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Large Aperture, Solid Surface Deployable Reflector

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Project Background

• Deployable RF reflector to provide larger apertures for earth science missions
  – Unique concept design similar to TDRS but using shape memory polymer materials
  – Offset-Fed reflector for clear aperture and clean data
  – Intermediate solution between rigid reflectors and deployable mesh reflectors
  – Solid surface for high frequency capability

• Advanced Component Technology (ACT) Funding from ESTO started in February 2009.

• Cross-cutting technology applicable to RF communications, RADAR, and radiometry
  – Technology feasibility demonstrated on internal funding
  – Commercial backing from S/C Prime contractor for tooling
  – Also builds on center-fed reflector demonstration
Why larger apertures?

- **Performance**
  - Optical resolution of an ideal telescope defined by $\frac{\lambda}{D}$
    - Larger apertures more critical for lower frequencies
  - Signal strength determined by gathering area
    - Passive RF likely to be dominated by signal/noise ratio
    - Active RF power requirements driven by signal strength

- **Why not larger apertures?**
  - Missions will only be designed to use what can be built and launched within budget
    - If no one knows you can build it, they won’t design for it.
What Earth Science Missions Have Used So Far

- Nearly all sensors have had small ~1m apertures
  - Some 2.5m apertures for dedicated launches
  - Science missions can’t consume larger footprints unless they are a flagship mission
  - 6m and 12m mesh apertures now being used (still small footprint)

**GOAL:** Open this range with solid surface deployable reflectors

Plot does not show \( \varphi/D \) relationship
Solid Surface Deployable Reflector

- Offset fed RF reflector that packages to 1/3 width
  - Continuous graphite reflective surface
    - Low CTE
    - Can be metallized for high frequency RF
- Demonstration unit will use reflective surface from available 2.5m by 4m mandrel
Baseline program was SMAP

- Offset fed provides clean aperture
- Solid surface reflector accurate to Ka band
- SMAP timing not feasible for technology maturity
Other Possible Applications

- **ACE**
  - Baseline for 5m main and secondary reflectors require very large volume
  - High frequency, 94 GHz very challenging

- **SCLP**
  - Large aperture needed to get resolution required
  - RF frequencies in ideal bands for CTD reflectors
  - No baseline design yet??

- Specific mission definition critical for TRL advancement
Enabling Technology:
TEMBO® Elastic Memory Composites

- A Multifunctional Structure/Actuator
- TEMBO® Elastic Memory Composite (EMC) can be used both as deployment mechanism and deployed structure
- Low Part Count results in low cost
- Repeatable, micron level precision
TEMBO® Stiffener

TEMBO® stiffener as manufactured with “shaping”

Packaged TEMBO® stiffener with “shaping”
Packaging and Deployment Cycle with Center-Fed Parabolic Reflector

- Fully Deployed
- Packaging
- Stowed
- Deployment

Heat and force

Cool

Heat & it Deploys

Cool and shape holds

a.) Fully Deployed
b.) Packaging
c.) Stowed
d.) Deployment

Cool
Center-fed Reflector Deployment
Offset Reflector Packaging

1. Pull tension on edges of reflector (vertical and horizontal)
2. Apply an opposing buckling force at the 5 vertical tooling beams to initiate the wave shape
3. Draw both outer edges in to complete the wave shape
4. Move the beams to drive the reflector into a tighter package
   - The two outboard backside beams move inward towards the center beam which is stationary
   - Front side beams also move towards the center but at half the speed and apply load and moves with the pleat towards the back of the reflector.
Offset Fed Reflector and Backing Structure Offloaded

- Outrigger translation cart
- Keel determinate
- Outrigger free in 5 DOF
- Outrigger counter-balance
- Shell whiffle tree
- Outrigger suspended at center-of-gravity
- Shell attach points free in 6 DOF
Offset-Fed Reflector
Backing Structure Integration

- Cross beams fabricated
  - Eight cross beams manufactured
  - Each cycled through stowage/deployment
  - Match bonded into backing structure
TRL Status and Plans

• Entry TRL = 2
  – Concept defined for specific application

• Current TRL = 3
  – **Achieved at end of third quarter 2009**
  – Demonstration of packaging/deployment of all required elements for reflector including cross beams, gap closers, and reflector shell

• TRL = 4
  – Expected third quarter 2010
  – Proof-of-concept through packaging and deployment of 2.5m by 4m reflector

• TRL = 5
  – Expected end of 2011
  – Completion of packaging, deployment, and environmental testing of a mission specific 4m reflector
  – Requires sufficient definition of representative mission to simulate environment including S/C interface and mounting
Key Milestones

• Identify baseline program and develop specific requirements
• Develop system design for baseline program
• Identify technology gaps and customize technology roadmap
• Complete fabrication of demonstration unit
• Perform RF testing of demonstration unit
• Package and deploy demonstration unit
• If additional funding available from commercial source, environmental testing of demonstration unit