FIDELITY VERSUS COST
AND ITS EFFECT ON MODELING & SIMULATION

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Abstract:

In both the private sector and government organizations, pressure is continuously applied to the work force to produce “better, faster, and cheaper.” “Cheaper,” or more professionally stated as reduction of expenditures, is my focus and its effect of the end product and its customers, or users.

The Modeling & Simulation world is not immune to rising costs and reduced budgets. Included in the applications of Models and Simulations are training, analysis, experimentation, and acquisition. Each of these applications can be adversely affected by poor fidelity. In some cases cost may be either the culprit or contribute to the problem. Questions we must answer are: “Is the resultant simulation ‘good enough’ to meet the customer’s need?” Assuming that the simulation is “good enough,” the following need to be considered: “Is the customer satisfied with the simulation?” “Even if the simulation is accurate but some features are missing, will the end user trust the simulation?”

Another area of concern is safety. The fidelity of an aircraft simulator comes to mind. If the fidelity is poor, will the pilot, air crew, and their families suffer due to poor training? We may be forced to reduce fidelity in order to save money or meet a budget. In some cases the trade-off is insignificant while in others the result cannot be conveyed in currency.

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Take for instance the following comparison:

The fidelity of a model or simulation can affect the intended end user's understanding of the real world entity being simulated. In turn, this understanding can affect the end user's performance when taking the controls of the real world entity for which he/she were training. Consequences of poor fidelity can range from insignificant to catastrophic. Using the example between an ejection seat simulator and an aircraft simulator can help to display the difference. From experience, an ejection seat simulator teaches the trainee the ejection procedure which is the same for nearly all ejection seat aircraft. Differences do exist between ejection seats; however one trainer can be used for nearly all types of ejection seats. Next, let's consider the case of an aircraft simulator. A similar scenario as the one above can be considered, this time referencing the internal turbine temperature of a turbo-prop engine. Once airborne, if the indications are not the same as the flight simulator, the pilot cannot simply stop the aircraft and exit as in an automobile. The pilot is faced with a potential life threatening situation for he/she and his/her crew. While both scenarios face safety risks, the latter has the potential for a more catastrophic outcome.

This paper will explore the sacrifices in fidelity of simulations due to cost restrictions and their potential impact upon the end user.

Fidelity:

Fidelity, as defined by the Simulation Interoperability Workshop (SIW) Integration Study Group (ISG), is "The degree to which a model or simulation reproduces the state and behavior of a real world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner." [2] Fidelity is also considered to be an absolute measure of M&S representational closeness to reality as compared to validity, which is considered to be a judgment.[3] The following quote has a great deal of insight:

"all models are wrong, but some models are useful"
- AGARD Aerospace Medical Panel, 1998

With the above quote in mind, we can deduce that a perfect simulation is impossible to achieve, therefore measuring fidelity is essential as a metric to determining the usefulness of a model or simulation. A multitude of methods to measure fidelity exist; some quantitative while others are qualitative.

Qualitative descriptions are inevitable to human nature and unavoidable. In fact, they do have usefulness because perception to the target audience is reality unless proven otherwise. And then, human nature may still not be convinced. Qualitative descriptions include: high, medium, and low. What do these terms really mean? They may mean different thing to different end users, thus they are primarily human perceptions.

Quantitative descriptions and metrics are normally ignored because they are difficult to determine. Difficult questions to resolve include: What is most important to the simulation? Do all aspects need to be of equal fidelity? Will less fidelity in some areas affect the end user's perception of the simulation? All are difficult to answer without extensive studies and data collection. While we are not focusing upon these questions in this paper, actions taken in response to these questions when creating a simulation can affect the cost of the simulation, thus a tie between cost and fidelity is real.

Cost:

When discussing cost one normally thinks of a monetary value. Cost can also come in the form of human life especially when the model and simulation affects the safety aspects of the simuland. Cost , in most cases, increases in representational fidelity are coincident with increased development costs.[4] While considering the degree to which fidelity is "good enough" for the end user, the modeling and simulation team must consider the cost of this increased fidelity and the risk associated with the end user with a reduction in the amount of fidelity.[6]

Much of the cost of state-of-the-art flight simulators are driven by capabilities such as the fidelity of the graphics, the availability of motion-sensors, networking options as well as other features available.[5] This prevents most organizations, including flight schools, other than government organizations from purchasing high fidelity simulators.[5]

Flight simulators are not the only simulator types affected by cost versus fidelity issues. A Landing Craft Air Cushioned (LCAC) vehicle simulator in San Diego cost the Navy $29 million. Mike Coligny, chief executive officer of Flyit Simulators in San Diego felt that 70% of the $29 million simulator could be provided for approximately $200,000.[7] In this case, 70% does not reflect 70% fidelity. Hypothetically, let us assume the $29 million simulator realized 95% fidelity. The alternative simulator would have represented 66.5% fidelity. Thus the additional 28.5% cost $28.8 million. This translates to over $1 million per percent of increased fidelity as compared to $3007 per percent fidelity of the less expensive simulation.

A graphical representation of the fidelity versus cost dilemma is seen in figure 1:

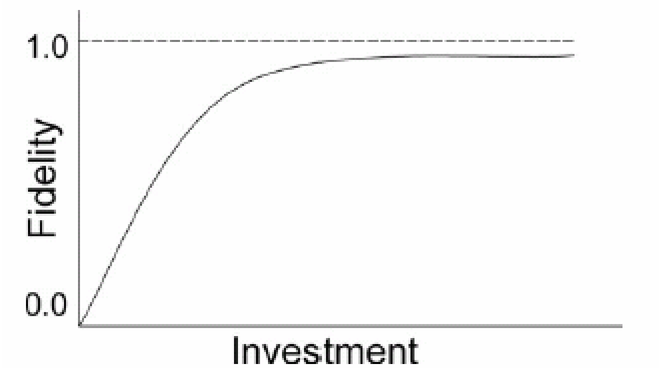

Figure 1: Fidelity is the Degree to Which a Model Reproduces a Referent as Modified from Gross et al. 1999

Most likely one can expect diminishing returns at some point in the model and/or simulation development. Deciding where this point exists is determined by the modeler and/or the M&S team.

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