KEEL® Technology

in support of

Mission Planning and Execution

delivering

Adaptive Command and Control

Compsim White Paper

Objective: Mission Planning Objectives: Mission Planning requires a continuous evaluation of the battlespace (Maritime, Land, Air, Space, Information, Electromagnetic, and Time) balancing competing objectives, while continuously coordinating, synchronizing, and prioritizing activities to support the Field Commander in deployment of Force Elements.

Information drives Mission Planning activities. Without information, Mission Planning cannot be performed with any hope of success. Mission Planning Software is developed to capture information in order to 1) display the battlespace for Situational Awareness and 2) to augment the decision-making process in the pursuit of Mission Goals. In more advanced systems Mission Planning is used to deliver Adaptive Command and Control for Battlespace Management for active field operations. It is also used for testing purposes in a Modeling and Simulation (M&S) or Live, Virtual, Constructive (LVC) environment prior to deployment in order to evaluate risks or develop and test new tactics and strategies.

This paper separates Mission Planning Software into two domains:

1. Rendering of the area of operation (Providing a high level graphical view of the area of operation)
2. Decision-making (Operational Policy Development, Testing, Executing, and Auditing)

This paper focuses on the decision-making component (#2) with the use of Knowledge Enhanced Electronic logic (KEEL) Technology, and not on creating a picture of the area of operation (#1).

Why KEEL for Mission Planning and Execution:

- Better Decisions (with higher fidelity understanding of the problem space)
- Better Actions (with higher fidelity control)
- Create and Test "Adaptive Plans" (to account for change)
- More Rapid Decisions and Actions (at computer-speed not human-speed)
- More Rapid Operational Policy Development and Test (with a visible value system)

- Eliminate "coding errors" (auto-generated code)
- 100% explainable and auditable operational policies (mathematically explicit)
- Plans executable by machines (and understandable by humans)
- EASY to learn
- EASY to apply
- EASY to deploy
- EASY to audit
- EASY to extend
- Platform and Architecture independent (NO dependencies)

KEEL Technology and Mission Planning: In its simplest form, Mission Planning is the process of evaluating information in the form of risks (threats) and rewards (opportunities) to most appropriately allocate valued resources to achieve measured goals. This definition is applicable from the executive level down to the warfighter in the field.

If you cannot measure it, you don't understand it!

If you cannot measure it, you cannot fix it!

One might suggest that the amount and quality of training and experience that a human has been exposed to, along with the quality of the presentation of information describing the field of operation, will dictate the success of the planning activity. However, in the fog of war, things happen fast. And large volumes of changing information can overwhelm human capacity. And, as the field of operation redefines itself at Internet speeds, there is no way human-in-the-loop systems can survive. This requires automating the Mission Planning function, which will, in turn, have to be integrated with the Mission Execution function so that the forces can self-organize in real-time. This is the domain of KEEL Technology.

KEEL Technology: KEEL was developed to address complex (dynamic, non-linear, inter-related, multi-dimensional) problem sets. There are two primary components of KEEL Technology: 1) The KEEL cognitive processing model that is delivered as KEEL "Cognitive Engines" that provide human-like judgment and reasoning. 2) The KEEL Dynamic Graphical Language that makes it easy to create and test operational policies.

Concepts: Mission Planning requires the interpretation of valued information. Human-driven mission planning requires the planner to interpret the valued information and understand how pieces of information influence a decision or action. Options, sometimes independent and sometimes not, are balanced against other options (strategies and tactics). Resources are allocated. Multiple actions may be simultaneously deployed. There are never sufficient resources to do everything. Alternatives are balanced to achieve the best overall outcome. Then, once deployed and when things don't go as expected, the mission aborts, is redefined, or starts over again.

When the mission is planned by humans, individual impressions and perceptions drive the decisions and actions. It is impossible to look inside the human mind to see the value system used by the human in making decisions. Every human will evaluate every situation somewhat differently.

Figure 1
KEEL Dynamic Graphical Language
(See and Interact with the Value System)

Interactive Rendering

KEEL-based Operational Policies: Mission Planning with KEEL Technology is not focusing on any particular mission. With KEEL, one is capturing "how to think", or how to interpret complex information sets. The KEEL DGL allows the policy maker to visualize the value system and to see how valued information is integrated to influence the decision or action.

Calculus is defined as a method of defining functional relationships between data items. The KEEL Dynamic Graphical Language does the same thing, but without the learning curve, and without the necessity of mentally translating judgmental values into numbers. The visual nature of the KEEL Dynamic Graphical Language allows the policy maker to "see values" and "see the impact of functional relationships". The dynamic nature of the Dynamic Graphical Language allows the policy maker to "see the impact of changing information" and "see how information influences the behavior of the policy". This makes the development of complex information fusion models far easier (and far faster) than using higher level mathematics.

