Paper ID: #179

14TH ICCRTS

C2 and Agility

Voice-on-Target: A New Approach to Tactical Networking and Unmanned Systems Control via the Voice Interface to the SA Environment

Track 2: Network and Networking

Eugene Bourakov
Center for Network Innovation and Experimentation
Information Sciences Department
Naval Postgraduate School
ebourako@nps.edu

Dr. Alex Bordetsky
Center for Network Innovation and Experimentation
Information Sciences Department
Naval Postgraduate School
abordets@nps.edu

Introduction

Since 2004 the authors have been actively involved in the innovative Tactical Network Topology (TNT) experimentation program, which the Naval Postgraduate conducts quarterly with the United States Special Operations Command (USSOCOM) to explore emerging agile adaptive tactical networks. One of our first findings was a set of solutions enabling rapid adaptation of broadband wireless networks to the commander's needs, which we have named Network-on-Target (Bordetsky and Bourakov, 2006). According to the Network-on-Target (NoT) operational concept the adaptation starts at the level of the situational awareness interface used by the local commander. When the commander desires to have one of the mobile nodes (operators, vehicles, unmanned platforms) move to a target location which is beyond the current network range, he drags the selected node icon on his display to the target position . In response, the self-aligning robotic antennas autonomously adjust their orientation to establish and support the short-term network links between mobile nodes.

Our subsequent experiments with agile adaptive networking on the move at high-speed and through rugged hazardous terrain (NPS MIO 08-4 After Action Report, 2008) showed significant limitations when using visual representation, i.e. when using computerized viewing of the common operational picture as the main human-computer interface for developing situational awareness and remotely controlling networking robotic nodes.

In operations involving small vessel interdiction at high speeds of 30-50 nautical miles per hour, the remote control of Unmanned Aerial Vehicles (UAVs) while moving rapidly through rugged terrain, or conducting casualty assistance while still in the hostile area, even the most experienced operators have no chance to concentrate on opening and viewing a computer screen with the map-based situational awareness interface.

Unlike the common operational picture view, rich in content voice communication doesn't interfere with the operators ability to navigate and focus visually on the target. This represents almost the only feasible solution for getting the situational awareness messages, adjusting the position and orientation of robotic units, or operating unmanned vehicles and remote sensors, while keeping hands and eyes free for split second actions.

The Voice-on-Target (VoT) approach extends the earlier NoT concept into the new unexplored and very promising field of the unified voice communication interface to robotic adaptive elements of the emerging tactical network-centric environment. The paper describes first groundbreaking results in developing the VoT architecture, the tactical portal, and field experimentation with designed solutions.

1. Voice-on-Target: Concept and Portal Architecture

The last decade has shown advances in VoiceXML, CCXML, CallXML, and other voice controllable Internet surfing techniques, with the latest applications created by the telephony community. Together they provide a unique background for the new research dimension, voice control of a computer's peripheral infrastructure, robots, and sensors.

The most generic approach utilizing voice controllable robots for military applications is presented on Figure 1. It highlights the core elements of Voice Portal Infrastructure. The Voice Portal is considered herein as an addition to the well-known and widely used network enabled robotic systems. The voice command may be delivered to the robot for execution either over a wide area network connection, like the Internet, or from within the tactical local area network infrastructure. The use of a combination of both types of networks may be very beneficial since it brings a global reach capability to the tactical level of robotic systems controlled by voice commands.

Any commercial cell phone can be used as a voice terminal to provide a communication interface to the robot. The regular ground line telephone, VoIP, and Soft Phone may also be used as a voice terminal device. Another new element, employed in the Voice Portal infrastructure, is a computer system to support voice specific services. The basic set of services provides two-way voice communication and includes Session Initiation Protocol (SIP), Voice recognition, and Text-to-Speech (TTS) service. Literally, implementation of such a system allows an to operator to "talk to robot". As a result, the operator will keep his hands free, and not preoccupy his vision with the computer's graphical user interface (GUI).

