No formal effort has been made to verify or validate EXHALT, since it is a relatively simple desktop model akin to more ubiquitous spreadsheet models. Many of the expressions in EXHALT that are used to estimate various real-life phenomena have not been formally reviewed for faithfulness but have been based on numerous detailed analyses at RAND and elsewhere that suggest these are reasonable representations. Other expressions are merely notional and are intended to provide rough estimates of various effects as placeholders until more phenomenological models can be developed. However, we have taken quite a number of quality-control measures, many of which exploit modern desktop-computer technology to address issues that we have long considered important to verification and validation:

- **Conceptual model.** This report documents the conceptual model, as distinct from details of the implementing program.
- **Visual design.** The visual-programming methods of Analytica are extremely useful in sharpening issues of design and facilitating review. We made countless changes along the way as the result

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of discussions focused on the diagrammatic representation of the model.

- **Verbose variable naming.** We have used relatively long and descriptive variable names to clarify meaning.

- **Array methods.** We have exploited a number of Analytica’s array features, which greatly simplified mathematical expressions and, in the process, improved clarity and reviewability of the algorithms.

- **Automatic verification methods.** Analytica highlights variables it does not recognize (usually due to typographical errors) rather than assuming them to be new legitimate variables. In some cases, we replaced long If-Then-Else statements with tables, which greatly simplified review.2

- **Module by module testing.** We did extensive module-by-module testing, which is straightforward in the Analytica environment.

- **MRM.** Because of the MRM design, we were able to start module-by-module testing with highly aggregated modules and, once they appeared valid, to test submodels within the modules.

- **Visual displays of outputs.** All such testing is greatly assisted by graphical outputs, which can be generated on a node-by-node basis.

- **Comparisons.** We have made numerous comparisons of results with those of previously developed models, including an analytic closed-form model for special cases, an Excel model we had used in earlier work, an Excel model developed by colleagues, and work done with a theater-level model (JICM).

- **Calibrations.** Some parts of EXHALT are calibrated to a more detailed model (PEM), which in turn was motivated by and calibrated to high-resolution simulation at the entity level (Davis, Bigelow, and McEver, forthcoming).

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2The value of tables in the language itself was first dramatized in the RAND-ABEL language developed by Edward Hall and Norman Shapiro and used in the RAND Strategy Assessment System (RSAS). Our colleague Manuel Carrillo implemented the table feature for use in Analytica.
Although errors and other shortcomings will surely be found and although we plan to correct and improve standard versions of EXHALT from time to time as necessary, we believe that users can largely focus their concerns on (1) what assumptions to make about inputs and their uncertainties and (2) the inherent limitations of any model, such as EXHALT, that omits much of the richness of war (e.g., the role of maneuver forces, details of terrain, and operations with allies) to bring out certain analytically useful insights.