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

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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

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Introduction

Since 2004 the authors are actively involved in the innovative Tactical Network Topology (TNT) experimentation, which Naval Postgraduate is conducting quarterly with the USSOCOM to explore emerging agile adaptive tactical networks. One of our first findings was a set of solutions enabling rapid adaptation of broadband wireless network to the commander needs, which we named Network-on-Target (Bordetsky and Bourakov, 2006). According to Network-on-Target (NoT) operational concept the adaptation starts at the level of the situational awareness interface used by the local commander. Based on the dislocation of mobile nodes (operators, vehicles, unmanned platforms), local commander drags the selected node to the target position for network to extend. In response, self-aligning robotic antennas 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 the rugged hazardous terrain (NPS MIO 08-4 After Action Report, 2008), showed significant limitations in using visual representation, i.e. computerized viewing of common operational picture, as main human-computer interface for developing situational awareness and remotely controlling networking robotic nodes.

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

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

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

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

The last decade advances in VoiceXML, CCXML, CallXML, and other voice controllable Internet surfing techniques, created lately by the telephony community provide an unique background for the new research dimension, voice control of 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 considering 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 wide area network connection, like the Internet, or from within the tactical local area network infrastructure. The use a combination of both types of networks may be very beneficial since it brings a global reach capability to the tactical level of robotic system 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 Voice Portal infrastructure, is a computer system to support voice specific services. The basic set of services providing two-way voice communication includes Session Initiation Protocol (SIP), Voice recognition, and Text-to-Speech (TTS) service. Literally, implementation of such system allow operator to "talk to robot". As the result, operator will keep his hands free, and not preoccupy his vision with computer's graphical user interface (GUI).

