National Aeronautics and Space Administration

FY24 Topic Areas Research and Technology Development (TRTD)

Stereophotogrammetry with Rotating Synthetic Aperture Imaging Systems

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Strategic Focus Area: Advanced Optics Systems and Telescopes

Objectives: This R&TD matures a prototype for a Rotating Synthetic Aperture (RSA) imaging system, making collections more traceable to future overhead concepts. This study seeks to:

- Complete end-to-end field instrument development + processing for a mission-traceable RSA concept
- Demonstrate the performance and suitability of RSA systems to serve Earth science surface topography needs
- Produce high-quality color topographic products that are quantifiably comparable to more expensive and difficult approaches
- Provides a low-cost approach to developing wide-field, very-high-resolution, space telescope or stereo imaging satellite

Background: High-resolution science measurements with global coverage and persistence over targets can be achieved through an inclined MEO vantage point. However, achieving high-resolution 3D structure currently requires large telescopes, which are costly to develop and launch. RSA imaging represents a transformational approach to low-cost option to space telescopes. Its strip-aperture primary mirror maximizes its instantaneous angular resolution for any given amount of collecting area.

Approach and Results:

- Advanced registration and aperture synthesis algorithms for fully rotating strip-aperture imaging systems.
  - Super resolution image reconstruction using Poisson Maximum aposteriori (PMAP)) estimation to maximize the signal-to-noise ratios to generate L1 products
- Quantified the topographic performance of RSA systems against the nominal collections
- Upgraded our RSA Field Demonstration Camera with a 3-axis stabilized gimbal to collect concept-traceable data sets
- Performed two field tests collecting data to demonstrate the performance of the RSA imaging system for topographic applications
  - *Vasquez Rocks* and *Red Rock Canyon State Park*
- Generated 3D color point cloud models from synthesized RSA L1 Products and demonstrated 4x better performance over conventional stereo imaging

Significance/Benefits to JPL and NASA:

RSA provides the highest-performance for mass and cost

- RSA requires the least hardware to be implemented for any resolution need
- RSA instruments can be uniquely optimized for much larger fields of view with any given detector format

