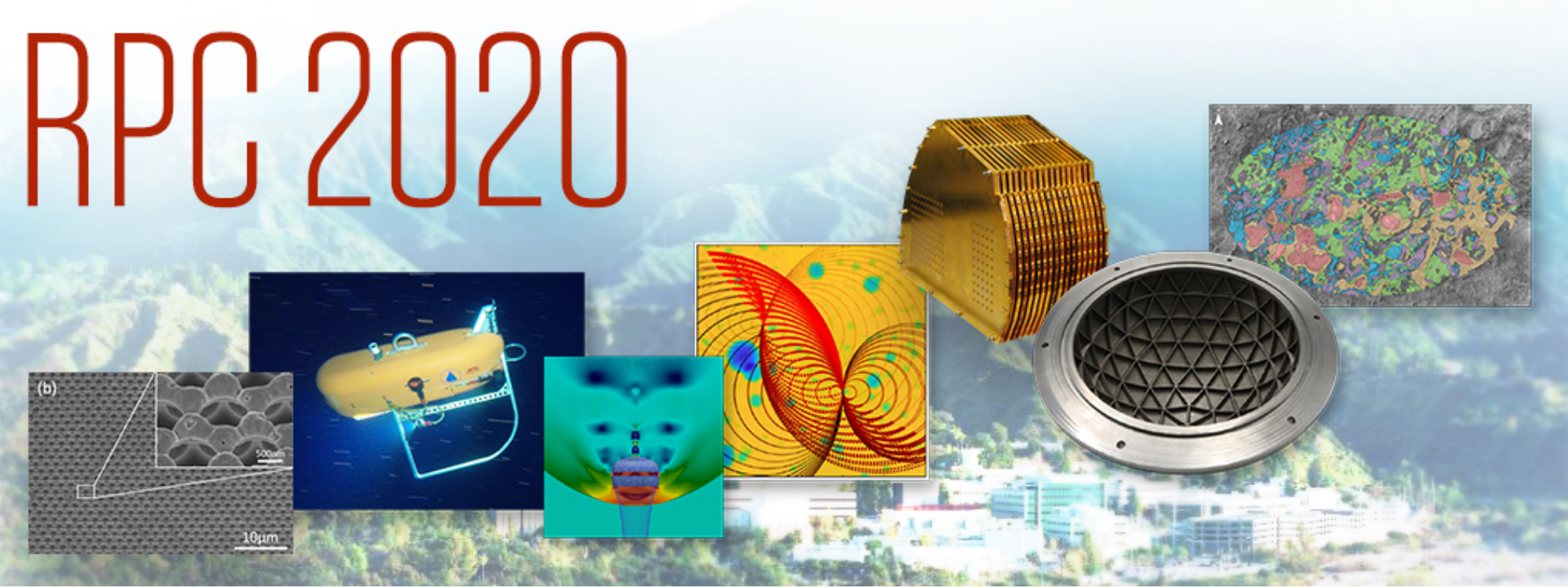

Virtual Research Presentation Conference

Demonstration of Advanced Ranging Techniques

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Program: (Strategic Initiative R&TD)