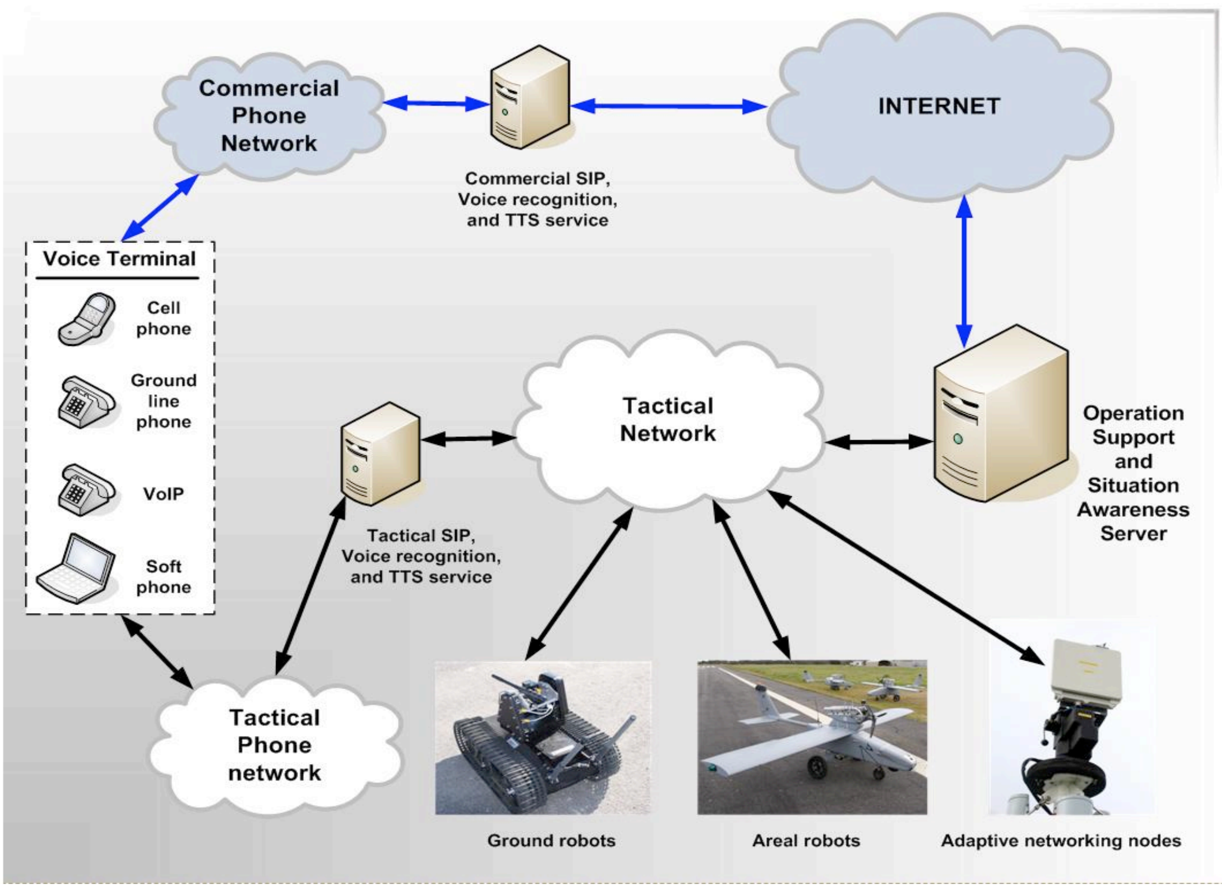

Figure 1. Voice-on-Target Portal Infrastructure

Hyper Speech is defined as a voice hyperlink to navigate fragments of voice application, and provide voice browsing between different voice applications. Like any hyperlink, it offers a great flexibility and immense usability to voice applications. Being combined with seamless XML-based protocol, such as VoiceXML, voice application allows develop and implement simple but practical voice controlled robotic system. 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 single voice application package.

The example of voice dialogue is presented on Figure 2. User initiates voice navigation process by placing a phone call to the system. Depending on user's selection, voice application running on SA Server collects all necessary information for task execution within 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's 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.

