Science-Based Planning Support to Vancouver 2010 Security: Two Case Studies

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During the Vancouver 2010 Olympic Games, all vehicles and persons were screened prior to entering official venues. Vehicle Screening Areas (VSAs) and Pedestrian Screening Areas (PSAs) were designed and operated by the Vancouver 2010 Integrated Security Unit (V2010 ISU). The requirement for simultaneously effective and efficient screening areas presented V2010 ISU planners with significant challenges, given the huge scales of the undertakings (e.g., ~2 million pedestrian screenings), the need to collaborate with external stakeholders, and the uncertain nature of a host of planning parameters. From September 2007 to February 2010, Defence Research and Development Canada (DRDC) provided a range of science-based support to the V2010 ISU's VSA and PSA planning efforts, from process mapping and computer modelling to quantitative analysis and exercise support. This paper describes the science-based approach that underpinned the V2010 ISU's twin VSA and PSA development campaigns, how it reduced uncertainty during pre-Games planning, and how it ultimately decreased risk during Games-time operations.

1. Introduction

The XXI Olympic Winter Games (referenced herein as "V2010" or "the Games") was a major international sporting event staged by the Vancouver Organizing Committee for the 2010 Olympic and Paralympic Winter Games (VANOC) from 12–28 February 2010 at multiple venues in the vicinities of Vancouver and Whistler, British Columbia, Canada. Security for the Games was planned and provided by the Vancouver 2010 Integrated Security Unit (V2010 ISU), a multi-agency body led by the Royal Canadian Mounted Police and incorporating members of the Canadian Forces as well as the Vancouver and West Vancouver Police Departments.

During the Games, the V2010 ISU operated Vehicle Screening Areas (VSAs) and Pedestrian Screening Areas (PSAs) to reduce the risk of vehicle-borne and person-borne prohibited items (e.g., weapons) entering V2010 venues. However, given the Games' posture as primarily a sporting event rather than a traditional security operation, it was important that VSAs and PSAs did not unduly delay the entry of vehicles and persons into V2010 venues. Moreover, given the considerable volumes of vehicle and pedestrian traffic involved (e.g., ~2 million pedestrian screenings at PSAs alone) as well as the large quantities and scales of such screening areas, significant fractions of the overall V2010 security workforce and budget were required to staff and fund them (i.e., several thousand personnel and more than 100 million dollars). Consequently, during the VSA and PSA planning phases, a careful trade-off was sought in order to yield simultaneously effective, efficient, feasible, and cost-effective approaches. As natural starting points for its planning efforts, the V2010 ISU's Physical Security section considered VSA and PSA approaches used during previous Olympic Games. However, official observers' anecdotal opinions and media reports [1-6] concerning prior Games suggested that such earlier approaches may have involved undesirable trade-offs that the V2010 ISU would want to avoid.

To help avoid unfavourable trade-offs amongst the various screening area design objectives, the V2010 ISU requested Science and Technology (S&T) support from Defence Research and Development Canada (DRDC) in August 2007 and March 2008 for VSAs and PSAs, respectively. DRDC support commenced almost immediately in each case and was provided continuously on a full-time basis during a 2.5 year period that included the Games. During that interval, DRDC provided V2010 ISU planners and decision makers with a multitude of practical and timely, science-based advice that arose from two comprehensive VSA and PSA development campaigns.

Though distinct, the VSA and PSA development efforts each followed a systematic, phased approach analogous to that routinely employed by experimentalists in the physical sciences and others. During the initial phase of each effort, essential performance requirements, planning assumptions, dependencies, constraints, and process options were identified. Thereafter, software-based models were developed in each case to:

a) deepen planners' qualitative understanding of screening area dynamics and
b) translate planning assumptions rigourously into quantitative projections of screening area performance, based on the existing concept of operations and modified versions thereof.

