Radio Searches for Extraterrestrial Technologies at NASA

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Jet Propulsion Laboratory
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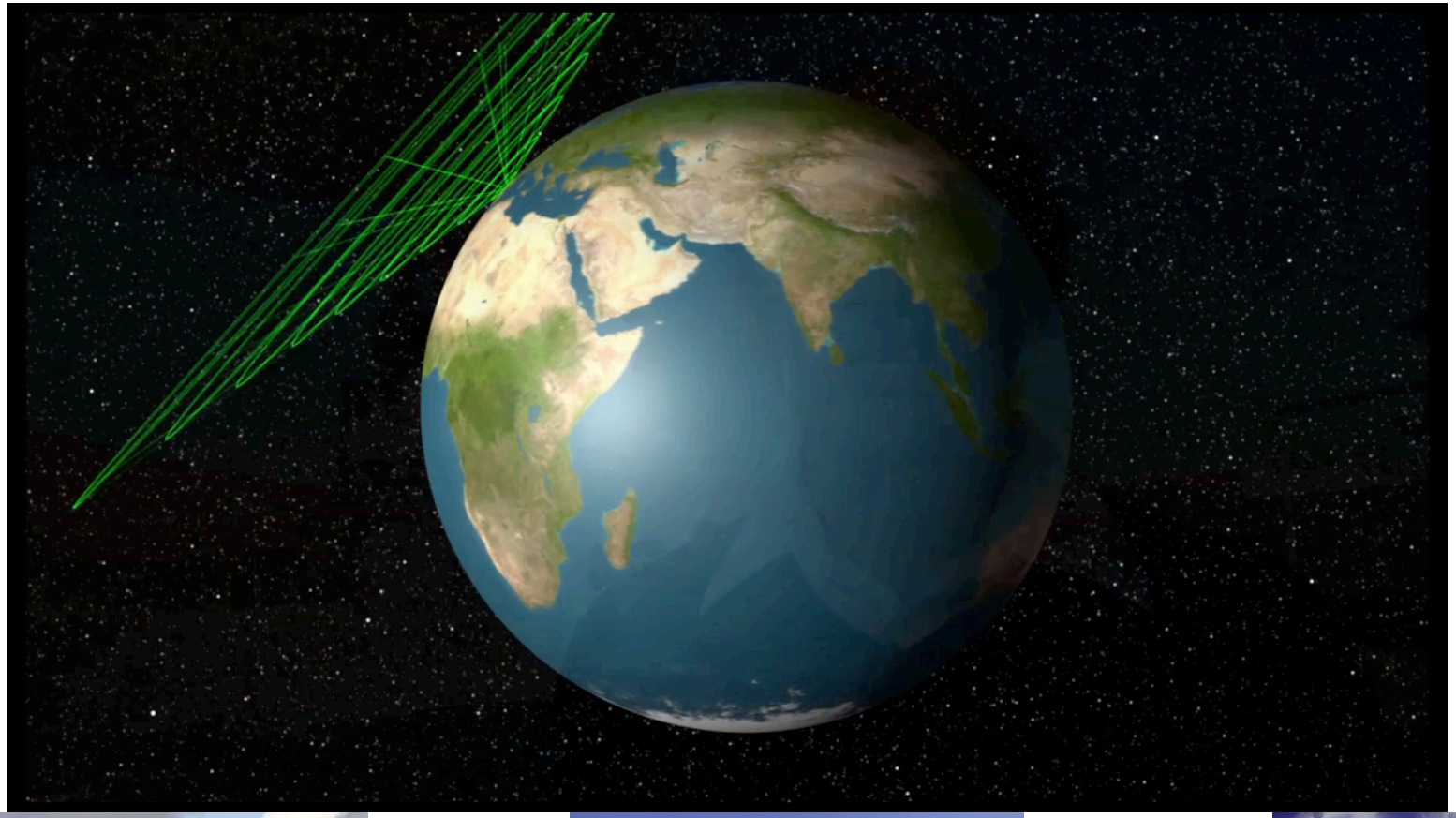
Part I

NASA as a Technosignature(!)

Deep Space Network



National Radar Assets

Goldstone DSS-14 (NASA/DSN)
70 m antenna, 500 kW transmitter, 4 cm wavelength (X band)

Arecibo (NAIC)
300 m antenna, 1 MW transmitter, 13 cm wavelength (S band)

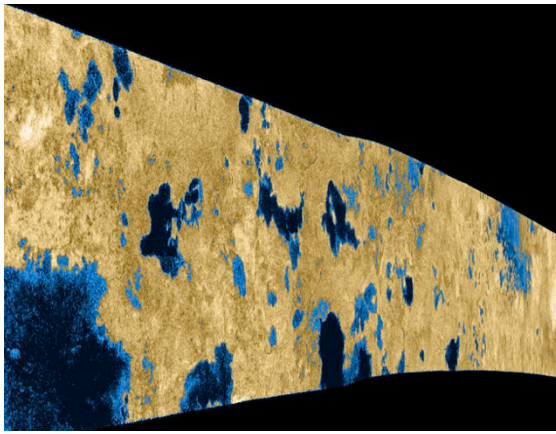
Green Bank Telescope (GBO)
100 m antenna, no transmitter

