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DISA Perspective on Dynamic Spectrum Access and Policy-Based Spectrum Management

DOE IMC 2012 and Spectrum Technology Workshop

David Fritz

The MITRE Corporation
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Disclaimer

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DoD Spectrum Availability Trends – US

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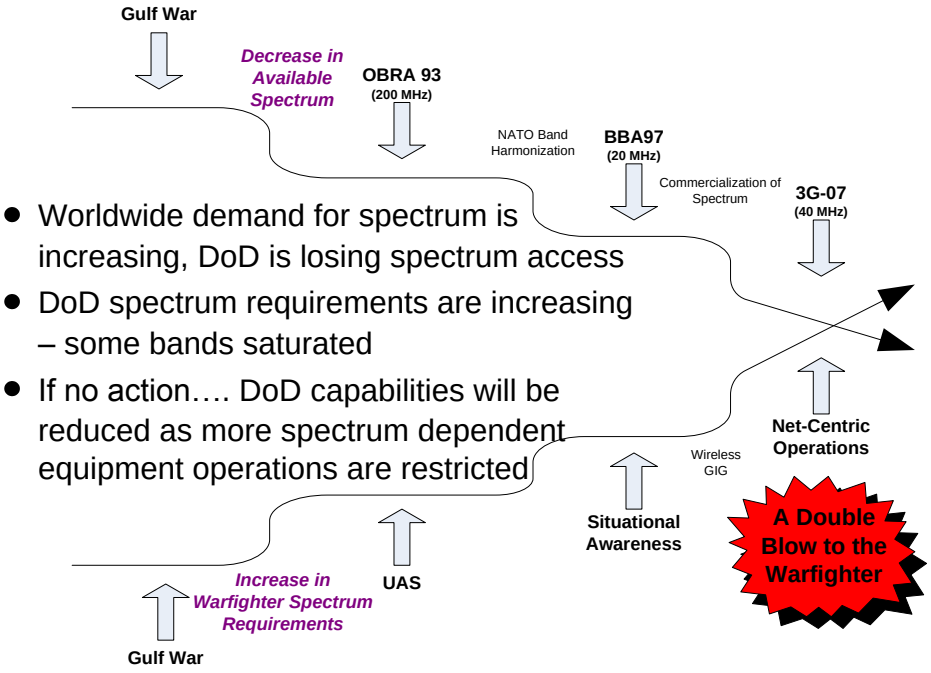
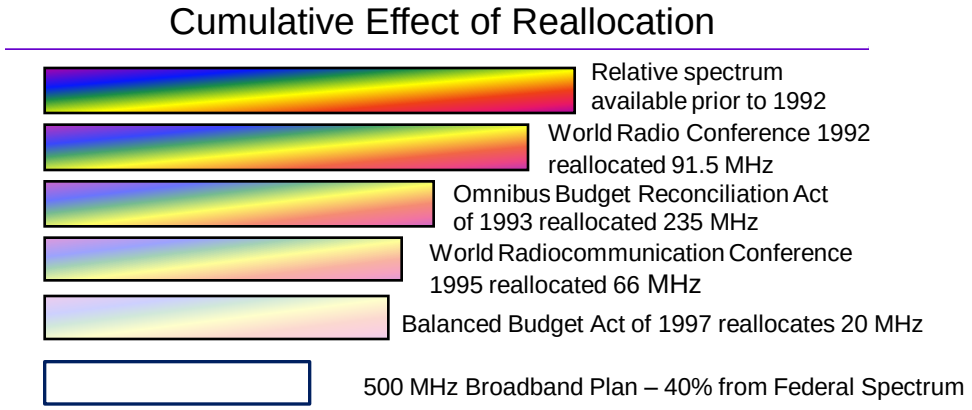
- **Spectrum is the lifeblood for all DoD operations**
  - **Pressure to open more spectrum to commercial sector is increasing**
  - **Spectrum is inherently limited**
  - **Technology can improve efficiency and utilization of this resource**
- **Must find ways to support greater spectrum use density**





Since 1992, spectrum relocations have reduced DoD spectrum access 412.5 MHz

Growing DoD Spectrum Requirements

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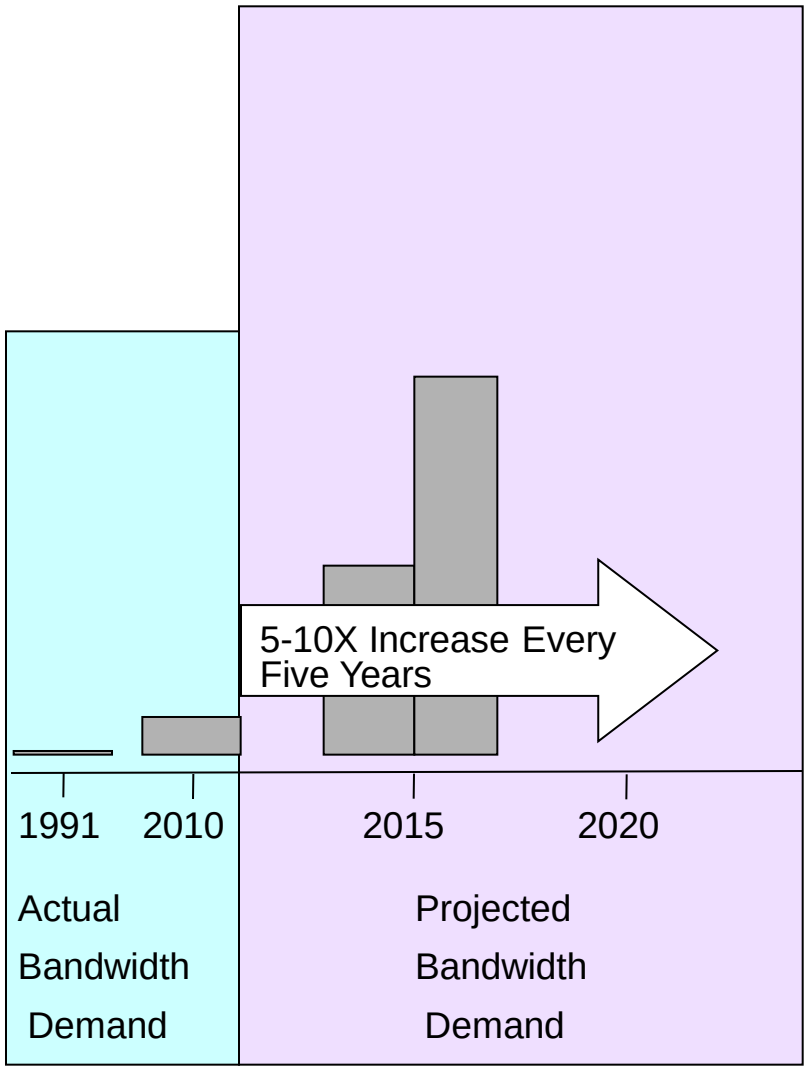
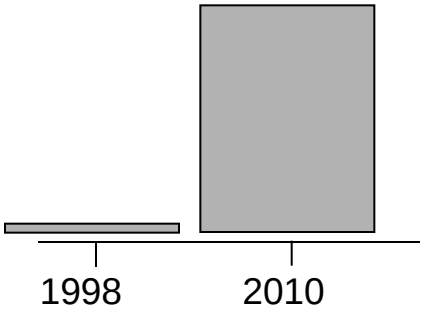
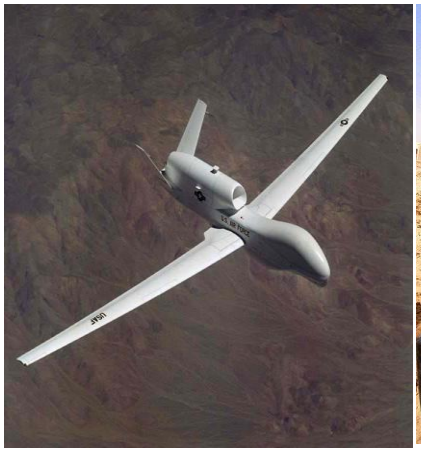


