Spectrum Sharing Innovation Test-Bed

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Test-Bed Participants

Through a public process the following organizations were selected to participate in the Test-Bed Pilot Program:

- Adapt4 LLC
- Adaptrum Inc.
- BAE Systems
- Motorola Inc.
- Shared Spectrum Company
- Virginia Polytechnic Institute and State University

Test Plan Development Process

Test plan development was instructive but a time consuming process

- Phase I (laboratory) testing:
  - Public notice
  - Participant meetings
  - Draft test plan development
  - Agency review and comment
  - Participant review and comment
  - Public review and comment
- Phase II/III (field) testing
  - Test plan development steps and timeline are similar to Phase I

Overview of Phase I Testing

PHASE I TEST CASES (LABORATORY)

- **DUT Emission Characterization**
  - DUT Modulated Emission Spectrum Measurement
  - Temporal Characteristics of DUT Emissions
  - DUT Modulated Emission Spectrum Measurement:
  - DUT Out-of-Band Emission Levels
- **DUT Sensor Characterization**
  - Detection Sensitivity for Non-Faded, Co-Channel LMR Signals and a Noise Signal
  - Detection Sensitivity for Faded, Co-Channel LMR Signals and a Noise Signal
  - Adjacent Channel Interference
  - Sensor Desensitization
  - Sensor Out-of-Band Interference Rejection
  - DUT Cooperative Sensing
- **DUT Geo-Location Characterization**
  - DUT Geo-Location Policy Database
  - DUT Geo-Location Sensor
  - Loss of Geo-Location Fix
- **DUT Spectrum Access Behavior**
  - Channel Availability Check
  - Paired-Channel Availability Check
  - DUT Geo-Location Channel Availability Check
  - DUT Spectrum Sensor and Geo-Location Channel Availability Check

- **LMR Emission Characterization**
  - LMR Modulated Emission Spectrum Measurement
  - Temporal Characteristics of LMR Emissions
- **LMR Receiver Performance Characterization**
  - LMR Receiver Co-Channel Rejection
  - LMR Receiver Off Frequency Rejection
  - P25 Header Obfuscation

PHASE I TEST CASES (TABLE MOUNTAIN FACILITY)

- Channel Availability Check in a Simulated Channel Environment
- Sensor Performance in a Simulated Near/Far Incumbent System Environment
- Geo-Location Channel Availability in a Simulated Channel Environment
- DUT Channel Loading

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Anticipated Phase II/III Testing*

Phase II Test

- **DUT Sensor Behavior**
  - Pre-conditions
  - Scenario Assumptions
  - Test Procedure
  - Performance Metrics
  - Data Analysis and Interpretation

Phase III Test

- **LMR Hidden Node Test**
  - Downlink Test
  - Uplink Test

- **DUT Sharing with Conventional LMR System**
  - Downlink Test
  - Uplink Test

- **DUT Sharing with Trunked LMR System**
  - Downlink Test
  - Uplink Test

- **DUT Geolocation Characteristics**
  - Pre-conditions
  - Scenario Assumptions
  - Test Procedure
  - Performance Metrics

* The Phase II/III test plan is currently in the review process

Phase I Testing Challenges

- Each participant's DSA device has employed fundamentally different architectures, so the test methods had to be adapted to each model

- Complex test fixtures are required since DSA characteristics must be measured in realistic two-way communications scenarios

- Lack of uniformity in test modes means test fixtures have to be customized for each new device
  - Some test modes were incompatible with our ATE.