Canberra DSS-43 (NASA/DSN)
70 m antenna

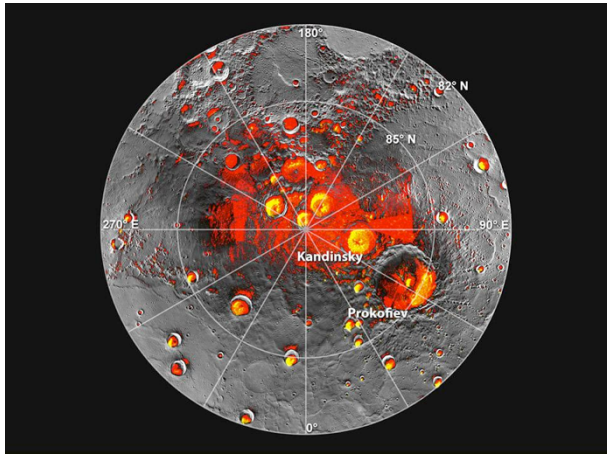
DSN Radar Accomplishments

- First indications of Venus retrograde rotation (1962)
- Probing the surfaces of asteroids (1976)
- First radar returns from Titan (1989-1993), suggestive of icy surface but with potential liquids
- Anomalous reflections from Mercury (1991), indicative of polar ice

Magellan radar image of Venus (NASA/Caltech/JPL)



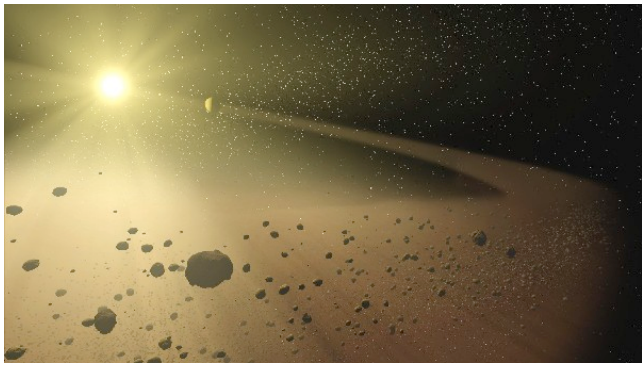
Cassini radar image of Titan (NASA/JPL/USGS)



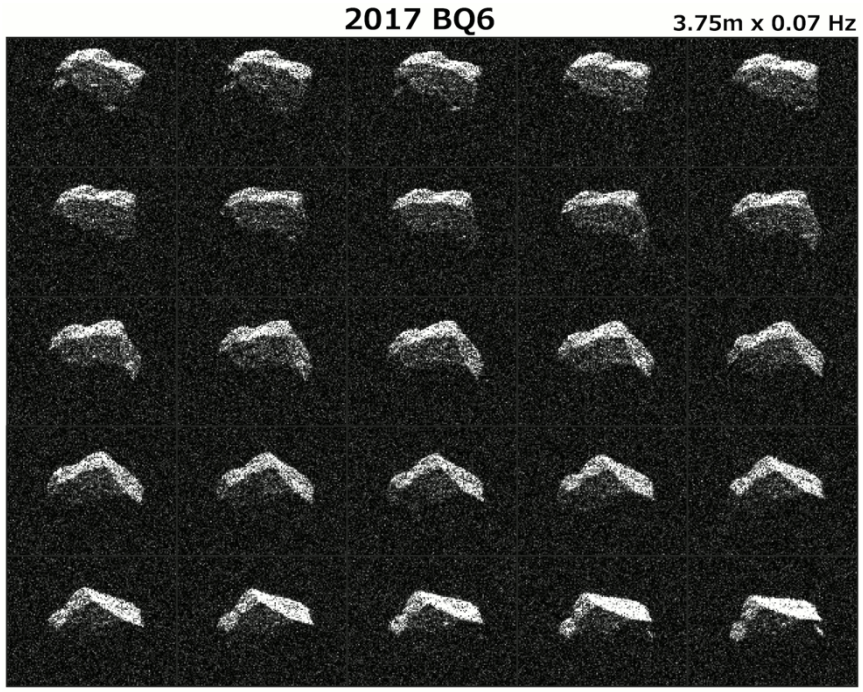
MESSENGER+radar image of Mercury (NASA/HU APL/CIW/NAIC)

Radar Observations of Asteroids

Radar delivers size, rotation, shape, density, surface features, precise orbit, non-gravitational forces, presence of satellites, mass, …



- **Science**: Decipher the record in primitive bodies of epochs and processes not obtainable elsewhere
- **Missions**: Navigation, orbit planning, and observations
- **Planetary defense**: Orbit determination for hazard assessment



