



# Engaging with the Problem of Metadata Heterogeneity

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# An archivist's job can be complicated

- If data were all of the same type
  - Simply maximize usage of a one-size-fits-all container
  - Users come to the archive knowing what Qs to ask



*What fun would that be?*

# An archivist's job can be complicated

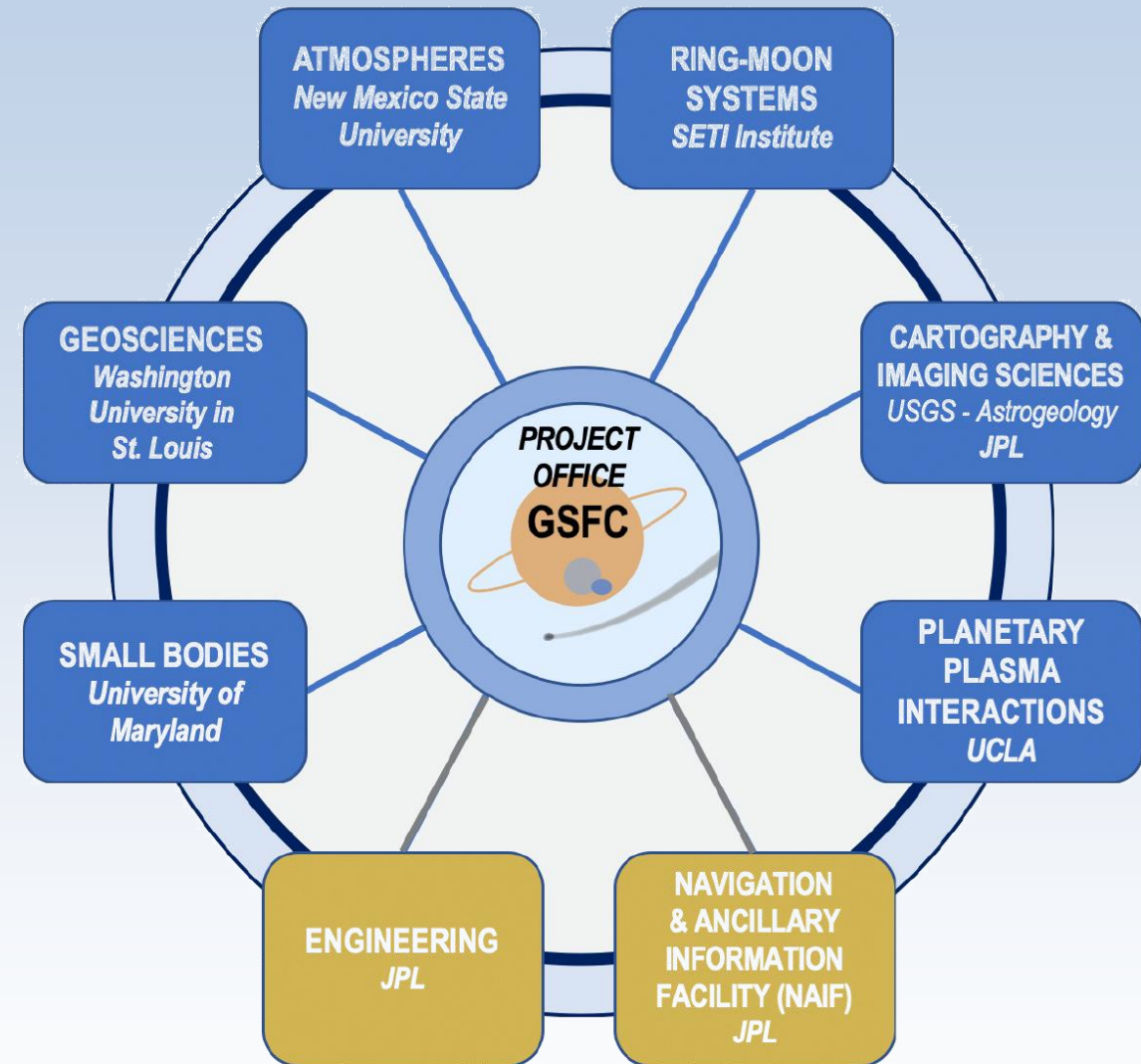
- Reality: Data is diverse
  - Many different kinds of things may be part of one archive
  - Some more than others
  - Containers must allow for all possibilities
  - Users come to the archive with diverse things in mind

***This makes our job challenging (and interesting!)***



# The Planetary Data System and PDS4

- PDS is NASA's archive for Planetary Science
- The PDS4 Information Model provides framework
  - Rigorous structure and definition of metadata
  - Simplified file structures
  - Designed to remain functional for decades to come
- But is it enough?



# Heterogeneity in Data Type

- Many types of scientific disciplines
  - Astronomy
  - Spacecraft
  - Physics stations
  - Biology
  - Laboratories on Earth
  - and more...

***To our knowledge, there is no single metadata attribute that applies to every data product in PDS***

- Many types of instruments
  - = Planets
  - = Spectrometers
  - = Moons
  - = Dust particle detectors
  - = Asteroids
  - = Charged particle detectors
  - = Comets
  - = Magnetic field detectors
  - = Surface features
  - = Electric field detectors
  - = Magnetospheres
  - = Seismometers
  - = and more
  - = Weather stations
- Many targets within each type
  - Layered geology
  - portable chemistry
  - equipment
- Many coordinate systems
  - The naked eye
- and more...
  - and more...

