RFTSAT:

Demonstrating Passive RF Sensor Tags Using Backscatter Data Communication

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RF Backscatter communication allows for wide range distributed sensing.

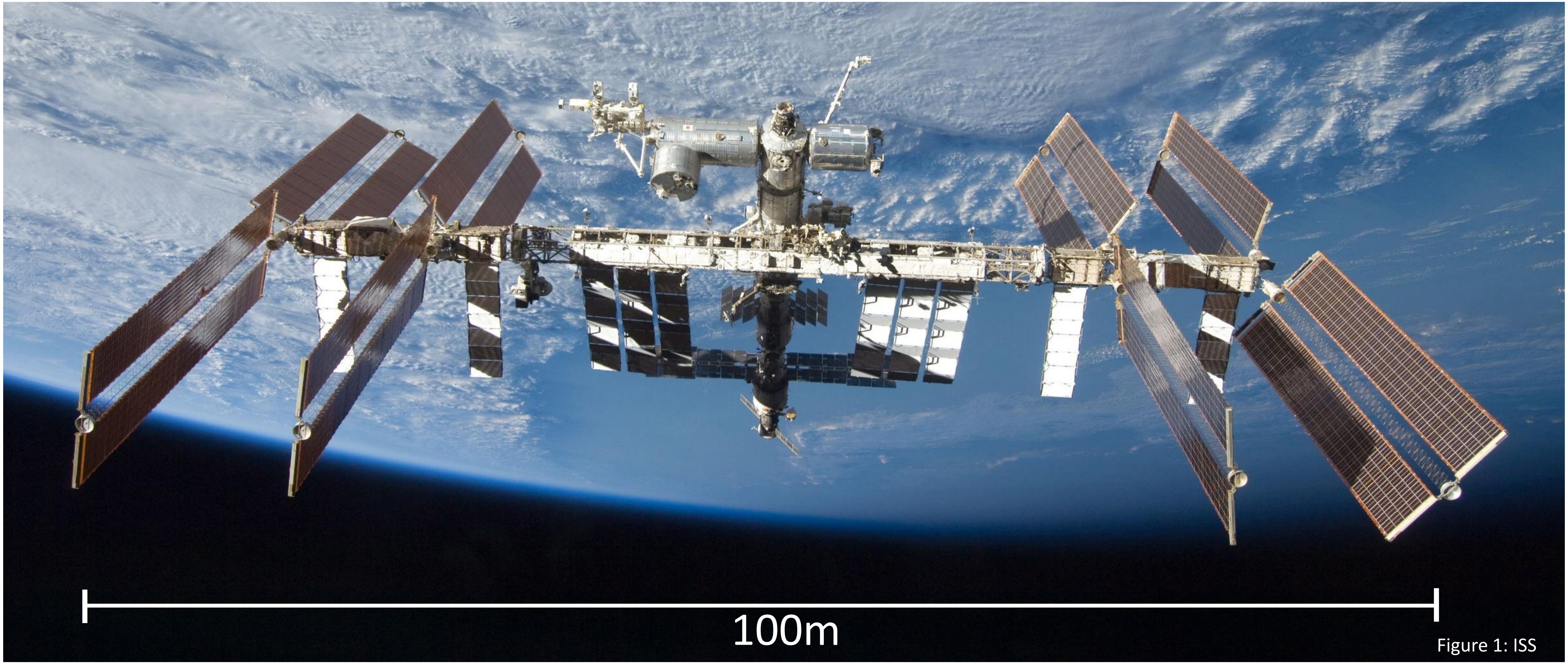
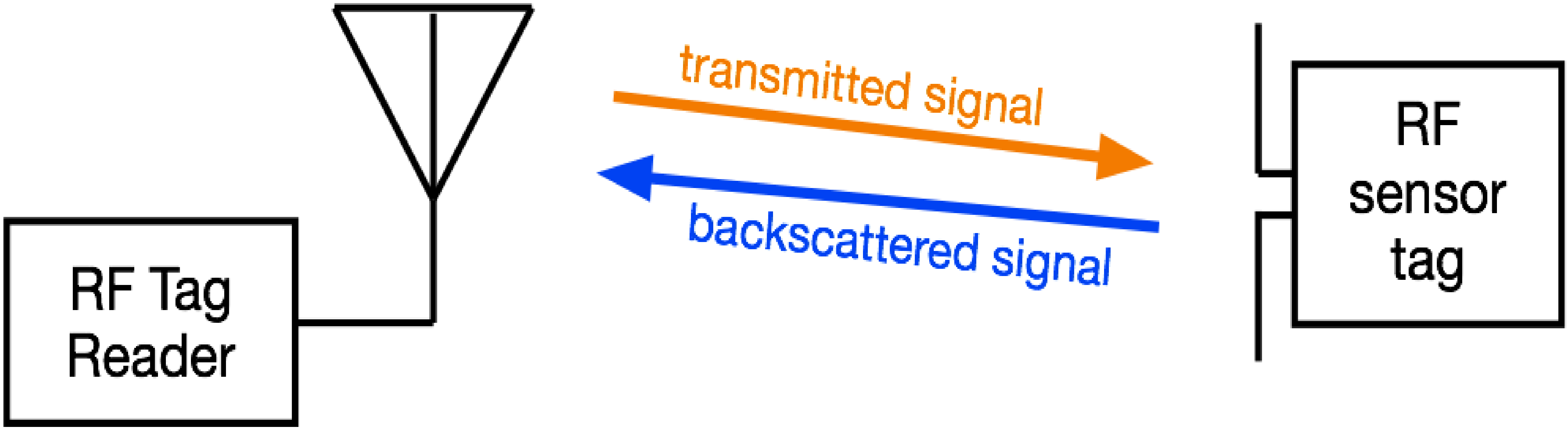


Figure 1: ISS

RF Backscatter communication utilizes a carrier wave with modulated backscattered signals to send data.



RF power is maximized by antenna gain and transmitted power.

Power-Up Link Budget:

$$P_t \propto \frac{P_{Tx} G_{Tx} G_t}{r^2}$$

Bistatic Backscatter Link Budget:

$$P_R \propto \frac{P_{Tx} G_{rx} G_{Tx} G_t^2}{r^4}$$

P_t = Power received at the tag

P_{Tx} = Power transmitted by the reader

P_R = Power received at the reader

G_t = Gain of tag antenna

G_{Tx} = Gain of reader tx antenna

G_{rx} = Gain of reader rx antenna

r = radius between reader and tag

Backscatter communication provides many benefits and in-space applications.