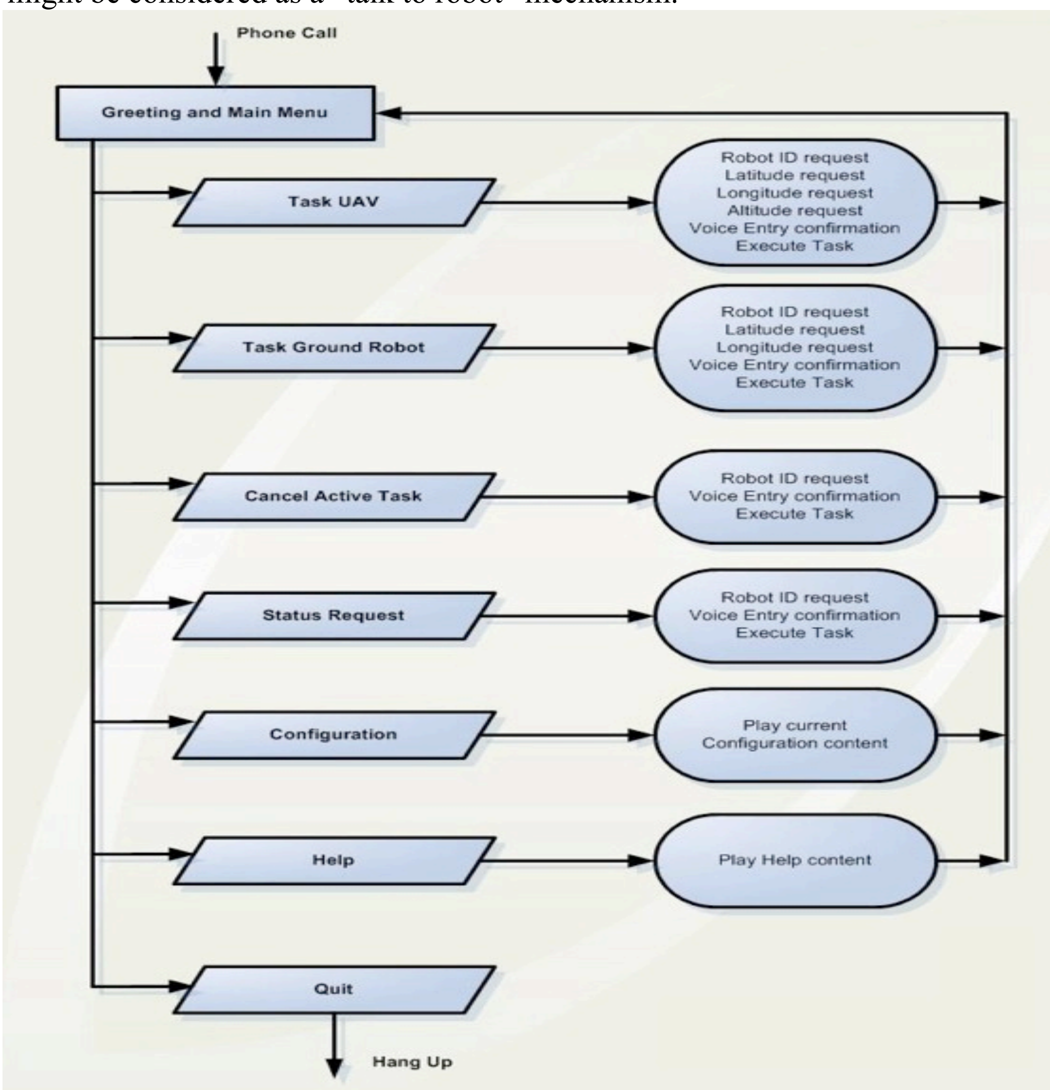

Figure 2. Voice Control diagram

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

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

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

The device, developed at 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 TNT Situational Awareness (SA) interface;
- by command sent over commercial GPRS cell phone network;
- by voice command sent to CENETIX (Center for Network Innovation and Experimentation) Voice Portal over commercial cellular network.

Figure 3 illustrates the network-controlled nano sensor setup, which was placed on the casualty simulating site of the mannequin.

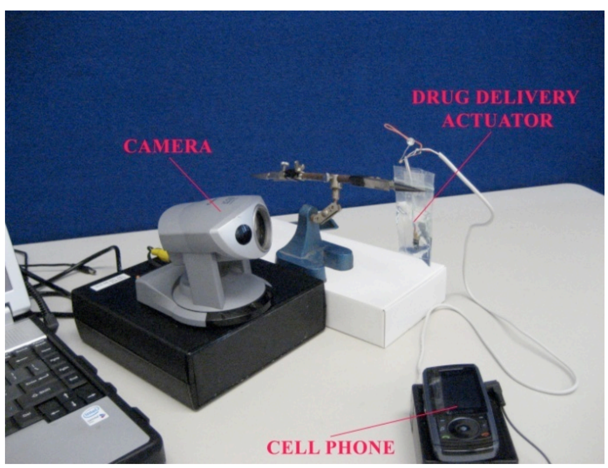

Figure 3. Network-controlled drug actuator setup

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

Step 1: The casualty role playing mannequin was positioned at the remote area.
The battlefield medic was located on the Light Reconnaissance Vehicle (LRV) site forward deployed close to the casualty location. The LRV was connected to tactical network via the broadband wireless link. The e-tag reader was placed with medic onboard LRV. The GPS

position of the e-tag reader provided casualty position. The e-tag health data transferred via Bluetooth link to the e-tag reader, and then propagated further via the GPRS link to the medical data base in the remote location.

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

Step 3: The onboard high resolution camera used to take a picture of casualty and deliver it to the TOC and forward deployed medic's cell phone.

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

In accordance with the described plan the experimentation team successfully initiated delivery of liquid drug release into liquid vial worn on casualty's life vest by sending drug release voice command over CENETIX Voice Portal, than repeated it again by sending command over GPRS wireless cellular phone (Blackberry handheld) device. After each voice command activation, 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 UAV controlled by voice commands successfully captured high resolution image of casualty location during flyover of the casualty and successfully relayed this high resolution image to the Tactical Operations Center (TOC) video Wall.