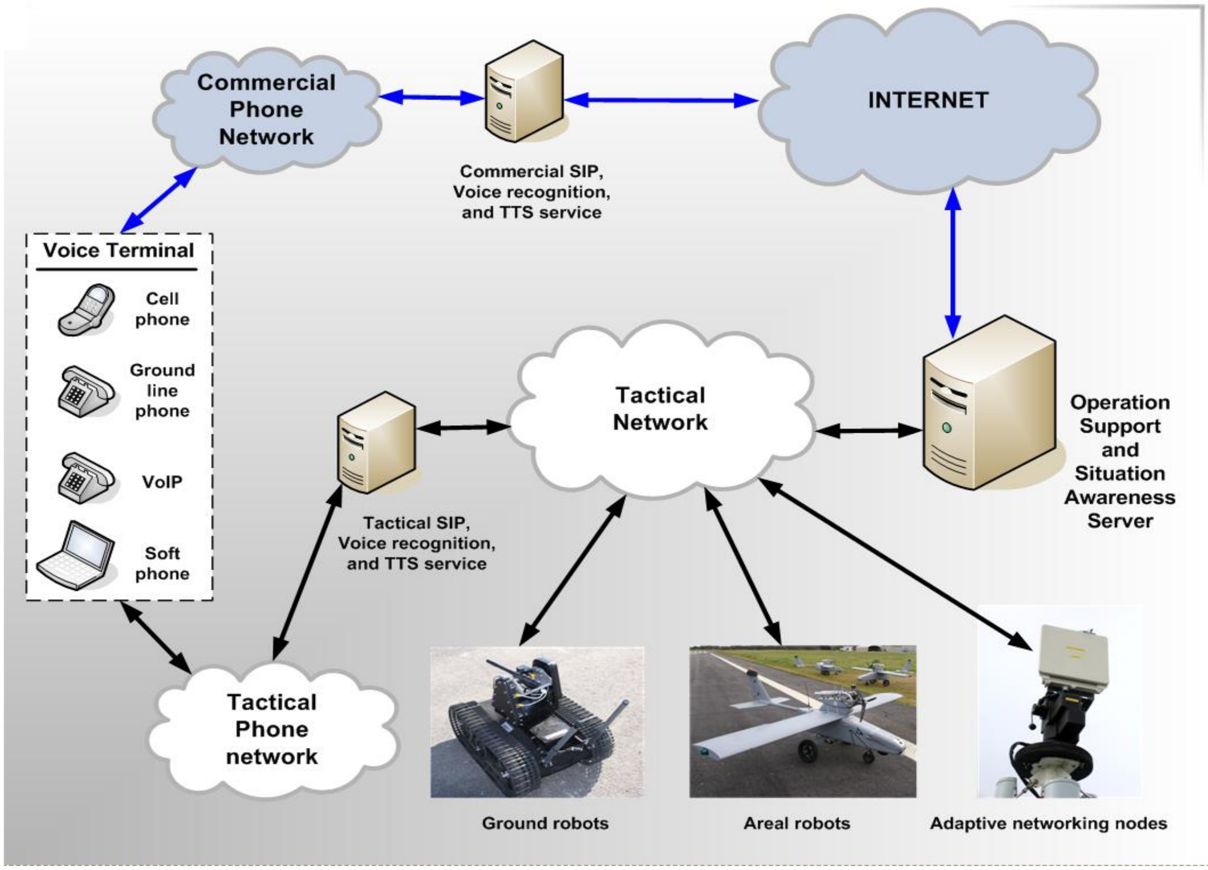

Figure 1. Voice-on-Target Portal Infrastructure

Hyper Speech is defined as a voice hyperlink to navigate fragments of voice application, and provides voice browsing between different voice applications. Like any hyperlink, it offers a great flexibility and immense usability to voice applications. When combined with seamless XML-based protocol, such as VoiceXML, voice application allows development and implementation of simple but practical voice controlled robotic systems. The Operation Support and Situation Awareness Server (SA Server), shown on Figure 1, is employed to integrate Hyper Speech navigation, VoiceXML media delivery protocol, and logic of robotic system control into a single voice application package.