Representative Driver

Unmanned Aerial Vehicles (UAVs)





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Current Status

- **DoD shares spectrum everyday**
  - **Among diverse systems both DoD and non-military systems**
- **But we need and can do it better**
  - **Higher fidelity engineering**
  - **Take advantage of processing power and predictive algorithms to identify and cancel interference**
  - **Make more use of the temporal aspect of spectrum use**

These steps are necessary just to meet DoD's own growing demands

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Recent Spectrum Sharing Drivers

- The Federal Communication Commission (FCC), *National Broadband Plan* (NBP), March 2010
  - 500 MHz of spectrum to be made available over 10 years
  - Expand opportunities for "innovative spectrum access models"
  - Further R&D of opportunistic uses across more radio spectrum
    - *Numerous Notice of Inquiries*
- Presidential Memorandum, *Unleashing the Wireless Broadband Revolution*, June 2010
  - Directs NTIA to collaborate with FCC to reach 500 MHz target in 10 years
  - Calls for R&D plan on *sharing techniques*
- NTIA, *Plan and Timetable to Make Available 500 MHz of Spectrum for Wireless Broadband*, October 2010
  - Use modern technologies that mitigate interference and facilitate sharing of spectrum

"We can't keep saying NO to reallocation – we need to invest in technology to help with this. We learned this lesson 10 years ago, but didn't follow through"

General James E. Cartwright
Vice Chairman of the Joint Chiefs of Staff

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Representative Responses

- IEEE Standardization Activities
  - IEEE P1900.X pertains to DSA with P1900.5 focused on a policy-controlled radio reference model
- Cognitive Radio/Network initiatives within Service Labs and DARPA
  - Most are derivatives of P1900.5 implementations (e.g., policy/sensor)
- JPEO JTRS Small Business Innovative Research Programs
  - DSA-enabled Wideband Networking Waveform (WNW) experiments
- National Science Foundation Workshop on Enhancing Access to the Radio Spectrum (EARS)
  - Broad technology goals including DSA-related goals
- Inter-Agency Working Group on Spectrum Sharing established under the National Information Technology Research & Development (NITRD) Program
  - Spectrum sharing technology R&D planning
- European Cooperation in Science and Technology (COST)
  - 96 MILLION EURO through 2014 focused on heterogeneous network coexistence and regulatory frameworks for Cognitive Radio/Software Defined Radio

DSA Overview

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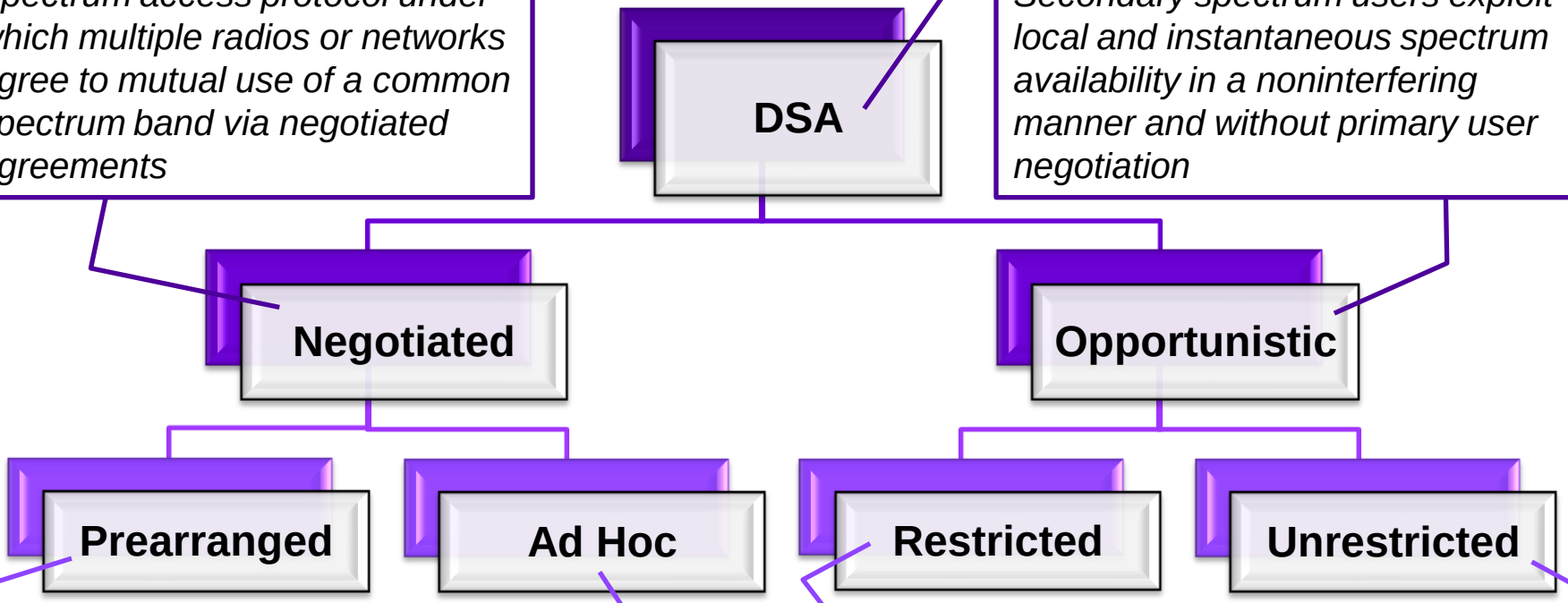
*The real-time adjustment of spectrum utilization in response to changing circumstances and objectives**