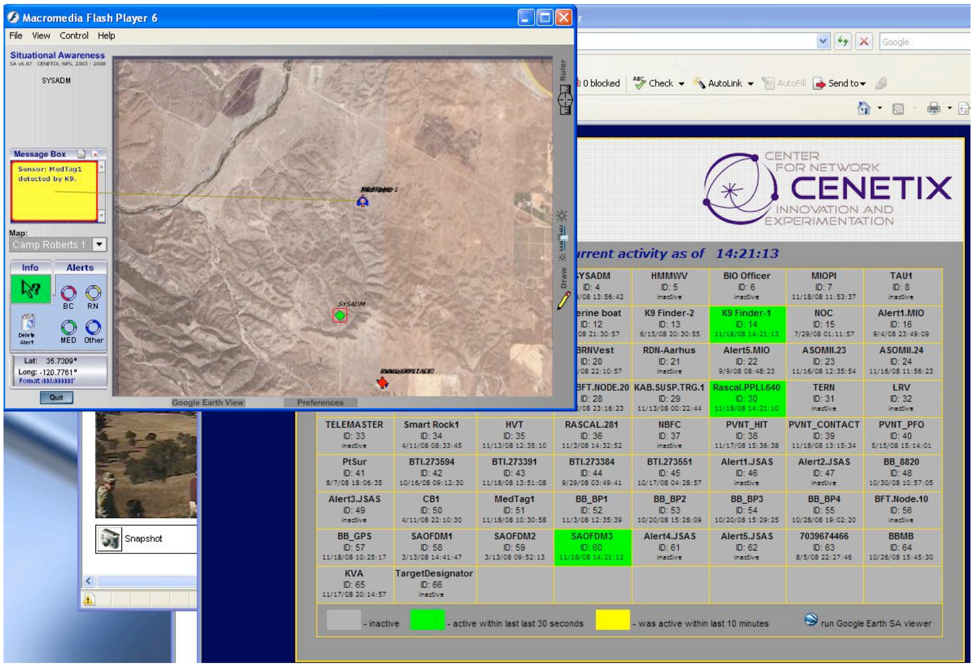

Figure 5. Casualty e-tag alert activation and propagation it to the shared SA view.

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

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

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

All together the Special Forces battlefield medics managed target the NPS UAV to the casualty site, inject medication, control the surveillance camera , and record observations into the experiment Observer Notepad, by successfully "talking" to UAV and sensors via the CENETIX Voice Portal using standard Blackberry handheld with a head set.

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

- 4 of 4 drug deliveries to casualty events of voice commands to inject liquid drug into liquid vial on casualty mannequin were successfully completed;
- 5 out of 5 voice comments were successfully recorded in Observer Notepad over CENETIX Voice Portal;
- 1 out of 1 overlooking voice-controlled camera pointing command was successfully sent over Voice Portal;
- 10 out of 10 voice commands for overlooking voice-controlled camera was successfully sent to adjust camera orientation;
- 4 out of 5 tasking commands were successfully sent and executed to call NPS UAV to the casualty location for high resolution imagery. One of voice commands did not go through, possible caused by pour GSM coverage in the area of operation, and was substituted by sending command over 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 update of target's weather condition information by sending it to the control algorithm while parafoil is descending. It also allowed monitoring and descending parameters adjustments from the remote locations over network connection and of Voice Portal, described in the previous example. The network diagram utilized Voice Portal Client to assign target coordinates over regular GSM handheld (Blackberry phone) is shown on Figure 9. The overall set of GSM-enabled parafoil payload and weather station with voice control utilization is presented on Figure 10. For field experiment two payloads with parafoil were attached to aircraft's canopies and delivered to the area of operation. The command to release canopy and drop parafoil was send by voice command. When parafoil got unfolded in the air, another voice command was sent to provide exact landing GPS position. Voice commands were sending from the regular GSM cellular phone (Blackberry phone) by placing the call and following the Voice Portal instructions (Figure 2).

