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An overwhelming sense of security

Can impediments to the territorial security problem be resolved through sensor networking and data fusion? **Lee J Nelson** focuses on leading-edge efforts to surmount real-time challenges

When persons or goods transit a border or perimeter, "territorial security" deals with their detection, an apposite response and potential interdiction in the event of unauthorized activity. Protecting strategically important areas, such as international crossings, transportation and critical resources, presents significant, substantial hurdles.

Preventing, detecting and responding to illicit cargo and/or people, crossing a boundary, is a concern of domestic as well as global proportion. The state-of-the-art in perimeter-security relies on physical barriers, sensors (audio, infrared, motion, vibration, video) and personnel (camera operators, entry guards, random patrols). Those can be effective in a limited scenario where few entrance points are constrained by well-delineated physical margins.

Territorial security, however, deals with larger tactical threats to border crossings, public services (energy, water and sewer, emergency response), road networks and transportation systems (airports, bridges, rail yards, tunnels, public transit). Due to the scale and scope, safeguarding those linked resources proves difficult and expensive. Operators frequently suffer from fatigue, stress, inattention and overload, due to the influx of data. And, knowledge-sharing among authorized users requires an unprecedented degree of cooperation.

TRADING TACTICS

Design engineers at Telephonics Corporation (Farmingdale, New York, US) began to investigate a real-time integrated approach for outdoor areas, public buildings and transit hubs in 2004. The company's Advanced Communication Tactical Information Control & Surveillance System, TACTICS, was to combine multi-modality event-monitoring with rapid threat evaluation for triggering mass notification alerts; applicable from small, streamlined schemes to large, ultra-secure facilities. Apparently, the concept was before its time as Telephonics Corporation was unable to obtain funding to further TACTICS.

Today's perimeter-security systems demonstrate the effectiveness of fixed, wired sensors. A network of nodes, positioned along a boundary, captures disparate and diverse types of data. Take, for example, color and infrared video cameras that detect and recognize intruders; acoustic sensors react to digging activities while sonar and radar locate marine- or air-based targets.

Due to dimensional concerns, territorial security must be more adaptable from a deployment standpoint than traditional perimeter systems. Sensors, themselves, have to be transportable and, in fact, may reside on mobile platforms like autonomous ground or aerial vehicles. Sensor-node mobility affords the requisite flexibility for wide-area coverage.

Larus Technologies Corporation (Ottawa, Ontario, Canada) proposes a novel, real-time decision-support system intended to extend overall territorial security to areas of strategic importance. Their modular architecture sustains a rich repertoire of data sources, tailored to assess a given environment.

To provide desired transportability, through their collaboration with GE Intelligent Platforms (Charlottesville, Virginia, US), Larus Technologies is able to equip stationary and relocatable platforms with payloads that collect audio, visual, radar and GPS (Global Positioning System) coordinates. Bandwidth-intensive acoustic and video data must be compressed prior to transmission. GE Intelligent Platforms' video CODEC (compressor/decompressor) enables wireless transmission even as Larus Technologies' feature extraction works on real-time visual data.

"The combination of data mining and fusion forms a decision-support system and helps delimit inflow to a manageable level while alleviating strain"

Larus Technologies' Nexus for Territorial Security performs motion, intrusion and fire/smoke detection plus localization, tracking, recognition and classification. The system not only traces movement, Nexus notes stopped as well as abandoned objects. Moreover, the capability is unimpeded by compression artifacts, suboptimal focus or certain environmental variables (ambient light, moderate wind, rain).

To recognize incursions along a lengthy perimeter, the tide of incoming data must be interpreted rapidly and continuously. That information is not restricted to sensor readings and may include databases,