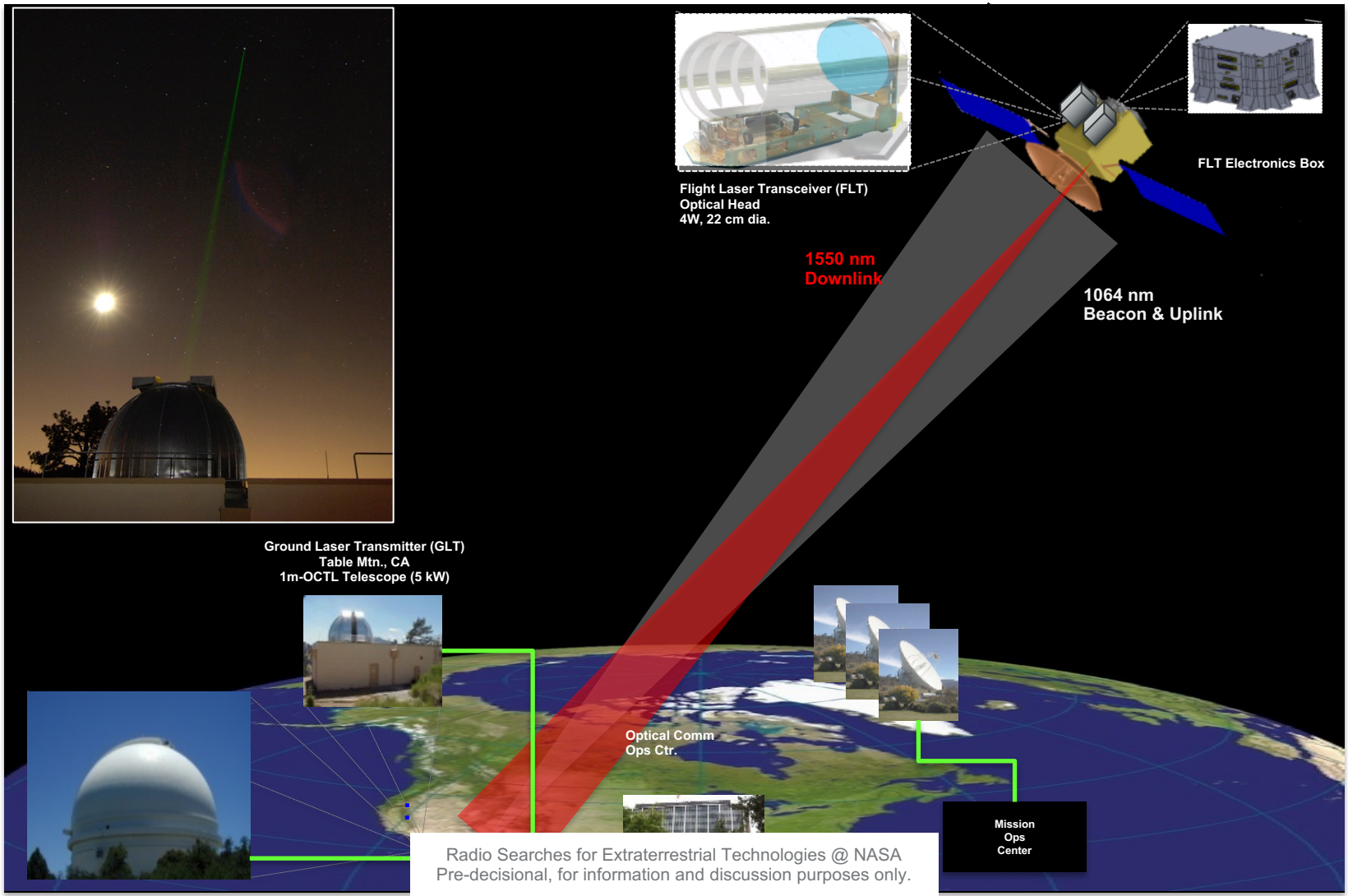
Goldstone Radar Images
Feb 7, 2017 04:39-05:50 UTC

Radars as Technosignatures

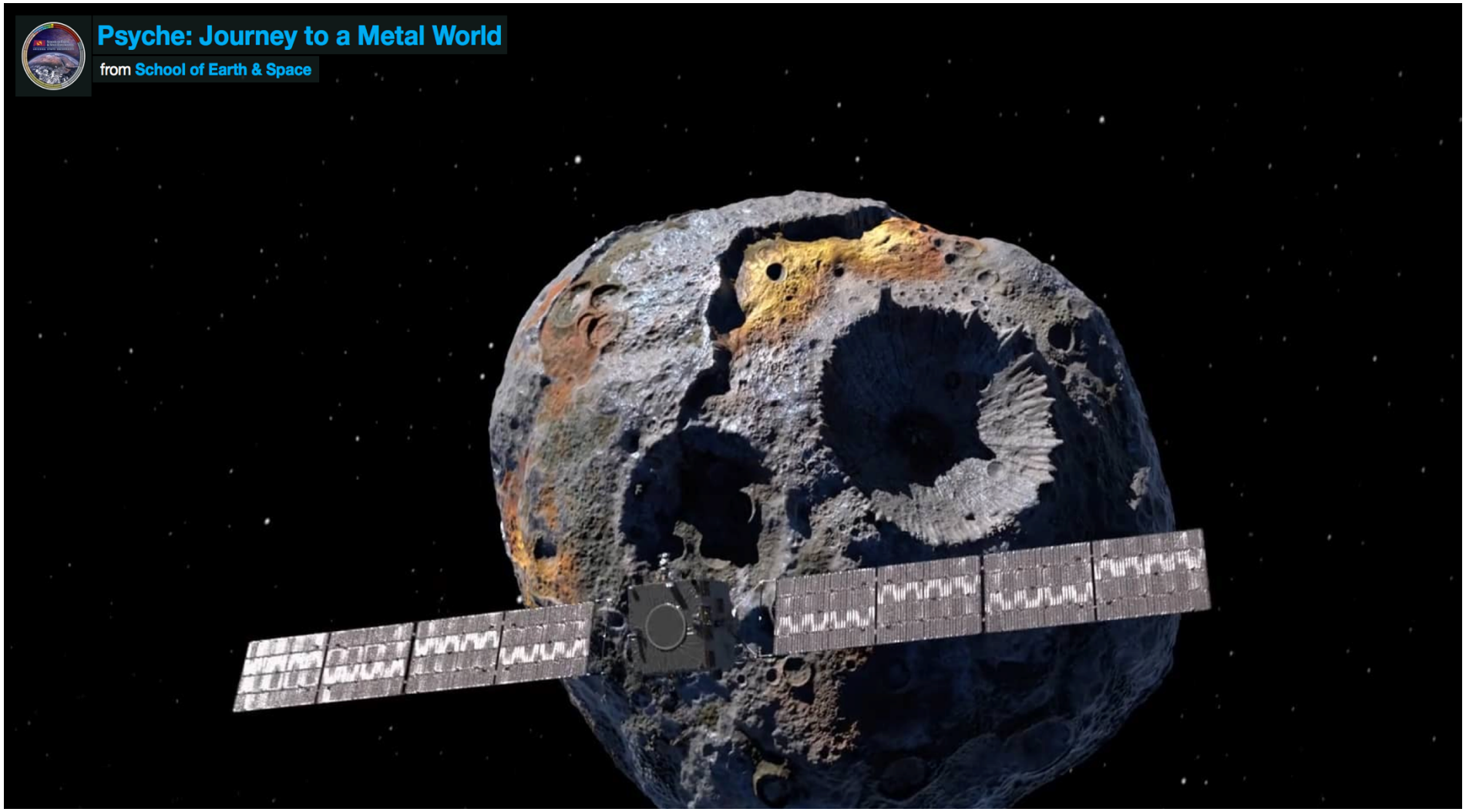
	Goldstone	Arecibo	Kickapoo (AFSSS)
Frequency	8.5 GHz	2.3 GHz	[illegible]
Power	450 kW	900 kW	[illegible]
Gain	76.7 dBi	78.5 dBi	[illegible]
EIRP	21 TW	64 TW	[illegible]
Bandwidth	40 MHz	20 MHz	[illegible]
Flux Density (@ 10 pc)	44 μJy	270 μJy	[illegible]

