

Utha Small Satellite Confernece 2022, SSC22-WKIII-02

**Low-Cost SAR Antenna
with Wide Swath and High Ground Resolution**

Hirobumi Saito, Kosei Ishimura
Waseda University

5-15-6 Kamiiuma, Setagaya-ku, Tokyo, Japan; 81-3-3413-3813,

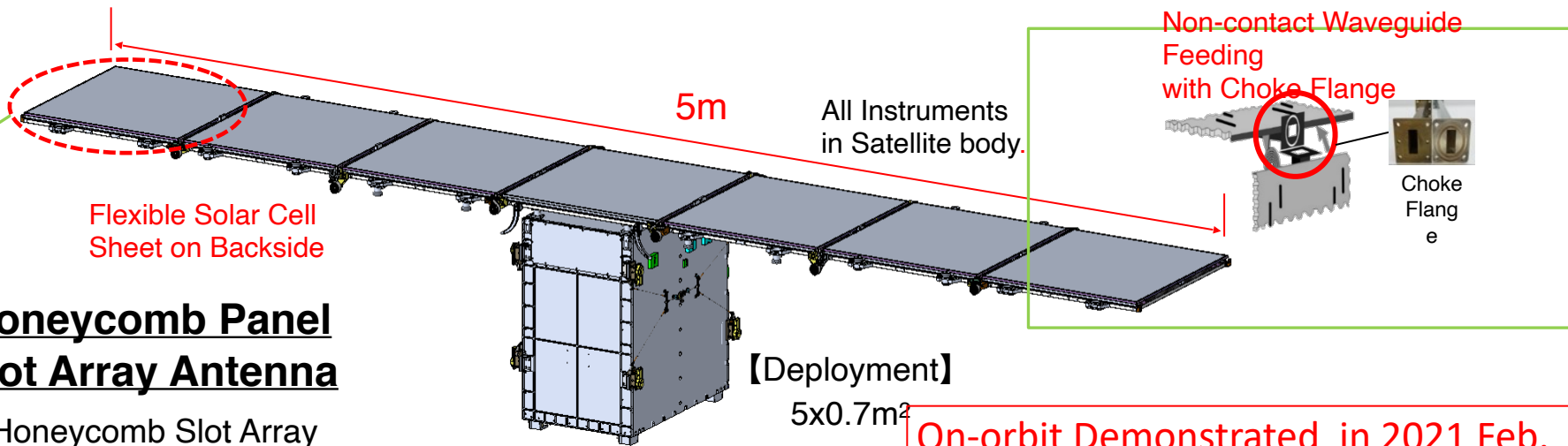
Saito.hirobumi@aoni.waseda.jp

Jiro Hirokawa, Takashi Tomura
Tokyo Institute of Technology

Contents

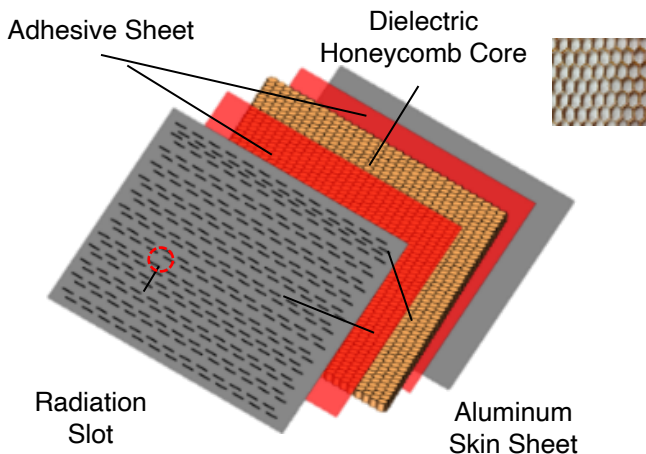
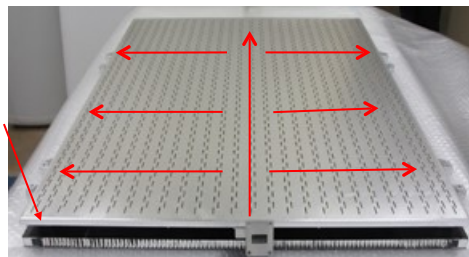
1. JAXA /Tokyo Tech Inst have developed Small SAR system with unique passive array antenna. The first in-orbit demonstration was by start- up company Synspective.
2. This paper describes next generation **of Small SAR with Low Cost, Wide Swath and Hight Resolution.**
3. 600MHz Bandwidth, CFRP Antenna.
4. 1200MHz Bandwidth, Parallel Feed Antenna with 25cm ground resolution.
5. Proposal of DiskSat SAR.