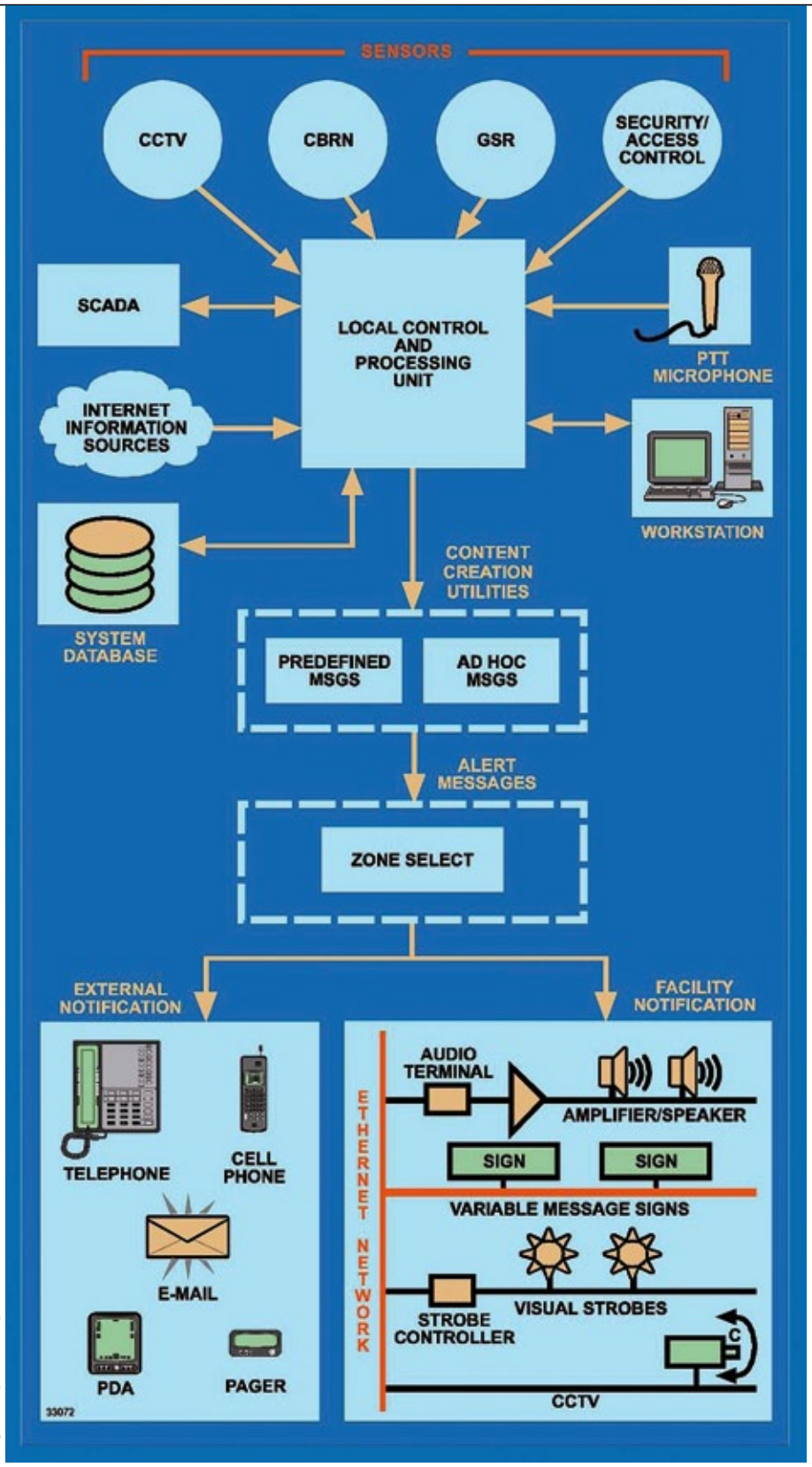

Image © Telephonics Corporation

A then novel concept (from 2004) for the Advanced Communication Tactical Information Control & Surveillance System. Funding limitations prevented it from becoming a reality

individual reports and complementary source materials. Nexus marries all in real-time, issuing alerts whenever anomalous behavior is suspected. Furthermore, raw data can be screened with an autologous set of knowledge patterns. The combination of data mining and fusion forms a decision-support system and helps delimit inflow to a manageable level while alleviating strain. Users' consoles display local and global views, aggregating relevant events and warnings and bestowing great flexibility for planning appropriate countermeasures.