Quantitative analyses of the model data were then conducted to identify the most promising potential approaches in each case for further study. Such approaches were later investigated and compared during a series of experiments and field trials, under conditions that were increasingly representative of the anticipated V2010 environment. Whereas early experiments were designed to help ascertain the most productive and feasible screening approaches, subsequent field trials aimed to elucidate, in detail, the manner in which the V2010 ISU might best implement its chosen VSA and PSA concepts during the Games. Finally, dedicated troubleshooting personnel operated during the Games to adjust VSA and PSA operations to real-world circumstances when the latter differed from anticipated conditions. In the following sections of this paper, each phase of this systematic approach is described within the contexts of the VSA and PSA development efforts.

2. Problem Definition Phase

The development and implementation of V2010 VSAs and PSAs required collaboration between the V2010 ISU and VANOC. Given its mandate with respect to Games security, the V2010 ISU designed each of the various screening areas and provided the screening workforce during the Games. Consequently, screening effectiveness and costs were key considerations for the V2010 ISU. As the Games' organizer, VANOC allocated the physical space, provided the required infrastructure, and supplied support personnel for the V2010 ISU-operated screening areas. Thus, the minimization of screening-related delays and spatial requirements were principal considerations for VANOC, in addition to screening effectiveness and costs. Therefore, although similar, the mandates and priorities of the two organizations were not identical. The interdependence of the two bodies further heightened the need to develop VSA and PSA approaches whose effectiveness, efficiency, spatial requirements, and associated costs would be acceptable to both organizations.

However, the design of effective, efficient, feasible, and cost-effective PSAs and VSAs was complex, due to:

a) the large number of design parameters involved,
b) the variability of such parameters from venue to venue, and
c) the often considerable amount of uncertainty associated with each parameter.

For instance, successful PSA design requires accurate estimates or foreknowledge of:

a) the types of items that the screening process is intended to detect,
b) venue configurations (e.g., an indoor versus outdoor setting as well as the ratio of seated versus standing spectators),
c) pedestrian profiles (e.g., quantities and categories of pedestrians; the quantity and nature of items worn and borne by each pedestrian type; and corresponding distributions of pedestrian arrival times),
d) available pedestrian screening resources (e.g., the quantity, type, and capabilities of screening personnel and equipment; the quantity and shape of available physical space; and associated costs),
e) the manner in which pedestrian screening tasks would be conducted (e.g., the quantities of time, space, personnel and equipment required for each screening task; the probabilities that each screening procedure will be required for a given pedestrian; and the time-sequencing and effectiveness of various screening tasks),
f) relevant human factors (e.g., the likely behaviours of pedestrians and screeners in various circumstances; the ability of the security workforce to remain effective during potentially lengthy, monotonous, and/or physically demanding shifts; and safety), and
g) environmental conditions (e.g., the potential effects of temperature, precipitation, wind, humidity, lighting, and air quality on pedestrian profiles and behaviour, the screening workforce, and screening equipment).

Indeed, VSA design was even more complex, since vehicles also had to be screened, along with their occupants and their possessions. To be done successfully, such design requires accurate estimates or foreknowledge of all PSA-related aspects listed above as well as:

a) vehicle profiles (e.g., quantities, dimensions, and typical occupancies of each vehicle type; the likelihood of pre-screening for each vehicle type, and the distribution of vehicle arrival times for each vehicle type),
b) vehicle traffic flow considerations (e.g., the conditions under which vehicles are permitted to enter and exit; means of traffic control; vehicle travel routes; and the dimensions and locations of vehicle search bays),
c) available vehicle screening resources[1],
d) the manner in which vehicle screening tasks would be conducted[2],
e) relevant human factors[3], and
f) environmental conditions[4].