We would suggest that humans (mission planners) develop plans that are comprised of combinations of three types of decisions (information fusion models):
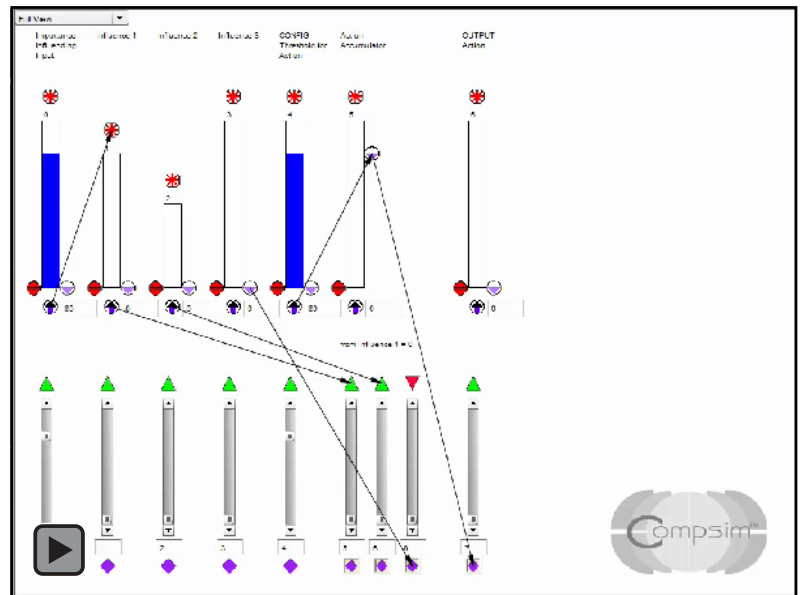
- Go/No-go Decisions (or do something, or refrain from doing something)
- Select from Mutually Exclusive Options
- Allocate Resources across one or many domains

Complex plans (or adaptive command and control) is a combination of these three types of decisions.

Digging deeper into the functional relationships that drive the decisions and actions is the concept of "influencing factors". In complex webs of information relationships, one finds that pieces of information influence other pieces of information in the information fusion process. Among the ways that influencing factors work together are:

- Information can influence the importance of other information fusion points.
- Information can contribute to the interpretation of other information items.

These relationships can be linear or non-linear. With KEEL, all of these relationships are developed without resorting to higher level mathematics or complex low-level programming.

KEEL is Component Technology: The policy maker (using KEEL) develops the information fusion model and then, using the KEEL Toolkit, auto-generates conventional code in the user's programming language of choice. The software component code is delivered as a text file that is then copied and pasted into the user's development environment where the Mission Planning System application is compiled.

KEEL Value Proposition: In many cases it may be appropriate to test the KEEL-based operational policy in a simulation before deploying it for production in the field. It may be that the M&S environment is different than the production environment. This is no issue for KEEL because the same operational model can be delivered in another language, with just the click of a button. KEEL Engine "code" is auto-generated.

Testing a KEEL-based policy in a simulated environment is helpful to identify problems with the policy as it is being developed. While it is possible to test the KEEL-based policy within the KEEL Toolkit, additional testing can be accomplished in the M&S environment. An additional service, built into the KEEL Toolkit is a service called "Language Animation" which allows real-world information to drive the Dynamic Graphical Language. This way the user can "watch the system think." By this, we mean that the user can see how valued information propagates through the system to drive the decisions and actions.

When operational Mission Planning Software applications are delivered to the field, it is often helpful to be able to explain the decisions and actions. However, maybe more important is the ability to explain why other decisions may not be the best decisions. This may be helpful if the Mission Planning Software is supporting human planners.

KEEL Operational Policy Development Process: One would not expect to create and deliver all planning / operational decisions at one sitting. As with human systems, there is likely to be a hierarchy of information fusion models, just as a human organization is made up of humans with different fields of expertise. One would expect a user to model decisions and actions through some kind of prioritized process. When delivering a solution, one integrates multiple KEEL Engines in a similar way that one organizes a team of experts. The system designer architect defines when and how often the KEEL Engines exchange information, just like the manager of an organization. A KEEL Function Block Tool, can assist in the integration process.

Summary: KEEL Technology is platform and architecture independent component technology that can be used to plan and test mission plans, KEEL has an added benefit that those same policies can be executed by machines and support mission planning at Internet speeds; and ultimately where the policies can be distributed up and down the command and control hierarchy. KEEL is proprietary technology that is covered by granted and pending US patents. KEEL Engines have a very simple API allowing them to be used in new or existing applications. KEEL-based policies incorporated in KEEL Engines can "adapt". The level of adaptability is under the control of the policy maker. The behavior of KEEL Engines is "explicit". It is not the result of interpolation between taught patterns. KEEL has been granted EAR-99 status by Department of Commerce.