# Heterogeneity in Data Type

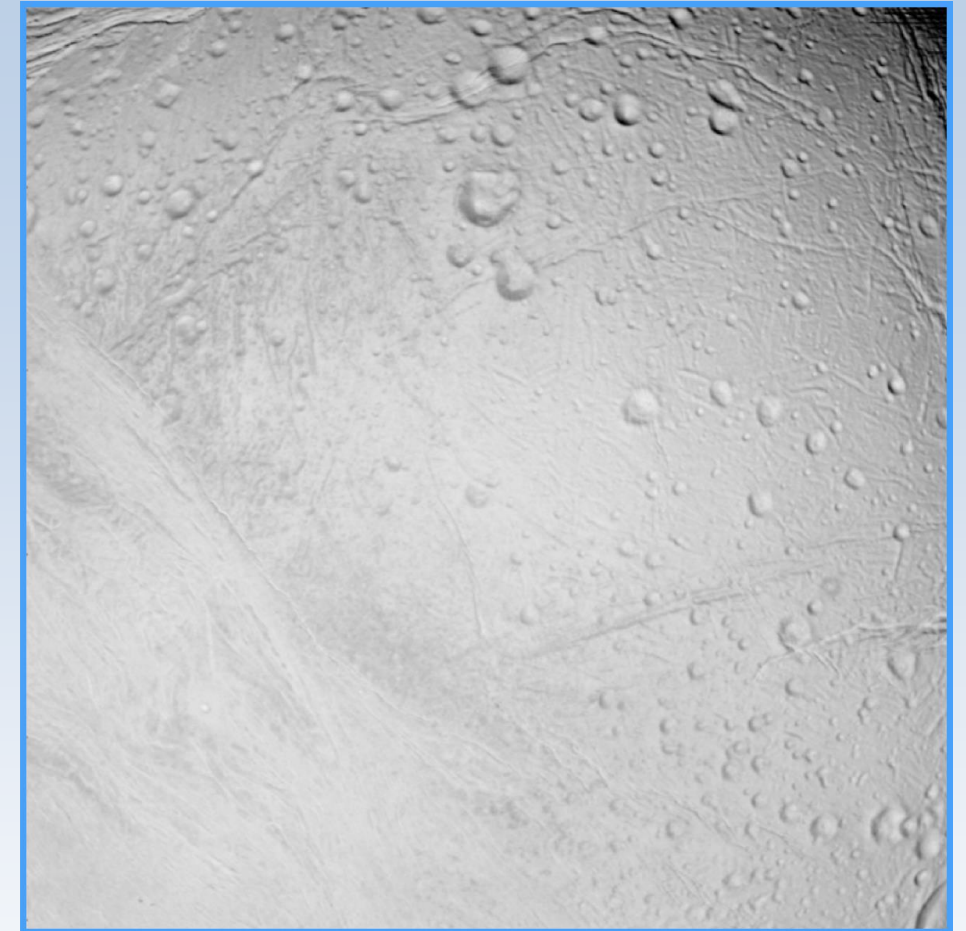
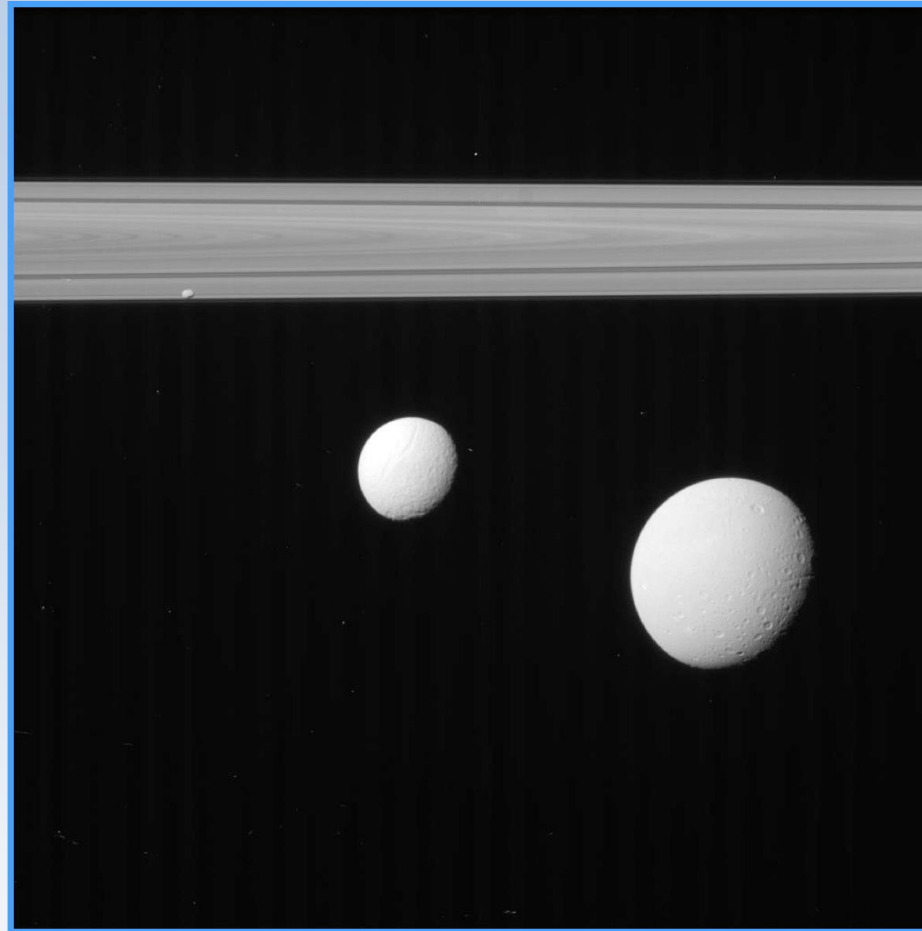
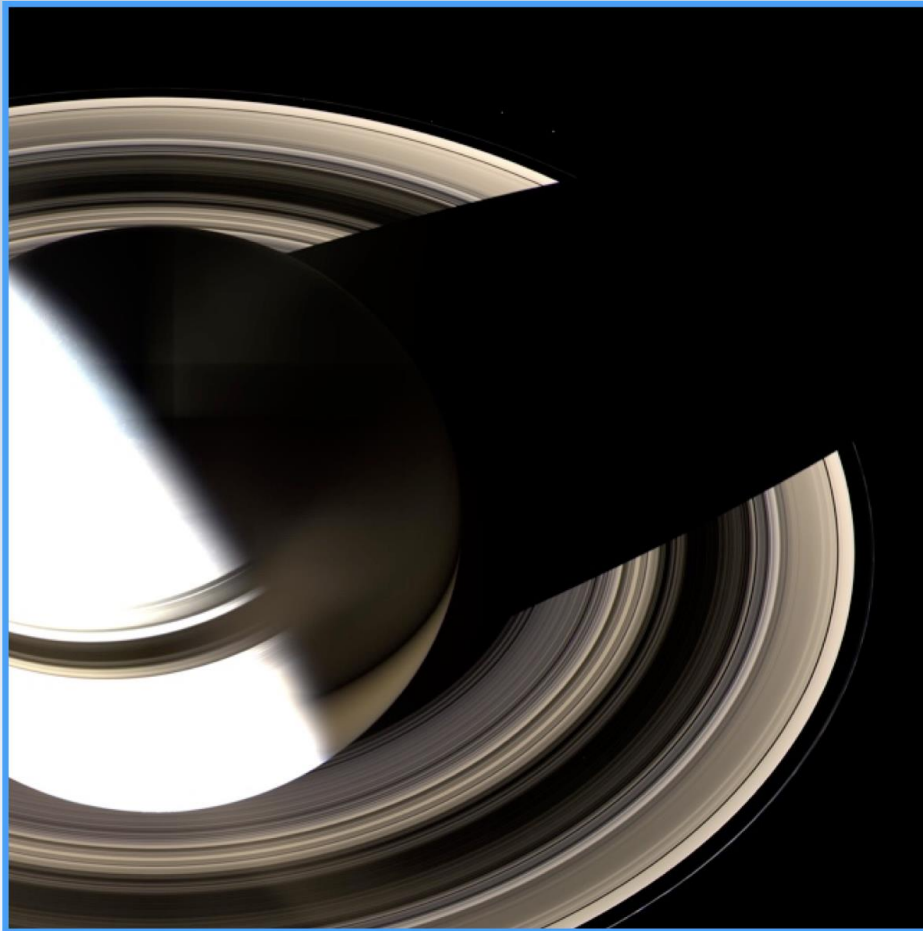
- Data diversity poses challenges for discoverability
- “One-stop shopping” is a great concept
  - Is it practical? Will it work?
  - The more diverse the data, the more merit in diverse discovery tools
  - Requires educating users



