TECHNICAL
REPORT

Enhancing Strategic Planning with Massive Scenario Generation

Theory and Experiments

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RAND NATIONAL SECURITY RESEARCH DIVISION

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Summary

A general problem in strategic planning is that planning should be informed by a sense of what may lie ahead—not only the obvious possibilities that are already in mind, but also a myriad of other possibilities that may not have been recognized, or at least may not have been understood and taken seriously. Various techniques, including brainstorming sessions and human gaming, have long been used to raise effective awareness of possibilities. Model-based analysis has also been used and, over the last decade, has been used to explore sizable numbers of possible scenarios. This report extends that research markedly, with what can be called massive scenario generation (MSG). Doing MSG well, as it turns out, requires a conceptual framework, a great deal of technical and analytical thinking, and—as in other forms of scientific inquiry—experimentation. This report describes our recent progress on both theory and experimentation. In particular, it suggests ways to combine the virtues of human-intensive and model-intensive exploration of "the possibility space."

Vision: What MSG Might Accomplish

MSG has the potential to improve planning in at least three ways: intellectual, pragmatic, and experiential. Intellectually, MSG should expand the scope of what is recognized as possible developments, provide an understanding of how those developments might come about, and help identify aspects of the world that should be studied more carefully, tested, or monitored. Pragmatically, MSG should assist planners by enriching their mental library of the "patterns" used to guide reasoning and action at the time of crisis or decision, and it should also help them identify anomalous situations requiring unusual actions. MSG should facilitate development of flexible, adaptive, and robust (FAR) strategies that are better able to deal with uncertainty and surprises than strategies based on narrow assumptions. As a practical matter, MSG should also identify crucial issues worthy of testing or experimentation in games or other venues. And, in some cases, it should suggest ways to design mission rehearsals so as to better prepare those executing operational missions. At the experiential level, if MSG can be built into training, education, research, and socialization exercises, it should leave participants with a wider and better sense of the possible, while developing skill at problem-solving in situations other than those of the "best estimate."

The Challenge and Related Needs

It is one thing to have a vision of what MSG might be good for; it is quite another to define what it means, what is necessary for it to be effective, and how it can be accomplished. Such definition will require considerable work over a period of years, but our initial research, described here, provides direction, numerous technical and analytical suggestions, and better-posed problems for that future work.

The Need for Models of a Different Kind

The value of MSG for strategic analysis depends on whether the scenarios that are generated are meaningful and understandable. There is little value in a magical machine that spews out scenarios that are merely descriptions of some possible state of the world; we need to be able to understand how such developments might occur and what their implications might be. In practice, this leads to the need to generate scenarios with a model that can provide the necessary structure and explanation. A dilemma, however, is that models often restrict the scope of thinking—the exact opposite of what is intended here—because they represent particular views of the world and reflect a great many dubious assumptions. Another problem is that in strategic analysis it is often necessary to begin work without the benefit of even a good prior model.

Metrics for Evaluating Methods of MSG

Because of such issues, we suggest that the virtues of a particular approach to MSG can be measured against four metrics: not needing a good initial model; the dimensionality of the possibility space considered; the degree of exploration of that space; and the quality of resulting knowledge.

Two Experiments

With these metrics in mind, we conducted two MSG experiments for contrasting cases. The first case began with a reasonable but untested analytical model, one describing the rise and fall of Islamist extremism in epidemiological terms and relating results to hypothetical policy actions and numerous other parameters. The second case began without an analytical model, but with a thoughtful list (provided by another study) of the conditions that might characterize and distinguish among circumstances at the time of the next nuclear use (NNU). Such a list of conditions might have been developed by, for example, a political scientist writing a thoughtful essay or a strategic-planning exercise in which a number of experts brainstorm about the NNU. The two experiments with MSG therefore covered very different cases, the first having advantages for ultimate knowledge and exploration and the second having the advantage of not requiring an initial model.

In the first experiment, we discovered how inadequate the usual approach to modeling is for the purposes of MSG. The initial analytical model was quite reasonable by most standards, but it omitted discussion of factors that, in the real world, might dominate the problem. This was hardly unusual, since ordinary modeling tends to gravitate toward idealizations, which have many virtues. Nonetheless, in our application, we had to amend the model substantially.