Compact Honeycomb Panel Slot Array Antenna



Honeycomb Panel Slot Array Antenna

Honeycomb Slot Array Antenna

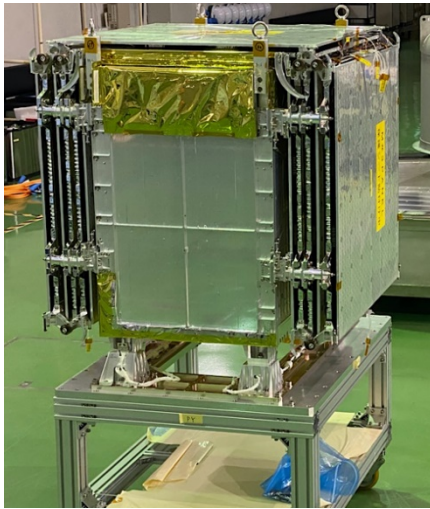


On-orbit Demonstrated in 2021 Feb.
Synspective Inc. 1m Ground Res.
Tokyo Bay, Rainbow Bridge.



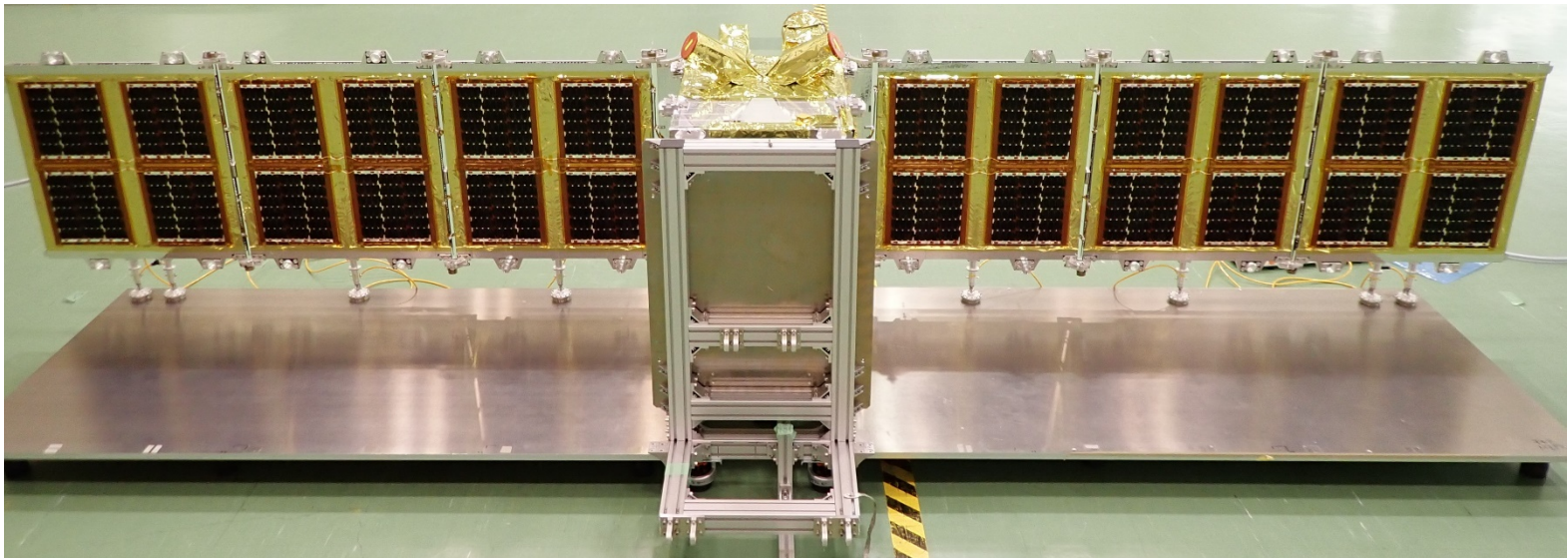
Micro-X-SAR Satellite

Antenna Stowed



2 Satellites have been already launched.

Antenna Deployed with Solar Cell on Backside



Summary of SAR Antenna and SAR Application

Passive Phased Array

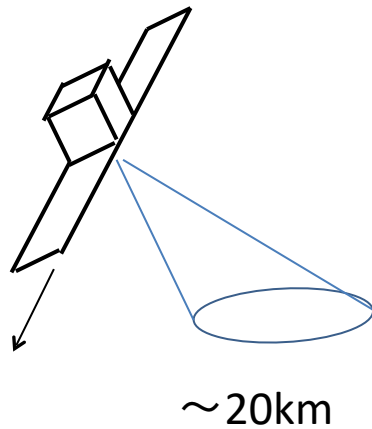
Mesh Parabola

Merit/
Demerit

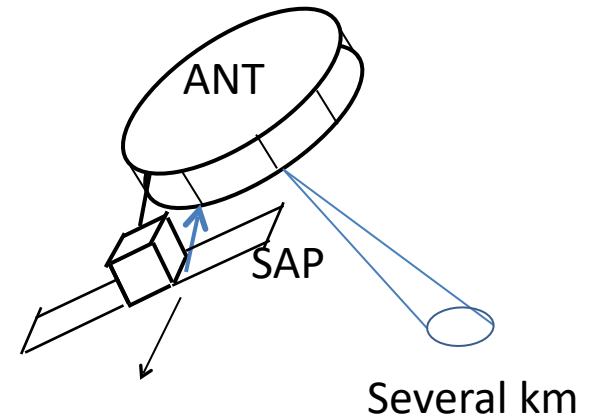
Low cost (simple honeycomb antenna with solar cell on backside)
Medium swath/resolution

