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National Aeronautics and Space Administration

NASA's Surface Deformation and Change Designated Observable Architecture Study Current Status

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INTERCONNECTED CORE MISSIONS

SURFACE BIOLOGY AND GEOLOGY

Earth Surface and Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

AEROSOLS

Particles in the Atmosphere

MASS CHANGE

Large-scale Mass Redistribution

SURFACE DEFORMATION AND CHANGE

Surface Deformation and Change (SDC)
Architecture Study Objectives

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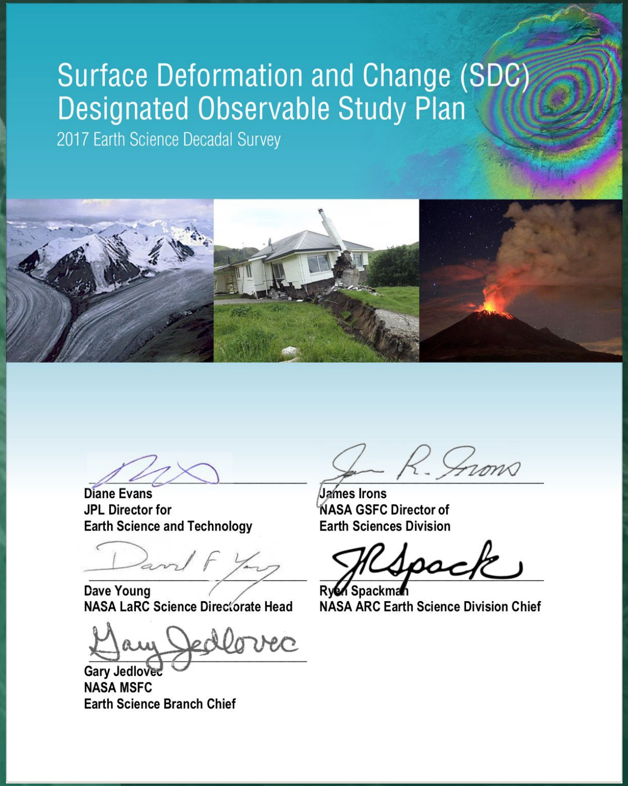
- Determine cost-effective SAR-based architecture to implement the Decadal Survey's SDC geodetic observables

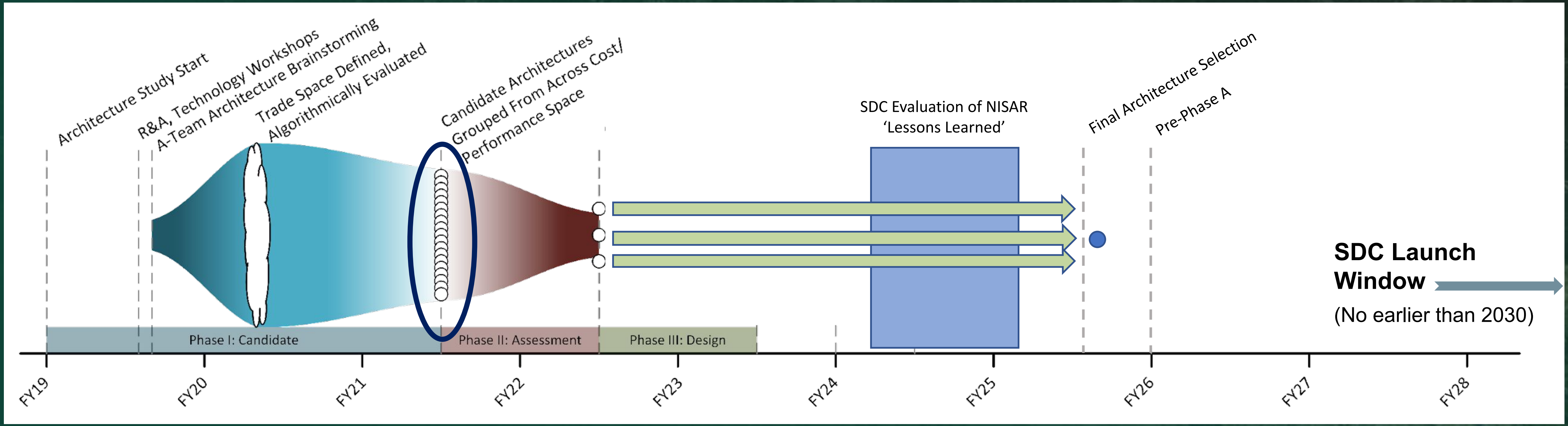
- Understand the cost/benefit of other Science and Applications in the SDC trade space

- Engage emerging best and new practices in industry including smallsat constellations and commercial data purchases

- Explore international partnerships to leverage capability and reduce cost.



