

# Using System Dynamics (SD) to Introduce Artificial Intelligence (AI) to the Operational Environment: Lessons from government research and development (R&D)

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**Abstract:** Complex System Dynamics (SD) and other types of Modeling and Simulation (M&S) methods can support the introduction of Artificial Intelligence (AI) to address technical and analysis gaps for proposed real-world operational systems. This presentation reviews four types of SD models to identify opportunities to introduce AI. As an SD introduction, the presentation begins with a population biology example of wolf reintroduction to Yellowstone, which presents the three key aspects of SD complexity: feedback, stock-flow (integration), and nonlinearity, each of which confounds human decision making, but together make complex system nonintuitive.

The presentation then covers three different types of SD models that have been constructed with government Research and Development (R&D) to address complex problem domains of interest to the US government, which are these: 1) technical systems and systems of systems, 2) socio-technical and political, military, and economic systems; and 3) supply chain and logistics systems. For each of these systems, an initial, early attempt is shown with a subsequent, more sophisticated implementation that incorporates the learning and insights gained from creating the first model.

Reviewing these three classes of models reveals three AI opportunities. First, there are opportunities to transition these models into an enterprise system. Usually, such systems are addressed initially with data and a Graphical User Interface (GUI), but experience shows that this significantly hampers model creation as the data provided may not be adequate for the necessary models, and the resulting model outputs may not match up to the envisioned GUI functionality. Instead, leading with model development and then collecting data and designing GUIs may be the preferred approach.

Second, SD experts can build models by hand, but such expertise is rare and expensive. With enterprise software, creating modules, templates, or design patterns for a problem domain that can be instantiated and composed by non-expert analysts to address specific problems remains an ongoing opportunity that can potentially be addressed with AI.

Third, traditional forms of model Verification, Validation, and Accreditation (VV&A) can never prove that a model is correct for all envisioned use cases. Instead, SD VV&A proposes a set of tests that cover a range of use cases, each of which improves model quality. Finally, the presentation concludes with a range of resources and insights that may prove useful for SD practitioners addressing similar research questions.