Snapshot imaging with modern radio telescope can achieve ~ 100 μJy

Deep Space Optical Communications (DSOC) Concept



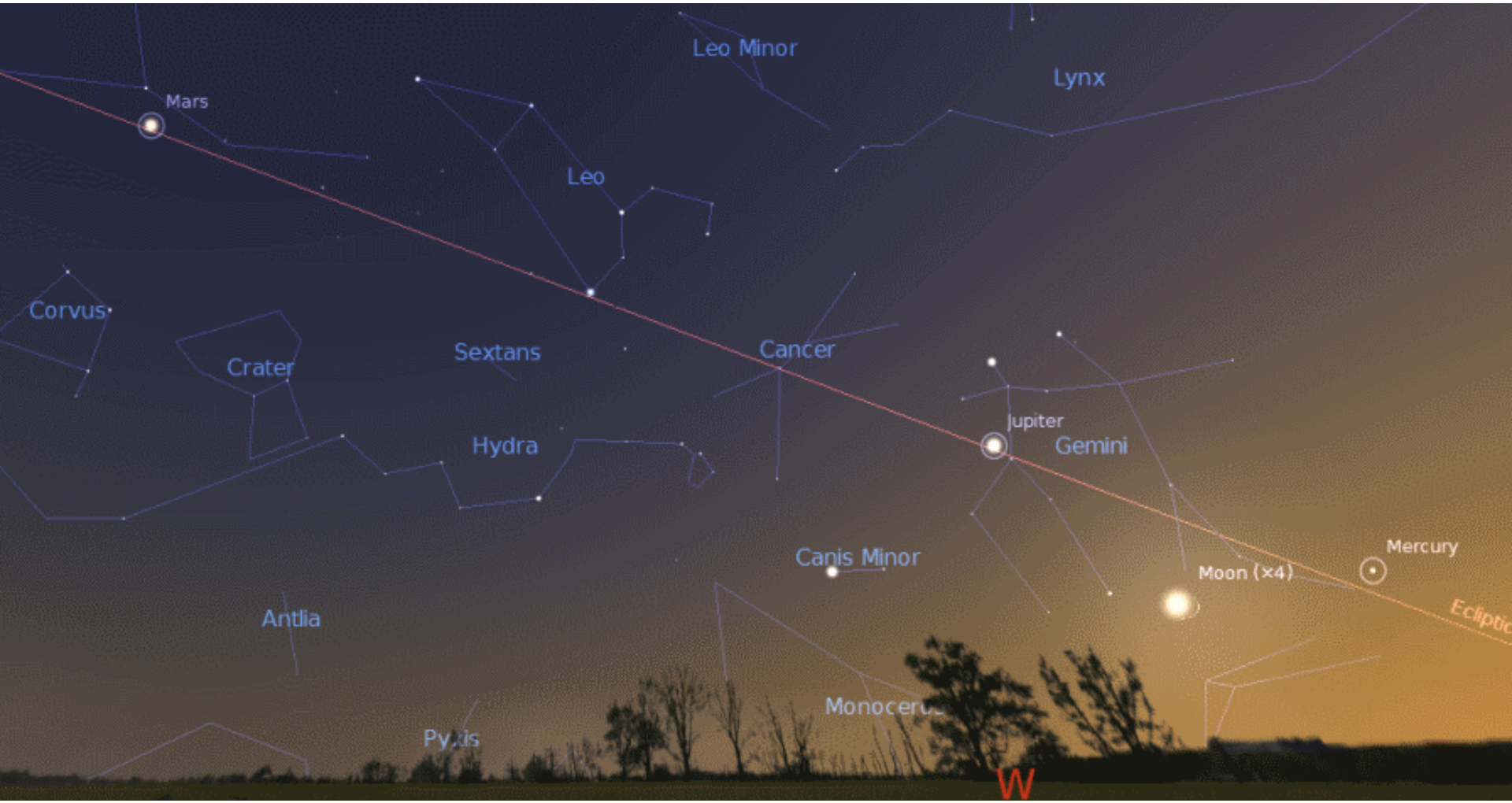
DSOC Demonstration



Part II
Radio Searches at NASA

Earth Transit Zone