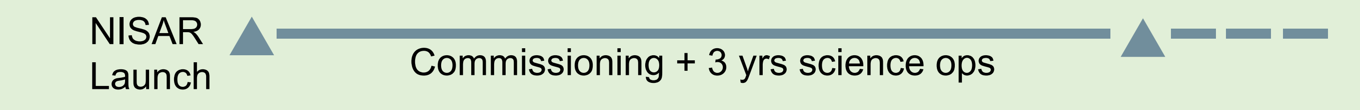
Where are we today?



- Original SDC Study Timeline

- ESO: Lessons learned from NISAR will guide the SDC architecture development and selection

- Final SDC selection will likely be mid-2025



NISAR is a "trailblazer" for the ESO

- The SDC Study Team just completed the initial downselect

- **Today we will review the SDC downselect approach and architectures that were selected.**

SDC Downselect Process (Phase II.a)

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Phase II.a Assessment

Science: Performance tool + heuristics
Applications: Feasibility + Mapping
Cost: High-level parametric/analogs
Risk: Initial mapping from survey
Programmatic Factors: Expert Opinion

Phase II.b Assessment

Science: Performance tool (+ heuristics), refined methodology
Applications: Refined methodology
Cost: Refined parametric/analogs, independent cost estimate
Risk: Risk matrix, technology readiness assessments
Programmatic Factors: Expert Opinion

Phase I

Potential Options (40)

- Large number of options with varying capabilities
- Identify key architecture elements/building blocks
- Identify drivers and trade-offs
- High-level metrics used to consolidate and refine architecture set
- Point of departure for deep dive assessments

June 2021
HQ Sync Point

Feasible Options (10)

- Smaller set of feasible architectures, warranting deeper dive
- Science, cost assessments are refined
- Risk, Programmatic factors are assessed
- Concurrent Eng. Studies

June 2022
HQ Sync Point

Recommended Options (~3)

Phase III

Nov. 2022
HQ Sync Point

TBD FY25

Final Arch.

Phase III Assessment

Decision structuring: Identifying what is different relative to previous downselects
Assessment approach: Designing and implementing decision-making structure
Facilitation: Supporting assessments, analysis, and documentation of decision

Architecture groups

Flagship

Distributed Repeat Track

Multi-Squint Formation

Lowered Inclination

Helical Orbit Formation

Alternative Water Vapor Techniques

Value in the SDC Study

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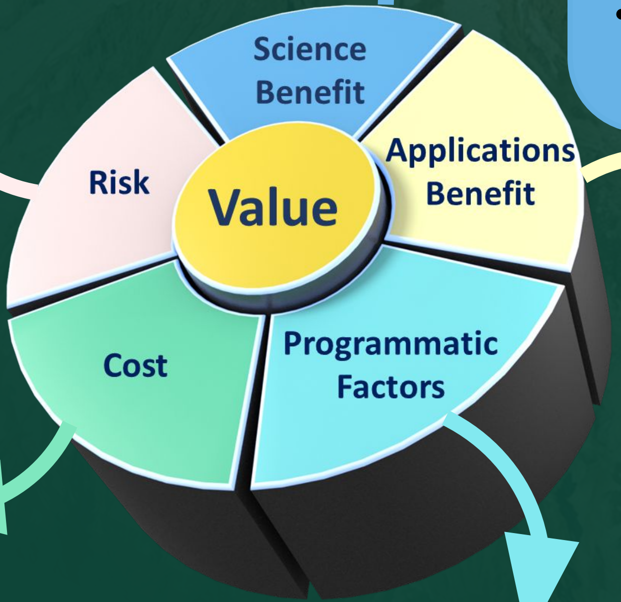
- Architecture Grouping (e.g. single flagship) risks
- Individual Architecture risks

- **Feasibility** quantifies likelihood an architecture achieves Science performance targets for an Observable
- **Relevance** weights the utility of an Observable to a DS Goal
- **Benefit** is product of Feasibility and Relevance, aggregated at DS Goal level or higher



- 12 Communities and 26 Potential Enabled Applications mapped to Observables

- NASA Instrument Cost Model
- Historical Analogues for Spacecraft
- NISAR-based operations estimates

