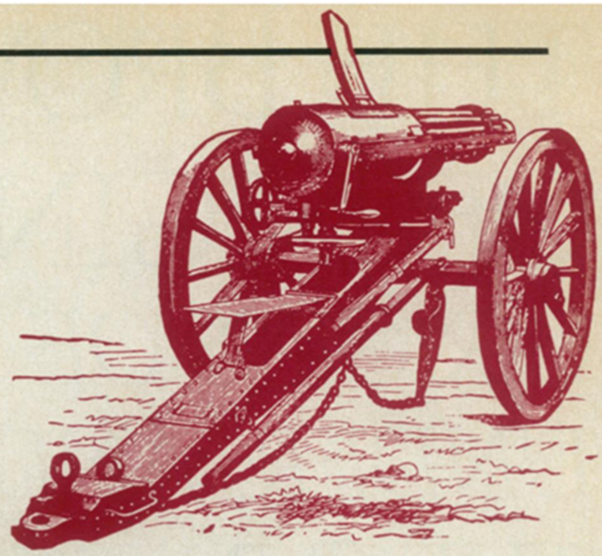
The Chaos of War



"The nations were caught in a trap, a trap made during the first thirty days out of battles that failed to be decisive, a trap from which there was, and has been, no exit." — Barbara Tuchman, The Guns of August

The months before the start of World War I — a conflict eventually triggered by "some damned foolish thing in the Balkans," as German Chancellor Otto von Bismarck had predicted decades before — saw desperate attempts by the nations of Europe to draw back from the apparent inevitability of a major war. But by that time, it was already too late. The inexorable steps toward war had been taken.

This image of nations unable to control their own destinies and the loss of predictability in the period before a war made a powerful impression on Alvin M. Saperstein, a physicist at Wayne State University in Detroit. It was one of the ideas that led him last year to suggest that "war be viewed as a breakdown in predictability: a situation in which small perturbations of initial conditions, such as malfunctions of early-warning radar systems or irrational acts of individuals disobeying orders, lead to large unforeseen changes."

Predictability and control are lost at the threshold between peace and war, Saperstein contends, just as they are lost when a smoothly flowing stream of water breaks up into a chaotic state of shifting eddies and swirling whirlpools. This analogy between war and turbulent fluid flow suggests that the mathematical ideas and equations now being used to describe the development of chaos in physical systems (SN: 7/30/83, p. 76) may provide useful models for the steps leading to war.

Mathematical models are not new to political science. More than 20 years ago, L. F. Richardson, for instance, developed simple mathematical expressions (a pair of coupled, first-order, linear differential equations) to represent an arms race between two competing states. His model included such variables as expenditure on arms, percentage of population in the military and so on. The solutions to these equations, which describe the stability of the situation as an arms race develops, are highly predictable. Changing the initial conditions slightly will have only a small effect on the answers.

In contrast, the nonlinear differential equations of fluid dynamics produce solutions that represent either smooth flow (predictable behavior) or turbulent flow (chaotic, unpredictable behavior). The nature of the flow changes from smooth to turbulent when some parameter increases beyond a certain critical value. Says Saperstein, "Any single model of an arms race between nations should include regions of predictable behavior, regions of chaos and transitions between such regions."

Developing and solving the appropriate equations, however, is no simple matter. And systems of nonlinear equations are notoriously difficult to solve, often requiring hours of computer time. For his paper in the May 24 NATURE, Saperstein was content to come up with a crude, rather simplistic model for a two-party arms race to illustrate the principles involved. When the editor at NATURE asked for sample numbers, Saperstein plugged in what scanty data he could find for the arms races before World War II and showed that, according to his model, the German-Soviet arms race fell in the chaotic region while that between Germany and France was very close to the transition zone. The current arms race between the United States and the Soviet Union lies within the stable region of his model.

These results don't really mean anything, says Saperstein, because his equations are so unrealistic. Nevertheless, more sophisticated future versions could provide useful "flags of warning," he says. "You may not be able to predict when or where such a transition [from a stable to a chaotic state] will occur, but at least knowing that such a transition is possible should make you a lot more humble about feeling that you can guide things, predict things.

"I'm suspicious of models in terms of actual numbers," Saperstein adds, "but at the same time I recognize that with sufficient work, you can come up with useful models." And whether you like it or not, planners and strategists at the Pentagon, universities and elsewhere often use such models, he says.

Saperstein hopes that his paper and ideas will provide an incentive for further research. "I think the idea of a transition from laminar to turbulent flow or, if you will, from predictable international relations to chaotic international relations is important," he says. Saperstein is now trying to improve his model.

"It's a legitimate, honest and quite useful effort," says Joseph Ford, chaos theory guru and a physicist at the Georgia Institute of Technology in Atlanta. "For the most part, we have played with differential equations that gave you behavior like a pendulum or like a solar system — ones that were very ordered, very happy and friendly," he says. "What we're finding out is that most of, say, Newtonian dynamics is not that way." Turbulence or chaos play an important role. Such concepts could be relevant to questions of peace and war.

"Given a lot of people working on it and a lot of time, it's conceivable that the models could begin to approximate national behavior," says Saperstein. "Then you might be able to get some idea as to where the transitions are going to occur. Of course, the policy would be to stay away from there." — *Ivars Peterson*