An example of voice dialogue is presented on Figure 2. The user initiates a voice navigation process by placing a phone call to the system. Depending upon the user's selection, voice applications running on the SA Server collect all necessary information for task execution with additional voice dialogue. Then it asks conformation for tasking and sends the control message to the robot to proceed with the assigned task. The Status Request will initiate robot and SA Server database queries to collect current and history log data and deliver it back to the user in voice format. That is what might be considered as a "talk to robot" mechanism.

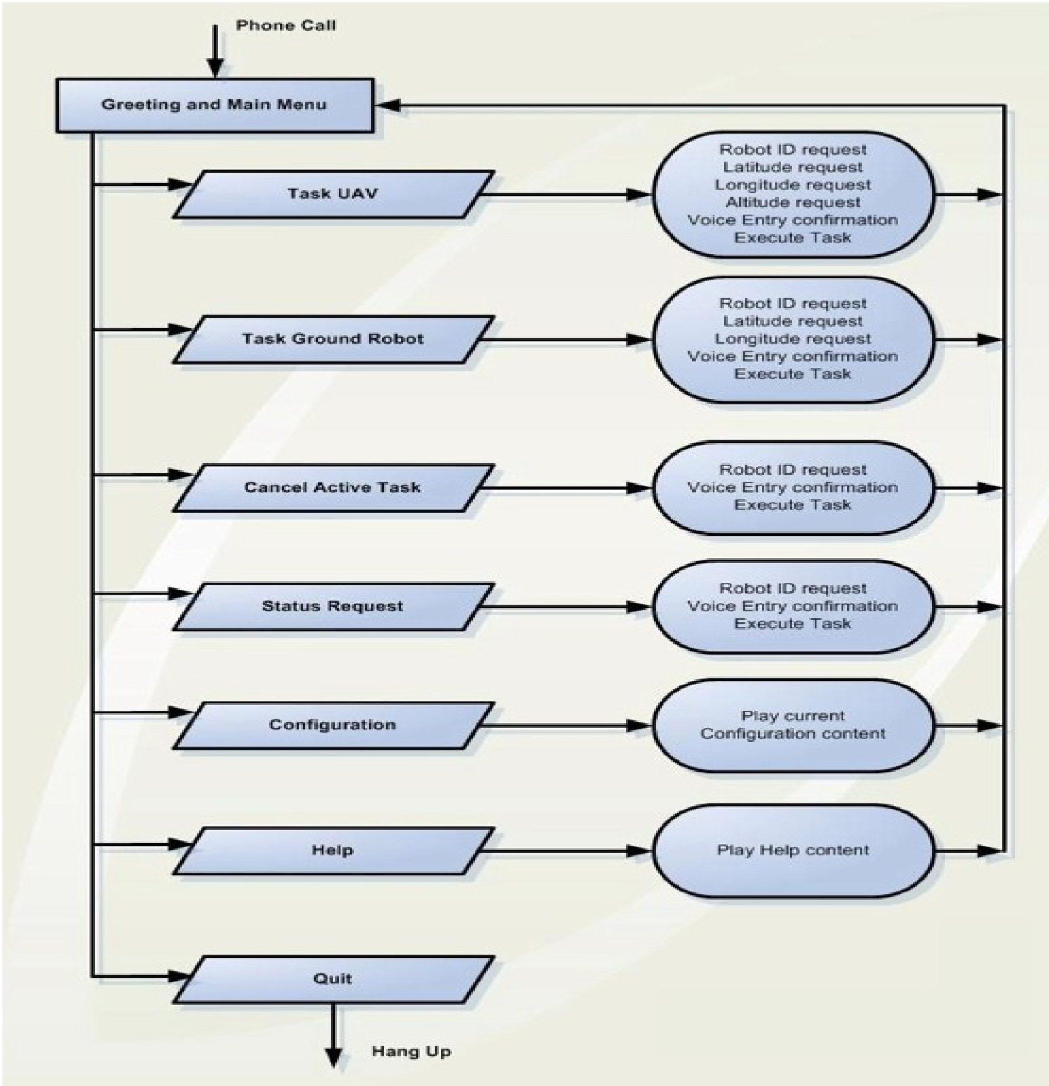

Figure 2. Voice Control diagram

The following on examples describe the first successful field experiments with the VoT portal.