- 14 Programmatic Factors defined by study leadership with HQ

Selected Architectures

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Architecture	Characteristic	Orbital Phasing Groups	Pol.	Repeat Period (Days)	Per Satellite Swath (km)	Relative Cost
L1C	NISAR w/PWV inst.	1	Quad	12	240.0	2.9
L4A	2x NISAR w/ROSE-L	4	Quad	3	240.0	3.6
L5A	NISAR via 5 Smallsats	5	Dual	2/8	60.0	1.6
L6C	ROSE-L Active Multi-Squint Co-fliers	2	Single	6	80.0*	1.0
L6E	ROSE-L Passive Multi-Squint Co-fliers	2	Dual	6	80.0*	2.0
L8A	Sub-Daily Repeat	1	Dual	0.25/12	30.0	2.1
L9A	NISAR via Multi-Squint Co-fliers	3	Dual	4/12	80.0	2.4
L12B	Multi-Baseline Helical Orbit	2	Dual	6	40.0	2.3
L12C	Fast Revisit Low Cost per Sat.	12	Single	1/4	60.0	1.8
L18A	Multi-Squint Low Cost per Sat.	6	Single	2/8	60.0	2.2

*Reported swath is for the co-fliers, not ROSE-L.

Architecture Science Benefit scores per Focus Area

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Arch.	Cryo.	Eco.	Hydro.	Solid Earth	Geo Haz.
L1A	0.74	0.82	0.57	0.70	0.56
L1B	0.74	0.82	0.57	0.70	0.56
L1C	0.73	0.82	0.57	0.75	0.57
L2A	0.76	0.84	0.59	0.79	0.59
L2B	0.74	0.82	0.57	0.77	0.57
L3A	0.69	0.76	0.55	0.73	0.62
L4A	0.78	0.85	0.60	0.80	0.63
L4B	0.69	0.74	0.54	0.73	0.65
L4C	0.26	0.77	0.56	0.61	0.56
L5A	0.71	0.78	0.57	0.78	0.72
L6A	0.69	0.76	0.54	0.69	0.70
L6B	0.69	0.76	0.55	0.76	0.60
L6C	0.69	0.74	0.54	0.76	0.56
L6D	0.69	0.79	0.53	0.69	0.56
L6F	0.26	0.79	0.57	0.67	0.60
L6E	0.69	0.74	0.54	0.76	0.56
L9A	0.69	0.74	0.54	0.76	0.62
L12B	0.71	0.80	0.54	0.78	0.59
L12C	0.63	0.50	0.51	0.75	0.79
L18A	0.62	0.50	0.50	0.74	0.58
L18B	0.62	0.50	0.50	0.74	0.58

Arch.	Cryo.	Eco.	Hydro.	Solid Earth	Geo Haz.
S1A	0.72	0.79	0.56	0.70	0.56
S1B	0.72	0.79	0.56	0.70	0.56
S2A	0.74	0.81	0.57	0.78	0.59
S2B	0.72	0.79	0.56	0.77	0.58
S3A	0.67	0.74	0.54	0.73	0.65
S4B	0.67	0.72	0.52	0.73	0.65
S4C	0.24	0.74	0.54	0.61	0.56
S6A	0.62	0.72	0.51	0.70	0.69
S6B	0.70	0.78	0.55	0.76	0.62
S5A	0.69	0.75	0.55	0.78	0.72
S6D	0.69	0.79	0.53	0.69	0.56
S9A	0.67	0.72	0.52	0.75	0.62
S12B	0.67	0.72	0.52	0.75	0.62
S6F	0.24	0.76	0.55	0.67	0.60
S12C	0.61	0.47	0.49	0.75	0.79
S18A	0.60	0.47	0.49	0.74	0.58
S18B	0.60	0.47	0.49	0.74	0.58
C6C	0.66	0.80	0.51	0.75	0.58
C4A	0.70	0.78	0.55	0.73	0.59

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S5A	0.69	0.75	0.55	0.78	0.72
S6D	0.69	0.79	0.53	0.69	0.56
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S12B	0.67	0.72	0.52	0.75	0.62
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S18B	0.60	0.47	0.49	0.74	0.58
C6C	0.66	0.80	0.51	0.75	0.58
C4A	0.70	0.78	0.55	0.73	0.59