Benefits:

- Low powered: 10μW – 10mW
- Typically small: few square inches, 40g
- Perform basic computing functions
- Integrated on space craft after deployment

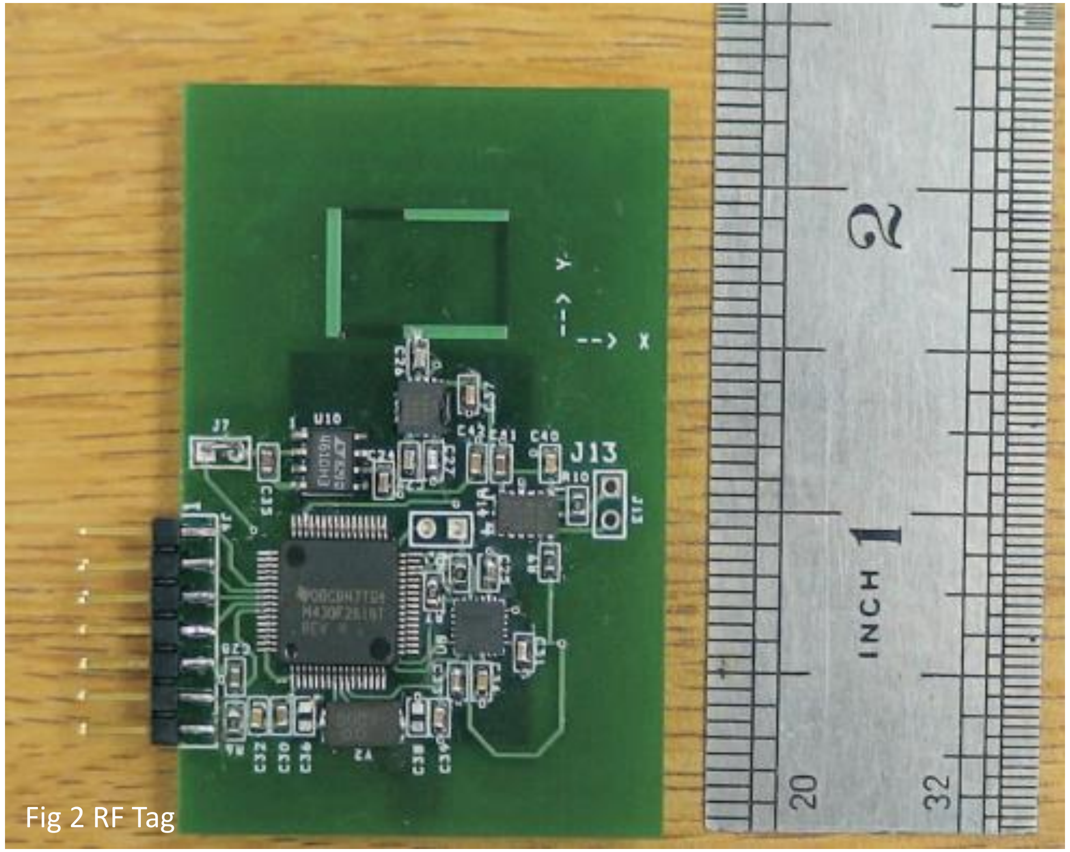


Fig 2 RF Tag

RF Backscatter communication provides many applications for wide range distributed sensing in space.

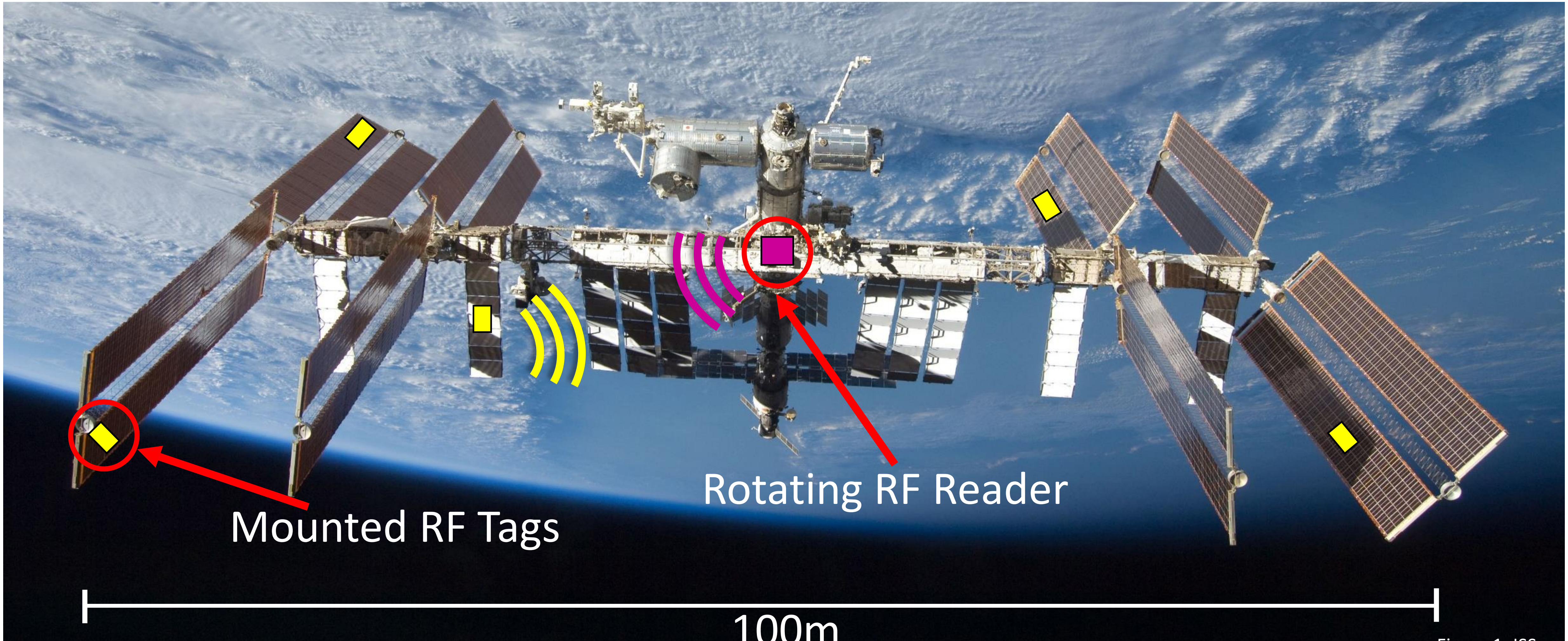


Figure 1: ISS

RF Backscatter communication provides many applications for wide range distributed sensing in space.