# Heterogeneity in Detail

- A different kind of heterogeneity
  - Every data provider has their own context
  - Teams develop a characteristic way of doing things
  - Similar concepts and quantities expressed differently in archived metadata
- Example: Spectral Filters
  - Cassini ISS had a filter called RED, covering  $0.57 \mu\text{m}$  to  $0.72 \mu\text{m}$
  - Hubble WCF3 has a filter called F689M, covering  $0.65 \mu\text{m}$  to  $0.72 \mu\text{m}$
  - Archived metadata alone may not help you link these related observations
- Example: Coordinate Systems
  - One data provider gives planetocentric lat/lon, another planetographic
  - One data provider gives solar hour angle in hours, another longitude in  $^{\circ}$

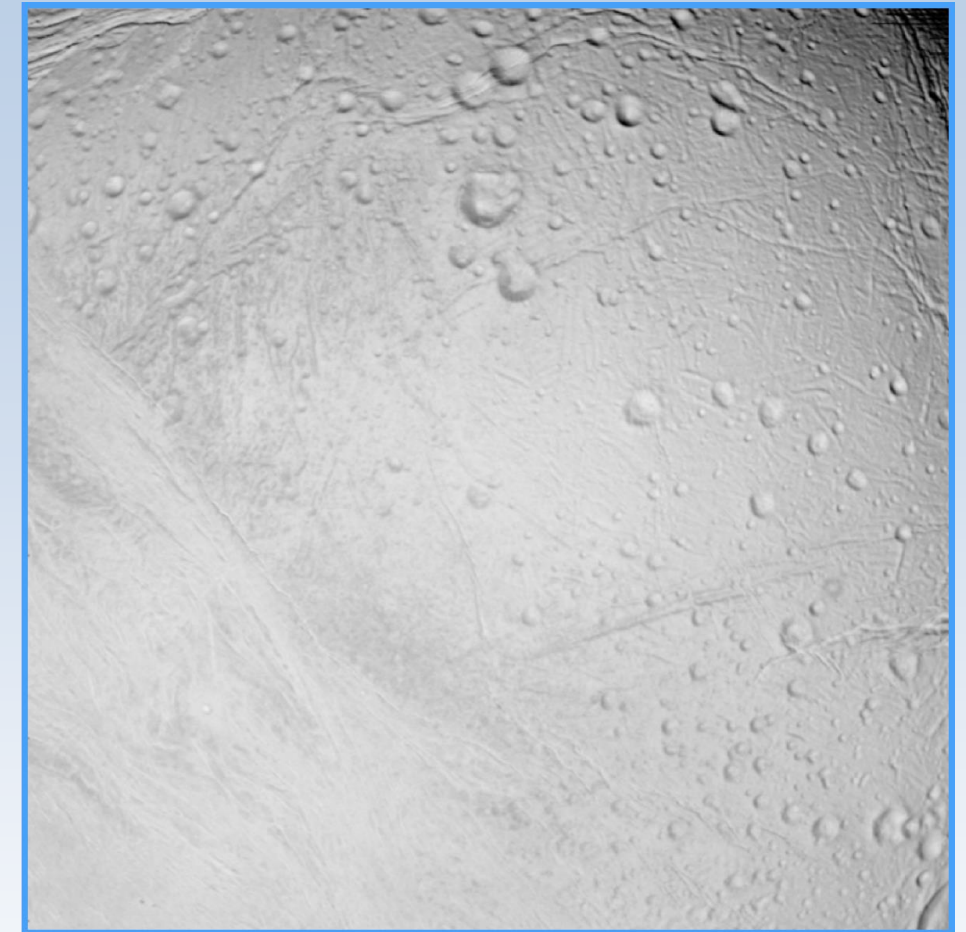
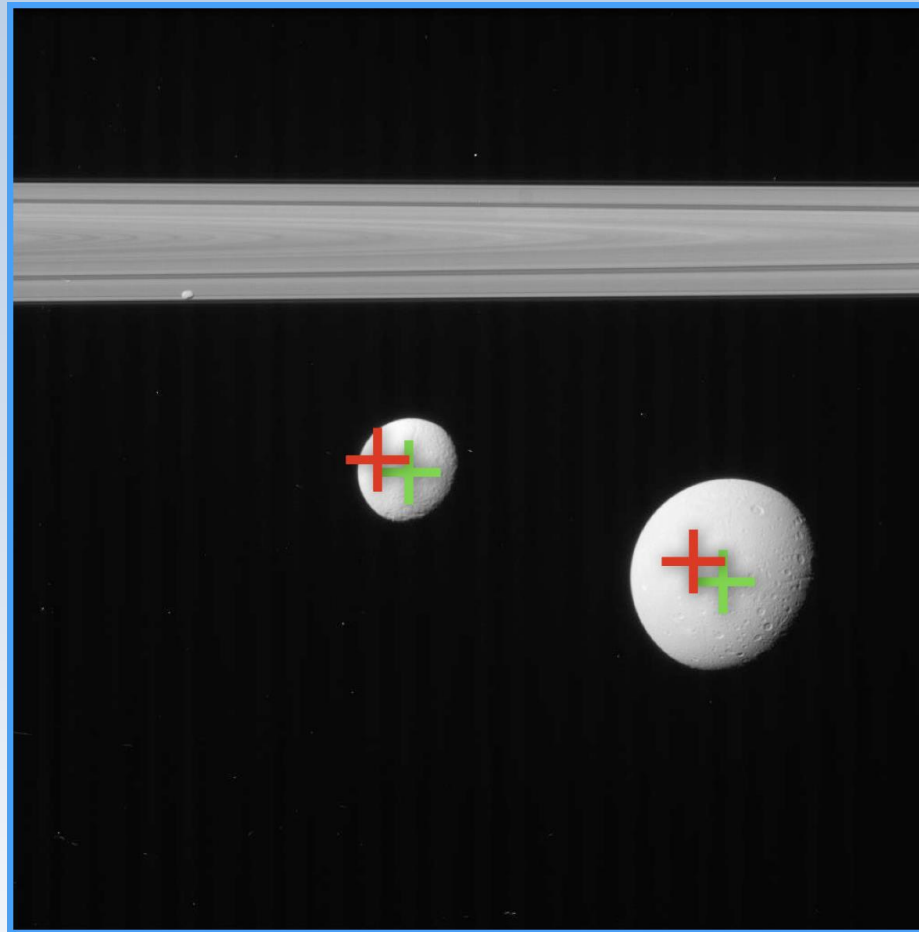
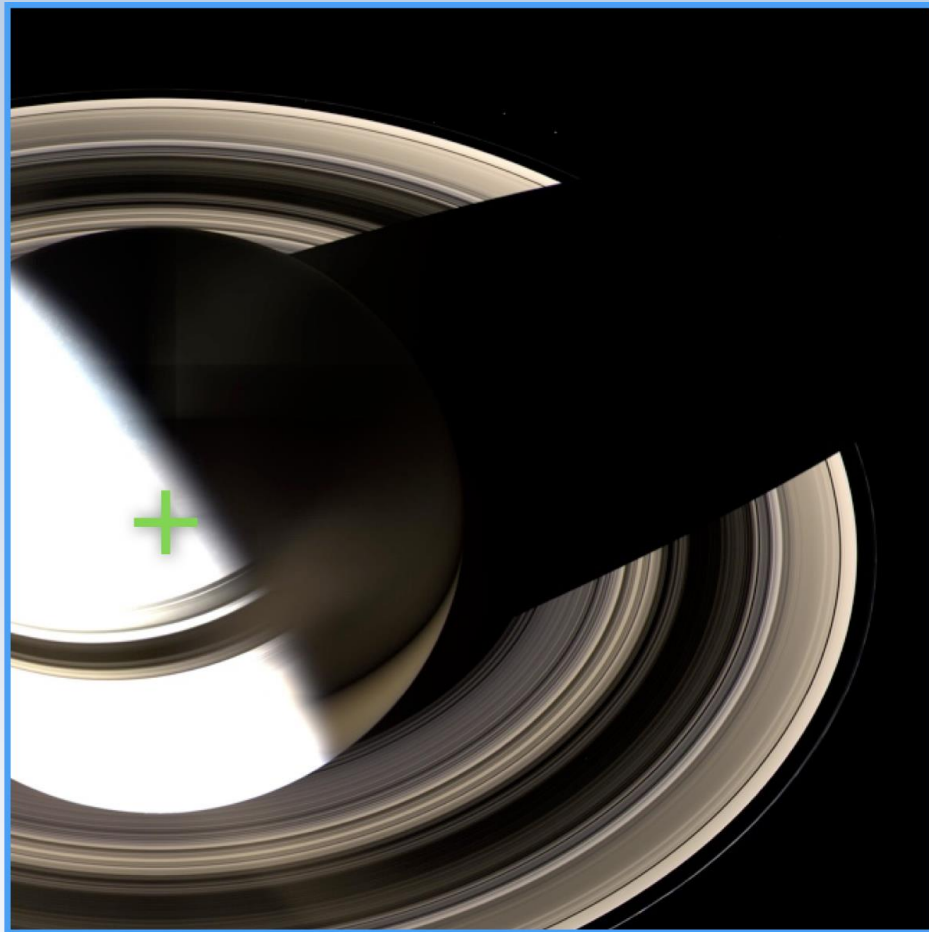
# Heterogeneity in Detail: Geometric Metadata



