ALFUS Workshop #5 Notes and Discussions

May 3-4, 2004, Amerisuites Atlanta Airport South Hotel, Atlanta, GA

1. FCS presentations and Discussions

In its first workshop, ALFUS planned for FCS to be its first concern. This workshop, ALFUS #5, was the first meeting that LSI and its contractors were invited.

The presentations given by Tom Adams and Glenn Rolader of LSI indicated that the program is interested in technology transfer, leveraging government technology, and facilitating industry participation. They stress sharable, common technology, such as common platforms and components. For example, SOSCOE specifies a common middleware. Interoperability and net-centric architecture are among the key features in the program.

Glenn Rolader and Charlie Bishop presented the ANS perspective of levels of autonomy. There is a levels of autonomy chart in place, which could use enhancement in terms of measurability, testability, and coverage. For example,

- autonomy levels may be expressed in a vector format for the various system aspects as opposed to a linear format;
- autonomy levels need to cover a wide range of tactical behaviors beyond mobility;
- task complexity and environmental difficulty must be considered.

All of these are consistent with the ALFUS concepts, fit well with the objectives of ALFUS, and could be the focal points for applying the ALFUS results. The ALFUS results should be presented in such formats as metrics and process and not as specification or constraints.

Commonly acknowledged, unresolved issues include whether higher levels of autonomy encompass requirements or capabilities identified for lower autonomy levels. Needs for a test and evaluation method and facility for autonomy levels (NUSE2?).

This ALFUS-FCS model or process, once successful, could be used as a reference for the ALFUS results to be applied to other ongoing programs that may have existent contractual constraints on autonomy levels.

The issue of an exit strategy/major milestone was discussed. In the inaugural workshop, it was decided that, while the first concern should be FCS, the overall scope of ALFUS would be open and generic. Therefore, a conclusion was for us to generate an “exit strategy” for the FCS collaboration portion of the ALFUS workshop series. Charlie Bishop volunteered to help drafting this statement, which could include such items as process and metrics leading toward testability of the existent ANS autonomy level chart and addressing autonomy concerns in other FCS aspects. After the milestone has been accomplished, the participants (general industry practitioners should be invited by then) are to decide the direction, including whether to pursue a next use case, DoT intelligent transportation systems, UCAR, etc.

2. Scenarios

Kerry Pavek presented an operational scenario. The missions involve maneuver and assault, mounted and dismounted, performed by a Company (2 MCS platoons and 1 Infantry platoon). The mission subtasks were clearly articulated, making the scenario easily analyzable and applicable.

The ALFUS objective was to collect a series of scenarios as a part of the envisioned test suite. So far, we have collected two other scenarios, one on autonomous lawn mower (non

DOD), also contributed by Kerry, and a UCAR scenario contributed by Dennis Overstreet. Kerry agreed to serve as the ALFUS "scenario czar."

3. Additional Autonomy/Control Presentations and Discussions

Jim Albus presented a method for analyzing the complexity of software systems developed based on the NIST 4D/RCS reference architecture. An analysis for on-road driving behavior was presented. Glenn and Charlie expressed interest in similar analyses for off-road driving as well as in descriptions of the process, as FCS's approach would leverage government technology.

Two additional, very informative presentations: Dave Musliner presented survey results on control architectures, conducted earlier for FCS. Mikel Atkins presented UCAR that uses the ACL to specify autonomy levels. ALFUS interactions might be mutually beneficial.

4. ALFUS Metrics

Updated metrics were presented. Questions and comments generated include:

- Time between interventions, % of time that the robot operates autonomously, and Operator-UMS ratio sounded useful HRI metrics.
- How do the metrics account for the situations when highly capable robots detect and anticipate problems and initiate interactions with humans as opposed to those that force operators to have to deal with unplanned failures only?
- Skill levels affect other metrics, including workload and Operator-UMS ratio (how many UMSs can a skilled operator handle). Some correlations among the metrics seem needed. Skill level requirements should be inversely proportional to autonomy levels.
- People often regard full autonomy as no HRI. To be more specific, ALFUS uses the concept of modes of operation (full/semi autonomous) to reflect the extent of the HRI, meantime, uses all the three axes to handle levels of autonomy.
- Should HRI consider the difficulty/complexity factor, as the other two axes do? One thought is that while control difficulty/complexity might be a factor (push a button vs. latch a switch vs. dexterous manipulation), it should not be confused with environmental difficulty (busy city vs. open and flat terrain) nor mission complexity (RSTA vs. straight line maneuver). Further studies are needed to characterize and coordinate the three types of difficulty/complexity, if they exist at all.
- Difficulty/complexity could be measured with failure rate—how often does the human make errors in performing the task.
- Workload might potentially be characterized with several attributes: complexity of the human task, time to plan for and execute a solution, how many other activities that the human can perform at the same time.
- Would the autonomy level change when the UMS drove with different speeds in the same environmental situation?
- Would linear density of objects, along the course of the vehicle, be a better metric than area density? This might have to do with the mission, which, in turn, determines which objects are of concern.
- There seems to be existent studies or standards (MIL, NATO) on terrain classification or terrain models. Should find out.
- How should the intent of an object be taken into account in an environmental profile?

- It sounds a good idea to use descriptors to capture the focuses of the autonomy levels. The group should take a look at the FCS level descriptors. Sheridan model addresses only a part of the ALFUS HRI aspects and might not be good descriptors for the HRI levels.
- Mission task decomposition could be arbitrary. Army has UTAL that might serve as a reference for the decomposition. Need to find out how comprehensive the UTAL is and how widely it is distributed. A pre-defined task/tactical behavior list (FCS seems to have one) might also help. It is a question whether subsystem/component configurations should be used to further constrain the decomposition, or whether the decomposition should be left independent of the particular configurations.
- Should the collaboration metric along the mission complexity axis consider the following three aspects: with man, with environment, and with other subsystems?
- An issue for the situation awareness metric is variability: how many parameters are needed to characterize a situation and what kind of flexibility can the parameters accommodate for the variations of the situation.
- A possible measure of the planning requirement or capability is the levels of details or fidelity that the planner can provide.
- If and how the criticality factor should be accounted for: mission criticality? Criticality of a particular human action? Similarly, factors of risks, costs, benefits (ref.. NIST 4D/RCS)?
- Autonomy levels could be derived by integrating the metrics but, in some situations, there might be a problem when the process could not be reversed, for example, when level N can not explicitly reflect individual measured values of the metrics.
- It was suggested that the metrics of the ALFUS framework could serve the role of providing testability and measurability to existent autonomy level charts.
- Potential uses of the ALFUS framework results: for PMs to articulate requirements, for users to compare two vehicles, for testing and evaluating vehicle performance, for forming a common reference on autonomy levels, either horizontally among the Services or vertically along the lifecycle chains.
- One can fix one of the axes (e.g., on a certain test course) and compare vehicle performance per the other two axes.
- It is desirable if the metrics could be used to describe autonomy levels at high, conceptual levels of abstraction for high level audiences as well as at detailed, quantified levels of abstraction for technical personnel—ALFUS framework does handle this.
- It is stressed that the ALFUS work is needed and important. Exit strategy is needed. It would be good if we could pursue adoption such as by JTA.

5. Next Workshop

LSI ANS volunteered to host the next meeting. The identified time frames are either the week of July 12 or the week of July 26. Charlie will look into the facility schedule. The location would be Huntsville, AL.

Please contact hui-min.huang@nist.gov for any concerns associated with the content.