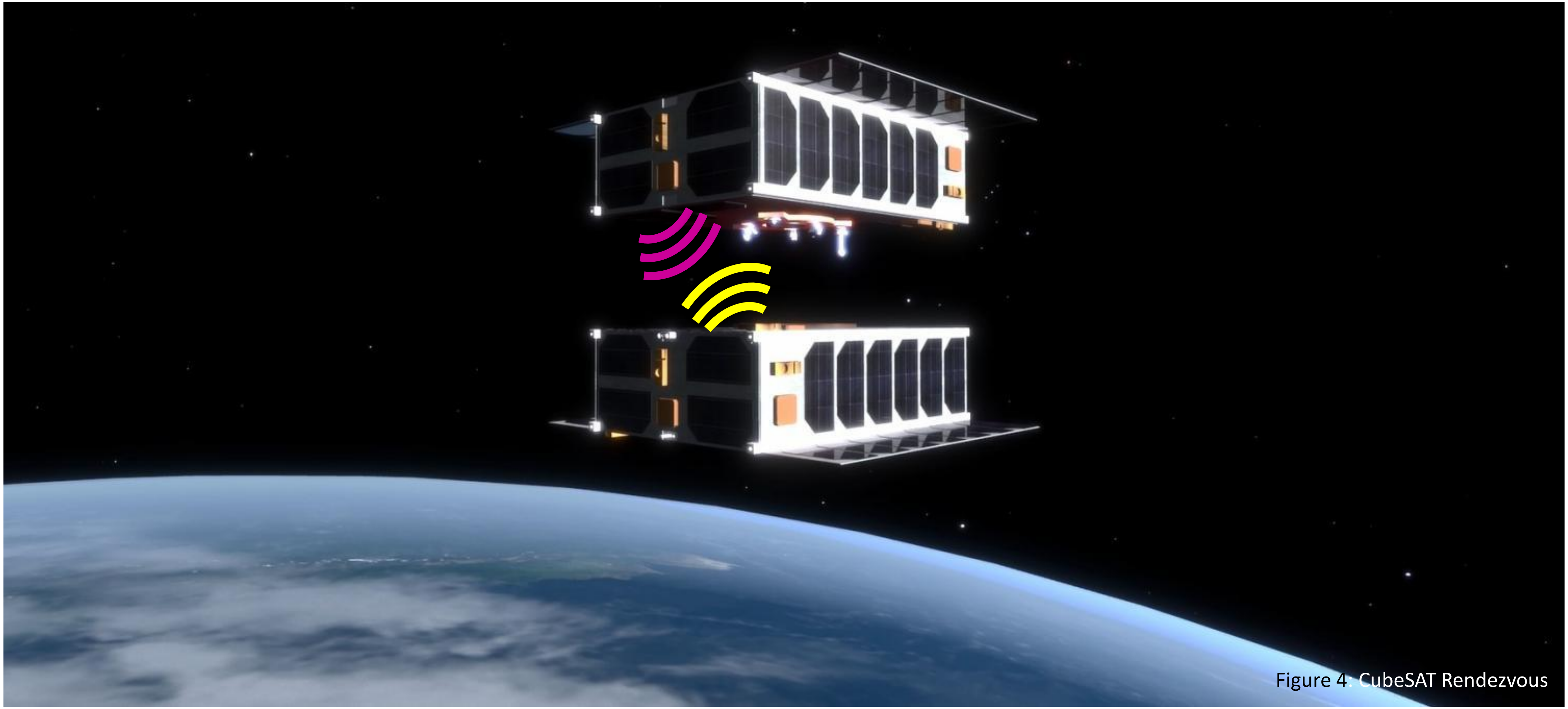
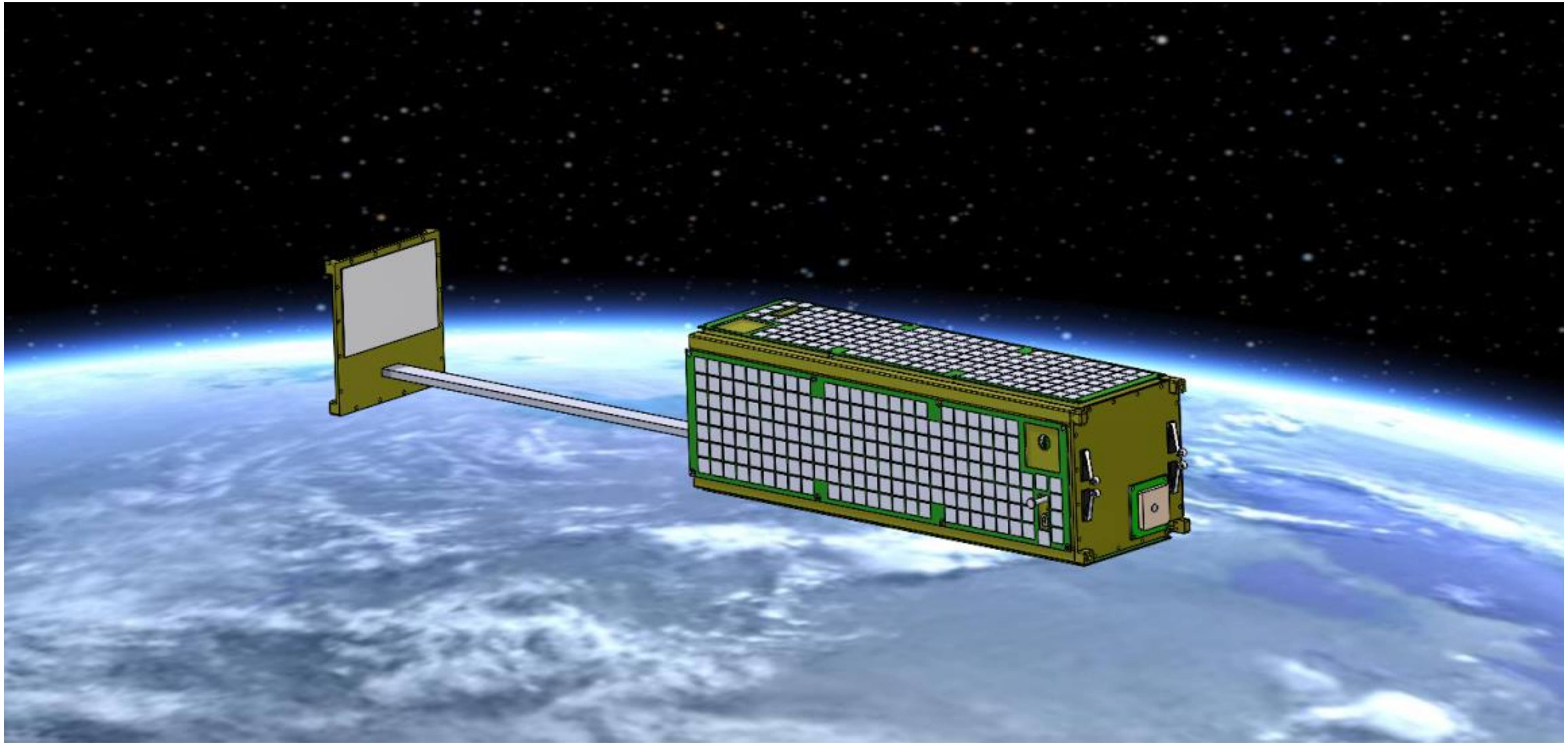
