The Proposed DESDynI Array-Fed Reflector Feed

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Outline

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  - Proposed Mission
  - Proposed Instrument
  - SweepSAR Concept
- Proposed Array-fed Reflector Design
  - Reflector and Feed Configuration
  - Feed Antenna Tile
- Predicted Performance
  - Modeling
  - Patterns and Gain
- Conclusions
Proposed DSAR Mission Overview

DSAR: DESDyniSAR
- Deformation
- Ecosystem
- Structure
- Dynamics of Ice
- Synthetic Aperture Radar

Proposed Mission Objectives:
• Determine likelihood of earthquakes, volcanic eruptions, landslides
• Predict response of ice sheets to climate change & impact on sea level
• Characterize effects of changing climate & land use on species habitats & carbon budget
• Monitor migration of fluids associated with hydrocarbon production and groundwater

Constraints:
• Single Radar instrument
• NASA cost-constrained (has been driving design)

Status:
• Currently in pre-Phase A studies
• TBD launch

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*Pre-decisional - for planning purposes only*

http://desdyni.jpl.nasa.gov/
Proposed Instrument Overview

Interferometric Synthetic Aperture Radar
Deployable Mesh Antenna
Patch Array Antenna Feeds
SweepSAR asymmetric Transmit and Receive
Transmit Receive Modules (TRMs)
Front-Side Processors (FSPs)
Digital Beamforming on Receive

- L-band for decorrelation
- S-band for sensitivity & lower ionospheric impact
- Quad-pol for biomass
- Short repeat intervals
  - 12 day equator
  - 3 day ice caps
  - 232km swath (quad-pol)
  - 12m resolution
Proposed Antenna System

“The DESDynI Synthetic Aperture Array-Fed Reflector” IEEE Array 2010

- **Deployable mesh antenna**
  - 12m projected diameter
  - Northrop AstroMesh or Harris Deployable Truss
  - High mass efficiency: 1.0 – 1.5 kg/m²
  - High TRL with many successful deployments

- **Array feed**
  - 12x2 dual-pol L-band (1.26 GHz) patch elements
  - 24x1 dual-pol S-band (3.20 GHz) patch elements
  - Separate TRMs for H-pol and V-pol
  - 3.1m length support structure
Proposed Sweep-SAR Concept

- On transmit, all feed elements are excited simultaneously, under illuminating the reflector resulting in a broad beam in elevation.
- On receive, signals at individual elements are processed sequentially as they are received, sweeping across TX footprint.
Proposed Antenna Optics and Performance

12m Diameter Prescription

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>D</td>
<td>Projected aperture</td>
<td>12 m</td>
</tr>
<tr>
<td>F</td>
<td>Focal Length</td>
<td>9 m</td>
</tr>
<tr>
<td>H</td>
<td>Edge offset</td>
<td>-1.4m</td>
</tr>
<tr>
<td>(\Psi_C)</td>
<td>Center angle</td>
<td>29°</td>
</tr>
<tr>
<td>(2\Psi_S)</td>
<td>Subtended angle</td>
<td>70°</td>
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Nominal L-band Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tx</th>
<th>Rx</th>
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<tbody>
<tr>
<td>Scan range</td>
<td>deg</td>
<td>N/A</td>
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<tr>
<td>Directivity</td>
<td>dBi</td>
<td>34.0</td>
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<tr>
<td>Loss</td>
<td>dB</td>
<td>1.7</td>
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<tr>
<td>HPBW az</td>
<td>deg</td>
<td>1.2</td>
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<tr>
<td>HPBW el</td>
<td>deg</td>
<td>11.6</td>
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<tr>
<td>Cross Pol</td>
<td>dB</td>
<td>-25</td>
</tr>
<tr>
<td>EIRP</td>
<td>dBW</td>
<td>63</td>
</tr>
</tbody>
</table>
• 2x2 tile of dual-probe-fed dual-polarization patch elements
  – 18cm elevation spacing (Xf), 13cm azimuth spacing (Yf)
  – Concatenated 6 times in elevation to form feed array
  – Dual probes fed in anti-phase to improve pattern symmetry and reduce cross-pol

• Tiles have integrated stripline feed circuits to split/sum signals

• 100W Transmit / Receive Modules (TRMs)
  – Separate TRMs for H-pol and V-pol eliminates polarization switch
Proposed Antenna Tile Construction

- Composite 18mm thick Astroquartz honeycomb Duroid tile assembly
  - Bonded using film adhesive in a high temperature cure
- Excellent RF performance and low coefficient of thermal expansion (CTE)
  - Proven performance and durability, as demonstrated on UAVSAR
- Stripline circuit board is fabricated using a fusion bond
  - Circuit traces are fenced with vias to ensure good isolation
- Probe interconnects couple capacitively from the patch to the stripline feed
Modeling The Proposed Antenna

- Generally don’t model entire feed in HFSS
- Stripline feed modeled in HFSS but generally not included in pattern synthesis
- Do not model loss, mesh, or faceting in GRASP
  - Sometimes do not include support structure and boom

MATLAB

HFSS
FEM

GRASP
PO/PTD/MOM

Radar Scattering

Sensitivity & Ambiguity versus range
• S-band elements offset in azimuth to reduce mutual coupling to L-band elements
  – Causes secondary pattern to squint in azimuth assuming neither feed is on focus
• Surrounding elements provide the good approximation to local BC
  – Typical pattern taken from middle elements (shown with dashed boundary)

• HFSS model has radiation boundary spaced min. ¼ wavelength (shown on 3 of 5 sides of solution box)
Synthesized L-band Feed Patterns

H-pol

V-pol

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Synthesized S-band Feed Patterns

H-pol

V-pol

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Synthesized L-band TX Secondary Patterns

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Synthesized L-band RX Co-pol Secondary Patterns
Synthesized S-band TX Secondary Patterns
Synthesized S-band RX Co-pol Secondary Patterns
Concluding Points

• Proposed DESDynI Synthetic Aperture Radar (DSAR) Mission:
  – Monitoring climate change, predicting earthquakes and volcanoes

• Interferometric SweepSAR with Digital Beamforming
  – Asymmetric ‘all on’ transmit versus sequential receive
  – Obtains wide swath with low repeat interval

• Array-fed reflectors:
  – Mass and cost-efficient large-aperture scanning antennas with high TRL
  – Limited scan capability relative to phased array but sufficient for proposed mission

• Patch Array Feed:
  – Low-profile, low-mass design that can readily adapt as design evolves
  – Proven design approach from previous missions, including UAVSAR and Deep Impact

• Performance and system validation
  – HFSS/PO/PTD/MoM pattern predictions at L-band and S-band
  – L-band design is mature and radar performance is good
  – S-band design is new and has some issues that are starting to be addressed:
    • Significant mutual coupling from S-band patch elements to L-band patch elements
    • Significant degradation is gain (4dB) at near and far-ends of swath (scanning many beamwidths)
Questions