2. Field Experiment: Applying VoT to a Battlefield Medical Networking Scenario

One of the first successful applications of the VoT solution took place during the Tactical Network Topology (TNT) Battlefield Medical Networking Experiment. In this particular discovery and constraints analysis experiment the VoT solution was used to explore the feasibility of directing an Unmanned Aerial Vehicle (UAV) to a casualty site, take images, and activate a drug delivery micro device (a prototype of the future battle suit nanotechnology patch).

The device, developed at the MIT Institute for Soldier Nanotechnology was integrated with the TNT network and set up for being activated by one of the following methods:

- through the tactical network over the TNT Situational Awareness (SA) interface;
- by commands sent over the commercial GPRS cell phone network;
- by voice command sent to the CENETIX (Center for Network Innovation and Experimentation) Voice Portal over a commercial cellular network.

Figure 3 illustrates the network-controlled nano sensor setup. The drug delivery actuator was placed on a simulated casualty (mannequin).

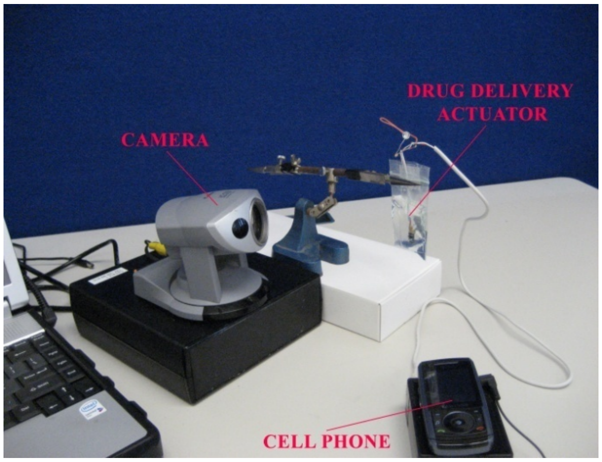

Figure 3. Network-controlled drug actuator setup

The experiment was conducted in accordance with the following experimentation steps:

Step 1: The casualty (mannequin) was positioned at the remote area. The person acting as the battlefield medic was located at the Light Reconnaissance Vehicle (LRV) site which was forward deployed close to the casualty location. The LRV was connected to the tactical network via a broadband wireless link. An e-tag reader was placed with the medic in the LRV. The GPS position of the e-tag reader provided the casualty position. The e-tag health data was transferred via a Bluetooth link to the e-tag reader, and then propagated further via the GPRS link to the medical data base in a remote location.

Step 2: The UAS was tasked to fly to the casualty site by the battlefield medic via a cellular phone GPRS interface, and by the medic's voice command over the VoT Portal.

Step 3: A UAS onboard high resolution camera used to take a picture of the casualty and deliver it to the Tactical Operations Center (TOC) and to the forward deployed medic's cell phone.

Step 4: The drug delivery device was activated via the GPRS network from the medical commander's cellular phone, and over the Voice Portal.

In accordance with the described plan the experimentation team successfully initiated delivery of liquid drug release into a liquid vial worn on the casualty's life vest by sending a drug release voice command over the CENETIX Voice Portal. This was repeated again by sending a command over a GPRS wireless cellular phone (Blackberry handheld) device. After each voice command activation, the medic provided voice comments to be recorded in Observer Notepad over Voice Portal for TOC feedback on his actions.

Figure 4. TOC Video Wall view of the casualty simulation mannequin and first release of liquid drug into vial (up-right corner of picture) upon voice activation from the medic's Blackberry handheld.