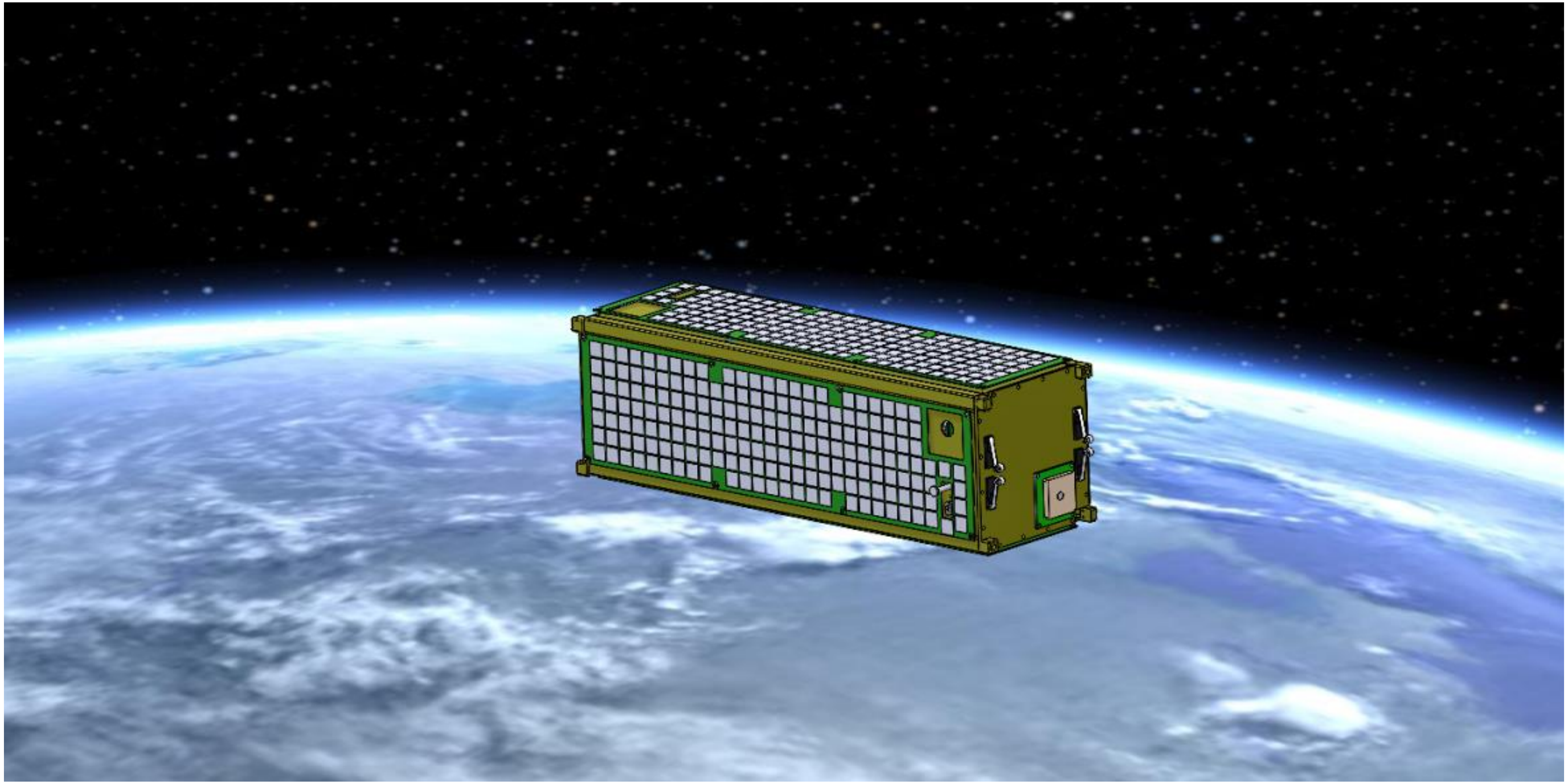