- Spacecraft teams generally provide metadata indicating the intended scientific target of each data product
  - But many products contain information relevant to more than one body
  - Moreover, serendipitous detections may not have metadata provided

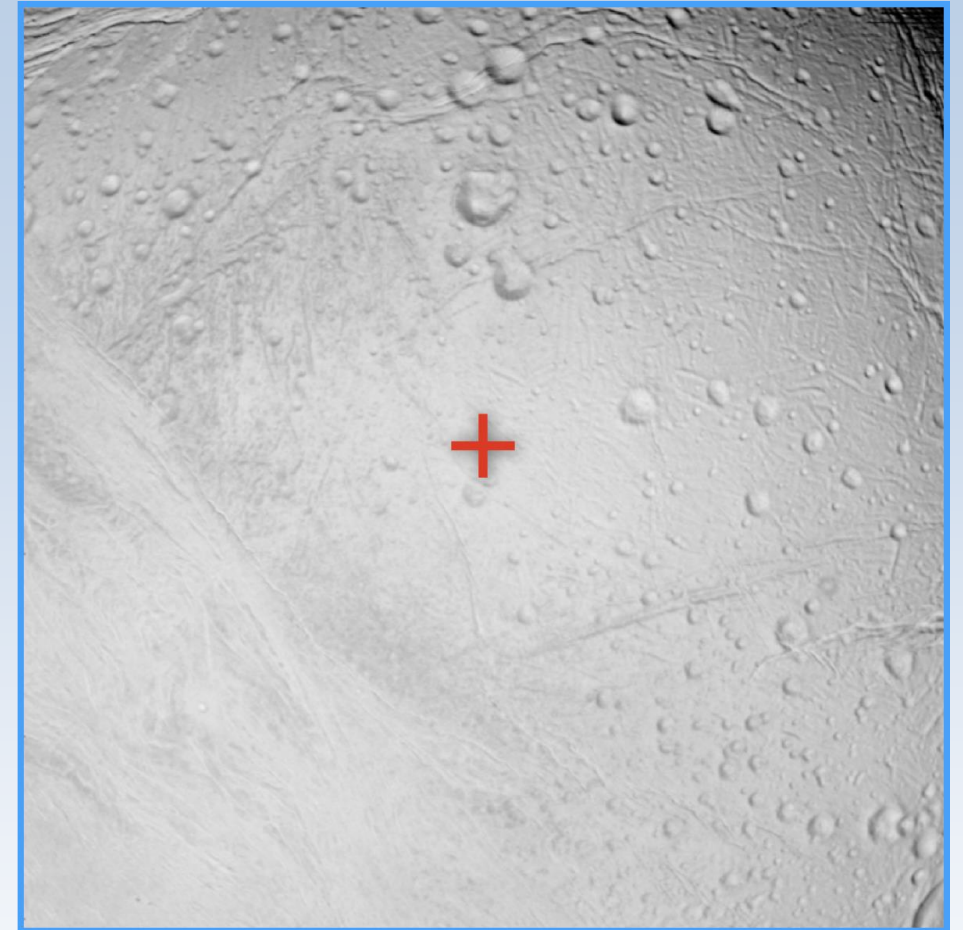
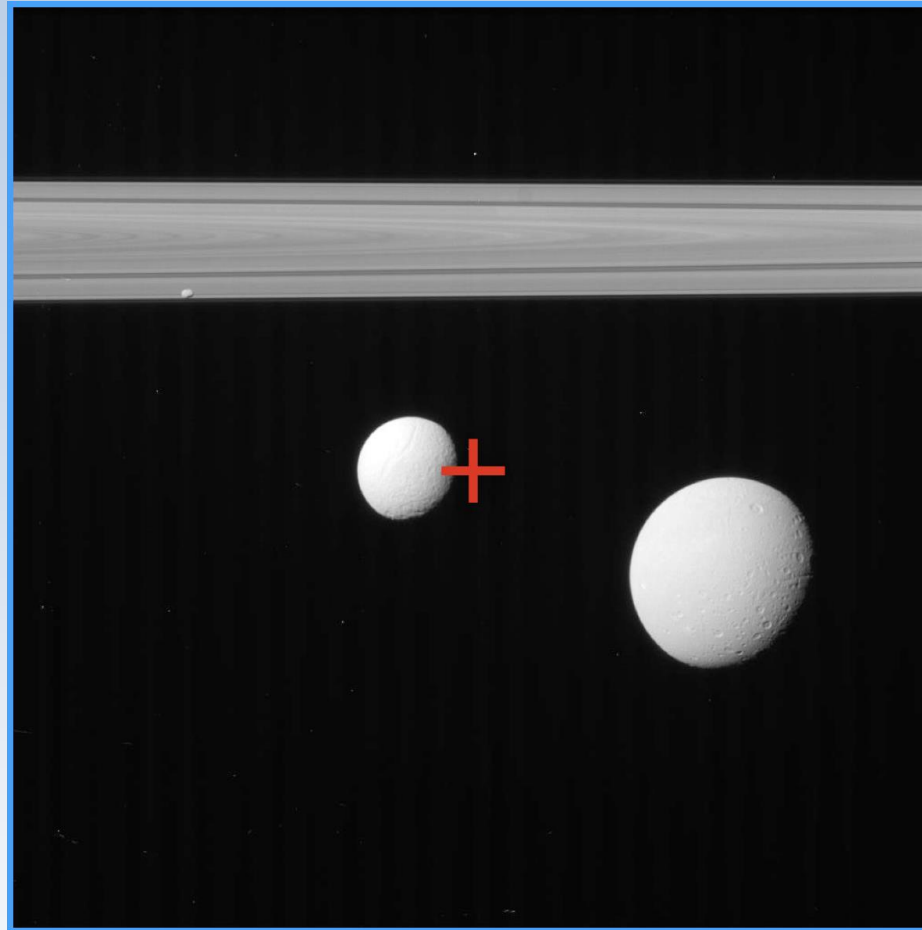
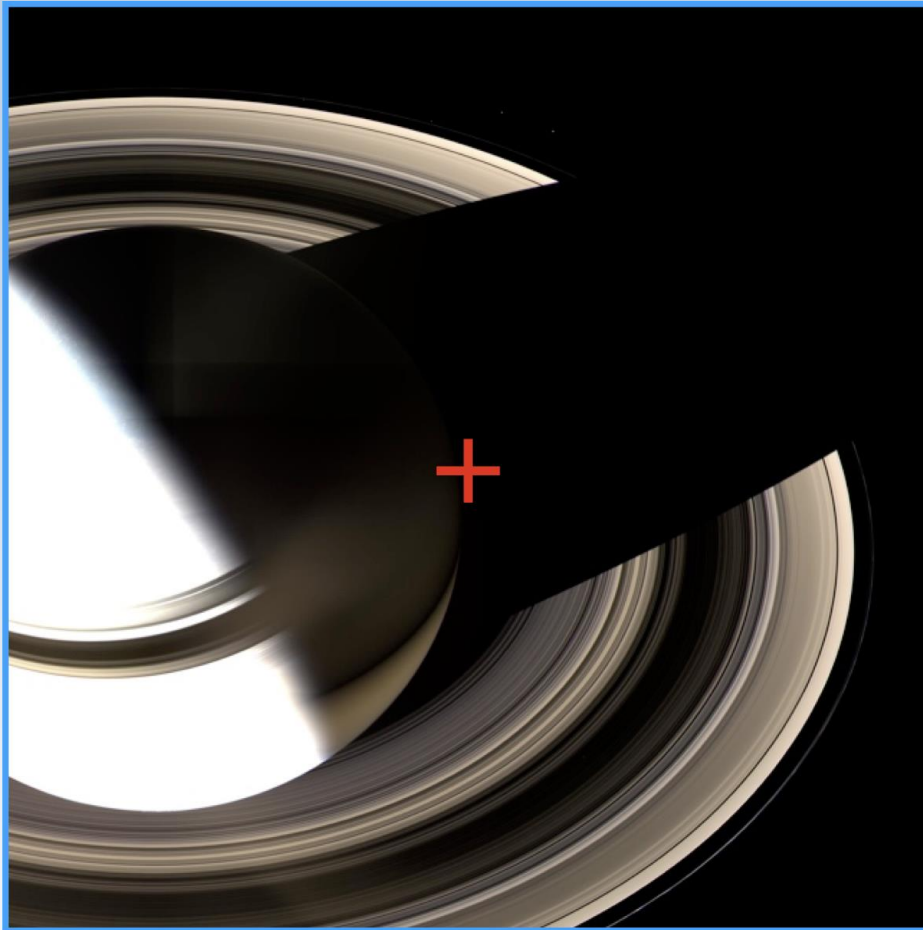


