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Final Report Forensics City Transport 2012

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0. Executive Summary

This project was to demonstrate practical Monte Carlo transport calculational methods applied to city models in prompt forensics. Typically 1 source gamma ray in $\sim 10^{18}$ is physically detected in most real world scenarios for this class of problems. Major factors are detector solid angles at \sim km distances, building and air attenuation, as well as huge variations in source intensities. We used the world-wide standard for transport calculations, MCNP, developed at LANL. We used ARA supplied city models used in consequence management. One indication of the extreme difficulty of these problems is that the huge numbers were larger than the space allotted by the code developers and were output as "*****". (LANL was very helpful in resolving multiple issues we encountered like this.) Hardware memory issues also needed to be resolved. Calculational success was achieved in the simpler WDC model by a combination of variance reduction, voxelized geometry eliminated the mcnp geometry errors in the NYC model, eliminating peripheral buildings, and convolution of the source terms.

1. Variance Reduction

Initial variance reduction efforts were somewhat stymied due to ARA's NYC input geometry errors and the fact that they were geometrically too large, requiring too much memory per node on the LC machines. This problem persisted for the 1st year of this project. Subsequently the city models were changed to voxel models by ARA, which eliminated geometry errors.

Weight window and dxtran methods in mcnp were successfully applied, which provided NYC prompt nuclear forensics estimates for urban canyon geometry and single time slice sources. To help ensure reliable calculations, we inserted nonzero estimates in weight window regions where the weight window generator failed to produce estimates.

Further variance reduction investigations were deferred for NYC while WDC problem was evaluated using a convolution method and geometrical breakup of the problem.

2. Convolution

The WDC problem greatly reduced the scatter due to low building heights. The city transport geometry was broken up to include only regions between the source and detectors. Additionally, the source was broken up for transport of each piece, then reconstructed via convolution. These steps provided the correct transported signal to the detectors.

3. Multi-source approach

MCNP was modified to simultaneously solve for multiple estimates due to multiple sources using a single transport calculation. With this modification, the convolution problem in section 2 is also solved within MCNP with very minimal post processing. A modified MCNP6 for this purpose has been delivered to LLNL for evaluation. Initial testing by Booth has been successful. Initial testing on LLNL problems is still to be done. One initial LLNL comment is that the convolution post processing mentioned in Section 2 should also be included in the multisource approach and all done entirely within MCNP.

4. Inverse Problem

A natural extension of the multisource approach is to express an unknown source as a function of parameters and solve for the parameter set that best matches a measured response. See the attached proposal, also documented in LLNL IM #654892.

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