Figure 4: CubeSAT Rendezvous

The NNU RFTSAT team is creating a 3U CubeSAT to perform an *in-situ* technology demonstration of RF backscatter communication.



Mission success is achieved through incremental data measurements.



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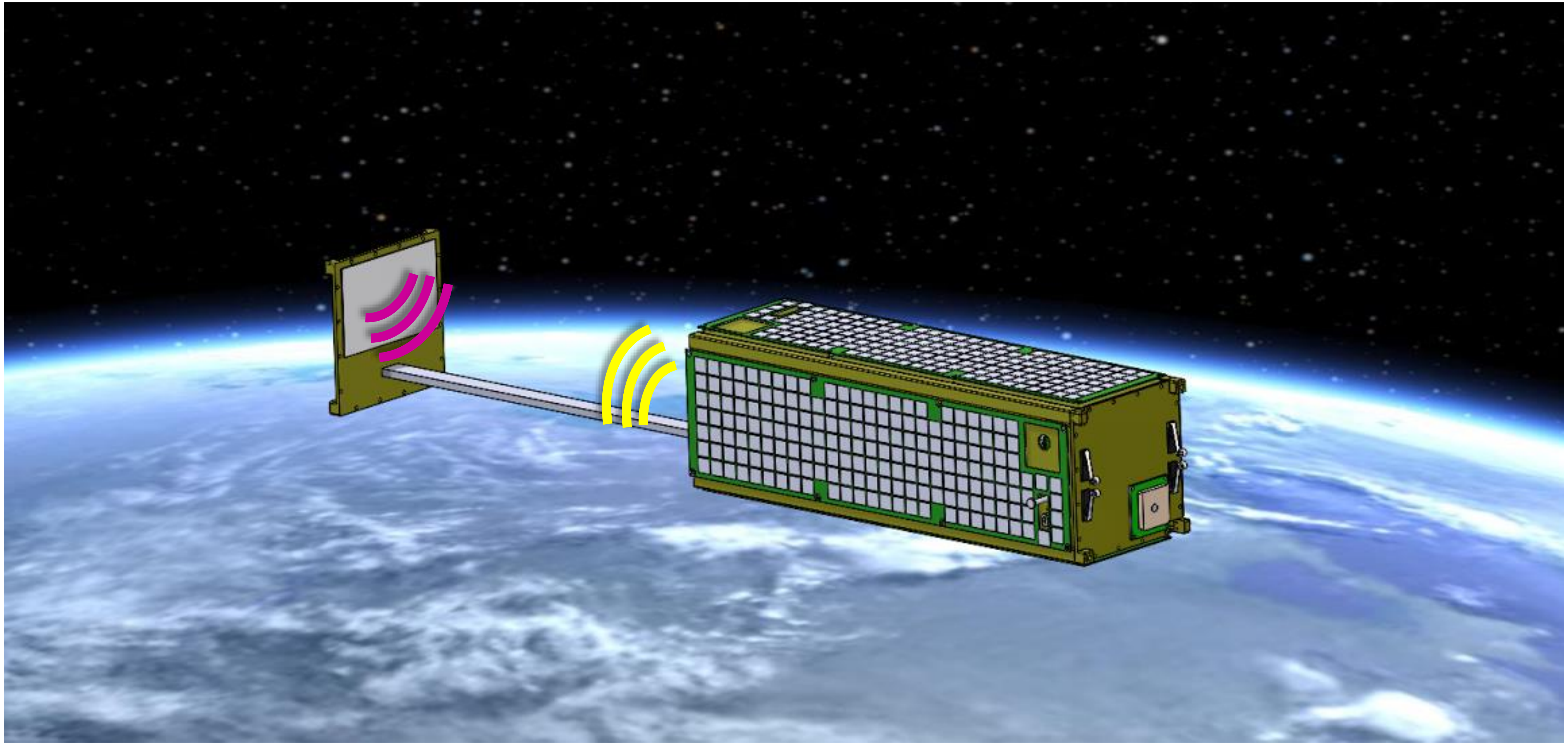
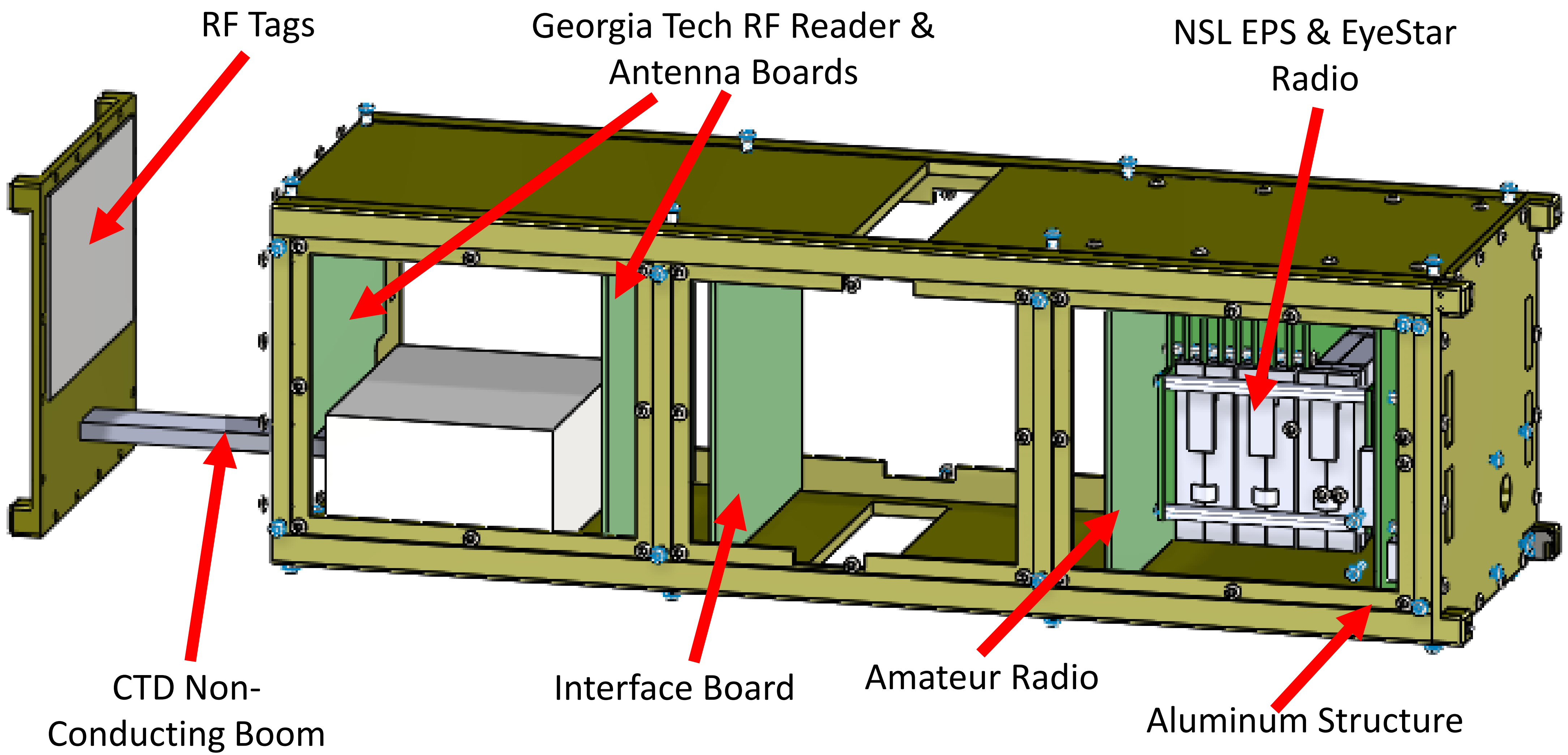


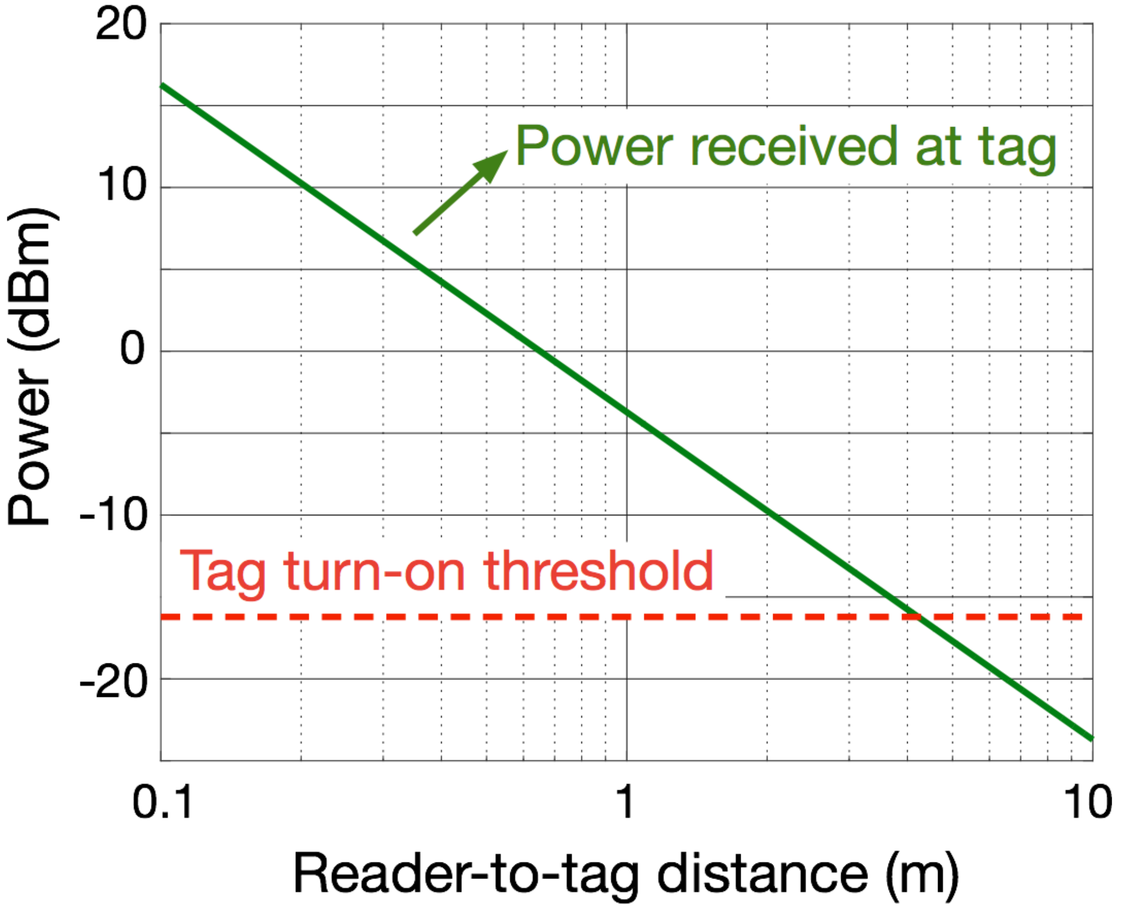
RFTSAT consists of six subsystems.