In particular, and despite our aversion to introducing stochastic processes that often serve merely to make models more complicated and data demands more extensive, we concluded that "exogenous" world events, which are arguably somewhat random, could have large effects on the rise or decline of Islamist extremism. Thus, we allowed for such events. We also recognized that well-intended policies to combat extremism are often beset by the possibility of their proving to be counterproductive. That is, in the real world, we often do not even know the *direction* of the arrow in an influence diagram! The result of our enhancements was to construct a highly parameterized model that also allowed for deep uncertainties about external events and when they might occur, and for deep uncertainties about the effectiveness of possible policies. The resulting MSG generated a much richer and more insightful set of possible scenarios than would otherwise have been obtained. Although our analysis was merely illustrative, as part of an experiment on MSG, we concluded that the insights from it were both interesting and nontrivial—enough, certainly, to support the belief that MSG can prove quite fruitful.

Our second experiment, on the NNU, required even more iteration and contemplation because the structure that we began with was "static," a set of possible situational attributes. This proved inadequate to the purposes of MSG, and we concluded that the appropriate approach from such a starting point was to construct quickly the sketch of a dynamic system model, even though not enough time was available to do so well. Once a relevant system-level "influence diagram" had been sketched, we could move to a first-cut dynamic model that was capable of both generating diverse scenarios and providing enough context and history to enable the scenarios to be more like significant causal stories. As in our first experiment, we found ourselves dissatisfied with the initial notions of influence and causality because they were far too certain to be realistic. Thus, we developed techniques that varied the directions and magnitudes of the postulated influences, while also filtering out some of those we considered to be impossible or beyond the pale. Any such filtering, of course, had to be done with caution because of the concern that applying apparently reasonable filtering could in fact eliminate possibilities that should be considered. In any case, having done the first-cut system modeling and introduced the uncertainties of influence and magnitude, we found that MSG produced "data" that included interesting scenarios that would not usually be considered and plausible insights that could affect strategy development. Although we were merely experimenting and would not want to exaggerate the real-world significance or credibility of the experiment's outcome, our conclusion—in contradiction to our initial thinking—was that the method showed significant promise. The key, however, was to recognize the importance of constructing a model early on, even if it could be only at the level of influence diagrams and initial rules of thumb. Taking that step changes the entire direction of scenario generation and provides a core that can be enriched iteratively through hard thinking, brainstorming, gaming, and other mechanisms.

Methods for Interpreting Results of MSG

A major part of our work consisted of experimenting with a variety of methods and tools for interpreting and making sense of the "data" arising from MSG. It is one thing to generate thousands or even tens of thousands of scenarios, but then what? In this study we used four primary methods: (1) ordinary linear sensitivity analysis, (2) a generalization using analystinspired "aggregation fragments," (3) some advanced "filtering" methods drawing on data-mining and machine-learning methods, and (4) *motivated metamodeling*. The first three methods were particularly useful for identifying which parameters potentially had the most effect on scenario outcomes, a prerequisite for developing good visualizations. The fourth method involved looking for an analytical "model of the model" (a metamodel) that would provide a relatively simple explanation for scenario outcomes. Motivated metamodeling applies standard statistical machinery to analyze data but starts with a hypothesized analytical structure motivated by an understanding of the subject area.

Tools for Visualizing and Interpreting Results

We used two primary tools, those of the Analytica® modeling system and those of the CARs® system, which can generate scenarios using various models and then help in analysis of the results with many statistical techniques, such as the filters mentioned above. CARs also has good visualization capabilities and can deal with very large numbers of scenarios (we routinely generated tens of thousands). One goal of our work with these tools (primarily CARs) was to find ways to use visualization methods to extract "signal from noise" in analyzing outcomes from MSG. We drew on much past work in doing so, but the challenges in the current effort were new in many respects. As discussed in the text of the report, we were heartened by the results and concluded that the tools have substantial potential. Pursuing that potential will be exciting new research.