*IEEE 1900.1 and NTIA

Spectrum access protocol under which multiple radios or networks agree to mutual use of a common spectrum band via negotiated agreements

Secondary spectrum users exploit local and instantaneous spectrum availability in a noninterfering manner and without primary user negotiation



Prior agreements established between all parties

Automatically established on an ad hoc or real-time basis without the need for prior agreements between all parties

Shares spectrum access only with a known, pre-specified set of other systems

Shares spectrum access with other systems that were unknown at the time the system was designed

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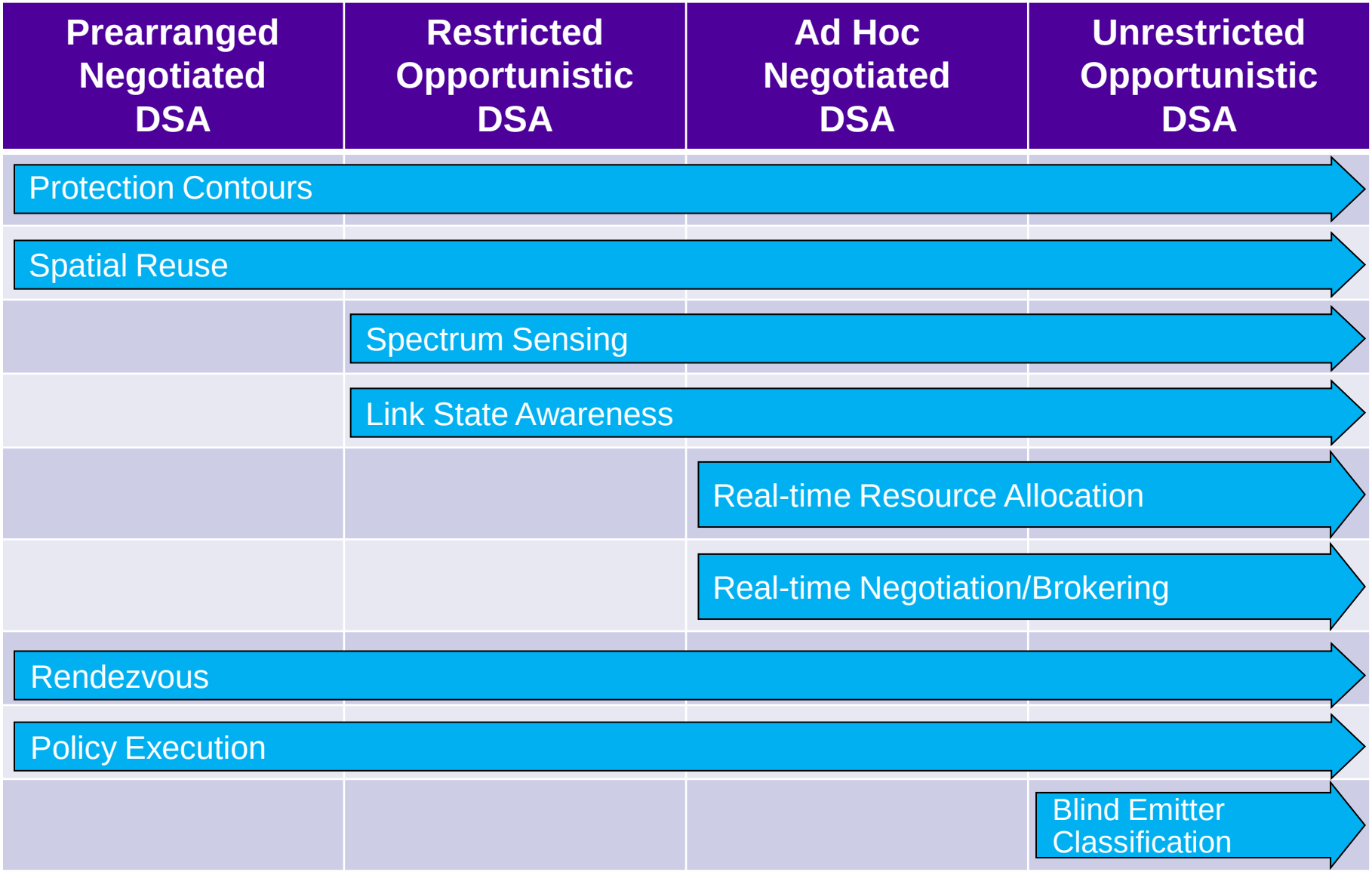
DSA Technology Progression



Negotiated DSA Concept – Geospatial Sharing

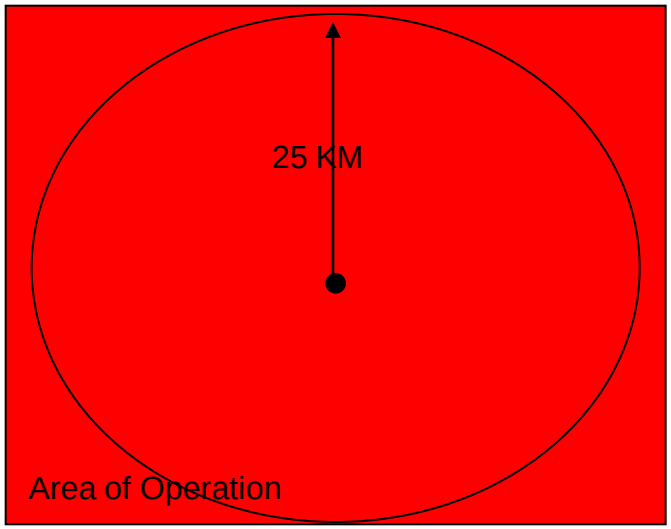
Overview: Spectrum Access required by a mobile system within a 25 KM radius area of operation

Current Spectrum Management Paradigm: Frequency assignment(s) cleared throughout area of operations and loaded into system. Specific location of system and specific instant in time of spectrum access requirement unknown to spectrum management