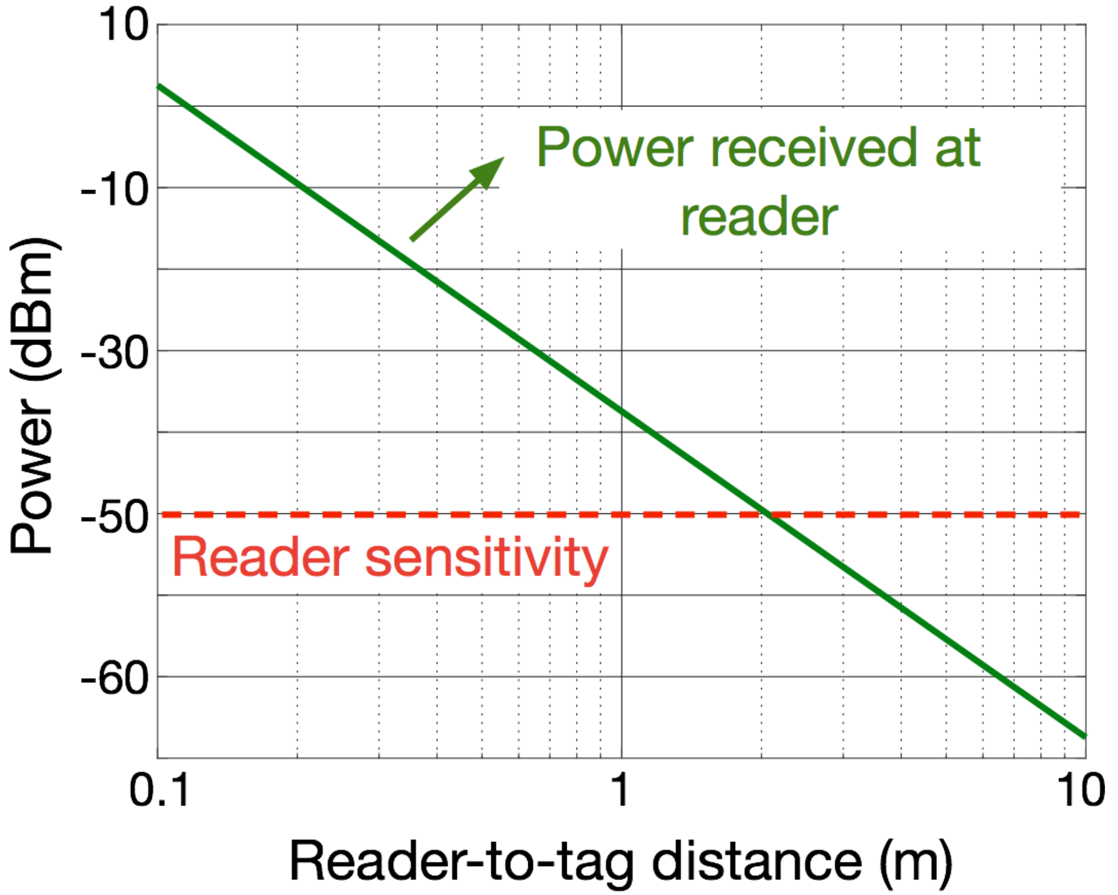


RFTSAT has enough power for its subsystems.

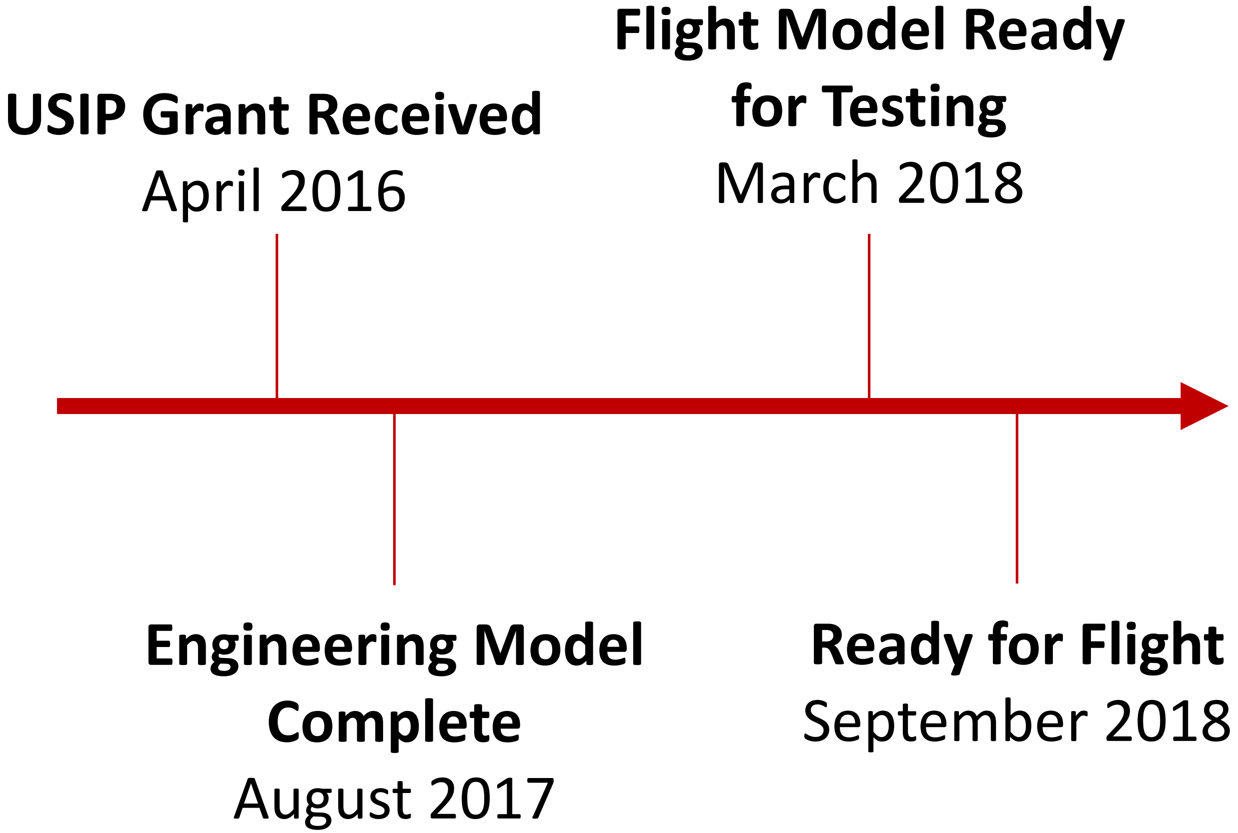
Power	Subsystem	Power (W)
P_{IN}	Solar Panel	1.80
P_{RFIDTx}	Reader	0.27
$P_{RFID\ Standby}$	Reader	0.18
P_{EPS}	EPS	0.5
P_{IB}	Interface Board	0.10
P_{motor}	Boom	0.04
$P_{radioTx}$	Simplex	0.08
$P_{radioStandby}$	Simplex	0.20
$P_{optional}$	Additional Payload	0.06
Power In (W)		**1.80**
Power Out (W)		**1.43**
Margin		**0.37**
Note: All calculations assume a 1.5-hour orbital time		