Programmatic Comparison

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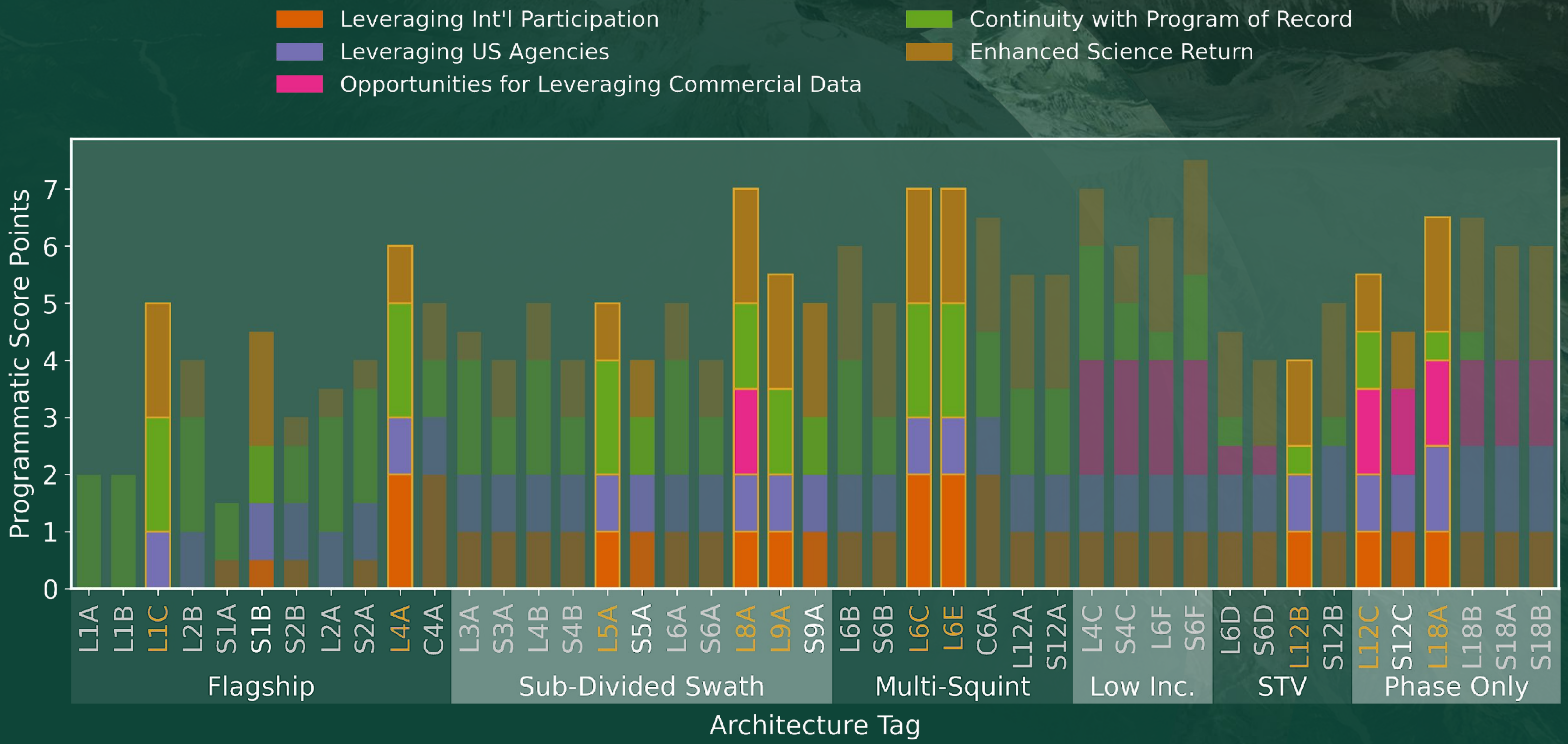
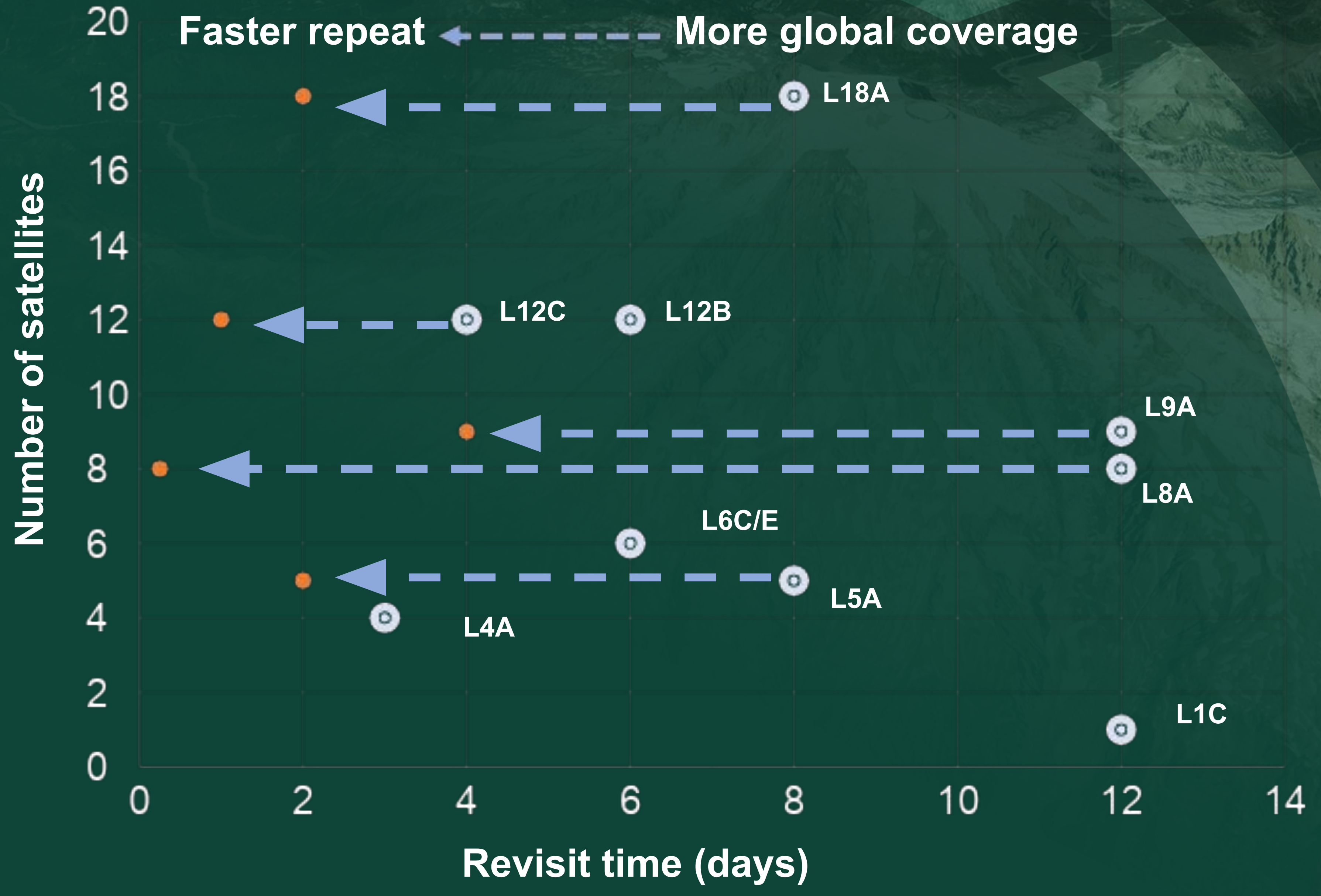