High resolution
Narrow swath

ANT/SAP



~20km



Several km

600MHz Bandwidth

2D-Waveguide Slot Array Antenna for 50cm Range Resolution

Design Value

Structure

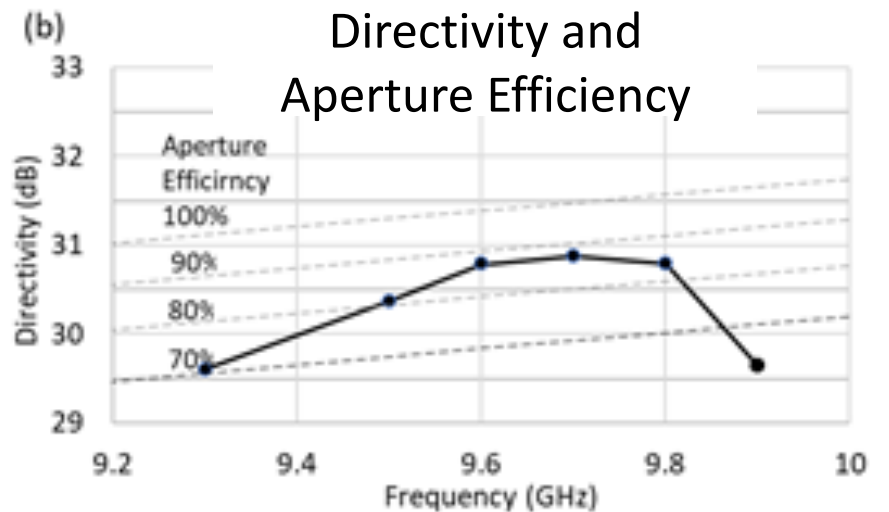
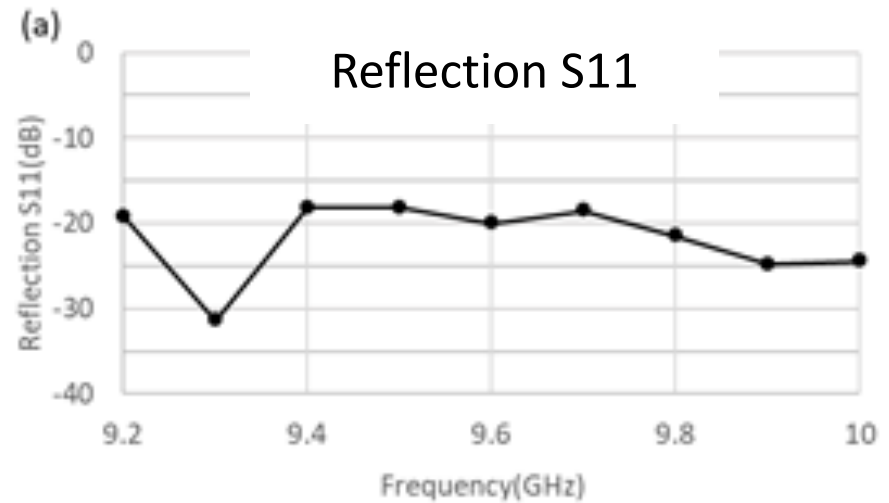
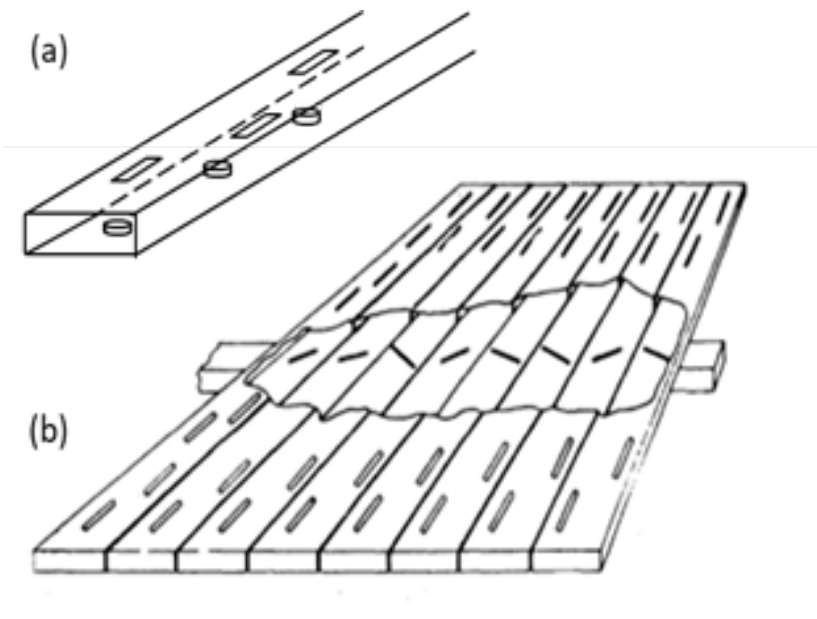


Fig.4 (a) Single Radiation Waveguide with Slot and Button to Suppress Reflection.

Manufacturing Technology

CFRP Forming
for Thermal Stability
35cmx35cm

(a)



Copper Plating
for Surface Conductivity

(b)



Now Antenna Assembling

25cm Resolution Requires 1200MHz Bandwidth

Parallel Feed Slot Array Antenna

Series Feed

600MHz, 50cm Resolution

(a)