The NPS UAS which was controlled by voice commands successfully captured a high resolution image of the casualty location during flyover of the casualty, and successfully relayed this high resolution image to the TOC video Wall.

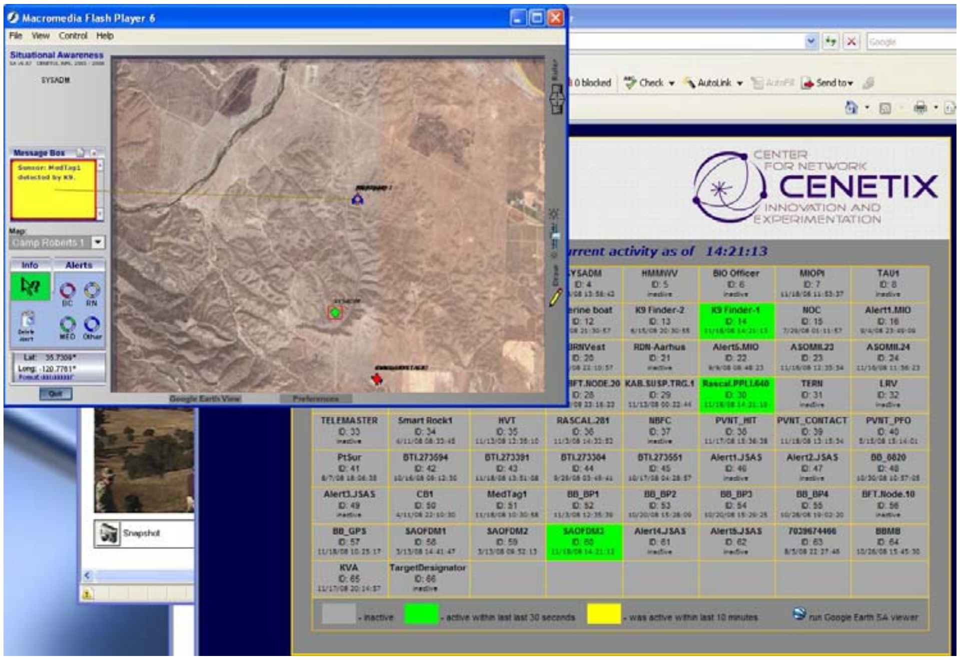

Figure 5. Casualty e-tag alert activation and propagation to the shared SA view.

Figure 6. Battlefield medic providing voice control of UAS medicine injection over the VoT interface

Figure 7. Casualty site overlooking voice-controlled camera on top of medic's LRV

Figure 8. High resolution imagery of the casualty site taken by NPS Rascal UAS while controlled by medic via the voice commands.

The Special Forces battlefield medic managed to direct the NPS UAS to the casualty site, to inject medication, to control the surveillance camera , and to record observations into the experiment Observer Notepad, all by successfully “talking” to the UAS and sensors via the CENETIX Voice Portal using a standard Blackberry handheld with a head set.

The results demonstrated sufficient accuracy for controlling the tactical sensor-robotic assets via the VoT interface:

- 4 of 4 drug deliveries of injected liquid drug into a vial on the casualty mannequin were successfully completed,
- 5 out of 5 voice comments were successfully recorded in Observer Notepad over the CENETIX Voice Portal,
- 1 out of 1 voice-controlled camera pointing command was successfully sent over the Voice Portal,
- 10 out of 10 voice commands for the voice-controlled camera were successfully sent to adjust camera orientation,
- 4 out of 5 tasking commands were successfully sent and executed to call the NPS UAS to the casualty location for taking high resolution imagery. One of voice commands did not go through, possibly caused by poor GSM coverage in the area of operation, and was substituted for by sending a command over the SA Agent Web interface.