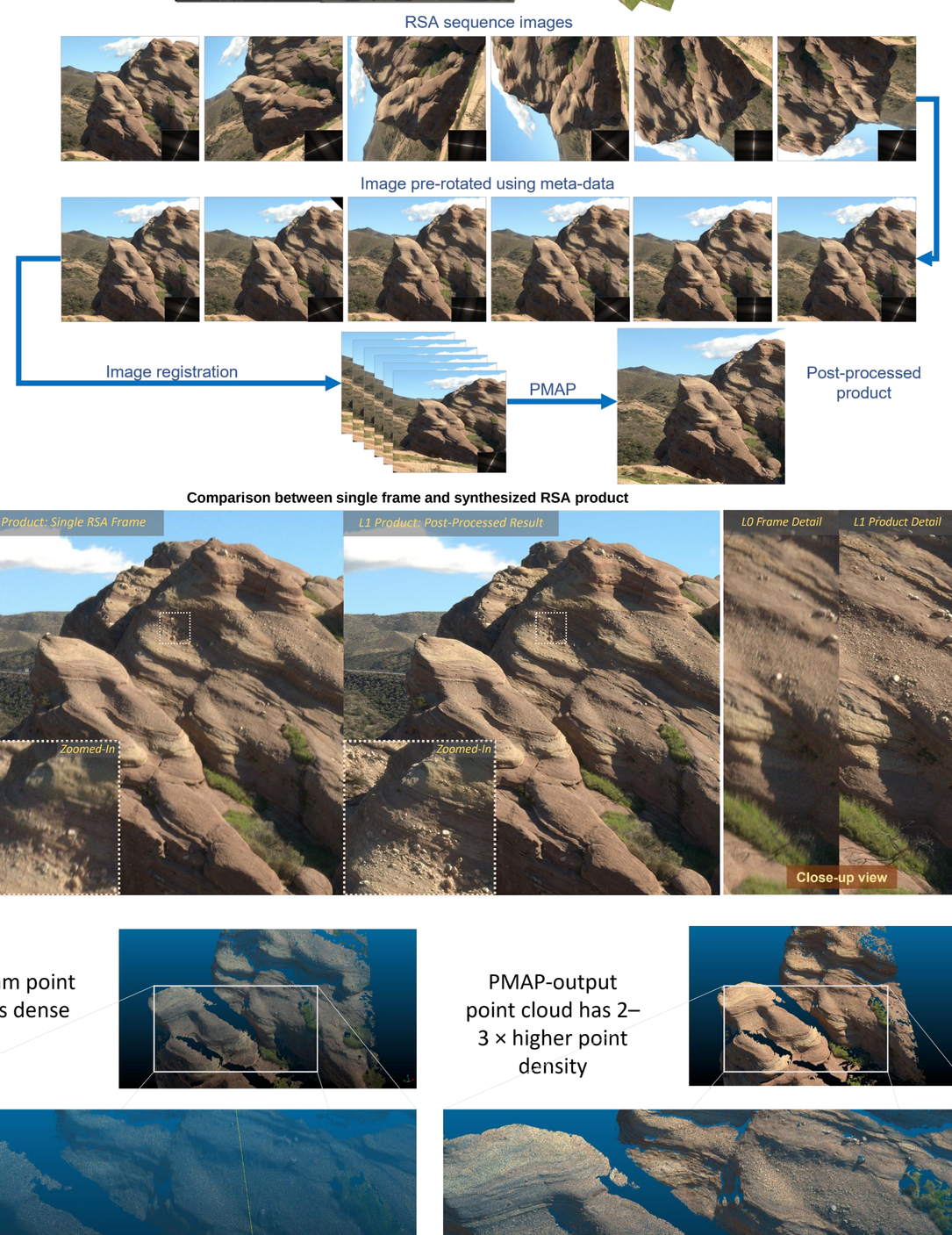
Future Earth Science / STV Missions

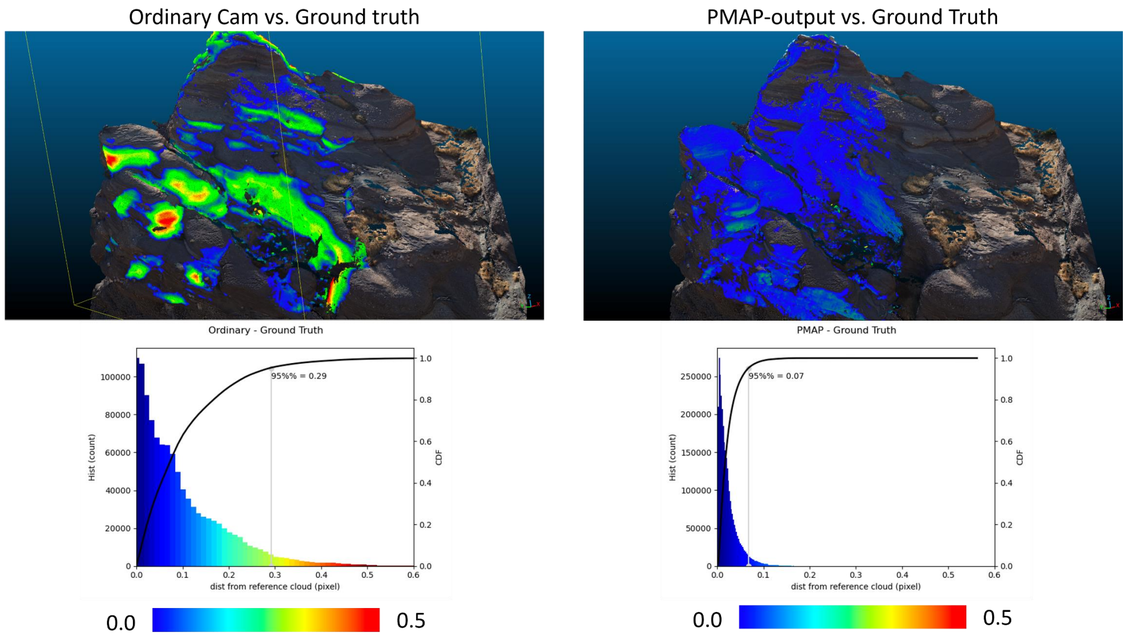
- RSA concepts are well matched to meet STV needs with a single spacecraft
- LEO constellations would cost more to achieve same responsiveness
- RSA Imaging is passive and lower risk than active imaging approaches

Future Astrophysics Missions

- RSA is a path to very large aperture telescope
- Enabling for low-cost high-resolution astronomy
- Enabling for exoplanet infrared spectroscopy with **1000x relaxed requirements** on wavefront error and stability

End-to-end pipeline for generating L1 RSA product





Cloud-to-cloud comparison between ordinary camera vs ground truth (left) and post-processed RSA product vs. ground truth (right). Scales at the bottom represent amount of distance to that of ground truth, with lower value denoting a higher similarity. Histograms describes the distribution of differences from ground truth

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