U.S. Defense Modeling and Simulation Office

Success Stories

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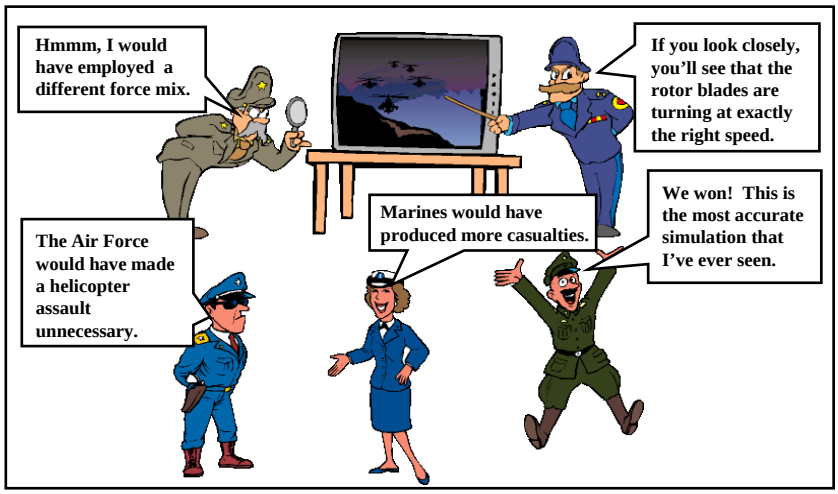
Building Objective Referents from Subject Matter Expert Knowledge

Currently, users and developers of theater-level simulations must employ subject matter experts (SMEs) for validation. In this role, SMEs serve to provide referent knowledge, interpret requirements, and decide validity by comparing simulation capabilities against the requirements and referent.



Parameter	Direct Fire Only	Direct Fire & Mortars	Direct Fire, Mortars & Artillery
Blue Travel Rate < Engaging (km/hr)	19 ± 11 [1.6, 3.0]	16 ± 4.8 [-0.8, -1.3]	21 ± 11 [1.5, 2.8]
Red Travel Rate < Engaging (km/hr)	16 ± 7.7 [1.4, 1.5]	14 ± 4.3[0.7, 0.3]	25 ± 7.1
Blue Travel Rate > Engagement (km/hr)	5.6 ± 3.5 [0.7, -1.9]	6.3 ± 3.5 [0.4, -3.1]	4.5 ± 3.3 [1.6, 2.5]
Red Travel Rate > Engaging (km/hr)	3.4 ± 2.4 [0.1, 0.1]	3.7 ± 2.6 [-0.3, 0.6]	3.7 ± 2.6 [-0.3, 0.6]
Blue Rate of Direct Fire (rounds/min)	3.5 ± 5.6 [2.4, 5.8]	1.3 ± 0.7 [-0.4, -3.9]	1.2 ± 0.5 [0.02, -0.7]
Red Rate of Direct Fire (rounds/min)	3.3 ± 5.7 [2.4, 5.9]	1.0 ± 0.4 [-0.8, 2.4]	1.0 ± 0.6 [0.5, 1.5]
Blue Rate of Mortar Fire (rounds/min)	-	3.4 ± 3.3 [1.3, 1.1]	2.9 ± 3.1 [1.6, 2.2]
Red Rate of Mortar Fire (rounds/min)	-	1 ± 0	0.9 ± 0.1 [1.7, -]
Blue Rate of Artillery Fire (rounds/min)	-	-	1.4 ± 0.7 [0.8, -1.8]
Red Rate of Artillery Fire (rounds/min)	-	-	1.0 ± 0.4 [0.5, 1.2]
Length of Battle (min)	420 ± 411 [0.3, -1.9]	427 ± 441 [0.8, -1.1]	336 ± 416 [1.3, 1.0]

The cartoon above illustrates a traditional method for employing SMEs in simulation validation. The table below it summarizes part of the ground combat referent obtained using survey elicitation of SME knowledge. The cells in this table contain the mean values, standard deviations, skews and kurtoses of the SME responses to the survey questions. The cartoon and table contrast the differences between the traditional and a new technique for employing SMEs in simulation validation. The availability of this new technique will improve validation decision objectivity even when SME knowledge is the only available referent source.

This situation inextricably couples several separate functions and leads to many problems including:

- Inconsistent validation assessment results,
- Lack of repeatability in validation decisions,
- Inability to identify the root causes of validity problems,
- Difficulties in reconciling the differences between individual SME judgments, and
- Reduced user confidence in simulation credibility.