3. Field Experiment: Applying VoT to Precise Parafoil Descending Control

Another example of successful voice interface implementation in robotic system control is a precise parafoil landing. The experiment was addressing small payload precise landing (with 10 meters accuracy) to deliver equipment, medicine, and such to the area of operation by manned or unmanned aircraft. Precise landing may be accomplished by periodic updates of the target’s local weather condition information by sending it to the control algorithm while the parafoil is descending. The network and Voice Portal allowed monitoring and descending parameters adjustments from a remote location . The network utilized Voice Portal Client to assign target coordinates over regular GSM handheld (Blackberry phone) as shown in Figure 9. The GSM-enabled parafoil payload and weather station with voice control utilization are presented in Figure 10. For this field experiment two payloads with parafoils were attached to an manned aircraft’s canopy and delivered to the area of operation. The command to drop the parafoil was send by voice command. When the parafoil got unfolded in the air, another voice command was sent to provide the exact landing GPS position. Voice commands were sent from the regular GSM cellular phone (Blackberry phone) by placing the call and following the Voice Portal instructions (Figure 2).

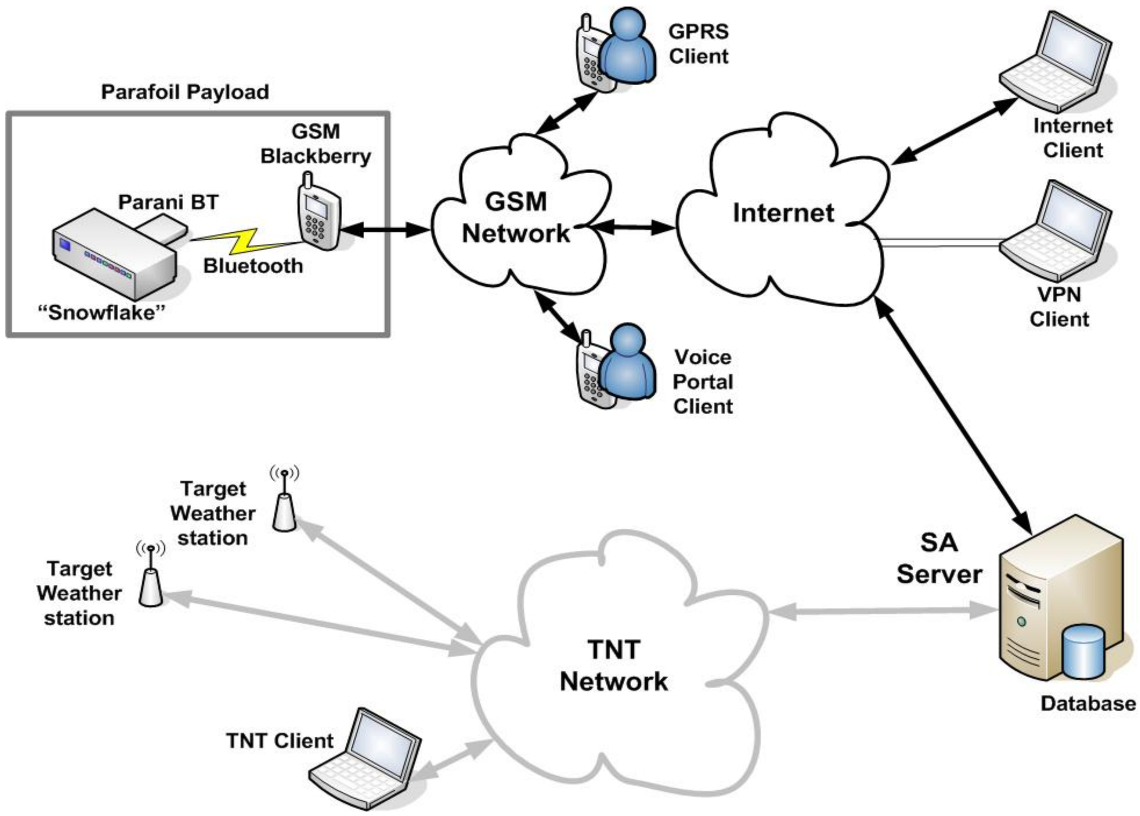

Figure 9. Voice control enabled parafoil network diagram.

