



## **Autonomy, Situational Awareness, and the User Interface — Part 2**

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*[Part 1](#) of this series speculated that, contrary to widespread expectations, increased autonomy would make the operation of unmanned systems more difficult, not less. Part 2 explores this hypothesis with David Bruemmer, a well-known authority on autonomy.*

### **Do you trust your robot?**

I voiced some of my concerns to a recognized expert on situational awareness and autonomy, David Bruemmer, Vice President of Research and Development at 5D Robotics, a software company that designs user-friendly, intuitive functionality for unmanned systems. He confirmed my suspicions that increased autonomy doesn't necessarily simplify the operation of unmanned vehicles. Also, he explained that the human operators' inability to manage increased data input wasn't the only stumbling block.

He explained that if appropriate interfaces are not designed, human operators may experience greater frustration and less trust with vehicles as they become more autonomous. The lack of transparency in the robot's motivations can be confusing. For example, telling a user that the robot will follow them doesn't necessarily explain how the user can expect the robot to deal with dynamic obstacles. Will the robot plan its motion in a map (which works well in static environments) or will it emphasize reactive obstacle avoidance (which works well in dynamic environments)? The human does not need to understand how the robot will reason, but the human does need to predict robot behavior at some level.

If we want humans and unmanned systems to work as a team, we need a way for them to develop shared understanding. Bruemmer explained that if we do this successfully, we provide a way for the human and robot to understand and support each other's limitations. Roboticists often try to hide robot limitations. Bruemmer thinks they would do better to state them clearly. These views are also held by Dr. Curtis Nielsen, who works with Bruemmer as the Chief Engineer at 5D. His doctoral dissertation studied the benefit to providing a 3D visual representation that supports shared understanding. Through a collaboration that involved Scott Hartley (another researcher at 5D) and colleagues at the Idaho National Laboratory, a series of experiments indicated that people are more likely to use a low-performing robot which they can predict and understand than a high performing robot which is complex and unpredictable. Research continues at 5D to insure that the benefits of autonomous robot behavior can be achieved without the drawbacks of increased complexity, confusion and distrust.



Bruemmer described an incident, in which the lack of trust hindered the utilization of unmanned vehicles operating in a radioactive environment. The vehicle refused to go through a door, which to the human operators observing by video, looked totally navigable. The human operators repeatedly attempted to manually steer the unmanned vehicle through the door, an action stubbornly resisted by the robot. This kind of “fight for control” characterizes Human Robot Interaction (HRI), when the human is not given an appropriate window into the “mind” of an autonomous robot.

### **The revolution in autonomy will not be televised**

Bruemmer argues that as autonomy increases, we need to change the nature of situational awareness accordingly. In the above example, the “fight for control” ended when the human operators switched from observing videos to using a 3-D abstract rendering of the walls. The abstract graphical display revealed that contrary to the view provided by the video, the door was too small for the robot to enter.

One characteristic of unmanned systems has been the explosion of video capabilities. UAVs have evolved from a single-image capability to 65 independent video feeds. However, as demonstrated by the above story, video is not always the best way of observing. “More the better” is not an iron-clad axiom for situational awareness. Abstract interfaces presenting only minimal data are often necessary for efficient HMI. The “information-rich environment with copious data” must die.

### **Too much information**

In addition to the above incident, Bruemmer cited numerous examples to support his advocacy of reduced-complexity user interfaces. The original radar display was simply a blip on the screen. When aircraft silhouettes and additional information were displayed on the screen, researchers discovered that the performance of radar operators actually declined. In another experiment, tele-operators of unmanned vehicles drove better using only abstract map displays, than they did using both video images and abstract map displays.

These apparently counter-intuitive results can be illustrated by the familiar GPS navigation systems found in many cars. Think of how confusing it would be if video feeds were added to the current mix of maps and verbal prompts. What users really want is less data and more information. This requires careful, artful craftsmanship in the design of both behaviors and interfaces.

Bruemmer has put his theory into practice with his “Real Time Occupancy Change Analysis” solution, which enables robots to detect motion changes of 10 CM in their environment. This is valuable for determining if a new occupant has entered a previously searched house. When a change happens, the robot then sends pixels of “footprints on a map” to a nearby patrol, so



they can investigate. Bruemmer points out that real-time occupancy change analysis removes the need for a user to monitor a 24-hour real-time video feed.

An approach that emphasizes utilization of abstract graphic displays over videos has several important implications. There would be less utilization of bandwidth as well as a lower update rate. Bruemmer estimates that 3-D abstract renderings require 50,000 times less information than live video. Considering how the growth of video feeds has overwhelmed military networks, this would be a welcome change.

### **One size does not fit all**

If video is no longer the default user interface, displays for unmanned system will have to become more application specific. This would require a change on the part of some robot manufacturers, who are trying to produce solutions that are everything to everybody.

“The unmanned systems community tries admirably to develop general purpose robots. The problem is that no one robot can do everything. At 5D we are focusing on portable mission-centric capabilities that can be used across multiple robots and sensors using an interoperable framework,” says Bruemmer.

If we do not use an interoperable framework, mission-centric capabilities could have the unfortunate side-effect of increasing dedicated hardware. If we are to avoid a proliferation of computers, each one committed to a specific application, Defense vendors will have to approach interoperability with the seriousness it deserves. Autonomous systems will need computers that are modular, open-platform, and flexible.

AMREL has taken a step toward computer interoperability with its Flexpedient<sup>®</sup> Solutions. This proprietary design uses swappable Application Modules to run multiple applications on a single computer. AMREL has already demonstrated the capability of a single computer operating different unmanned vehicles.

Just as one falling domino can unleash a cascade effect, one change in a Defense system can trigger a host of others. Increased autonomy causes a demand for increased situational awareness, which increases the data stream, which mandates a refinement in Human-Robot Interaction, which favors abstract mapping displays over videos, which initiate a demand for mission-centric capabilities, which strengthens the need for interoperability. Autonomy for unmanned systems is not the final solution; it's the beginning of the next challenge.