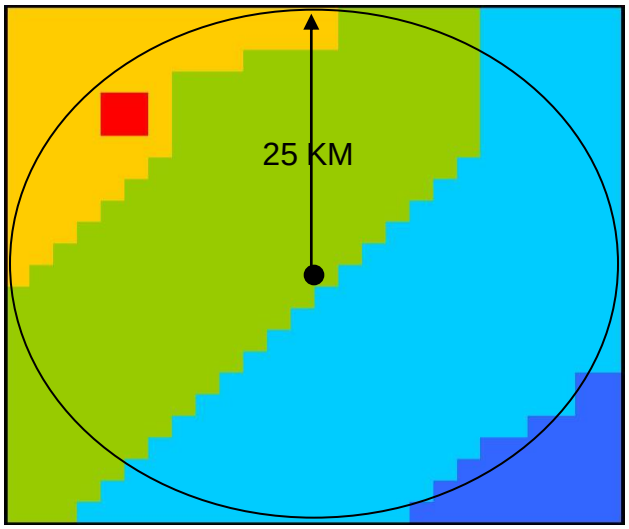
- For notional example, only 1 channel made available to mobile system

Future Spectrum Management Paradigm: Location-specific policies developed and loaded into system. System uses policy applicable to its specific location to access spectrum when needed.

- For notional example, up to 5 channels available to mobile system



Current



Future

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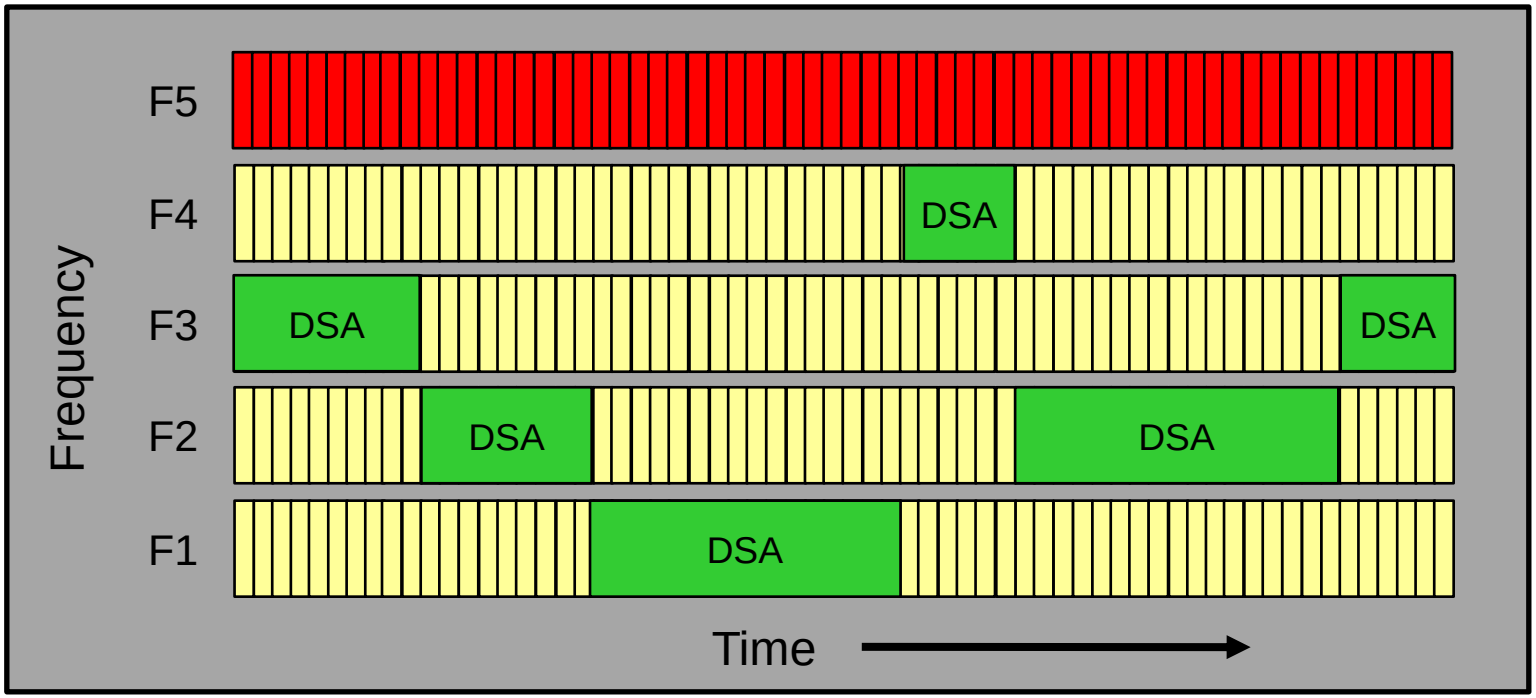
Opportunistic DSA Concept – Temporal Sharing

Overview: Opportunities exist to exploit underutilized spectrum

Current Spectrum Management Paradigm: Frequency assignment(s) typically reserved for 24/7 operation and 100% duty cycle with no ability to dynamically exploit underutilized spectrum. Specific opportunities to access underutilized spectrum not known to spectrum management.

Future Spectrum Management Paradigm: Location-specific coexistence policies developed and loaded into system. System uses policy applicable to its specific location and background electromagnetic environment to access spectrum when needed.



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Examples of DSA

- **Commercially available sensing-based solutions**
  - **WiFi: Dynamic Frequency Selection**
    - **Radar sharing service rules codified in CFR 47 Part 15**
    - **Documented in IEEE standards – 802.16**
  - **xMax**
    - **Proprietary solution for cellular base station and handsets**
    - **Unlicensed spectrum: 902-928 MHz**
  - **Alfred Mann Foundation Medical Micropower Network****
- **Emerging Database Solutions**
  - **Television White Space access rules governed by FCC Report and Order**
  - **Requires regular interaction between system and authorized database administrator**
- **Emerging DARPA-developed military solutions**
  - **NCRS-MAINGATE**
  - **WNaN**

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Standards for DSA
IEEE P1900 Working Groups

- **IEEE 1900.1: Definitions and Concepts for DSA: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management**
  - P1900.1a: Amendment: Addition of New Terms and Associated Definitions
- **IEEE 1900.2: Recommended Practice for the Analysis of In-Band and Adjacent Band Interference and Coexistence Between Radio Systems**
- **IEEE 1900.4: Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks**
  - 1900.4a: Amendment: Architecture and Interfaces for DSA Networks in White Space Frequency Bands
  - 1900.4.1: Standard for Interfaces and Protocols Enabling Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Networks
- **IEEE 1900.5: Policy Language and Policy Architectures for Managing Cognitive Radio for Dynamic Spectrum Access Applications**
  - P1900.5.1: Draft Standard Policy Language for Dynamic Spectrum Access Systems
  - P1900.5.a: Amendment: Define the interface description between policy architecture components.
- **IEEE 1900.6: Spectrum Sensing Interfaces and Data Structures for DSA and other Advanced Radio Communication Systems**
  - P1900.6.a: Amendment: Procedures, Protocols and Data Archive Enhanced Interfaces
- **IEEE 1900.7: Radio Interface for White Space Dynamic Spectrum Access Radio Systems Supporting Fixed and Mobile Operation**