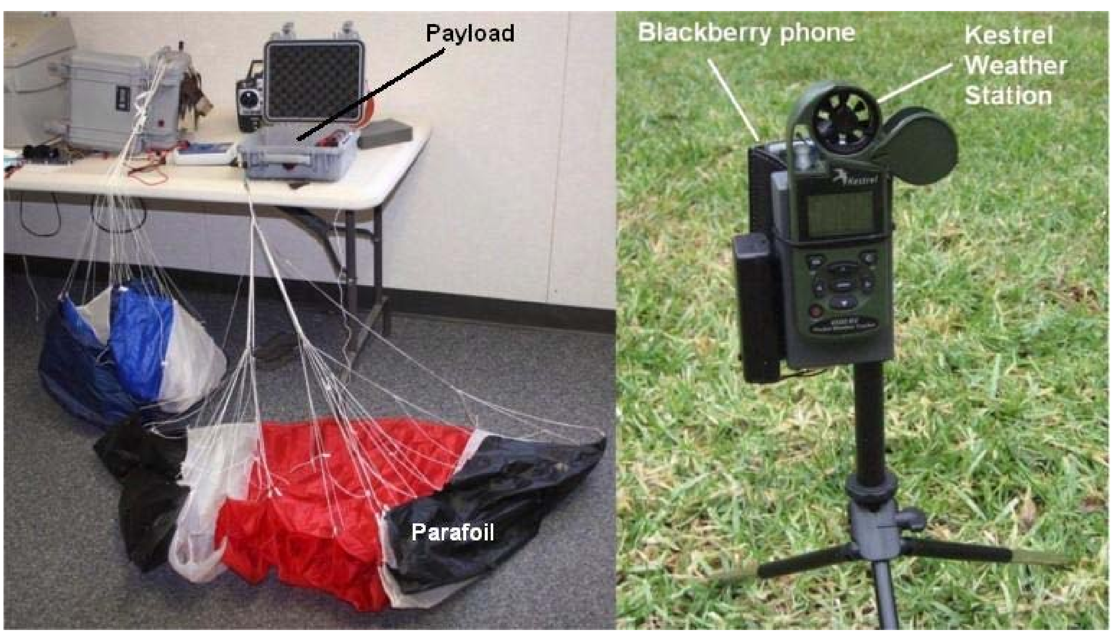

Figure 10. GSM-enabled parafoil payload and weather station with voice control utilization

Conclusion

The described VoT solutions represent good examples of an alternative approach to sharing situational awareness information between man and machine in the tactical network-centric environment augmented by unmanned robotic systems. It takes us significantly closer to the long time anticipated/desired seamless natural language with robots in the battlefield. The VoT approach also provides for a unique capability for "humanizing" the unmanned systems data exchange by enabling mapping data transfer commands into the voice commands. For example, the tactical operations commander could literally hear the unmanned systems "talking" (voice report) back to him, providing current status of task execution. This in turn enables the commander to start "sensing" unmanned systems networking, thus improving the commanders cognition and situational understanding. We would like to emphasize that GSM network utilization also naturally provides another attribute, global reach.

Acknowledgments

The authors are grateful to Dr. David Netzer for his inspiration, guidance, and extraordinary support of the described studies.

References

Bordetsky, A. and Bourakov, E. (2006). Network on Target: Remotely Configured Adaptive Tactical Networks, In: Proceedings of Command and Control Research and Technology Symposium, San Diego

Bordetsky, A., Bourakov, E., Hutchins, S., Looney, J., Dougan, A., Dunlop, W, Necoogar, F. (2006). Network-Centric Maritime Radiation Awareness and Interdiction Experiments: Lessons Learned, In : Proceedings of International Command and Control Research and Technology Symposium, Cambridge, UK

Naval Postgraduate School, TNT MIO 08-4 After Action Report: Networking and Collaboration on Interdicting Multiple Small Craft Possessing Nuclear Radiation Threat, New York-New Jersey/Ft. Eustis/Sweden/Denmark, September 8-11, 2008