Equipment Characteristics

Parameter	Test-Bed Participants				
	Vendor A	Vendor B	Vendor C	Vendor D	Vendor E
Transmit Bandwidth	Fixed	Variable	Variable	Fixed	Fixed
Channel Structure	Contiguous Channels	Non-Contiguous Channels	Non-Contiguous Channels	Single Channel	Single Channel
Monitoring Frequency Range	Variable	Fixed	Fixed	Fixed	Fixed
Monitoring Time	Variable	Variable	Variable	Variable	Variable
Duplex Channel Monitoring	Yes	No	No	No	No
Detection Method	Power Level Exceeding Threshold	Power Level Exceeding Threshold	Power Level Exceeding Threshold	Statistical Processing	Power Level Exceeding Threshold
Detection Threshold	Variable	Variable	Variable	Variable	Variable
Detection Time	Variable	Variable	Variable	Variable	Variable
Cooperative Sensing	Yes	Yes	No	Yes	No
Feature Detection	No	No	Yes	No	No
Control Channel	No	No	Yes	No	No
Channel Lock-Out	Yes	Yes	Yes	Yes	Yes
Channel Clearance Time	Variable	Variable	Variable	Variable	Variable
Channel Re-Visit Time	Variable	Variable	Variable	Variable	Variable
Automatic Transmit Disable	Yes	Yes	Yes	Yes	Yes

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Typical Compliance Test Configuration

Land Mobile Radio Receiver Example:
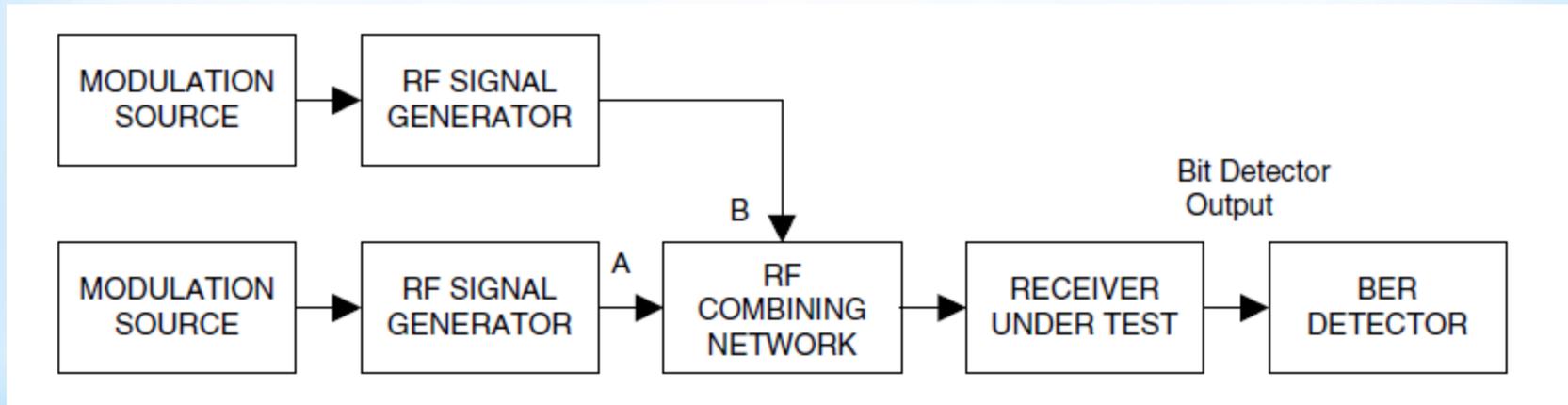
Typical DSA Characterization Test Configuration
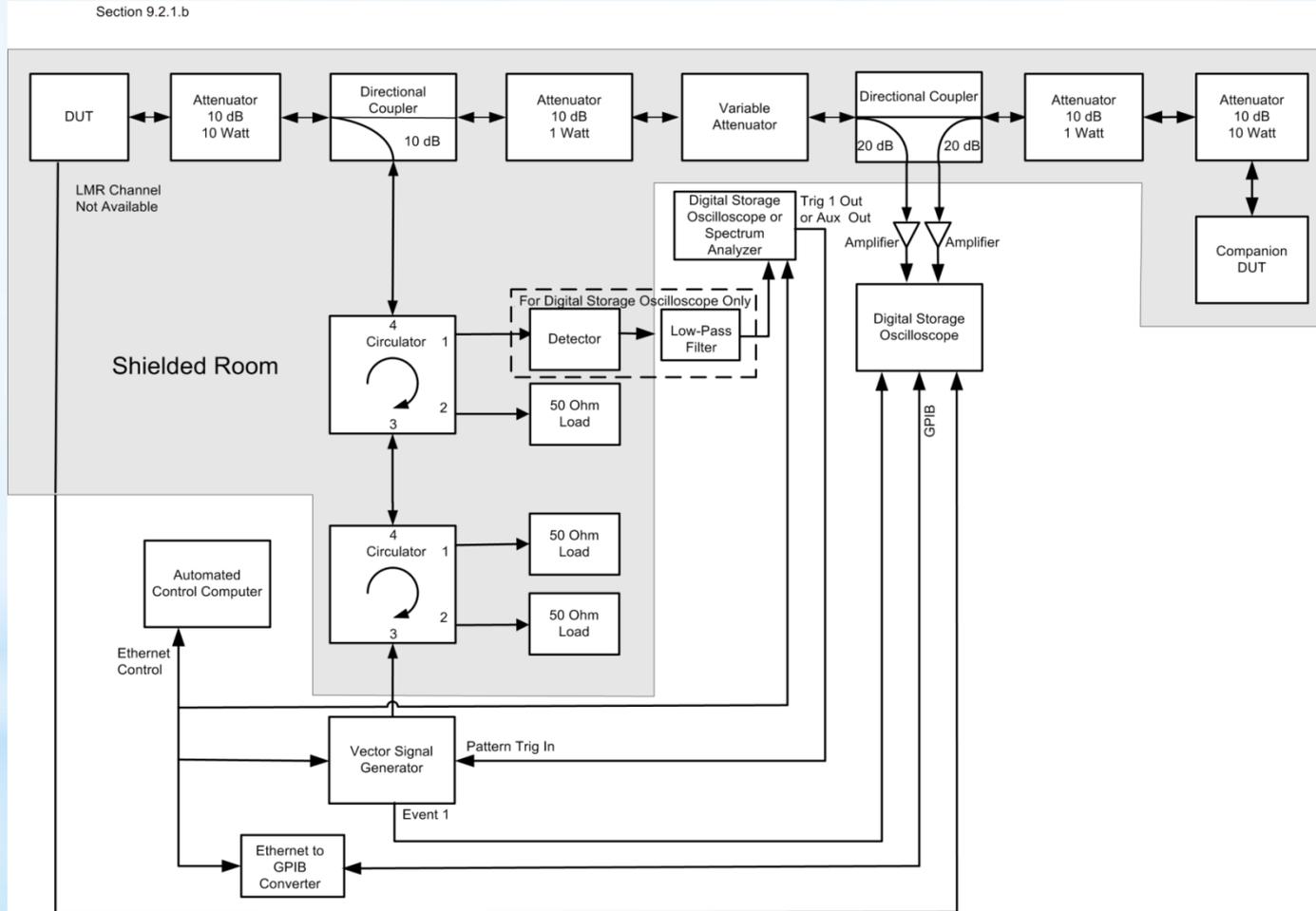
Program Challenges

