WiSAR (Wireless Synthetic Aperture Radar)
A Disruptive Technology for High-Performance, Smallsat-Based Synthetic Aperture Radar Missions

P. Fox, K. James, A. Thompson

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The Requirements of a SmallSAT SAR

• **The Requirement:**
  – Small satellites for broad range of SAR applications
    • High resolution
    • Wide area surveillance
    • X-band or C-band
    • GMTI Capability
    • Coherent Change Detection (CCD)
    • Compatibility with lower cost, responsive launch vehicles

• **The Challenge:**
  – Designing an active *reconfigurable phased array antenna* with **low mass and power** requirements, thus enabling low cost launch

• **The Solution:**
  – WiSAR™: A patented disruptive technology enabling low cost, high performance SAR satellites
Where WiSAR Fits

MDA is providing solutions for today’s SAR needs while developing the technology to enable the next generation of SAR capability.
Objectives

- **Maximize performance**
  - Single Beam, ScanSAR, SpotSAR, Swept Receive
  - GMTI
  - CCD

- **Minimize the Mass**
  - Enable lower cost Bus
  - Enable lower cost Launch

- **Minimize the Interface to Bus**
  - Decouple the SAR DC Power

- **Minimize Component Cost and Obsolescence**
  - Leverage the massive commercial investment in COTS RF components, CAN Bus and Lithium Ion technology

- **Minimize Deployment Risk and Cost**
  - Enable large (to very large) SAR antenna apertures to be deployed cost-effectively.

- **Minimize Requirements on Deployed Stability**
  - Minimize structural antenna and support structure mass
  - Measure and Compensate dynamically for shape changes

- **Make a scaleable architecture that decouples the antenna design from the mission**
  - No inherent feed constraints on length, width, # of Rows, # of Columns, etc.
  - Distributed power

- **Minimize Complexity**
The Key Elements: Space Feed

- **Active Lens Antenna approach with Space-Feed and frequency translation** as a means of eliminating the azimuth and elevation RF power distributions networks, including all associated harnesses.
  - Enables the reconfigurability in SAR frequency, antenna shape, size and number of apertures.
• **Self-contained active antenna node (WiNode)** that incorporates RF circuits (signal filtration, conversion, amplification and phase/gain control), and timing control and monitoring functions, and has dedicated solar power source and battery.
  - Eliminates power distribution cables and harnesses and the need for separate solar array panels and batteries to provide power for the antenna.
  - Increases reliability of the SAR DC power source.

• **Low Mass Subarray tightly integrated to the WiNodes and Quartz Honeycomb antenna panel**
  - Eliminates the need for separate structural components and radiating elements.
  - Reduces panel thickness and mass and enables deployment with standard Solar Panel deployment mechanisms
The Key Elements: Antenna Dynamic Distortion Compensation

**Metrology** for measuring the antenna geometry and dynamically computing the necessary phase corrections required to maintain the desired beam shape.
- Reduces the requirement for a stiff antenna panels and the support structures required to keep the antenna rigid and flat.

- **Antenna Dynamic Measurement System (ADMS)**
  - Array of RF ranging sensors (WiSense nodes) distributed over the antenna panels, and processing electronics located inside the REX subsystem.
  - The ranging system measures the distortion more than 5 times per second, without interrupting imaging, and supplies compensating phase information to the antenna, performing the Dynamic Antenna Distortion Compensation.
The Key Elements: Antenna Deployment

- Solar Array Technology for Antenna Deployment
  - Inexpensive reliable way of deploying large apertures
  - Keep mass less than 20kg/m² for the aperture (45kg/m² for RADARSAT-2)
    - Integration of structure and radiator
    - Space-Feed Array Architecture
    - Local (antenna) power generation, storage, and regulation (no DC harness)
  - Dealing with solar panel stiffness (e.g. 0.1Hz or less) and distortions
    - Dynamic Antenna Distortion Compensation (via dynamic phase adjustments)
    - Reduced by intrinsic properties of the lens configuration
  - Baseline is the third generation of deployable solar arrays; makes maximum use of existing technology
The Key Elements: Components

- The WiSAR design employs a combination of space qualified parts, and high performance, state-of-the-art, COTS parts.

- MDA employs a systematic and thorough methodology to properly select, evaluate and assess the COTS items for their end use application. This approach reduces space systems development times in a cost effective manner while increasing performance and maintaining high overall reliability of the end item system.