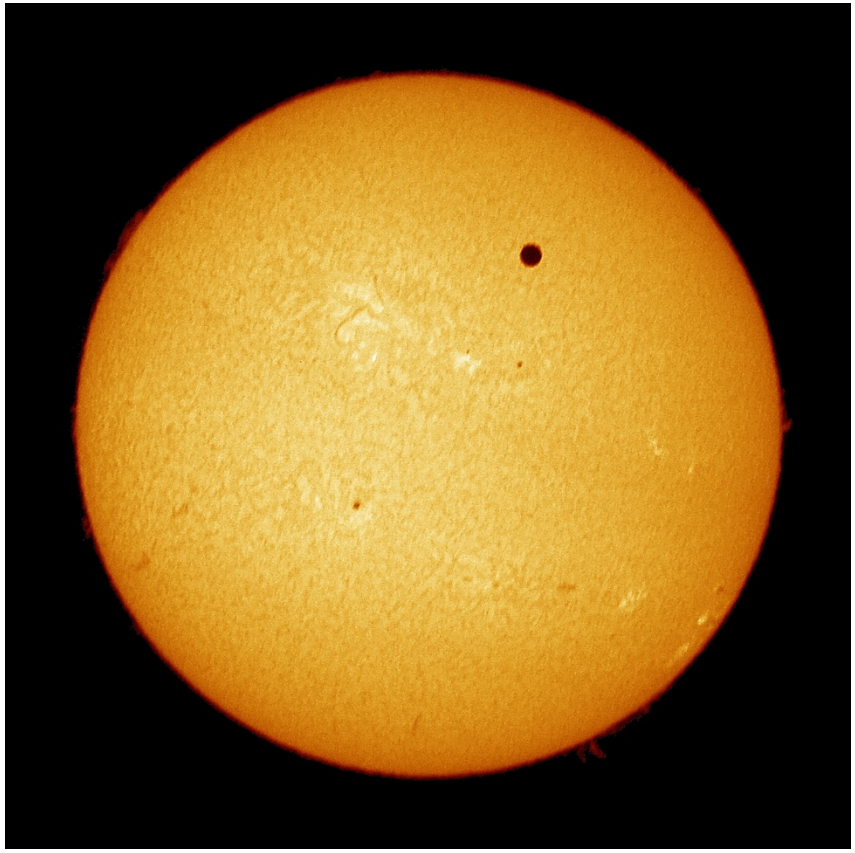
Ecliptic



Credit: Stellarium

Earth Transit Zone

Transit of Venus



Credit: ESA

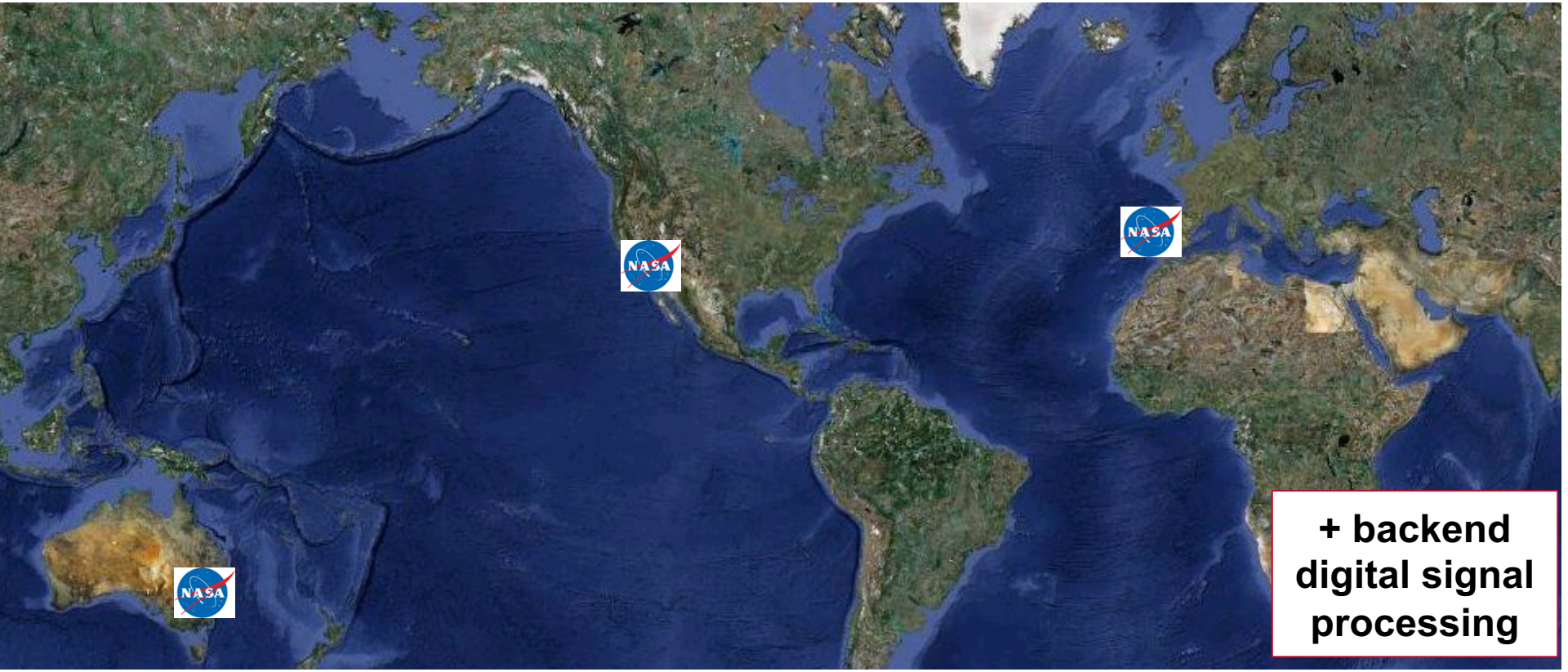
At Kepler level of technology, other civilizations should know about the solar system