# Heterogeneity in Detail: Geometric Metadata



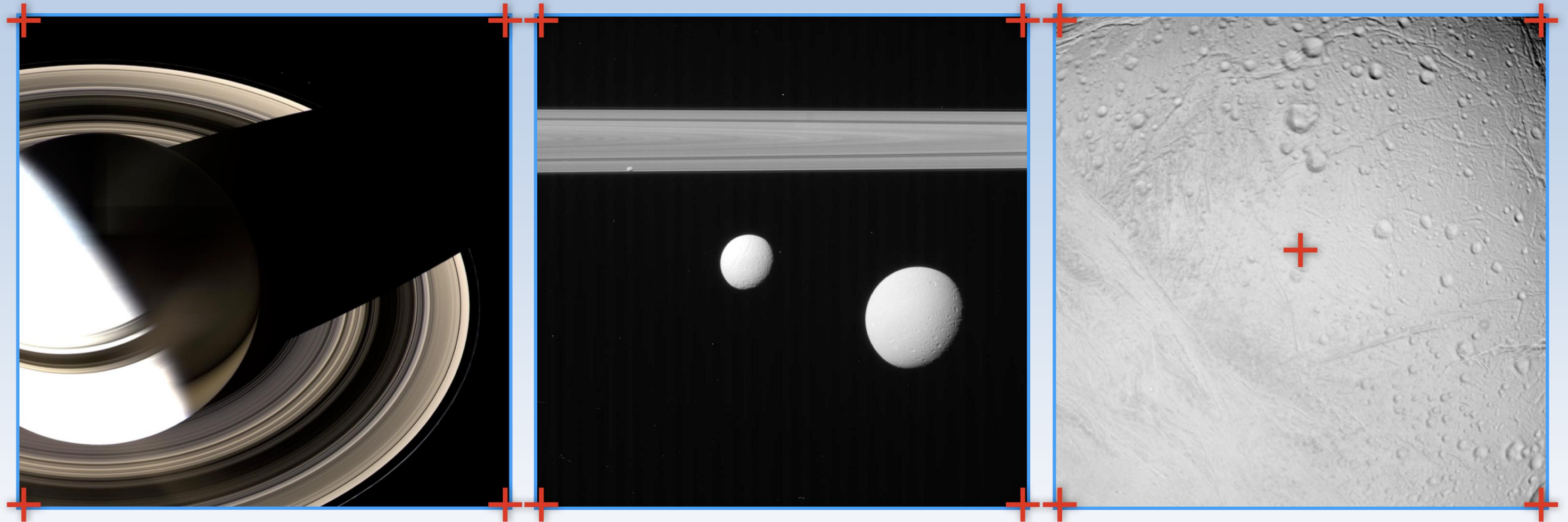
- Sometimes, team-provided metadata identifies the **sub-spacecraft** and **sub-solar** coordinates
  - However, this does not tell us whether the specified locations fall inside the field of view