Assigned Presentation #RPC-282

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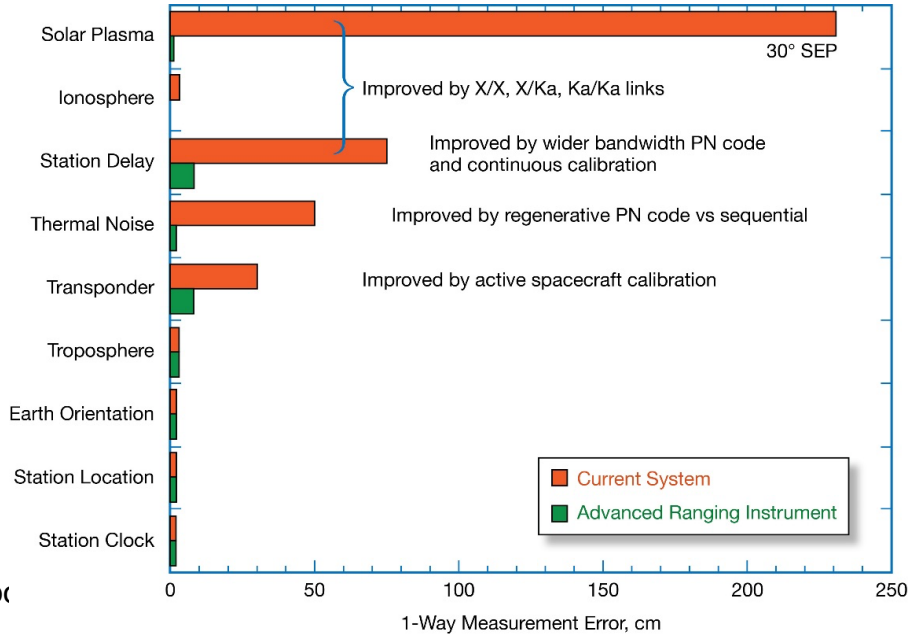
Introduction

- The accuracy of the current ranging system is 1 m for Sun-Earth-Probe (SEP) angle > 30º due to:
  - Solar plasma noises
  - Station delay
  - System noises
- The accuracy of newly developed Advanced Ranging Instrument (ARI) at DSS-25 is expected to be 10 cm unconditionally due to:
  - Dual-frequency uplinks, X & Ka
  - Wide-band PN code
  - Continuous measuring of station delay
  - Regenerative spacecraft transponder
- Demonstrate the performance of ARI and assess the ranging accuracy of ARI using DSS-25 and BepiColombo spacecraft, which is the only spacecraft in operation compatible with ARI.



ARI vs. Current Ranging system

DSN upgrades:

- Dual-frequency uplinks, X & Ka, and three downlinks, X/X, X/Ka, Ka/Ka
- Wide-band Pseudo-random Noise (PN) code ranging with higher PN chip rates
- Add a Zero Delay Device (ZDD) for Ka/Ka
- Open-Loop Ranging
- New ranging signal processor (ARP)
- Continuous measuring of station delay through Test Translator for X/X, X/Ka, Ka/Ka

Spacecraft upgrades:

- Transponder re-generates the uplink PN ranging signal

Comparison	ARI	Current Ranging
One-way Range Accuracy	0.1 m unconditionally	1 m conditionally
Restriction	Independent of SEP	SEP > 30°
Frequency Links Uplink & Downlink	Simultaneous multi-frequency ranging X/X, X/Ka, Ka/Ka	Single X/X
Plasma Calibration	Completely calibrate plasma noise	N/A
Station Delay Calibration	Continuously measure for X/X, X/Ka, Ka/Ka	Pre-cal or Post-cal
Tracking mode	Open-loop	Closed-loop
Signal Processing	Post-processing	During a track
S/C Transponder	Regenerative	Non-regenerative
DSN Uplink Ranging System	X and Ka	X
Ranging Scheme	T2B, T4B PN code (CCSDS)	Sequential, DSN PN
PN code chip rate	~3 Mcps for X, ~24 Mcps for Ka	~2 Mcps for X

Performances

Perform a series of ranging experiments with DSS-25 and BepiColombo and assess range measurement accuracy of ARI