The impossibility of collecting a rich set of experimental data describing actual warfare at a theater level makes using SME opinions for validation necessary for the foreseeable future. But, demands for increased simulation credibility create a critical need for new techniques to handle SME knowledge.

In an effort to build more objective simulation referents from SME knowledge, survey research techniques for collecting knowledge from a broad SME population were combined with statistical techniques for aggregating this knowledge into a single consistent referent. This referent can then be compared with results from a simulation to compute their accuracy. An experiment was designed and executed using the Joint Warfare System (JWARS) to test this technique.

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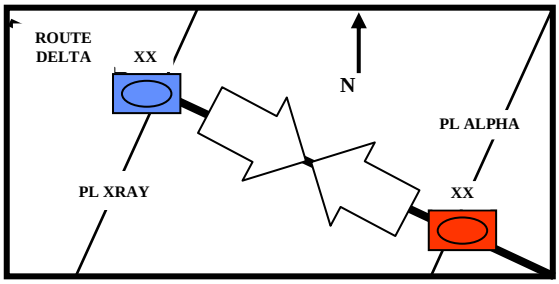
Objective Referents, p.2 of 2

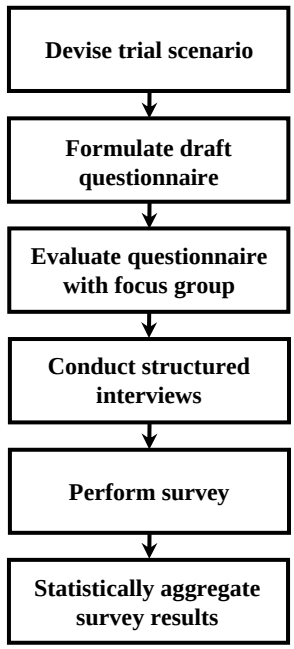
For this experiment, a scenario consisting of a simple meeting engagement of two division-sized armored forces on featureless terrain under good weather conditions during daylight was designed. Three variants of this scenario were then explored:



The baseline scenario for the objective referent experiment consisted of a simple meeting engagement.

- *Direct fire only* – the forces engaged with only their direct fire weapons
- *Direct fire and mortars* – the forces used mortars organic to their units to supplement their direct fire assets
- *Direct fire, mortars and artillery* – the forces employed field artillery to supplement their mortars and direct fire assets.

This experiment followed a conventional survey research regimen for constructing the questionnaire to sample SME opinion on the conditions and outcomes of this scenario. This regimen involved drafting an initial questionnaire then vetting it in a focus group of SMEs. The information collected from this focus group enabled the construction of a detailed questionnaire that was exposed to a set of SMEs in structured interviews. These interviews improved the quality of the questionnaire, but also increased the number of questions to 162 for a single scenario involving direct-fire-only with two variants (i.e., direct fire + organic mortars, direct fire + organic mortars + field artillery).



The experiment used standard survey regimen to construct and administer the ground combat referent survey.

This technique for building simulation referents from SME knowledge has several advantages over current techniques:

- **It reduces the subjectivity commonly encountered when employing SMEs for simulation validation.**
- **It reinterprets disparities and disagreements between individual SME opinions as statistical variations due to uncertainty thus turning these problems into explicit measures associated with the referent.**
- **It quantifies the referent's uncertainty and incorporates that into the validation process.**
- **It provides a means to quantify the contributions of any error sources that affect the referent knowledge.**
- **It applies well understood statistical techniques to treating the referent data thus improving the credibility of the validation results.**
- **It quantitatively identifies the boundaries of significance in comparisons of the simulation results against the referent and, in doing so, it creates measures of confidence of their agreement to support simulation accreditation decisions.**

The questionnaire was then distributed to an SME sample. Seven individuals responded. The means, standard deviations, skews and kurtoses of several key outcomes of the battle were characterized (the table on the previous page gives some of these results). The respondents' backgrounds were broad and directly relevant to the ground combat scenario.

Several significant lessons were learned from this experiment. Most importantly, that SMEs must be queried at a higher level of abstraction to reduce the questionnaire burden, to improve the precision of the results, and to generate a more broadly applicable referent (i.e., not limited to a single narrow scenario). Also, that there is value in following the wisdom from the survey research community for constructing questions and questionnaires.

In summary, this technique uses SMEs only as sources of referent knowledge and extracts the uncertainty associated with that referent from the variance in the SME predictions. It can then statistically compare simulation results against both the mean predictions and the uncertainty associated with those predictions. This statistical treatment permits estimating the confidence with which the simulation results agree with the referent.