During the VSA and PSA development efforts, various means were used to estimate or define the numerous information requirements listed above. In general, relatively few of them could be obtained readily with much confidence during the initial planning phase. Some data (such as estimates of vehicle types and arrival schedules) could be obtained directly from VANOC but their accuracy was difficult to verify. A small fraction of the required information (such as climate data and vehicle/equipment specifications) could be obtained from third parties via the

[1] Examples of which are directly analogous to those listed above for pedestrians.
[2] See Footnote 1.
[3] See Footnote 1.
[4] See Footnote 1.

internet as publicly available historical data or product manuals. However, the majority of the required planning data were peculiar to the future V2010 environment and were therefore difficult to estimate accurately during the early stages of planning. As starting points, many initial estimates and assumptions were based on the opinions of subject matter experts within the V2010 ISU and other organizations. Such estimates were subsequently refined as plans coalesced and following the analysis of data collected during VSA and PSA experiments/field trials.

Activities during the VSA and PSA problem definition phases were not confined to the identification and collection of required information. Rather, the VSA and PSA screening processes described in the V2010 ISU's initial concepts of operations were mapped diagrammatically and critically examined. Despite the use of simple means (such as whiteboard drawings and rough, "back-of-the-envelope" calculations), such examinations proved to be extremely valuable in two respects. First, they served to highlight additional planning considerations that had not been identified previously. Second, they revealed potential areas for improvement within the early concepts of operations. Such critical examination of the initial VSA concept (which was based on prior Olympic practices) was particularly important, as it revealed certain inherent inefficiencies. Analysis of those deficiencies quickly gave rise to novel approaches for overcoming them that could be studied alongside the conventional VSA configuration.

3. Software-Based Modelling

During early V2010 planning, DRDC developed software-based models that became key VSA and PSA planning tools. To keep pace with the V2010 ISU's high planning tempo, rapid model development was essential in order to provide timely planning inputs to each effort. The VSA and PSA models' degrees of sophistication differ, based on the levels of fidelity that were required to yield meaningful results for V2010 planning efforts and the amounts of development time available. For instance:

a) The Vancouver Integrated Screening Team Assessment – Vehicle Screening Area (VISTA-VSA) model is a sophisticated and flexible process model that can perform detailed simulations of vehicle screening operations over a wide range of conditions. Following four months of intensive development, VISTA-VSA became operationally useful in January 2008 and was immediately put into service. The model's ability to rigourously translate a multitude of planning assumptions into quantitative projections of VSA performance was very well-received by V2010 ISU planners, who requested an analogous, PSA-specific version (VISTA-PSA). Since VISTA-VSA was coded in a largely generic, modular fashion to enable the relatively rapid creation of model variants, it was estimated that VISTA-PSA would require two additional months to develop.

b) Shortly after the development of the VISTA-PSA process model began, a critical internal V2010 ISU planning deadline was brought forward considerably. This sharply curtailed the amount of time available for PSA model development and meant that the VISTA-PSA model could not be used for analysis purposes prior to the deadline. Consequently, VISTA-PSA work was halted and, in its place, a less powerful, but more readily constructed tool was built. The "PSA Calculator" consists of a system of equations developed for an idealized PSA process implemented in a Microsoft Excel spreadsheet. DRDC delivered the prototype and final versions of the tool to the V2010 ISU after two and four days' of development, respectively. Since PSA Calculator incorporates certain "best-case" approximations, it yields results with less fidelity regarding real-world PSA performance than would a sophisticated process model such as VISTA-PSA. However, the PSA Calculator proved itself to be highly valuable because it allowed the V2010 ISU to conduct rigourous, quantitative analyses of PSA performance over a range of options and conditions prior to the critical planning deadline. The confidence gained from using the PSA Calculator made it the preferred V2010 PSA planning tool for the remainder of the planning period.