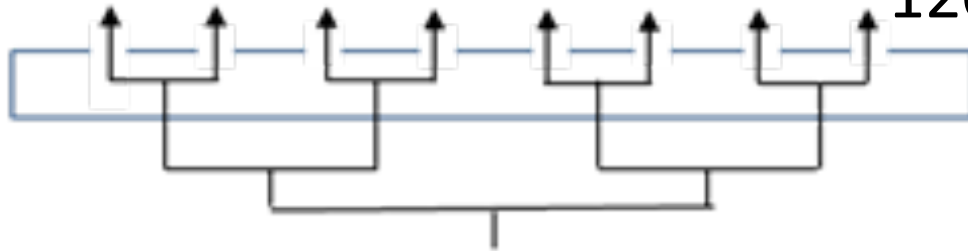


Phase mismatch occurs
at frequency edge

Parallel Feed

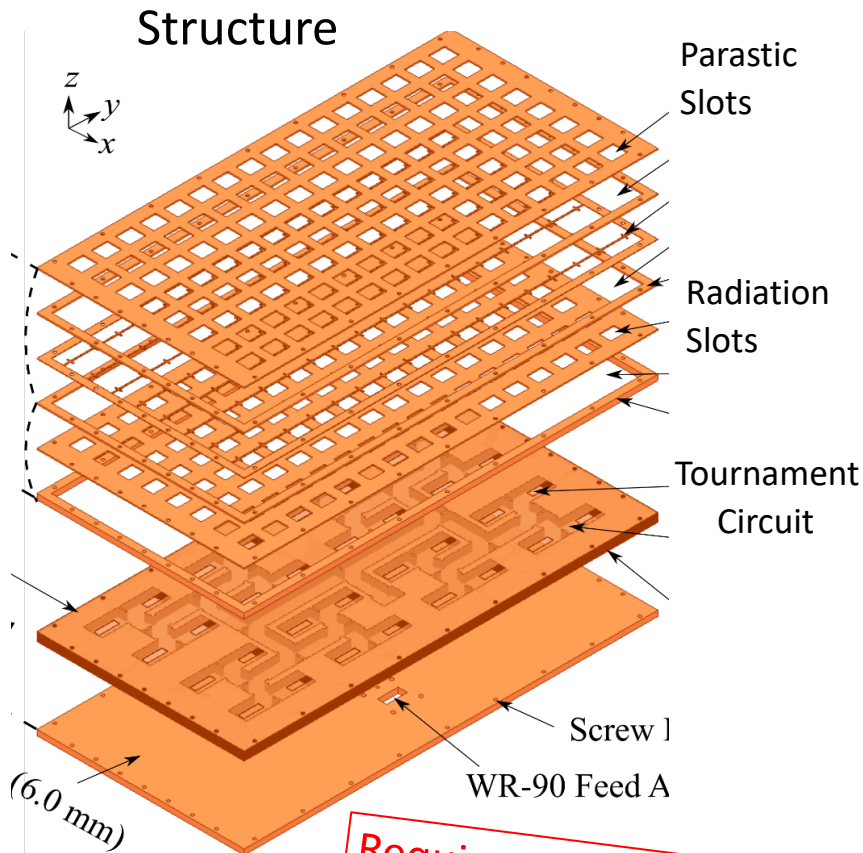
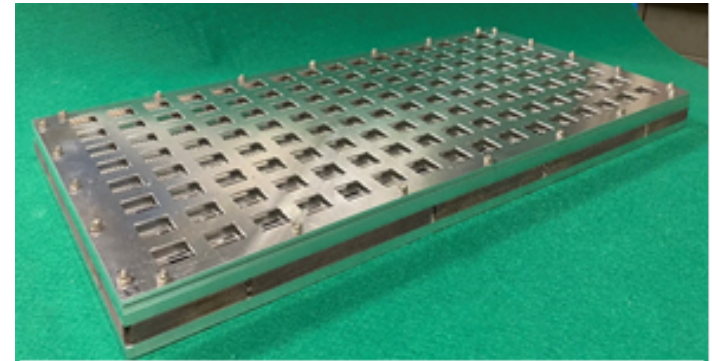