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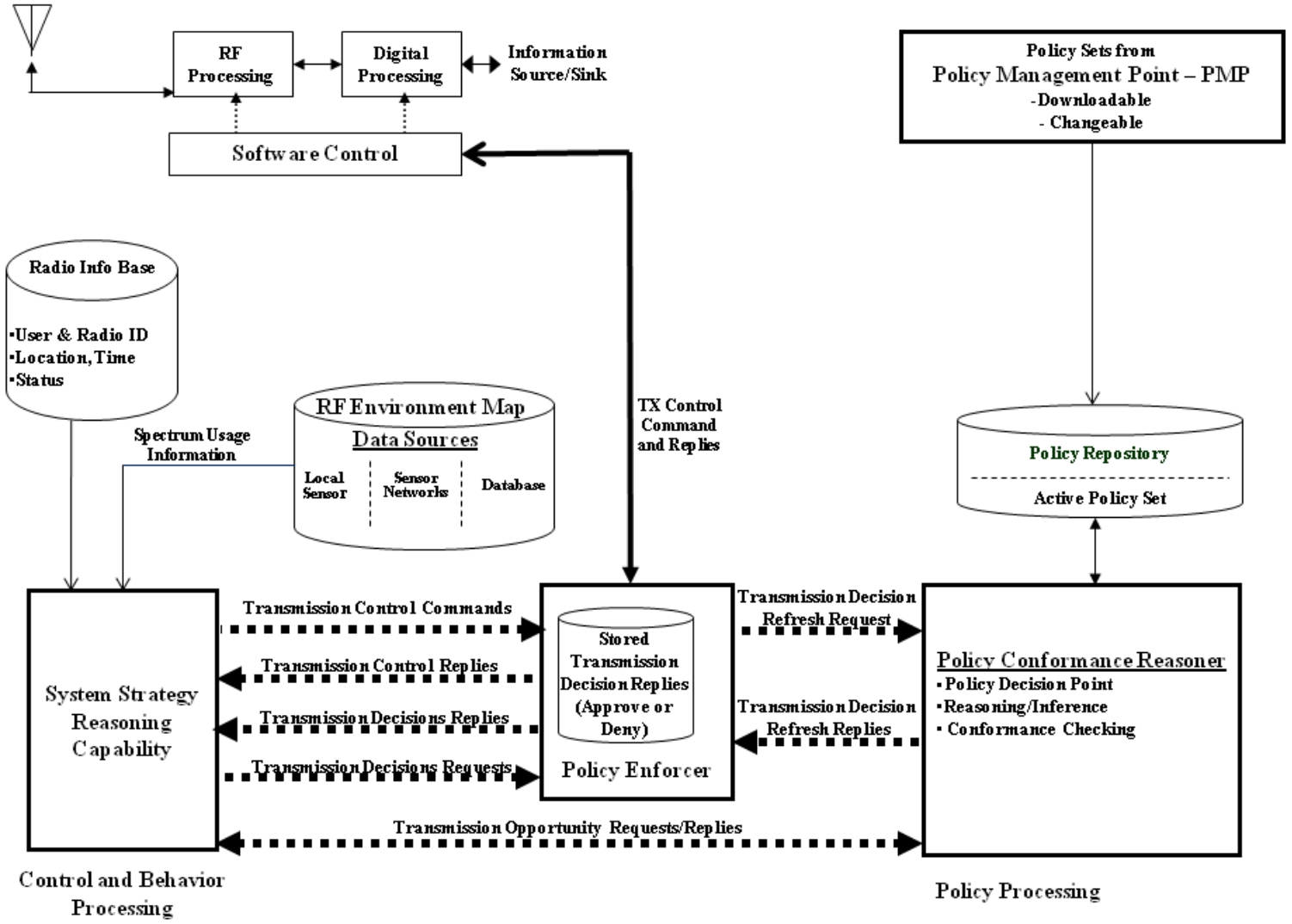
1900.5 Policy-Based Radio Architecture Balloting In Progress



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Ongoing DSA Activities Within DSO

- **Coexistence Framework**
  - Characterizing how DSA-enabled systems can share spectrum with other users
- **DSA Certification**
  - Identifying DSA-unique data requirements within end-to-end spectrum supportability
- **Standard Spectrum Resource Format (MCEB PUB 8) Extensions**
  - Extensions within a policy-based spectrum management/DSA paradigm
- **Architecture Development**
  - End-to-end architecture for generation, distribution, and consumption of policies
- **Security**
  - Identifying DSA security vulnerabilities and assessing mitigation techniques
- **Policy-based Spectrum Operations Transformation**
  - Joint Electromagnetic Spectrum Operations within a policy-based spectrum management paradigm
- **Standards Participation**
  - P1900.X, National Security Agency Digital Policy Management, TeleManagement Forum Spectrum Management Special Interest Group

DoD DSA SM Roadmap: A foundational product aligning goals and activities across DoD to fully exploit the promise of DSA