Despite their different degrees of sophistication, the VISTA-VSA and PSA Calculator models benefited V2010 planners in similar fashions. First, since the act of model building forces a developer to consider the relevant processes and parameters systematically and in some depth, it facilitated an early recognition and more complete appreciation of certain VSA and PSA aspects. Further, both models provided rapid, quantitative means for exploring and assessing the relative merits of myriad potential options and. In so doing, the models established rigourous bases for the selection of promising VSA and PSA candidate approaches for real-world experimentation. Moreover, repeated model usage enabled users to enhance their intuition regarding the potential impact of a particular option on VSA or PSA behaviour. Using such models, one could also identify the input parameters upon which VSA or PSA performance might depend most strongly, to guide efforts for refining the accuracy of key planning estimates.

Though used solely for planning purposes, such models also had potential applications during the Games. For instance, had they been populated with real-world V2010 data, forecasting of potential VSA or PSA performance could have been attempted. Similarly, if populated with real-world V2010 data, such models could have been used to diagnose VSA or PSA problems in near real-time and, thereafter, to estimate the utility of various potentially corrective measures.

4. Quantitative Analysis of Data

Quantitative analyses of various data were conducted during all phases of the VSA and PSA development efforts. However, those based on model data were perhaps the most influential, given their bearing on projected resource requirements and the junctures at which they occurred during the V2010 ISU's planning. Three examples of such analyses are presented below.

In response to a time-sensitive request, two DRDC personnel conducted a detailed quantitative analysis of existing V2010 VSA planning data in February 2008. After carefully verifying the internal consistency of existing resource estimates, the analysts used them in conjunction with the VISTA-VSA model to estimate vehicle screening capacities at various V2010 venues. The model was then used to identify potentially promising modifications to the existing VSA concept of operations and to quantify their impact on screening capacity projections for particular venues. The analytical results were highly influential in two respects. First, they informed a fundamental decision regarding the manner in which VSAs would be staffed during the Games. Second, the timely, relevant, and quantitatively based insights that they provided significantly contributed to:

a) the V2010 ISU's willingness to incorporate a science-based approach into its VSA and PSA planning efforts and
b) a broadening of the engagement between the V2010 ISU and DRDC.

During the early stages of its PSA development effort, the V2010 ISU identified numerous potential screening configurations whose resource requirements varied markedly. Presumably, the quantity and diversity of such options increased the likelihood that suitable pedestrian screening approaches would ultimately be identified and pursued. Initially, the many diverse candidates engendered considerable uncertainty and prompted much discussion. However, by analysing PSA Calculator's quantitative projections for such options, the V2010 ISU rapidly identified the approaches that it deemed most promising. In so doing, the V2010 ISU significantly reduced the prior uncertainty regarding the quantity and mixture of resources required for Games-time pedestrian screening.

As noted previously, VANOC provided many key inputs to the V2010 ISU's VSA and PSA planning efforts. During March 2008, two DRDC analysts used the VISTA-VSA model to obtain VSA performance projections based on two sets of quantitative estimates provided by VANOC. The results sharply underscored the importance of rigourously generated, self-consistent, and accurate planning estimates as well as the need for common understanding of such data amongst providers and recipients. The importance of good quality planning data was also clearly illustrated during the Games for both VSAs and PSAs.

5. Experimentation and Field Trials

In many respects, software-based models proved to be highly valuable to the V2010 ISU's VSA and PSA planning efforts. For complex environments, however, models inevitably approximate certain real-world factors that could strongly affect a system's performance – and may ignore others completely. For instance, whereas the VISTA-VSA and PSA Calculator models were generally well-suited for estimating screening efficiency, they offered few insights regarding how effective V2010 screening might be or how screeners and their equipment might perform under Games-time conditions. Furthermore, even if a model could be built that incorporated all relevant real-world factors, it would still need to be supplied with a multitude of accurate inputs in order to generate realistic projections of system performance. Consequently, the inclusion of experiments and field trials within the VSA and PSA development efforts was essential, given the inherently approximate nature of the screening models and the many, often uncertain planning parameters involved.