The RF System on RFTSAT has sufficient range for mission success.





RFTSAT will be ready for launch late 2018.



Acknowledgments

- 2016 NASA Undergraduate Student Instrument Project (USIP) Student Flight Research Opportunity (SFRO) Grant Program
- Georgia Tech Propagation Group
- NearSpace Launch
- Composite Technology Development
- Caldwell High School

Sources:

Figure 1 - ISS:

http://www.universetoday.com/118175/ammonia-leak-on-the-iss-forces-evacuation-of-us-side-crew-safe/

Figure 2 - RF Tag:

MS thesis Bashir Akbar, http://hdl.handle.net/1853/43666/

Figure 3 - CubeSAT Rendezvous:

https://www.google.com/search?q=cubesat+rendezvous&espv=2&source=lnms&tbm=isch&sa=X&ved=0ahUKEwja-o6Y-qnTAhUP-GMKHe8jD8kQ_AUIBigB&biw=1707&bih=827#imgrc=B-KjobEcDl0aAM:

Questions?

Link Budget Equations

Power-Up Link Budget:

$$P_t = \frac{P_T G_{Tx} G_t \lambda^2 \tau}{(4\pi r)^2}$$

P_t = Power received at the tag

P_{Tx} = Power transmitted by the reader

P_R = Power received at the reader

Bistatic Backscatter Link Budget:

$$P_R = \frac{P_{Tx} G_{rx} G_{Tx} G_t^2 \lambda^2 \tau}{(4\pi r)^4}$$

G_t = Gain of tag antenna

G_{Tx} = Gain of reader tx antenna

G_{rx} = Gain of reader rx antenna

r = radius between reader and tag

Mass Budget

Component	Mass (kg)
EPS/EyeStarRadio & Battery Stack	0.42
Aluminum Structure	1.20
Solar Panels	0.50
Interface Board	0.04
RFID Reader & Antenna	0.09
RFID Tag	0.04
Boom System	<0.30
Amateur Radio & Antenna	0.18
Camera	<0.10
Fasteners & Potting	0.50
Total	**3.37**