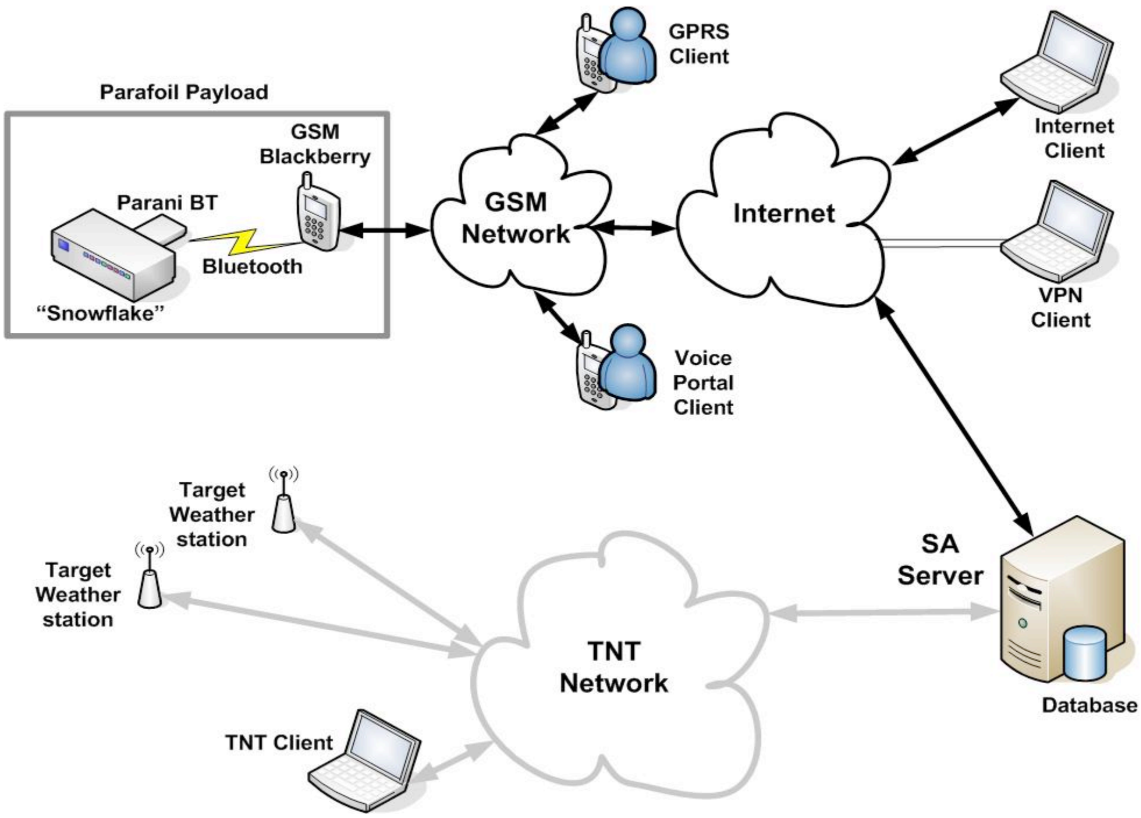

Figure 9. Voice control enabled parafoil network diagram.

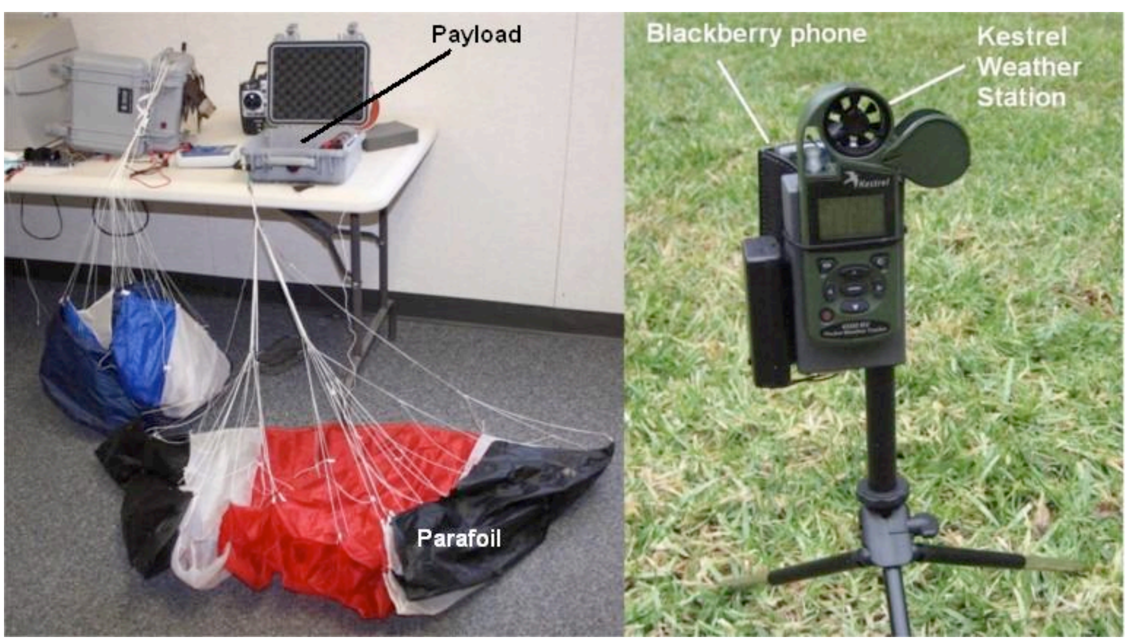

Figure 10. GSM-enabled parafoil payload and weather station with voice control utilization

Conclusion

The described VoT solutions represent good examples of 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 long time anticipated seamless natural language with robots in the battlefield. The VoT approach also provides for unique capability of "humanizing " the unmanned systems data exchange by enabling mapping data transfer commands into the voice commands. In result, as an example, tactical operations commander could literally hear unmanned systems "talking" back to commander providing current status of task execution voice report. This in turn enables commander to start "sensing" unmanned systems networking, thus improving commanders cognition and situational understanding. We also would like to emphasize, that GSM network utilization naturally brings very much desirable in many operations capability – a global reach.

Acknowledgments

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