Nexus employs well-developed approaches, like XML (Extensible Markup Language) and OWL2 (Web Ontology Language), to encourage cross-pollination with existing technologies and to facilitate future extensions. Information sharing and data synthesis are fundamental to Department of Homeland Security (Washington, DC, US) and MAJIIC (Multi-sensor Aerospace-ground Joint Intelligence, surveillance and reconnaissance Interoperability Coalition) initiatives. MAJIIC-participating nations include Canada, France, Germany, Italy, the Netherlands, Norway, Spain, the United Kingdom and the United States. All authorized users and collaborative systems have secure access to each sensor's data stream, current and historical information and fusion capabilities. NC3A (the NATO Consultation, Command and Control Agency, Brussels, Belgium) provides technical oversight of MAJIIC.

MARKING TERRITORY

Applied to territorial security, the Larus Intelligent Sensor and Actuator (LISA) and the LISA Network (LISANet) enhance collection with *in-situ* sensors, enabling communication among peripherals, controllers, motors, relays and custom devices. Through the company's proprietary Nexus fusion engine, LISANet upholds actionable intelligence for client decision-support and C^4I (command, control, communications, computers and intelligence) systems. Still image- and motion video-based visual analytics, pooled with user-generated inputs, also serve to inform course-of-action decisions and allow first-responders to communicate among themselves as incidents progress in real-time.

Larus Technologies hopes to direct the nascent technology to solve related problems: preventing unauthorized persons from entering secure, well-contained buildings or structures. The likes of a virtual fence can be required in a variety of military and civilian settings, now handled by "tripwire-based" techniques. The replacement technology would employ passive infrared. Such electronic tripwires could >>>

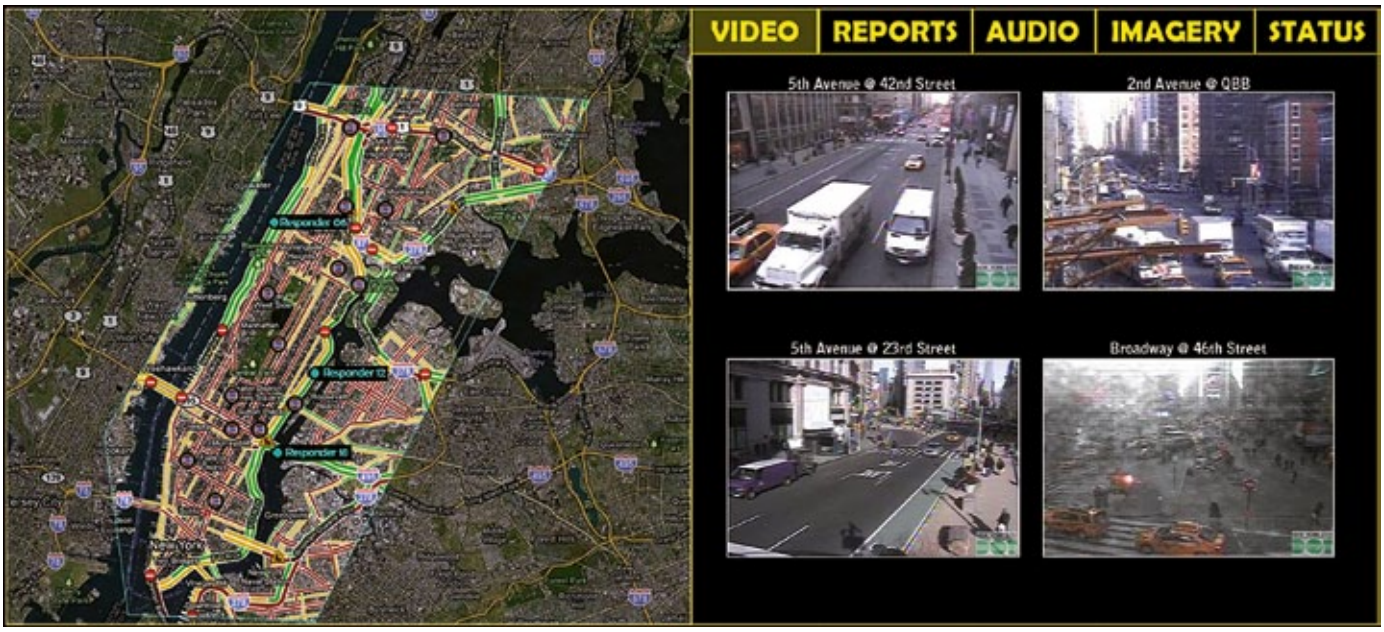

Image © IAVO Research & Scientific

Visual Integrated Knowledge Interface, combining multi-modality, real-time data streams with geospatially-referenced landscape features