1200MHz, 25cm Resolution

(b)



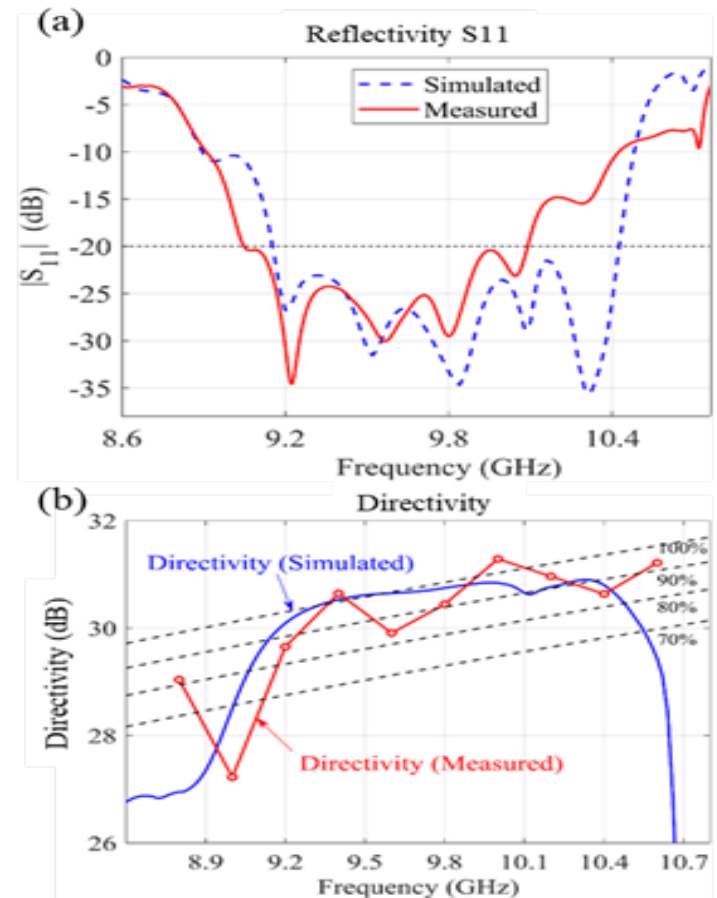
1200MHz Bandwidth Parallel Feed Slot Array Antenna for 25cm Range Resolution