Attitude Control

- Passive Attitude Control
- Magnet that will align with Earth's magnetic field

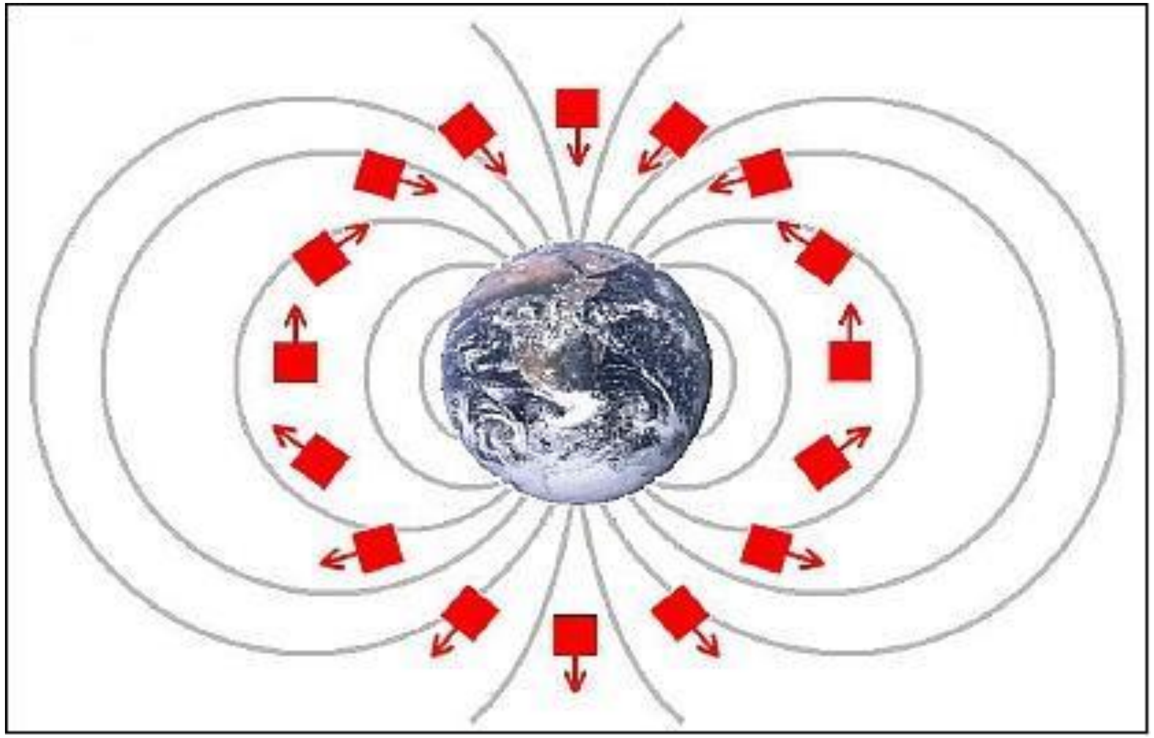
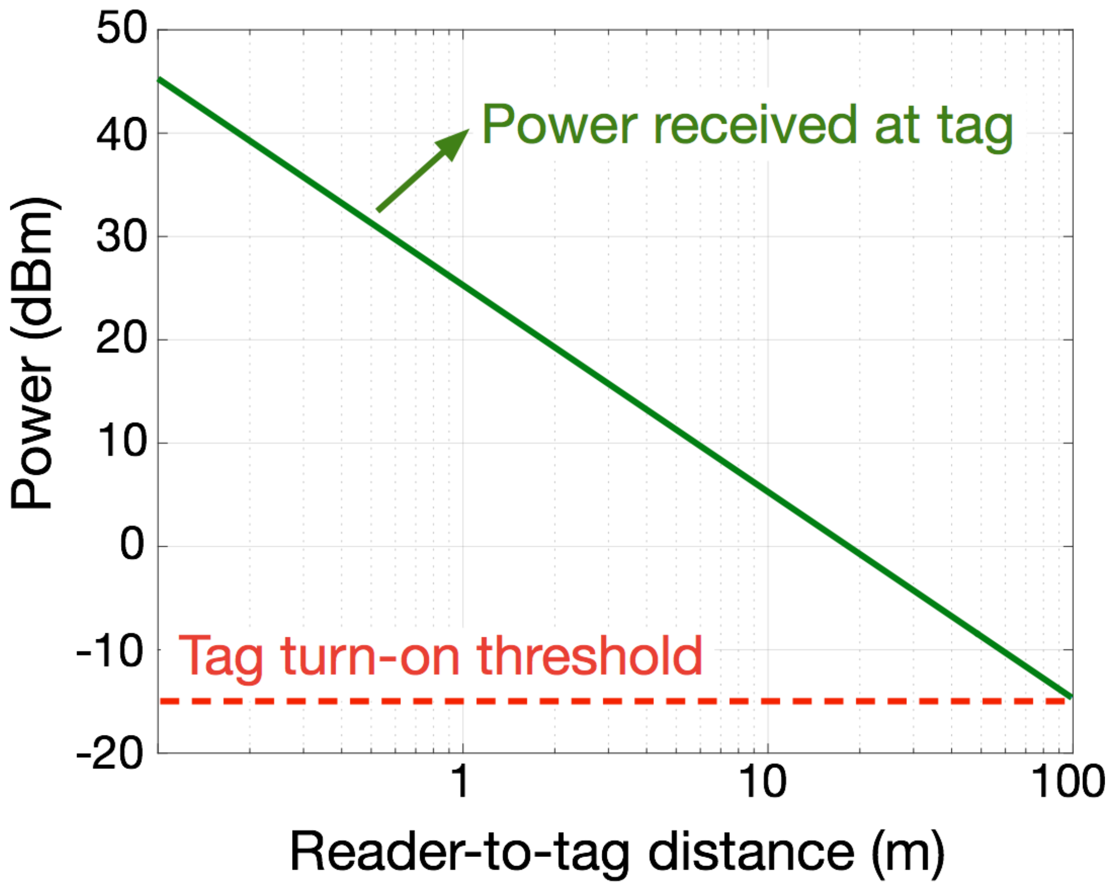
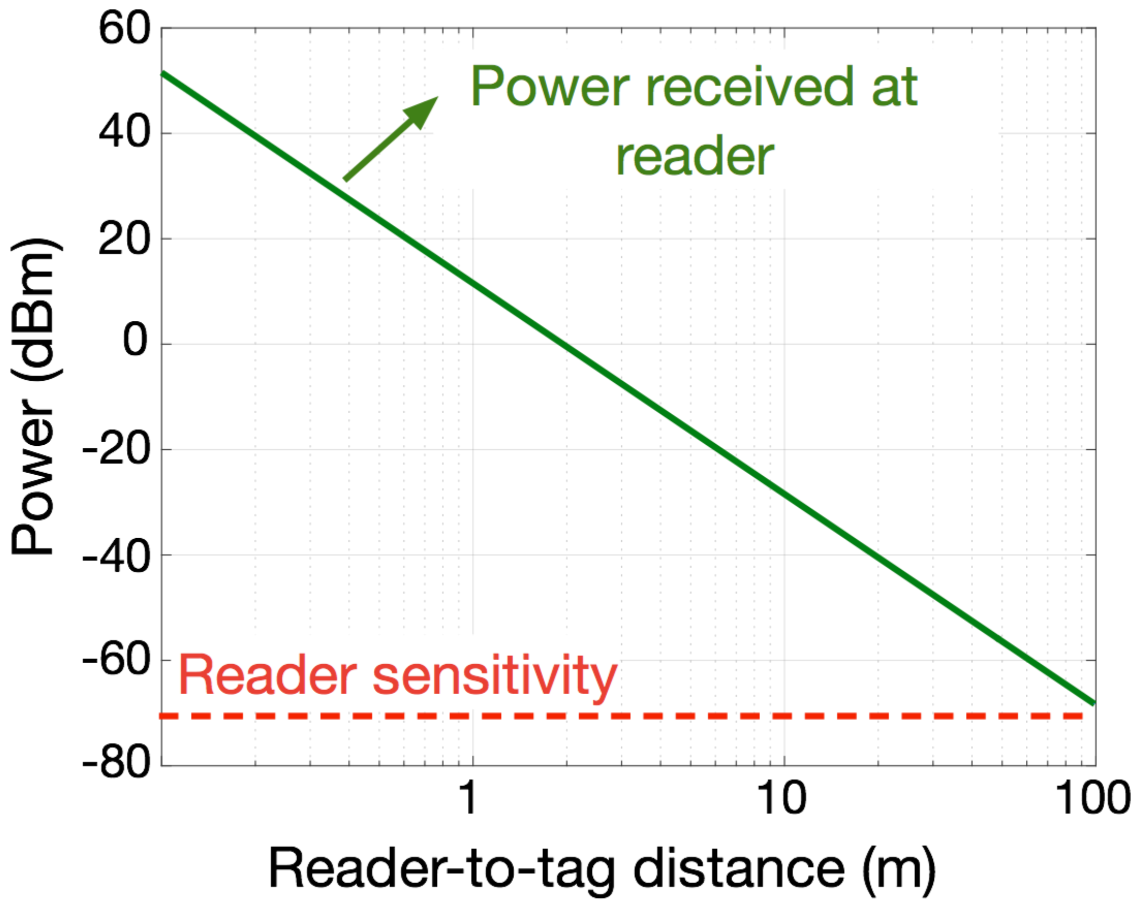


Image: http://space.stackexchange.com/questions/1599/passive-attitude-stabilization-with-magnets-are-there-studies-based-on-actual

Reaching 100m Distance





Link Budget Parameters

$\mathbf{P_{Tx}} = 24$ dBm

$\mathbf{G_t} = \mathbf{G_{Tx}} = \mathbf{G_{rx}} = 10$dBi

$\boldsymbol{\lambda} = 0.5$ cm

$\boldsymbol{\tau} = 1$