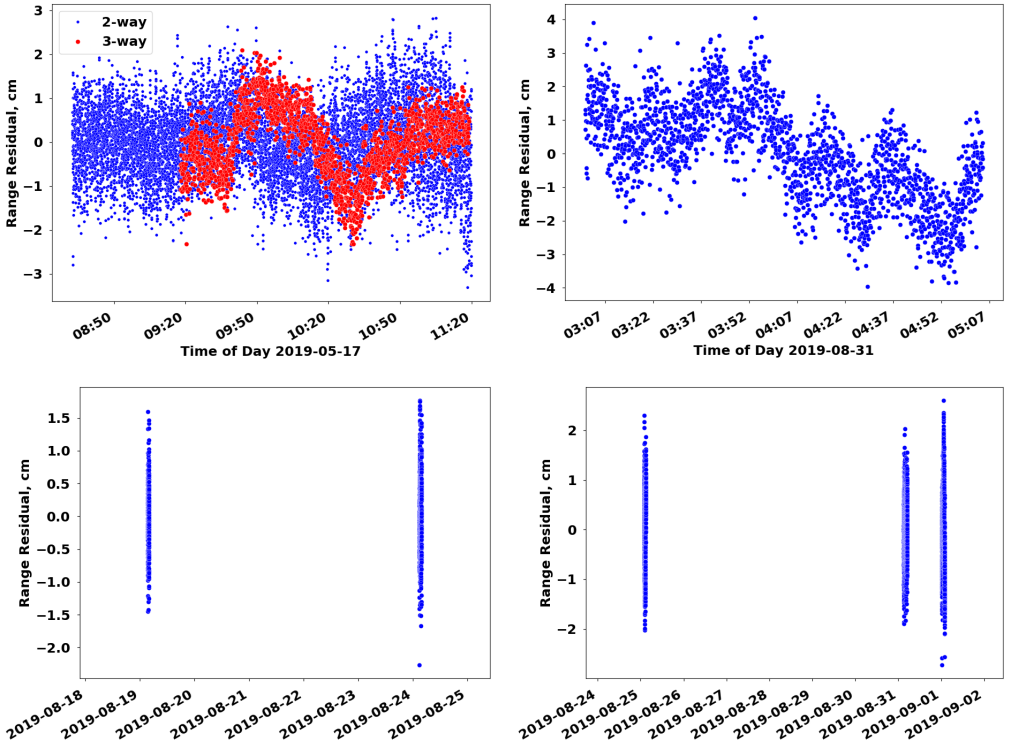
Two Ranging Campaigns:

- 12 Tracking passes in May, 2019
- 6 Tracking passes in August- September, 2019
- Two-way - uplink and downlink by DSS-25
- Three-way - uplink from Malargüe (MLG) station and downlink to DSS-25

Date	Duration	Mode	X/X Range	X/Ka Range	Ka/Ka Range	X Chip Rate	Ka Chip Rate
May 2, 2019	1.3 Hrs	3-way			Y		~24 Mcps
May 6, 2019	2.1 Hrs	2-way	Y	Y		~2 Mcps	
May 11, 2019	2.3 Hrs	2-way	Y			~2 Mcps	
May 12, 2019	1.7 Hrs	2-way	Y			~2 Mcps	
May 13, 2019	2.3 Hrs	3-way			Y		~24 Mcps
May 16, 2019	1.4 Hrs	3-way			Y		~24 Mcps
May 17, 2019	2.5 Hrs	3-way			Y		~24 Mcps
May 20, 2019	3.1 Hrs	3-way			Y		~24 Mcps
May 21, 2019	2.3 Hrs	3-way			Y		~24 Mcps
May 23, 2019	1.5 Hrs	3-way			Y		~24 Mcps
May 27, 2019	2.7 Hrs	2-way	Y			~3 Mcps	
May 29, 2019	2.7 Hrs	3-way			Y		~24 Mcps
Aug 11, 2019	2.5 Hrs	2-way			Y		~24 Mcps
Aug 19, 2019	1.5 Hrs	2-way			Y		~24 Mcps
Aug 24, 2019	1.4 Hrs	2-way	Y		Y	~3 Mcps	~24 Mcps
Aug 25, 2019	1.5 Hrs	2-way	Y		Y	~3 Mcps	~24 Mcps
Aug 31, 2019	2.5 Hrs	2-way	Y		Y	~3 Mcps	~24 Mcps
Sep 1, 2019	1.5 Hrs	2-way	Y		Y	~3 Mcps	~24 Mcps

Assessments

- Data were acquired at both DSS-25 and MLG station. Joint analysis of data from the two networks is required for validation of range accuracy.
- Data fits validated the precision and internal consistency of DSS-25 two-way at the sub-centimeter level.
- Further tracking data campaign and joint analysis with data from two stations are required to validate the absolute accuracy of 10 cm level.



Publications and References

Publications:

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