# Cognitive Radio Capability for Software Defined Radios

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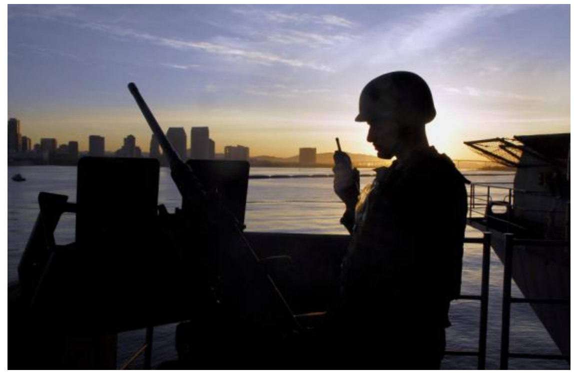

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## PROBLEM STATEMENT

U.S. Forces face unique spectrum access issues in each country in which they operate, due to competing civilian or government users of national spectrum. Coalition and allied operations are even more complex to manage, and severely limit the U.S. ability to fully exploit its superiority and investment in information technology. The problems addressed by this proposal are to: develop, test, and demonstrate a software application capable of running in real-time on a JTRS radio; monitor and characterize the Radio Frequency (RF) spectrum that is in use in a local area; identify available spectrum for reliable communications; and dynamically allocate spectrum usage to networking and legacy waveforms based upon a pre-programmed rule-set. Specifically, the Dynamic Spectrum Access (DSA) capability provides the following benefits:

- High communication availability and reliability
- Avoid intended/unintended jamming (operation in a CREW environment)
- Reduced propagation loss by selecting best frequency
- Enables robust spectrum pooling with peer users. This reduces the co-channel frequency reuse distance providing a 100X spectral efficiency improvement.
- Minimize host coordination issues by isolating all spectrum access related rules into a high-level language that is an order of magnitude easier for the host nation to regulate
- Efficiently and safely use encumbered spectrum (i.e., the DoD can use commercial spectrum)
- Reduce deployment labor costs and timelines related to frequency assignments

[1] Please be sure that any images that you include are in the public domain or are your own images.

Manual spectrum assignment is currently a difficult and inefficient process. Manual methods to assign frequencies are based on predicted radio locations, propagation models and equipment performance values listed in the DoD 1494 Form (filtering, transmit power levels, antenna type, antenna heights, etc). This process is labor intensive, must be centralized, and relies on incomplete knowledge of what emitters exist in the battle space and where the radios are located in the future. The manual approach coupled with dynamic parameter uncertainties leads to inefficient spectrum use. The manual approach is far from perfect; hence, it is very hard to resolve conflicting frequency assignments that are made.

The goal of this contract effort is to design and integrate the DSA software and capabilities into the JTRS Wideband Networking Waveform (WNW) running on the JTRS Ground Mobile Radio (GMR).

## WHO CAN BENEFIT?

The DSA radio software may be integrated/ported to most software-defined, modern digital radio. This presents a unique opportunity to transition to other tactical radios such as JTRS HMS, MIDS JTRS, UAV data links and robot data links

## BASELINE TECHNOLOGY

Our current DSA software approach enables a radio to adapt to RF interference in real time while being governed by a set of user-defined rules or policies. This enables robust spectrum sensing and adaptive software algorithms at the physical and MAC layer while enabling complex and varied rules to be abstracted in a high-level language which is interfaced to industry standards such as XML, OWL and MCEB Pub-8. By deploying the same core software algorithms on the majority of radios, a uniformed view of the RF spectrum and a uniformed set of employed rules and polices is achieved across a heterogeneous set of radio assets.