DoD Spectrum Operations Transformation and DSA Capability Attributes

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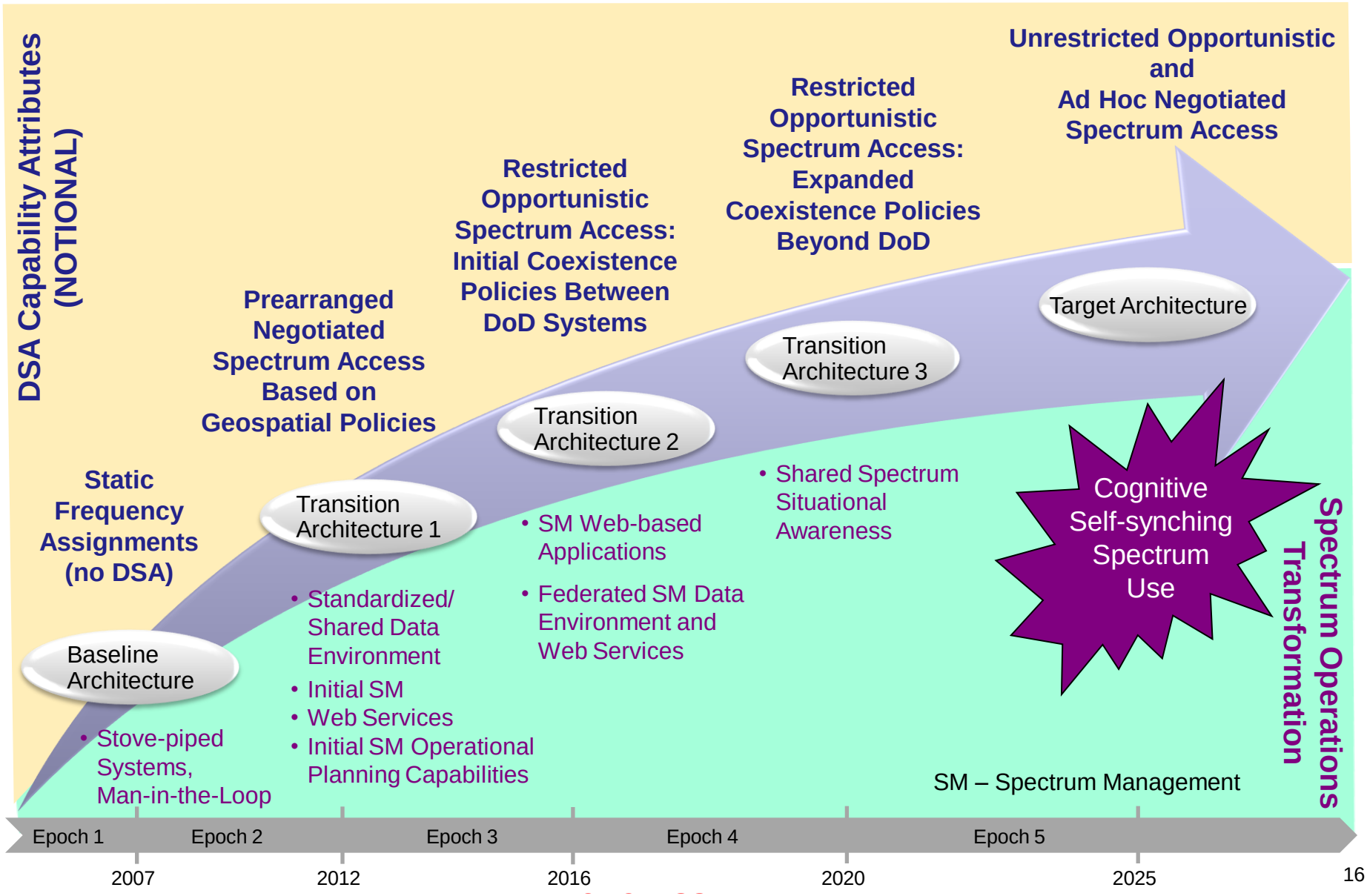

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DSA and Policy-based Management (PBM)

- PBM techniques are just one of a number of key elements required to fully enable DSA
  - Coexistence Analysis
  - Spectrum Operations Transformation
  - Wideband radio technology
  - Sensing techniques

- As a first step towards DSA, the development of policy-based spectrum management (PBSM) provides a foundation on which all other elements of DSA can be incorporated

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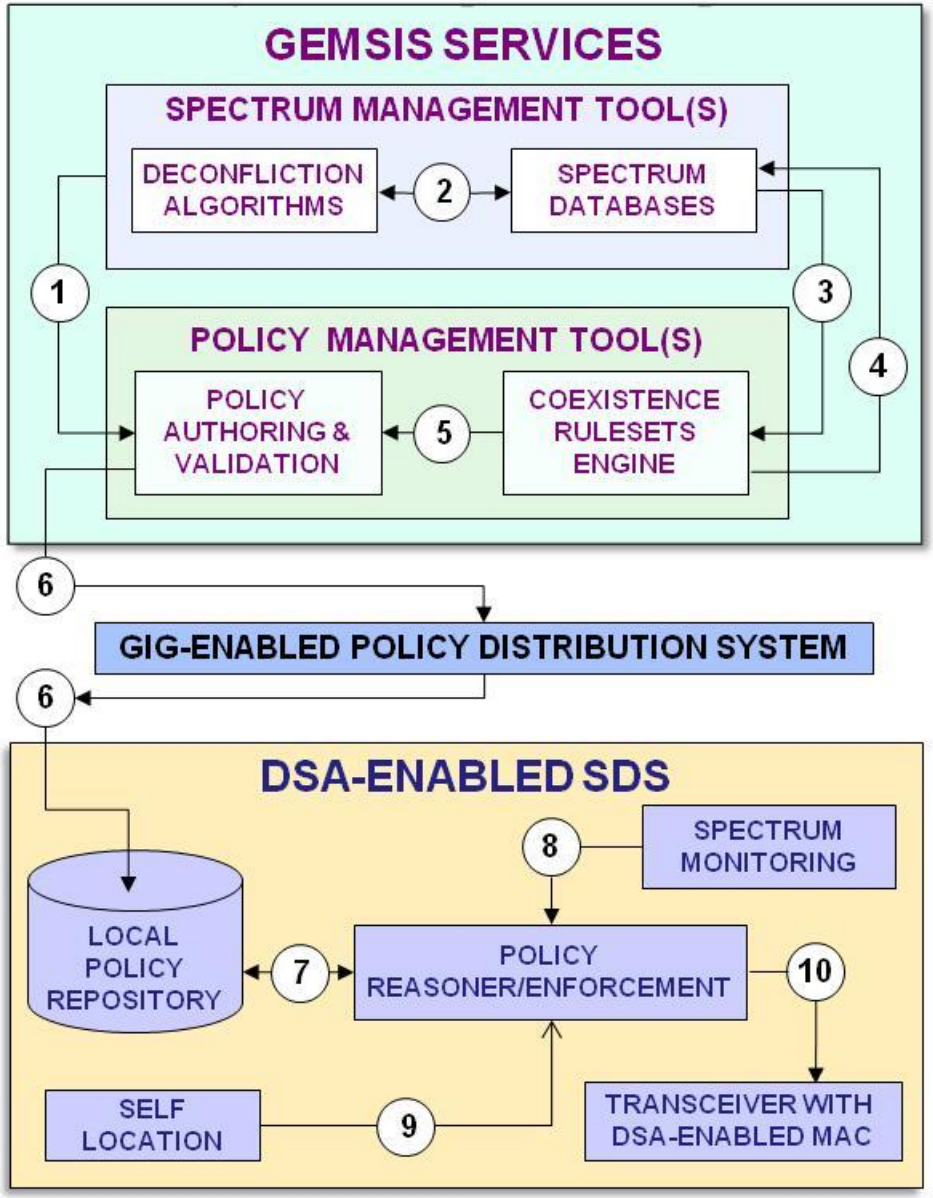
What Constitutes Digital Spectrum Policy?