- **Filippova & Strelnitskij (1988); also Filippova (1990)**
- **Heller & Pudritz (2016)**

DSN: Observing the Ecliptic

Deep Space Network

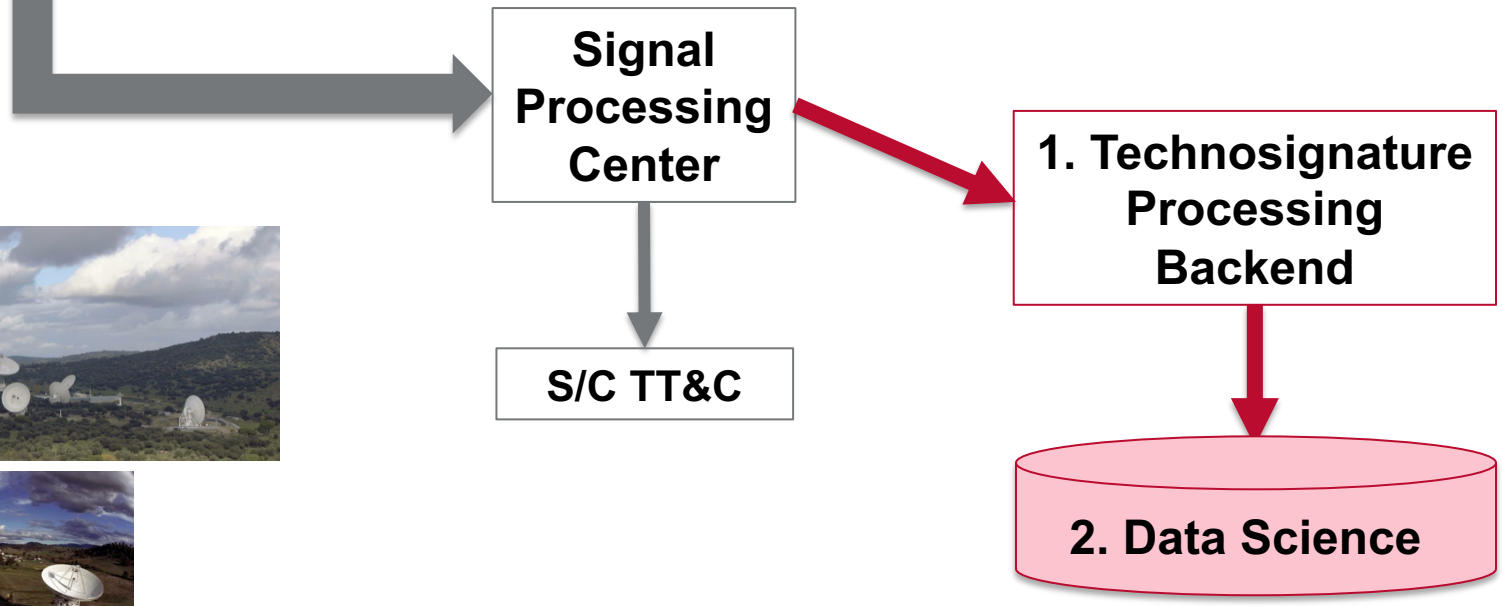
DSN Aperture Enhancement Project (through 2025)