be interconnected to form a Sensor and Actuator Network (SANet); once again, fusing data streams in real-time and, as with Nexus, issuing alerts whenever intrusions occur. Each with a horizontal detection angle of 110 degrees and a 10m (32.8ft) range, five passive infrared sensors, for example, would grant 360-degree coverage with 38 degrees of overlap between adjacent detection zones. (Localization resolution equals 38 degrees.) Acoustic, imaging and magnetic sensors could assist; helping to recognize and/or classify objects of interest and reducing false positive errors.

SEEK AND DEPLOY

Methods to search, navigate, extract and visualize information, relevant to problems of Homeland Security, continue to evolve on the research front. Currently, however, there are few options that adequately address real-time requirements and none that offer broad resources. What's needed is a system that can understand and respond to simple questions, make predictions, find interrelationships among disparate data sets and formulate answers. Such a solution, packaged as portable, intuitive software allowing users to invoke artificial intelligence products in a timely manner has yet to be attained. Operators are encumbered when attempting to dispatch alerts, quickly, to the community of first-responders or to find the most pertinent information for a particular task or unfolding scenario. Additionally, the accumulation of user-generated data must be analyzed for consistent secondary and tertiary trends, resulting from an initial event. The ability to collect, integrate and disseminate all that knowledge would permit a more thorough understanding of each situation. It is fundamental to achieving a complete picture of any Homeland Security incident and can serve as a "precision environment" for engaging a multi-disciplinary reaction.

IAVO Research & Scientific (Durham, North Carolina, US) is honing innovative methodologies to update and visualize data for first-responders. To that end, VIKI, the Visual Integrated Knowledge Interface combines real-time data streams, detailing events as they unfold, with geospatially referenced landscape features; creating the capacity to share information across local, regional and national scales, without and within the emergency-response community.

Interaction with VIKI will run the gamut from hand-held portable electronic devices, through standard mouse/keyboard inputs or touch-sensitive screens to high-definition wall-sized displays. Catering to users, two design principals are key: the information must be germane and its presentation should be intuitive. Records will be indexed according to ontological tags and formatted, as needed, for the applicable interface(s). The interface(s) through which each user interacts will depend on his/her role and functional platform.

The VIKI pre-processor will access dynamic sources and also retrieve static audio, imagery and textual data, a great deal of which are resident in state and federal archives. And, to profit from *de facto* industry-standards, VIKI will ingest map, road and traffic data (Google Inc., Mountain View, California, US) as well as orthogonal imagery and perpendicular three-dimensional scenes, where available. A touch translator will permit operators to scroll and renew data while a multi-windowing system will support several users, simultaneously.

An alert monitor will handle intra- and inter-level communications. The message router will decide who needs to be notified and will address alarms appropriately, based on the explicit destination (if any) together with the issuer's awareness domain, geographic position and all >>>