- Policies can be permissive or restrictive
- Key elements in early implementations include:
  - Allowed frequencies and/or bands of operation
  - Geospatial conditions
  - Temporal conditions
  - Sensing conditions
    - Sensitivity threshold
    - Shared Sensing data
  - Access Protocols
    - Listen before Talk
    - Channel Abandonment Time
    - Channel Revisit Time

Notional PBSM Architecture

DATA EXCHANGE DESCRIPTIONS

1. DSA-enabled SDS frequency assignments (in Standard Spectrum Resource Format (SSRF)) from which policies are developed
2. Background electromagnetic environment data (in SSRF format) used by deconfliction algorithms to determine frequency assignments
3. Background electromagnetic environment data (in extended SSRF format). Identifies systems and frequencies that DSA-enabled SDSs can share.
4. Updated background electromagnetic environment data (in extended SSRF format). Identifies systems and frequencies that DSA-enabled SDSs are sharing.
5. Coexistence rules for DSA-enabled SDSs to share frequencies used by other systems
6. Superset of Policies containing permissive/restrictive spectrum access rules that are loaded in to DSA-enabled SDS
7. Policies applicable to the specific location of the DSA-enabled SDS
8. Spectrum usage data provided by detectors
9. Specific location of the DSA-enabled SDS
10. Specific RF behavior of the DSA-enabled SDS



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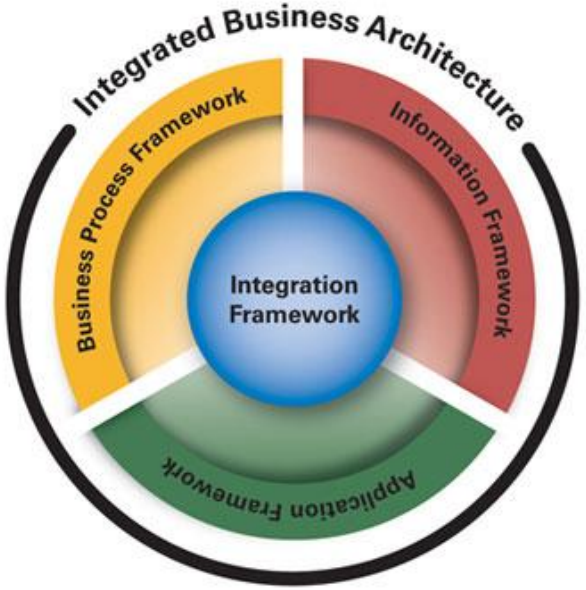
The TM Forum

- TMF establishes standards that support the design, development and integration of operations support systems (OSS)
  - AKA NetOps Systems

tmforum Frameworx

- TMF Standards address:
  - Business Process Model (eTOM)
  - Shared Information/Data Model (SID)
  - Application Framework (TAM)
  - Integration Framework (NGOSS)



- Benefits of TMF include:
  - Reduced cost for NetOps application integration
  - Reduced reliance on proprietary application software and databases
  - Increased flexibility in developing advanced NetOps services
  - Global industry adoption of DoD requirements

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TM Forum Spectrum Management Community

- Formed in Oct 2010. Focused on increased integration of network management (NM) with spectrum management (SM).
- Over 70 members from over 50 companies
  - Integrators
  - Product Vendors
  - Service Providers
- Initial Project: SM-NM Integration
  - Developing dynamic spectrum operations use cases for Defense and Commercial operators
  - Goal is to enhance business process framework with integrated SM-NM concepts
- Future projects to address PBSM and DSA

EXAMPLE MEMBERS

- Alcatel-Lucent
- BTC Mobile (PTY) Ltd
- Cisco Systems
- Ericsson
- Huawei Tech Co. Ltd
- Inst. for Telecomm Sciences
- Logica
- NATO C3 Agency
- Nokia Siemens Networks
- Northrop Grumman Corp
- T-Mobile Austria GmbH
- Thales Communications SA
- Telefonica Moviles España

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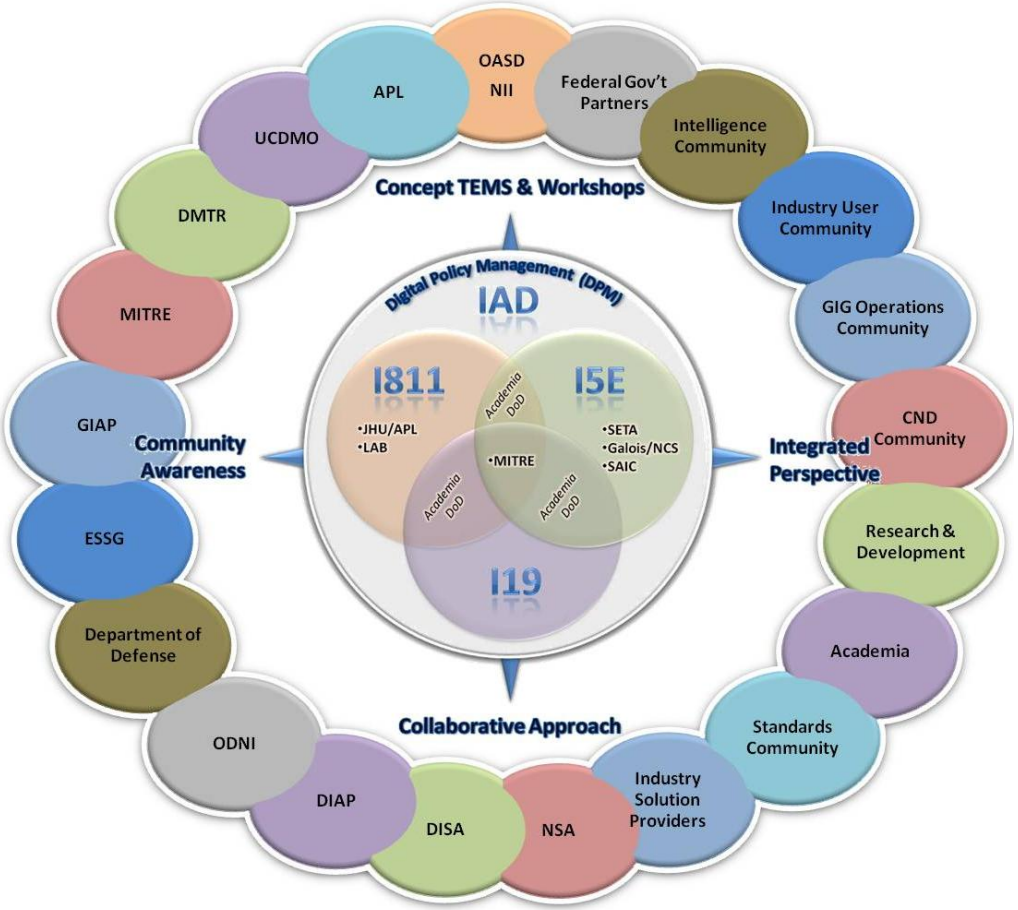
National Security Agency Digital Policy Management (DPM) Working Group