# Heterogeneity in Detail: Geometric Metadata



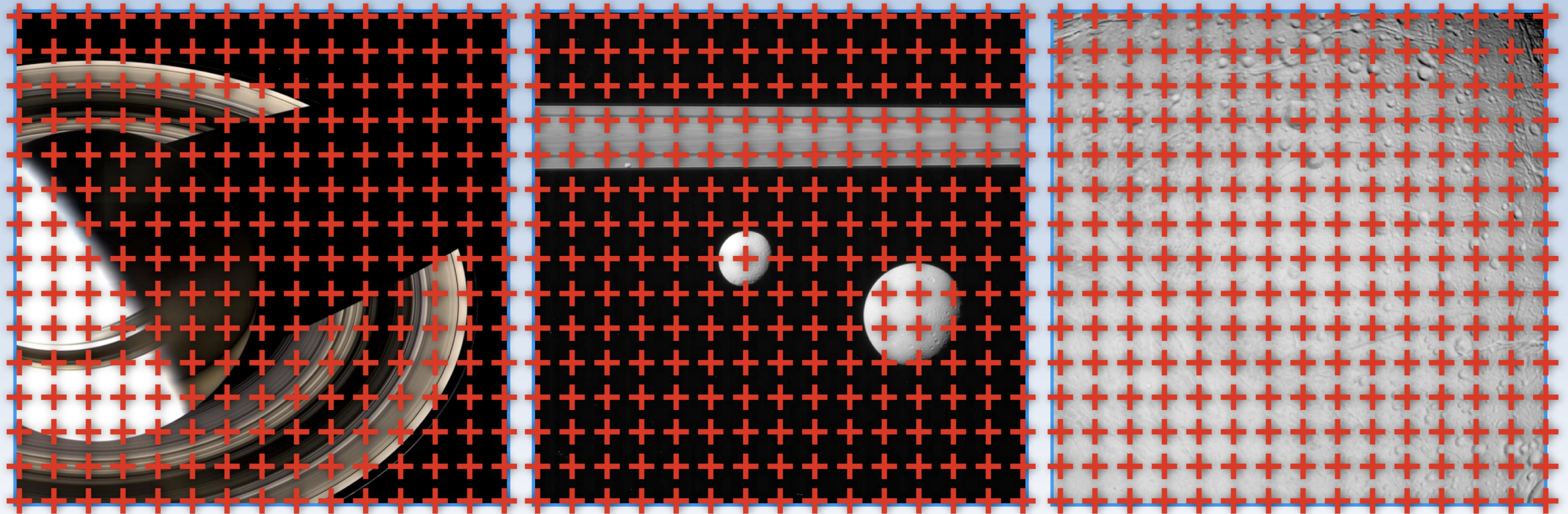
- Sometimes, team-provided metadata provides information about the **center of the field of view**
  - However, we cannot assume that these values are in any way representative of the product's actual content

# Heterogeneity in Detail: Geometric Metadata



- Sometimes, team-provided metadata provides information about what falls at the **four corners of the image**
  - However, we cannot assume that these values are in any way representative of the product's actual content

# Heterogeneity in Detail: Geometric Metadata



- OPUS metadata identifies every body/ring inside the field of view
- OPUS metadata is derived by densely sampling the field of view, and describing images by a range rather than a single value
- This approach provides a much more accurate description of the field of view

# Mitigating Metadata Heterogeneity

- Maximizing the usefulness of cross-mission search requires
  - Curation,
  - Interpretation, and
  - Standardization of metadata
- At the PDS Ring-Moon Systems Node (RMS), we prioritize
  - Generating our own supplemental metadata
  - Using standardized attributes
  - Carrying out detailed geometric re-calculations
- This approach drives improved cross-mission (even cross-discipline) search on our OPUS search tool ([opus.pds-rings.seti.org](https://opus.pds-rings.seti.org))

The screenshot shows the OPUS search tool interface. The top navigation bar includes 'OPUS3', 'Search', 'Browse Results 1,624,532', 'Cart 2', 'Detail', and 'Recent Announcements'. The main content area is divided into several sections:

- General Constraints:** A list of filters including Planet, Intended Target Name, Nominal Target Class, Mission, Instrument Host Name, Instrument Name, Observation Type, Observation Time, Observation Duration, Measurement Quantity, Right Ascension, and Declination.
- PDS Constraints:** A section for PDS-specific filters.
- Image Constraints:** A section for image-related filters.
- Wavelength Constraints:** A section for wavelength-related filters, including Wavelength, Wavelength Resolution, Wavenumber, Wavenumber Resolution, Spectral Information Flag, Spectrum Size, and Polarization Type.
- Occultation/Reflectance Profiles Constraints:** A section for occultation and reflectance profile filters.
- Surface Geometry Constraints:** A section for surface geometry filters.
- Ring Geometry Constraints:** A section for ring geometry filters.

On the right side, there are several filter panels:

- Wavelength [Wavelength] microns:** A range filter with Min: 0.0402, Max: 130629, N/A: 56. Below it, a table shows 'PDS4 Wavelength Ranges' with columns for Wavelength Range, Min, and Max. The ranges include Ultraviolet (0.01-0.4), Visible (0.39-0.7), Near Infrared (0.65-5), Infrared (0.75-300), and Far Infrared (30-300). Below this is a 'CRC Wavelength Ranges' section with a 'New Horizons MVIC 1897' filter and a '+ Ground-based 12' filter.
- Observation Type [General]:** A filter panel with options for Image (576510), Spectrum (1153), Spectral Image (274), Spectral Cube (962113), Time Series (58711), Spectral Time Series (24950), Occultation Profile (819), and Reflectance Profile (2).
- Intended Target Name [General]:** A filter panel with a description: 'The Intended Target Name represents the observer's intentions and is valid for all missions and instruments. To search for ANY body in the field of view (but only for some instruments), select Surface Geometry Target Selector under Surface Geometry Constraints in the left menu. To search for observations containing rings, use the Ring Geometry Constraints menu.' Below this is a '+ Venus 353' filter.

At the bottom, there are 'Reset Search' and 'Reset Search and Metadata' buttons. The footer text reads 'OPUS is a project of the PDS Ring-Moon Systems Node'.

# Mitigating Metadata Heterogeneity

- However, our approach is not well-suited to every data set
- Within PDS, other Discipline Node teams operate other data discovery tools that serve the needs of their user communities
- There is room for improvement
  - Better user education
  - Better common entry point
- We believe the best common entry point
  - Is not a single unified tool
  - But a platform that quickly guides users to the existing focused tool that best meets their needs

How Data Discovery Tools Proliferate