Canberra **Goldstone** **Madrid**

Technosignature Partnership Elements

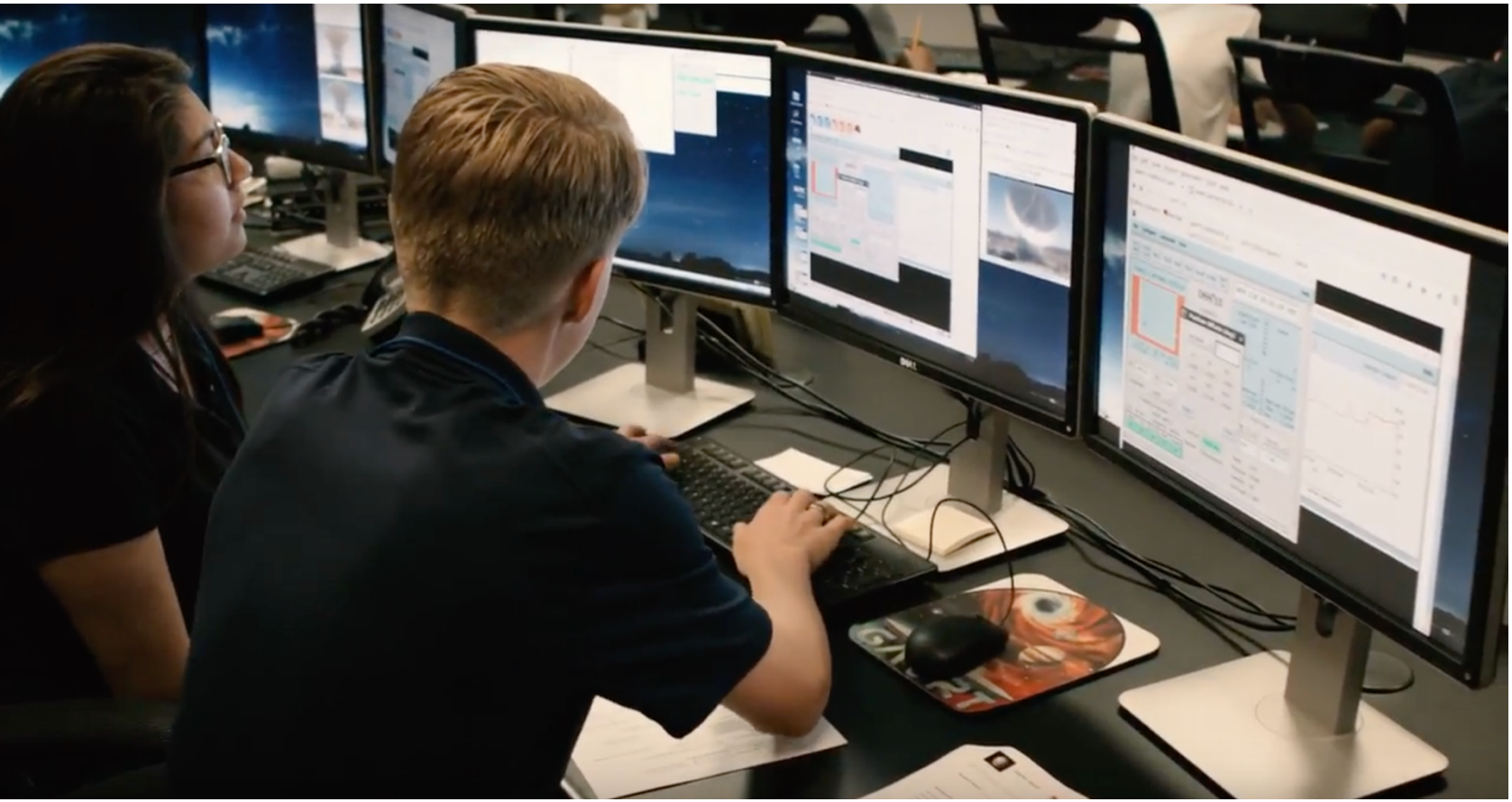
1. Processing Backend(s)
2. Data Science Techniques



Part III

Radio Searches, NASA, and STEM Education

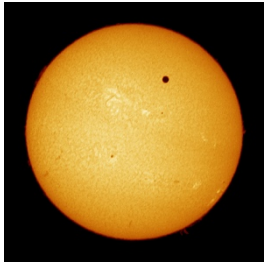
Goldstone-Apple Valley Radio Telescope (GAVRT)



GAVRT conducted in partnership with Lewis Center for Education Research

Summary

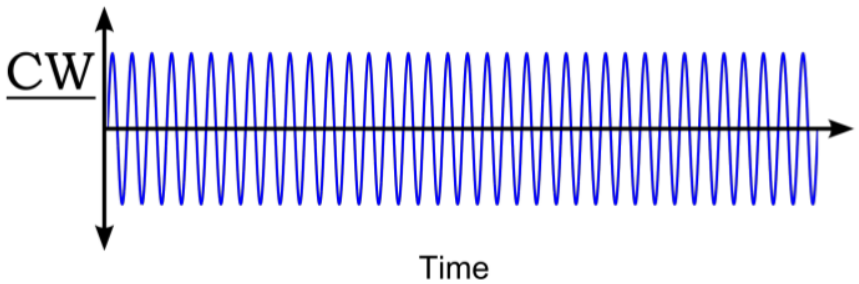
Earth Transit Zone



- **Current planetary radars plausibly detectable in solar neighborhood**
- **Solar system should already be known**
- **NASA's DSN spends substantial time observing ecliptic**
- **Digital signal processing and data science are elements of potential NASA technosignature partnership to monitor Earth Transit Zone**