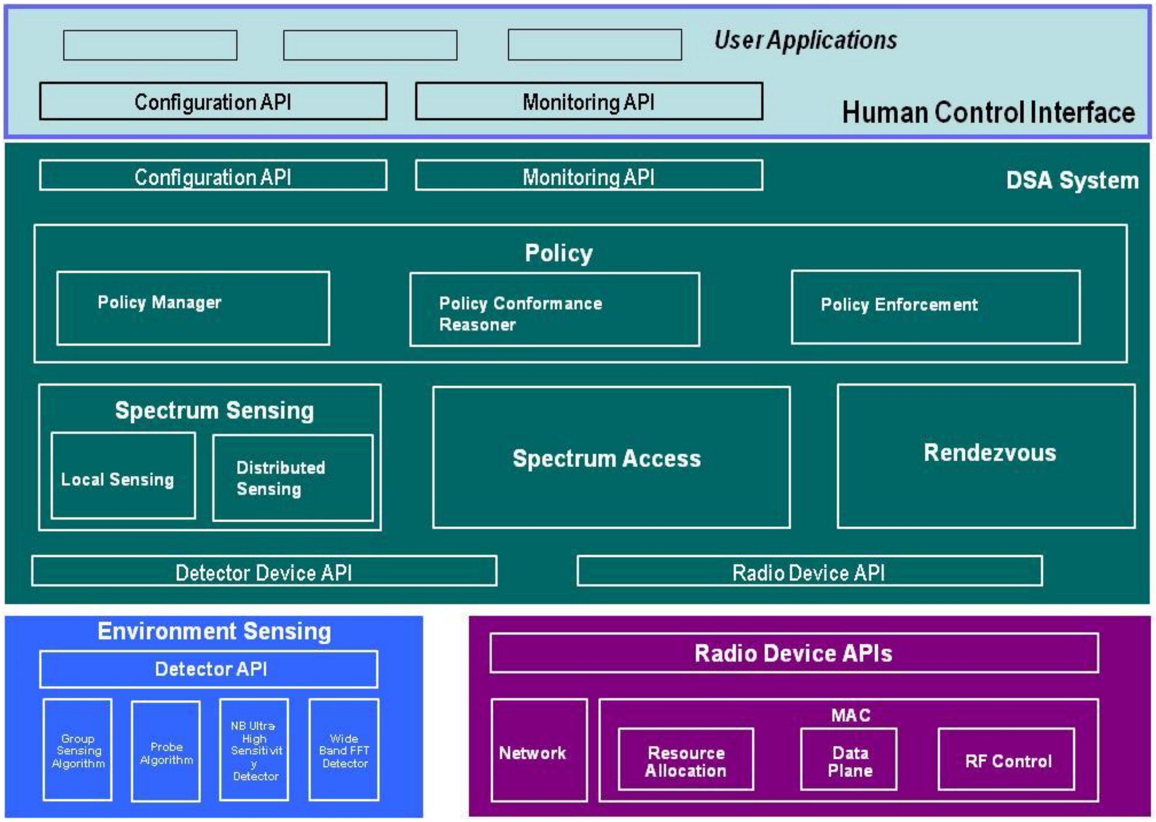


**Figure 1. Existing SSC DSA Software Architecture for Software Defined Radios**

The initial integration costs are based on the complexity of the radio system and the network which links them together. In a simple robot radio data link where a point-point solution is required, the integration cost is roughly $2M upfront, one-time cost which the per unit cost of the software being very low. The maintenance on the DSA software is also low in this scenario because the link is fairly basic. The initial integration costs for a JTRS are still being determined. Cost factors are based on the integration with the network, the spectrum available to the system and the targeted spectrum for sharing as well as potential changes in the software flow in the current JTRS WNW design to accommodate the exchange of real-time spectrum data within the radio and across the network.