DRDC provided comprehensive planning, exercise control, data collection, and analytical support throughout the V2010 ISU's VSA and PSA exercise campaigns. The V2010 ISU valued the collected data highly, since they provided a range of new insights as well as additional quantitative bases for its decision making and discussions with VANOC. Indeed, such empirical data (in conjunction with the models' results) fostered the adoption of significant new approaches within the V2010 ISU's VSA and PSA concepts of operations.

The V2010 ISU's initial VSA and PSA experiments were conducted during the Mock Area Screening Exercise (Ex MOCKASIN) that was held in Chilliwack, British Columbia, Canada during June 2008. From a VSA perspective, such experiments explored the relative performance and requirements of a conventional Olympic design versus promising alternatives that arose from the modelling and analysis efforts. The rigourously obtained results clearly demonstrated (both quantitatively and qualitatively) that two of the alternative approaches outperformed the conventional approach during the exercise. Moreover, a strong stakeholder consensus to that effect was achieved during the exercise by enlisting many V2010 ISU and VANOC members (who would otherwise have been passive exercise observers) as vehicle occupants. The clarity of the results and broad participant consensus greatly contributed to the V2010 ISU's decision to incorporate the alternative approaches into its VSA concept of operations. Consequently, the exercise strongly influenced a host of VSA planning considerations, including VSA staffing requirements, spatial requirements, internal configurations, tent quantities and specifications, etc. PSA-related time and motion studies were also conducted during Ex MOCKASIN. At that time, the V2010 ISU's PSA concept of operations was at an earlier stage in its development than its VSA counterpart. Thus, the PSA experiments were designed to be "discovery" activities that principally aimed to inform the development of potential approaches (not to compare them empirically, as in the VSA case). Nevertheless, despite their more modest scope, the PSA experiments yielded numerous valuable observations that advanced the PSA planning effort.

To refine each concept of operations further, additional field work was performed under real-world, wintertime conditions to identify additional requirements, potential gaps, and likely improvements in detail. To that end, the V2010 ISU conducted two VSA and two PSA field trials that included significant voluntary participation by the general public as part of Exercise BLUE (Ex BLUE) during January and February 2009. One large scale field trial of each type was held during major sporting events at or near future Olympic venues in Vancouver and Whistler, British Columbia, Canada. The VSA field trials involved highly detailed investigations of all aspects of the two alternative approaches that had performed so well during Ex MOCKASIN. The PSA field trials involved similar, highly detailed, empirical studies along with some experimentation to compare and refine potential approaches. Large bodies of valuable quantitative and qualitative data were collected during Ex BLUE that encompassed such diverse considerations as screening effectiveness and efficiency, staffing levels, shift durations, process modifications, spatial requirements, tent structures, equipment, human factors, safety, and environmental conditions. In general, the V2010 ISU made extensive use of the exercise's results when finalizing its Games-time VSA and PSA concepts of operations and screener training curricula. As with Ex MOCKASIN, Ex BLUE also offered V2010 ISU and VANOC stakeholders excellent opportunities to observe, discuss, and understand how VSA and PSA operations should be conducted, well in advance of the Games.

An additional series of experiments was conducted by the V2010 ISU with implications for both its VSA and PSA concepts of operations. During one of the Ex BLUE PSA field trials, a fundamental question regarding magnetometer usage arose that generated much stakeholder discussion. To address it, DRDC personnel rapidly designed and conducted additional, impromptu experiments during the exercise. Their results proved to be highly influential, as they led the V2010 ISU to reconsider a prior decision and to conduct more comprehensive experiments during the Instrument Configuration Exercise (Ex ICE) in Richmond, British Columbia, Canada during June 2009. Ex ICE's rigourously obtained and quantitative results significantly advanced the V2010 ISU's understanding of the core issues and informed a subsequent decision with important implications for Games-time VSAs and PSAs.