- DPM Goal ...Human Readable Policy to Computer Consumable Policy

- Assured availability, delivery, and protection of information and supporting infrastructure:
  - Assured Information Sharing
  - Computer Network Defense
  - Identity and Protection Management
  - Situational Awareness
  - Policy-based and Risk Adaptable access control methodologies
  - Enterprise Security Management
  - Supports Mission Commander's Intent

- DPM provides the ability to:
  - Translate English Language policies to machine consumable form
  - Deploy policies enterprise-wide
  - Reconcile conflicts between multiple policies
  - Coordinate policy updates across the enterprise
  - Monitor policies to ensure desired effect



DPM Stakeholders

Any individual, group or institution who is affected by the DPM project or has an interest (or stake) in the project

A Common Framework for DPM

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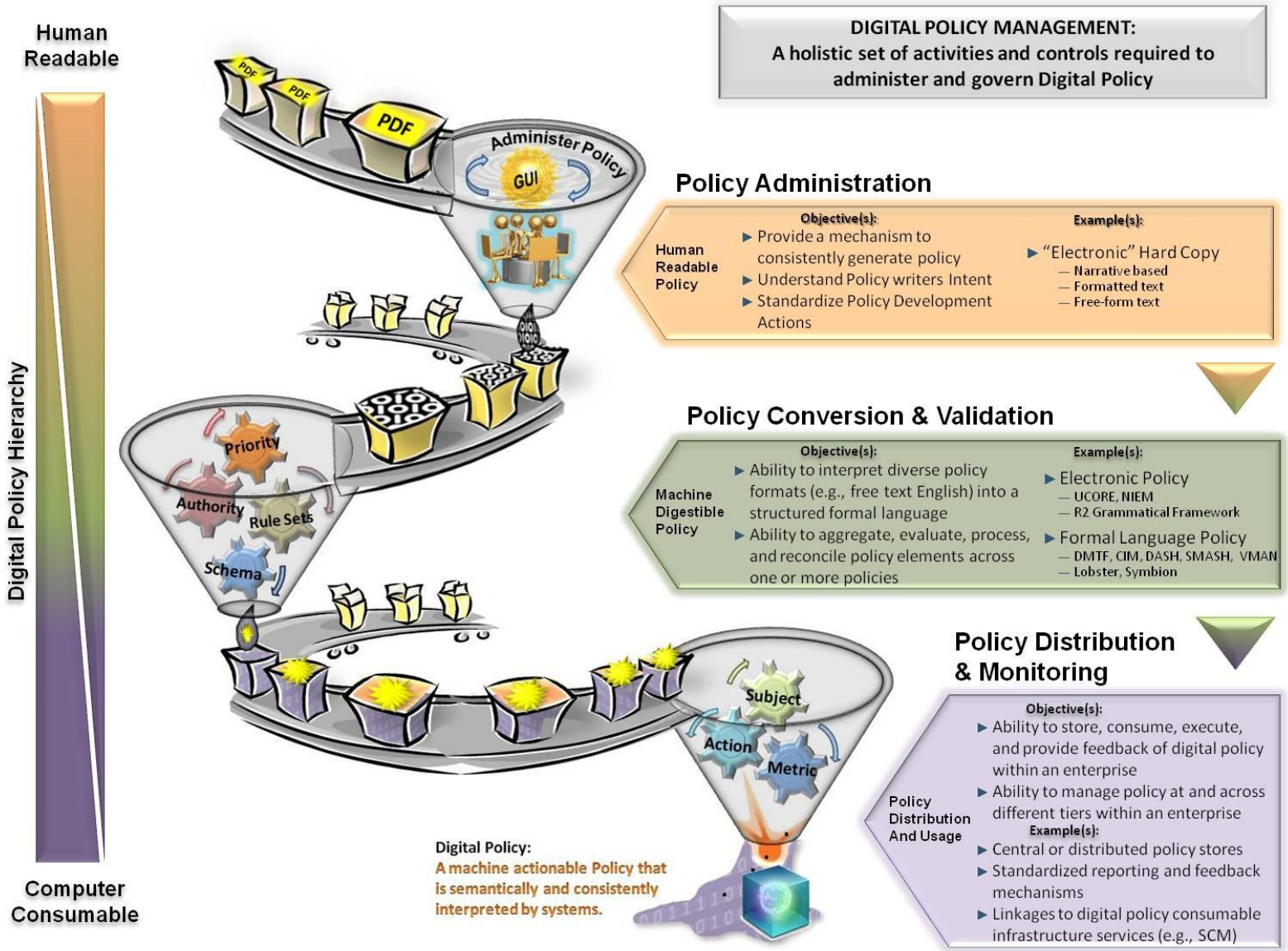

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Summary

- DSA is a key enabler for sharing and military operations in complex, congested, and contested electromagnetic environments
- Digital spectrum policy is fundamental to DSA
- Challenges remain (technology, regulatory, policy, standards) and are the focus of much effort
  - MCEB PUB 7 ➡ MCEB PUB 8 ➡ MCEB PUB X
  - Centralized Deconfliction Algorithms ➡ Decentralized Policy Reasoners
  - Compatibility ➡ Coexistence
  - I/N Thresholds ➡ QoS
  - Allocation/Allotment/Assignment ➡ Policies
  - Frequency Management ➡ Policy Management
- Successful implementation requires collaboration and synchronization across industry, academia, military and civilian government agencies

DSA IS COMING READY OR NOT

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Challenges

- **Technological**
  - **Overcoming the "Valley of Death"**
    - **DSA, PBSM, cognitive technologies need to transition to Programs of Record**
- **Cultural**
  - **Tearing down the Pillars of Excellence**
    - **NM**
    - **SM**
    - **EW**


DEFENSE INFORMATION SYSTEMS AGENCY