Outlook



Requires Mass Reduction !

Measured Results

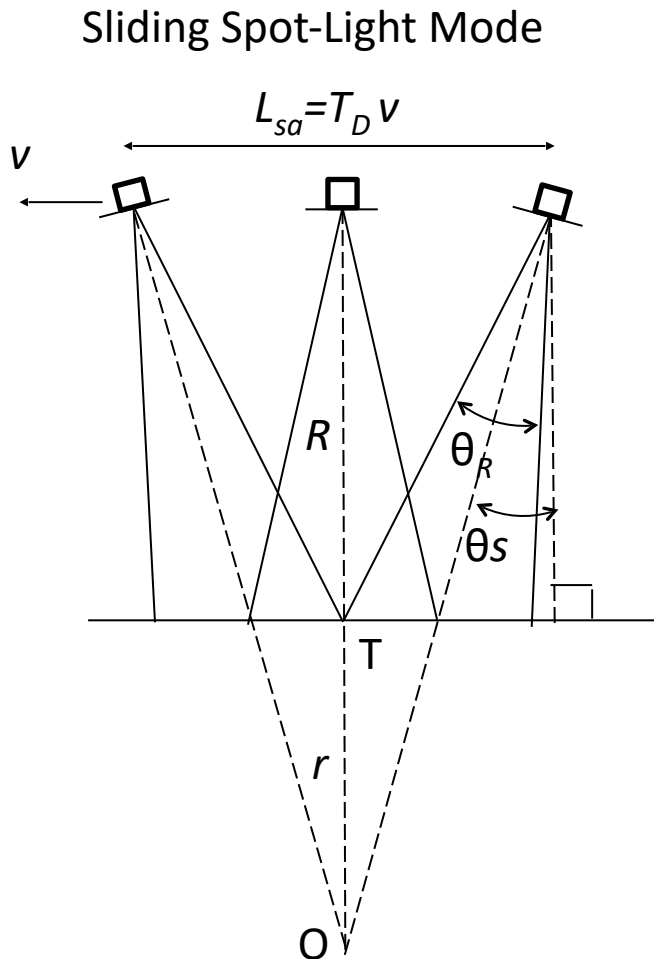


Sliding Spotlight Mode for High Azimuthal Resolution

25cm Azimuth Resolution Requires Large Synthetic Aperture.

S/C Rotates to observe the target for longer duration.

Tx Power $\propto 1/Rg$ Res
 Data Gen. Rate $\propto 1/Rg$
 Data volume $\propto (1/Rg \text{ Res.})(1/Az \text{ Reso.})$



