Mapping the Mountains: A Survey of Cognitive Engineering Methods and Uses

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The field of Cognitive Engineering has produced numerous methods for numerous uses. We performed a comprehensive survey of this landscape to identity those methods that are best suited to various phases of the System Engineering design process. Our product is a matrix of methods (rows) versus uses (columns) highlighting those cells that appear to offer the highest opportunity. These cells are the mountains in our mapping.

We group the methods of Cognitive Engineering into broad categories according to their intended purpose, i.e., (1) Describing Cognitive/Behavioral Processes, (2) Modeling/Simulating Cognitive Processes, (3) Modeling/Simulating Behavioral Processes, (4) Modeling Erroneous Actions and (5) Modeling Human-Machine Systems. Each of these broad categories includes more narrow classes of methods, e.g., in the category of "Modeling/Simulating Cognitive Processes" we include "Knowledge Elicitation" [1], "Cognitive Task Analysis" [2] and "Computational Cognitive Modeling" [3]. Each class then includes specific methods, e.g., in the class of "Cognitive Task Analysis" we include "Applied Cognitive Task Analysis", "Critical Decision Method", "Precursor, Action, Result and Interpretation Method" and others. The specific methods, of which we enumerate over one hundred, are displayed in the rows of our matrix. For each method, we provide a summary description and detailed citations in a web based format [4].

The columns of our matrix display the following phases of the System Engineering process [5]: "Concept Definition", "Requirements Analysis", "Function Analysis", "Function Allocation", "Task Design", "Interface and Team Development", "Performance, Workload and Training Estimation", "Requirements Review", "Personnel Selection", "Training Development", "Performance Assurance" and "Problem Investigation".

Our product is a matrix that maps methods of Cognitive Engineering to uses in System Engineering. For each cell of this matrix, we assess the applicability of a specific method (row) to a specific problem (column) based on our review of the cited literature. The main criterion used in our assessment is: How well does (can) the specific Cognitive Engineering method address a specific System Engineering problem?

Armed with this survey, our objective is to inject more Cognitive Engineering into System Engineering at MITRE's Center for Air Force Command and Control. The matrix helps by relating the methods of Cognitive Engineering, which are commonly employed in the study of Naturalistic Decision Making, to the problems of System Engineering in Command and Control applications. Thus, rather than a new "method", our contribution is a new "matrix" that illustrates where existing methods can best be applied to improve the system design process.

References

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[4] MITRE (2003). Center for Air Force Command and Control. Mental Models in Naturalistic Decision Making. http://mentalmodels.mitre.org

[5] Office of Naval Research, Science and Technology Manning Affordability Initiative. http://www.manningaffordability.com/