## TECHNOLOGY DESCRIPTION

Dynamic Spectrum Access (DSA) technology enables users of virtually any radio device to utilize dynamic spectrum access techniques and thereby dramatically improve spectrum efficiency, communications reliability, and deployment time. Fundamentally, a DSA-enabled radio, device or network node dynamically adapts to its RF environment to maintain reliable communications with other DSA-enabled devices, and it does so without interference to other DSA radios or to non-cooperative (NC) legacy radios. Furthermore, a DSA-enabled radio operates within prescribed policy constraints, which may vary depending upon geographic location, frequency band, time of day, spectrum activity, deployment scenario, and other anticipated or unanticipated factors. A DSA-enabled radio achieves this by operating over a wide span of spectrum rapidly detecting non-cooperative or legacy radios and adjusting its operating frequency or other parameters when it does so.

Figure 2 depicts the interrelationship between four key processes taking place in a DSA-enabled radio.

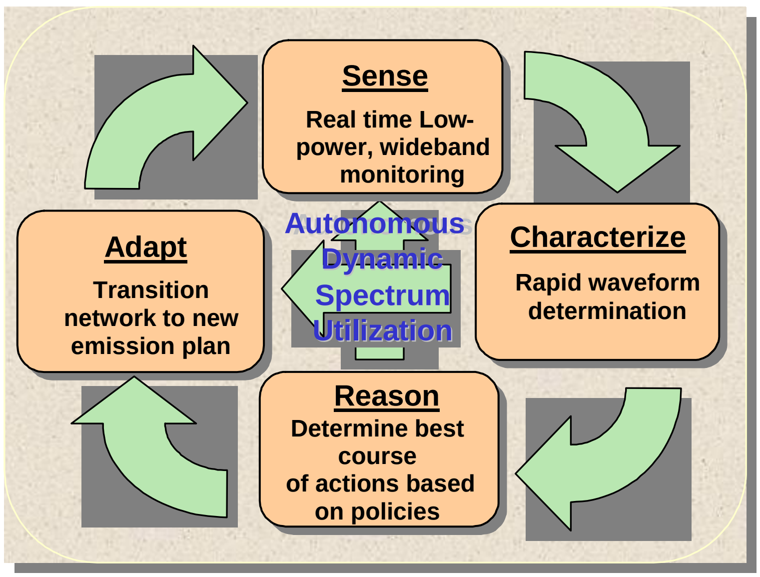


**Figure 2. Key DSA Processes**

The Reasoning process continuously monitors conformance of radio operations to a set of policies governing spectrum access rules. Within the Reasoning process real-time DSA requirements metrics are generated and validated, and the best course of action is determined dynamically based on policies and performance evidence presented to Reasoning by other DSA processes.

The Adaptation process governs the real-time radio emission plan and generates optimal radio settings according to metrics and an action plan provided by the Reasoning process.

The Sensing process, governing spectrum monitoring, is essential in the evaluation of the radio RF environment. The Sensing process utilizes a variety of detection methods to support objectives formulated by Reasoning via sensing requirements metrics.

The Characterization process is responsible for assessment of RF sensing results, and for classification of spectrum states. Based on this assessment neighbors are found and spectrum access decisions are made.

## CURRENT STATE OF DEVELOPMENT

The design phase for integrating DSA with JTRS WNW will complete in December 2010 followed by an optional OPNET Phase. An unfunded option to begin integrating the actual software into WNW remains unfunded and at risk.

## REFERENCES

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## WHEN THE TECHNOLOGY WILL BE READY FOR USE

In general, the technology has been demonstrated as proof of concept in TRL-9 and COTS radios in field demonstrations at military bases, in convoy scenarios, on military vehicles. The SBIR effort continues through 2012 if all options are exercised.

## ABOUT THE COMPANY

Shared Spectrum Company (SSC) was founded in 2000 to develop technology that dramatically increases the efficient use of RF spectrum resources. Over the past 10 years, SSC has become a leading expert and innovator in the development of cognitive radio technologies. Our work has been publicly cited by Google and Microsoft to the FCC and in 2010, the company was recognized for our innovation in spectrum management in the Wall Street Journal 2010 Technology Innovation Awards.