithm calculates the absolute and relative time differentials. It accounts for flow transitions, lane changes, and potentially faulty sensors or communications errors. If either value falls outside a predetermined range, an incident is recorded. Thresholds are adjustable and can be revised to compensate for traffic dynamics on an hourly basis. When an event is detected, NewTON outputs a descriptive warning on the operator’s workstation, logs it in a daily report, and takes appropriate action.

Appropriate action

Verification confirms the incident’s nature and location to enable the dispatch of suitable assets. NewTON checks incoming signals for noise (chatter), high-occupancy and low-occupancy conditions. Data processing is suspended for loops that are in chatter, above the maximum high-occupancy threshold, or beneath the minimum low, until values return to within the allowable range. After an incident is verified, NewTON alerts the traffic control system operator and identifies the location by its traffic control device number. In this manner, verification prevents needless response to false alarms.

Activation of pre-planned strategies for safe and rapid deployment of personnel and resources is the response. An emergency traffic control plan is initiated by the operator, and NewTON sequentially adjusts lane-use signals, message signs, speed limit signs and flashing signs to effect the desired management system configuration.

Emergency plans facilitate smooth transition of traffic control, avoiding abrupt changes to speed limits, lane-use availability, or traffic stoppages. There are over 100 stored traffic control plans that specify the display status for each control point. Operations invoked by stored plans usually spawn multiple subordinate plans to achieve the desired results. The system administrator can override, modify, enable, or disable execution of any plan.

Conflict resolution

NewTON is equipped with a set of conflict resolution rules. While an emergency overheight plan is in effect, for example, a subsequent overheight incident in that direction is prevented from invoking another overheight traffic control plan until the operator ‘clears’ the initial one. During this suspension period, NewTON continues to display warnings and post log entries for any overheight conditions it detects.

Similarly, NewTON parses all commands issued to the VMS controller. If a traffic control plan calls for left lane closure, downstream signals are turned ‘red’ and variable messages signs display ‘left lane closed’. Under that scenario, conflict rules would preclude commanding a lane-use signal to ‘green’ in the left-hand lane.

At the start of a traffic plan, the look-ahead feature checks the status of all affected equipment. If a device’s current state is to be set in a later stage of the plan, no adjustment is made. Thus, a plan calling for a lane-use signal initially to be ‘amber’, then ‘red’ would not apply a change if it already is ‘red’ when the plan commences.

Finally, safe and timely removal of stalled vehicles, wreckage, debris or spilled materials, and restoration of the roadway to full capacity, constitutes the clearance phase of incident management. When a stored traffic control plan is executed, the ‘before’ activation state of each lane-use signal, VMS, speed limit sign, and flashing sign is recorded. Following event clearance, NewTON affords the option of re-invoking either the previous plan or the default facility configuration.

MMMBT’s NewTON heralds leading-edge ITS deployment by Advanced Traffic Control. It facilitates movement of people and goods, and expedites resolution of incidents and hazards, particularly in underground sections where there is increased risk from exposure to pollutants. As such, NewTON is sure to serve as a model for further development and expansion of flexible, sophisticated traffic management systems in Virginia’s Tidewater region and beyond. ■

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