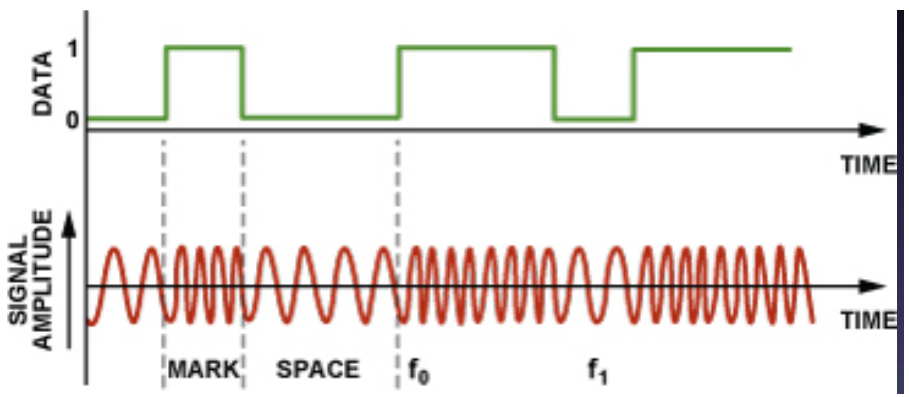
backup

Encoded Transmissions



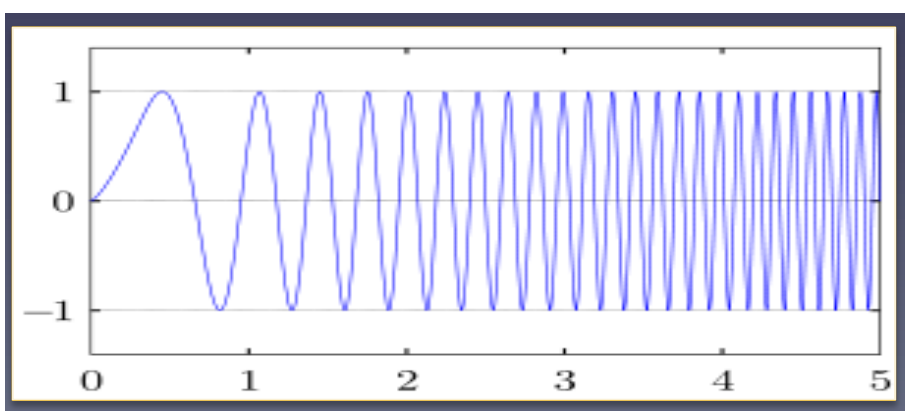
Continuous wave

Determine asteroid rotation



Binary phase coding

- **Time coded waveform**
- **Phase modulated with pseudo-random code**



Linear frequency modulation

Frequency modulated with linear ramp

M. Brozovic

Broadcasting III

Figure of Merit

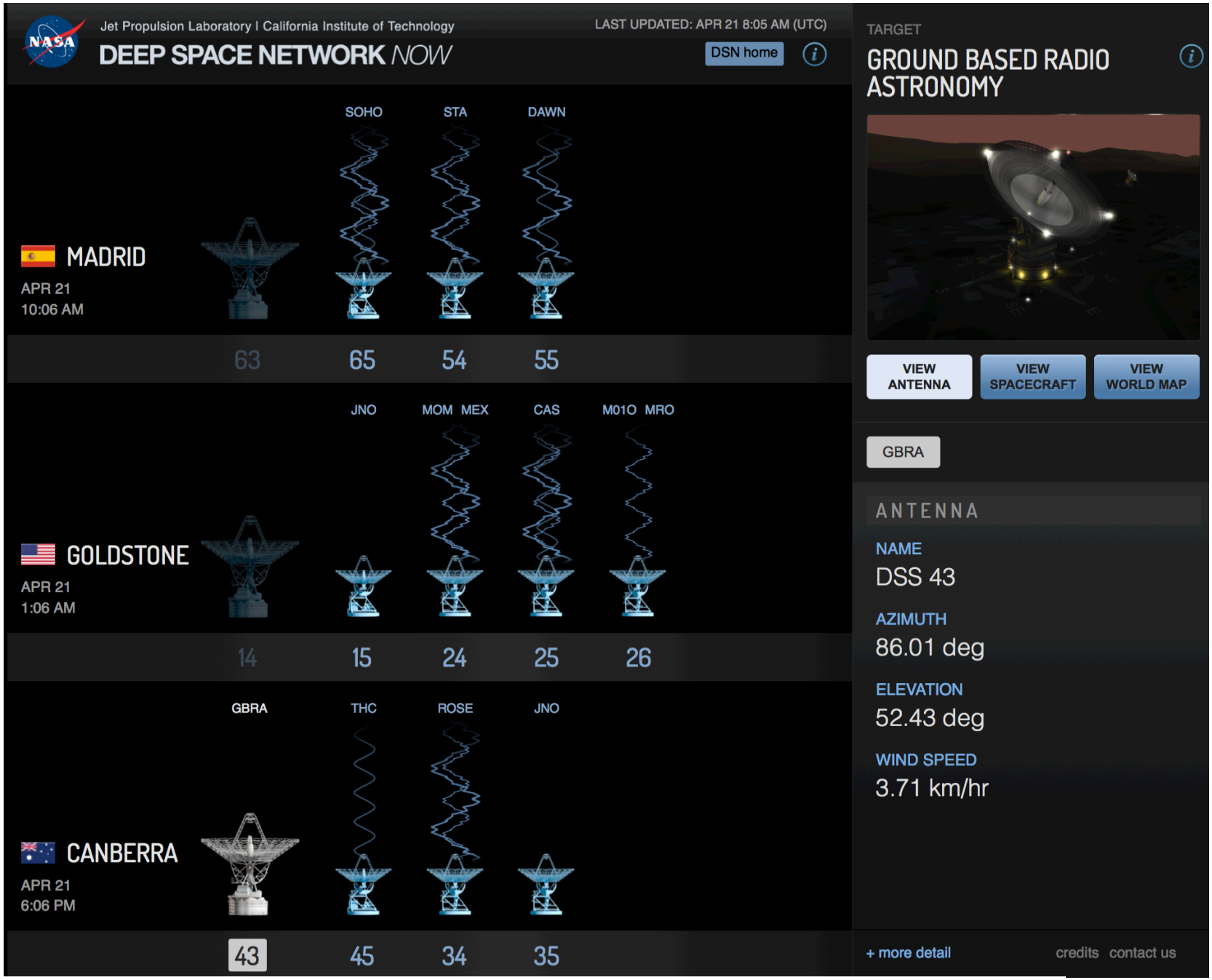
	Kickapoo	Goldstone	Arecibo	*Goldstone-upgrade*
FoM	**26 TW•hr**	**21,000 TW•hr**	**64,000 TW•hr**	***42,000 TW•hr***
Kickapoo	**1**	**~ 800**	**~ 2500**	***~ 1500***

Technosignature Processing Backend

Notional Parameters

	Required	Goal	Justification
Number of Inputs	5	8	Number of antennas per Complex
Instantaneous Bandwidth	1 GHz	1.5 GHz	Coverage of K band
Spectral Resolution	1 Hz	1 Hz	Typical radar transmit bandwidth for continuous wave signals

IND: Don’t Leave Earth Without Us



http://eyes.nasa.gov/dsn/dsn.html