Plan Understanding and Mission Assessment (PUMA): An Interactive Decision Support System for Autonomous Unmanned Vehicle Mission Management

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SIFT, LLC and the University of Virginia (UVA) have developed a decision support system, Plan Understanding and Mission Analysis (PUMA), which supports users in planning operations in advance of missions, monitoring missions in process, and replanning in-process missions to adapt to changing events. The main user interface component is a decision grid that presents multiple plan alternatives together on one screen, allowing operators to see at a glance how the plans differ on resource assignments, objectives satisfied, etc. The decision grid builds on the decision matrix system for resource assignments developed earlier at UVA, but extends it to complex missions with hierarchical tasks and objectives performed by teams of heterogeneous UVs, operating autonomously. Previous decision matrix software supported users in resource allocation (and reallocation) tasks, but was not adequate to the assessment of automatically generated replans for complex missions performed by highly capable and flexible systems like the UVs now coming into operation. Advanced autonomy software typically uses constraint satisfaction and/or constrained optimization algorithms to plan and adapt missions. Operators supervising such systems often have trouble determining the state of the automation, the state of the process being controlled, or how changes to state or automation parameters will affect performance. The decision grid uses a matrix format with mini time-bar symbols within cells, color-coding, and details on demand to indicate the relationships between a plan alternative and the constraints and objectives that have shaped that plan. PUMA allows users to evaluate the quality of alternative plans with a minimum of cognitive effort and a minimum of navigation actions, by depicting key aspects of plans in close proximity and by yoking together different interface elements. PUMA builds on research in human factors and psychophysics to utilize elements that minimize cognitive workload while amplifying the sensory and cognitive capabilities.

We have developed a challenging scenario involving multiple plan alternatives, as would be generated by autonomy software, and used this to guide our development and to support user evaluations. In this scenario, a number of unmanned surface vessels, submersibles, and aircraft carry out multiple sorties in pursuit of complex ISR and targeting objectives, and ancillary communications relay tasks. A new event (the departure from port of a suspicious cargo vessel) triggers the need to replan. The situation is over-constrained: not all objectives can be fully satisfied. Multiple alternatives are generated by the (stubbed) autonomy planning software, and the operator must compare and evaluate these alternatives preparatory to choosing one. The alternatives are not simply quantitatively different, one better than another, but *qualitatively* different, because they satisfy different subsets of the objectives using different resource allocations. We conducted two preliminary user evaluations with Navy personnel of early mockups of the user interface design and then implemented the final design to demonstrate an interactive, running version of the interface for this scenario.

We will present the design and modifications in a presentation as well as demonstrate the software during the demonstration session.