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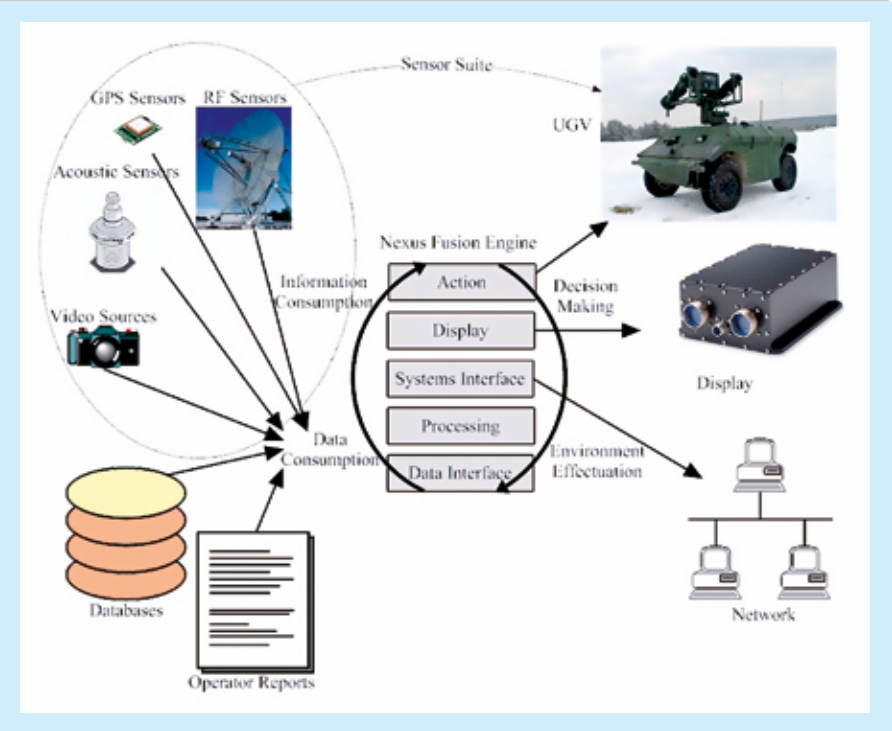

Nexus for Territorial Security platform consisting of an unmanned ground vehicle with data fusion payload, an integrated and deployable video CODEC and an acoustic data capture system running intelligent analytics software

potential recipients. Methods for updating "community knowledge", at this time, do not sort and aggregate data with a sufficiently fine-grained filter. That leads to information overflow in time-critical circumstances. IAVO Research & Scientific intends for VIKI to logically organize and present textual data, archival records, geospatial features and other media files at a multi-scale level; suited to singular responses or to situation rooms in which concurrent operations can be reviewed and tracked.

VIKI will deliver up-to-date information, sorted as per each unique responder's profile (emergency medical technicians, fire, police, Special Weapons and Tactics teams, etc.) and content preference. Messages will be relevant to each user and his/her physical location. Operators will be able to add their own functionality, through programming points, to help drive VIKI's logic engine. The flexibility afforded by its open architecture will maximize return-on-investment.

Given increasingly diverse markets for visualization and multi-scale user-generated software capabilities, IAVO Research & Scientific perceives an immediate opening for VIKI in local, state and federal law enforcement plus international humanitarian efforts. A mobile-device that facilitates communication and updates among varied users would have widespread application and appeal. The VIKI solution could offer a new methodology to join first-responders in a digital conversation about unfolding real-time events. Arguably, the most apparent effect would be the ability to access and revise community-wide knowledge, optimizing the way we collect and share information.

MISSION CRITICAL

Understanding how security events impact surroundings can help generate a "larger picture" of each incident, critical to the most advantageous deployment of personnel and reserves. IAVO Research & Scientific also is developing a resource allocation tool to permit *en route* alteration of pre-filed courses-of-action; as new conditions arise and exact redirection of assets. Overall, VIKI is expected to address the entire precision information spectrum with a broad audience and numerous potential applications: The American Red Cross, the Federal Emergency Management Agency and the United States Agency for International Development all must keep track of on-going issues and changing conditions during natural disasters or security episodes. The US Army, Navy, Air Force and Marines need for a solution to buttress multi-scale mission tracking and course-of-action planning.

Since the 2004 establishment of the US Department of Energy's National Visualization and Analytics Center, on the premises of the Pacific Northwest National Laboratory (Richland, Washington, US), a member panel representing government, academia and industry has been redefining directions and priorities for future efforts in real-time visual analytics. Unsurprisingly, the National Research and Development Agenda is tasked with innovating information visualization for earlier warning of terrorist activities, vulnerability assessments and for enhancing emergency-response analytical tools.

Even with emergency plans and procedures in place, several areas remain in which understanding and sharing of information can augment our ability to respond and reduce the probable impact of an attack. Real-time analytical monitoring can alert first-responders to unusual situations. Ready software supports varying types of communication for different audiences as robust sensor networks and real-time data fusion are poised to improve leading-edge territorial security systems. Anticipated solutions proffer flexibility in data acquisition and deployment while promising to ease operator overload, ensure interoperability and promote a unique data-sharing paradigm.

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