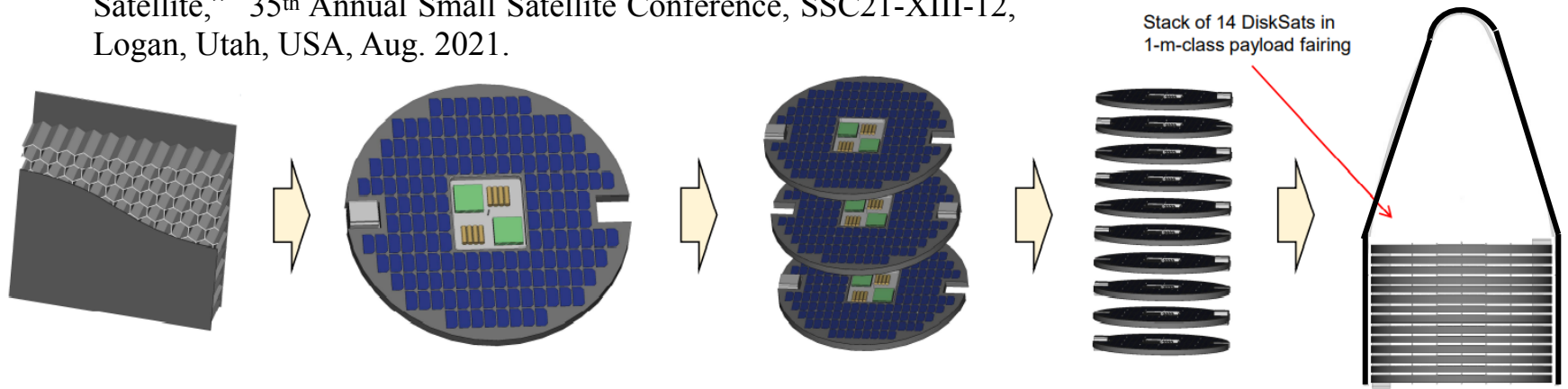
Observation Parameter	1st Generation	2nd Generation
Range Resolution δ_r (m)	1	0.25
Azimuth Resolution δ_{az} (m)	1	0.25
Observation Area ($Rg \times Az$) (km)	20 x >20	20 x >20
Chirp Bandwidth (MHz)	300	1200
Steering Factor A	0.4	0.1
Local Illumination Time T_D (s)	1.2	4.8
S/C Rotation Rate (deg/s)	0.45	0.65
Beam Sweep Velocity v_{sweep} (km/s)	3.0	0.75
Observation Time (20km x 20km) T_{total} (s)	7.9	31.5
Average TX Power P_{ave} (W)	250	1000
Data Generation Rate (Gbps)	1.5	6.0
Data Volume (20km x 20km) (Gbyte)	1.5	23.6

DiskSat SAR with Slot Array Antenna

Large Aperture, Mass Production, Containerization

DiskSat Proposal

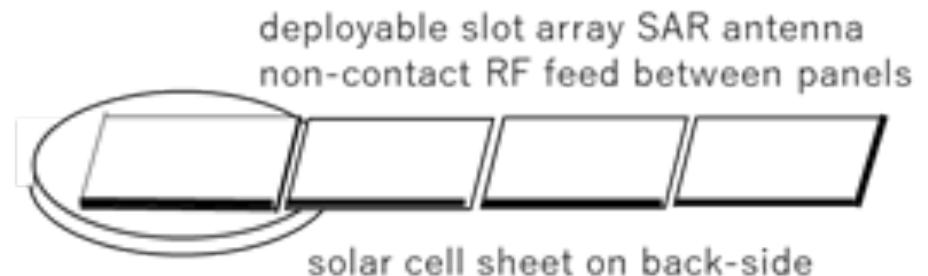
Richard P. Welle, Catherine C. Venturini, David A. Hinkley, Joseph W. Gangestad. "The DiskSat: A Two-Dimensional Containerized Satellite," 35th Annual Small Satellite Conference, SSC21-XIII-12, Logan, Utah, USA, Aug. 2021.



Our Antenna is very compatible to DiskSAR Satellite

Flat, No need Surface adjustment unlike Mesh Parabola

Compatible with Solar Paddle on Back Side



Conclusions

1. Passive 2D Slot Array Antenna is a unique, low cost, and wide swath SAR antenna.
2. For higher range resolution
 - 600MHz Bandwidth, CFRP Antenna.
 - 1200MHz Bandwidth, Parallel Feed Antenna with 25cm ground resolution.
3. For higher azimuthal resolution, sliding spotlight mode is effective.
4. Goal of 2nd generation SAR:
25cm ground resolution, 20kmx20km observation area.
5. Proposal of DiskSat SAR.