- Leverage off components developed for huge markets
  - **Wireless LAN** market (802.11a) and “Last Mile” (WiMAX and UWB) has developed a wide array of powerful microwave components
  - **Lithium Ion** batteries and single chip battery management systems driven by the cell phone market
  - **CAN Bus** communications and microcontrollers from the automotive industry.
• WiSAR Innovations impact the whole spacecraft

Innovations reduce cost

- SAR Antenna in Space Fed Lens configuration
- Frequency Translating Active Phased array
- Deploy SAR Antenna with Solar Array deployment technology
- Active distortion measurement and compensation
- Employ commercial parts where applicable
- Distribute Antenna Power generation and storage
- Antenna slew for Antenna battery charging

Impact

- Remove APDN & EPDN. Provide configuration flexibility and distortion tolerance.
- Remove most of ESS and simplify the AIT process
- Reduce design life cycle costs as well as Obsolescence impact
- Greatly reduce power demand on Bus. Remove DC Power Harness, Bus to Payload. Greatly simplify spacecraft EMC.

Benefits

- Reduced Payload Mass and Cost
- Reduced Spacecraft mass and cost
- Reduced Bus Mass and Cost
- Reduced Launch costs

MDA
BigSAT Versus SmallISAT SAR

<table>
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<tr>
<th>Parameter</th>
<th>Units</th>
<th>C-band RadarSAT-2</th>
<th>C-band WiSAR</th>
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<tr>
<td>Antenna Aperture</td>
<td>m</td>
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<td>7 x 1.4</td>
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<tr>
<td>Solar Panel Size</td>
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<td>Fairing Envelope</td>
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<td>Ø 2.35 , h = 1.7</td>
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<tr>
<td>Mass</td>
<td>Kg</td>
<td>2171</td>
<td>853</td>
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Launch Vehicles

LV Payload Envelope Profiles

Dnepr (standard)
Dnepr (2m extension)
Vega
Minotaur IV
PSLV

LV Performance Curves for SSO

- Dnepr - 5.0 kg/km (around 600 km)
- PSLV - 0.91 kg/km
- Vega - 0.70 kg/km
- Eurockot - 0.70 kg/km
- Minotaur IV -

C-band WiSAR
Ø 2350 mm
h 1700 mm

X-band WiSAR 12m x 1m
X-band WiSAR 9m x 1m
X-band WiSAR 9m x 0.75m

Payload Mass (kg)
Altitude (km)
A Focused Image of the ISS

• MDA has demonstrated the functionality of the WiSAR concept beyond any doubt.

• 2.84m x 1m aperture; 56 WiNodes; ~350W Peak RF power; ~75W Mean RF power; PRF=24KHz

• This image was made with a radar, pointed by hand at an object travelling at 7.7km/s, 344km away

Signal to Noise ratio = 31 dB
C-Band Performance and Ship Detection Example

- Swath widths from 20 Km up to 500 km
- 100m resolution in 500 Km swath mode
- 3m resolution in 20 Km swath mode
- NESZ values WC –17dB to –25dB, depending on the mode of operation
- Detect ships less than 40m
  - Pd=90%, Average Wind Direction, Sea State 5, Swath Width =350km
- The overall active phased array area is 9.43m² (1.37m by 6.88m), organized as 7 panels; each panel being one column of 32 rows for a total of 224 dual polarization sub-arrays
X-Band High Performance SmallSAT

- GMTI Capable Dual Aperture (left)
  - Array reconfigurability supports large phase centre separation and low MDV with 10m to 12m antennas

- High resolution X-Band SAR
  - 400km orbit.
  - 4m by 1.2m phased array.
  - High resolution (1m by 1m) and wide area surveillance capability with a ScanSAR mode
  - NESZ better than -19dB
  - This performance is delivered with an antenna mass of just 154kg, including all bus mounted deployment and tie down hardware, and including a 15% margin.

- A 2nd Generation X-Band WiNode Prototype (left) developed in cooperation with Defence Research and Development Canada (DRDC).
Summary

- SmallSAT SAR solution needs to provide high resolution, wide area coverage, excellent noise performance, Coherent Change Detection and GMTI capability at an affordable price point.

- MDA’s Wireless Synthetic Aperture Radar (WiSAR™) is the new SAR technology that offers uncompromised performance in both X- and C-band at significant reductions in cost and mass over the conventional state of the art.

- WiSAR™ provides unprecedented reconfigurability and modularity that enables the SAR to be responsively tailored to the mission, and to be rapidly assembled and aligned.

- WiSAR™ is ready for flight demonstration.