6. Games-Time Troubleshooting Support

On-site troubleshooting support was an essential component of VSA and PSA operations during the Games and was provided by a small number of V2010 ISU and DRDC personnel. It was necessitated by:

a) the great importance of maintaining simultaneously effective and efficient screening operations;
b) the large scales, multiplicities, and geographic disparities of vehicle and pedestrian screening operations;
c) the temporary natures of the Games' workforces and much of its infrastructure;
d) each screening process' complexity and sensitivity to a wide range of factors;
e) remaining uncertainties concerning numerous Games-time conditions; and
f) the potential for unforeseen circumstances to arise.

The comprehensive, science-based approach employed during the VSA and PSA development efforts proved to be extremely beneficial for troubleshooting purposes during the Games. In many instances, the numerous model, exercise, and analytical results obtained during pre-Games planning could be readily translated into timely, practical advice tailored to the real-world situation at each venue. In particular, Ex BLUE's large scale, similar locations, and high degree of realism provided excellent previews of the Games-time VSA and PSA environments in multiple respects. Moreover, the VISTA-VSA and PSA Calculator models were available for troubleshooting use, had they been required.

7. Impact of Science-Based Support and Concluding Remarks

Working-level planners within the V2010 ISU broadly embraced the application of a science-based approach to their VSA and PSA development efforts. Initially, V2010 ISU planners were cautiously receptive of prospective DRDC assistance because they did not know whether such support would be timely or relevant. This caution arose from the cultural and occupational differences that exist between the operational security and scientific communities. Such concerns were instantly dispelled when DRDC delivered its time-sensitive analysis of VSA planning data in February 2008. The analytical results were of great utility to the V2010 ISU, not just because they were timely and highly relevant, but also because they were quantitative, detailed, and rigourously obtained in an objective manner. Thereafter, the V2010 ISU's working-level planners welcomed, without exception, the detailed, science-based VSA and PSA support that DRDC provided or offered to provide.

The V2010 ISU's embrace of a science-based approach for its VSA and PSA development efforts yielded many important benefits. First, it provided a means by which innovative and efficient screening approaches could be devised, tested, analysed and refined in a rigourous manner – with very substantial, positive implications for associated costs and resource requirements. Further, the rigourous, objective, and generally quantitative nature of the science-based approach reduced much of the considerable uncertainty inherent to the V2010 VSA and

PSA planning environments. Consequently, V2010 ISU planners reported that the approach saved considerable time and effort by enabling them to focus their energies in promising directions more quickly and by instilling confidence in decisions taken. Similarly, the various analytical products delivered by DRDC significantly facilitated interactions between the V2010 ISU and VANOC by providing objective, rigourous, and quantitative bases for discussions. Finally, the science-based approach helped the V2010 ISU reduce risks associated with its VSA and PSA operations by:

a) reducing uncertainties inherent to the planning efforts;
b) facilitating the systematic development of improved screening methods;
c) providing insights to mitigate or eliminate potential Games-time difficulties beforehand; and
d) generating tools and knowledge to manage issues more effectively as they arose during the Games.

The credibility gained from the timely delivery of the apt initial VSA and PSA analysis products helped to promote and underpin many excellent working relationships that subsequently developed between V2010 ISU planners and supporting DRDC personnel. The same was true for a broad range of other DRDC support efforts, including command and control concept development, command centre design, and exercise analysis. The strong, direct relationships were furthered by DRDC's regular provision of analytical results, frequent visits to the V2010 ISU, and the embedding of a DRDC scientific advisor within the V2010 ISU. The importance of the trust built through each successive interaction to DRDC's support efforts cannot be understated. With the growth of mutual trust, the quantity, diversity, and importance of the V2010 ISU's requests for S&T support increased, as did the evidence that the resultant knowledge and advice were acted upon by the V2010 ISU.

8. Acknowledgements

The author gratefully acknowledges useful discussions with Mr. Ron Funk and Mr. David Shaw of DRDC regarding the manuscript.

9. References

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