- A lack of prior experience with DSA systems before test plan development makes test procedures heavily dependent upon preconceptions

- Problems encountered with prototype equipment aren't exposed until testing commences, *e.g.*, VSWR mismatch, level of protocol maturity

- Participants' ability to respond to ITS tech support requests without impacting their funded business activities

- ITS added a second test station to speed up testing; however, the second test station currently sits idle while awaiting participants' test articles

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Key Accomplishments

- Phase I testing soon to be complete for two devices
- Phase II/III draft test plan being reviewed by participants
- Devices being readied for Phase II/III field testing
- Test fixtures being readied for Phase II/III testing
- Test locations being coordinated with local entities and Federal agencies

Perspectives on Test-Beds

- Lab testing is indispensable prior to development of a field test plan

- Incumbent systems are complex and varied and require expert operation. Some are too expensive to strand at a test-bed or simply too large to move

- *in situ* testing provides necessary incumbent equipment for whatever scenario or topology is required

- In the future policy databases might facilitate controlled *in situ* testing
  - Less critical incumbent systems could be monitored
  - Critical incumbent systems could be operated during system maintenance windows

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Topics for Further Study

- Interference protection criteria (IPC)
  - IPC would precede development of spectrum sharing schemes
- Outside the scope of the test-bed:
  - Spectrum monitoring of newly deployed systems
  - Enforcement schemes and tool sets
  - Software configuration control and anti-tampering technology
  - Conformity assessment processes

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