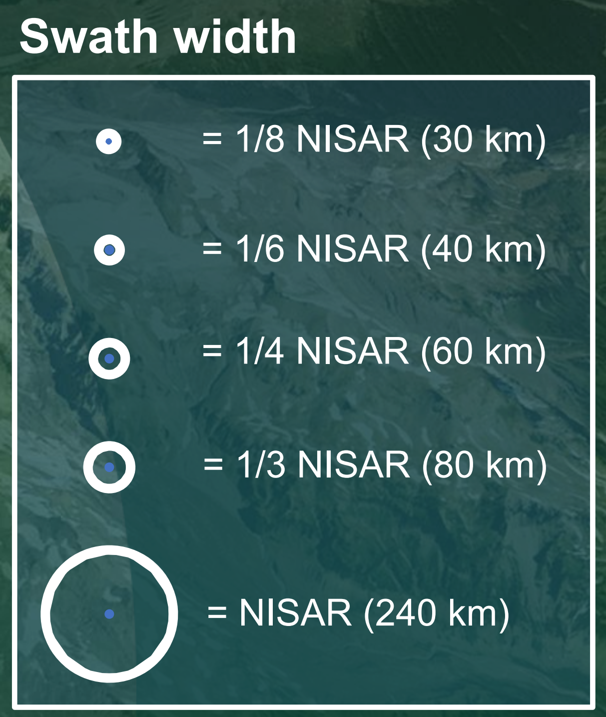


Revisit time vs # of satellites and swath width





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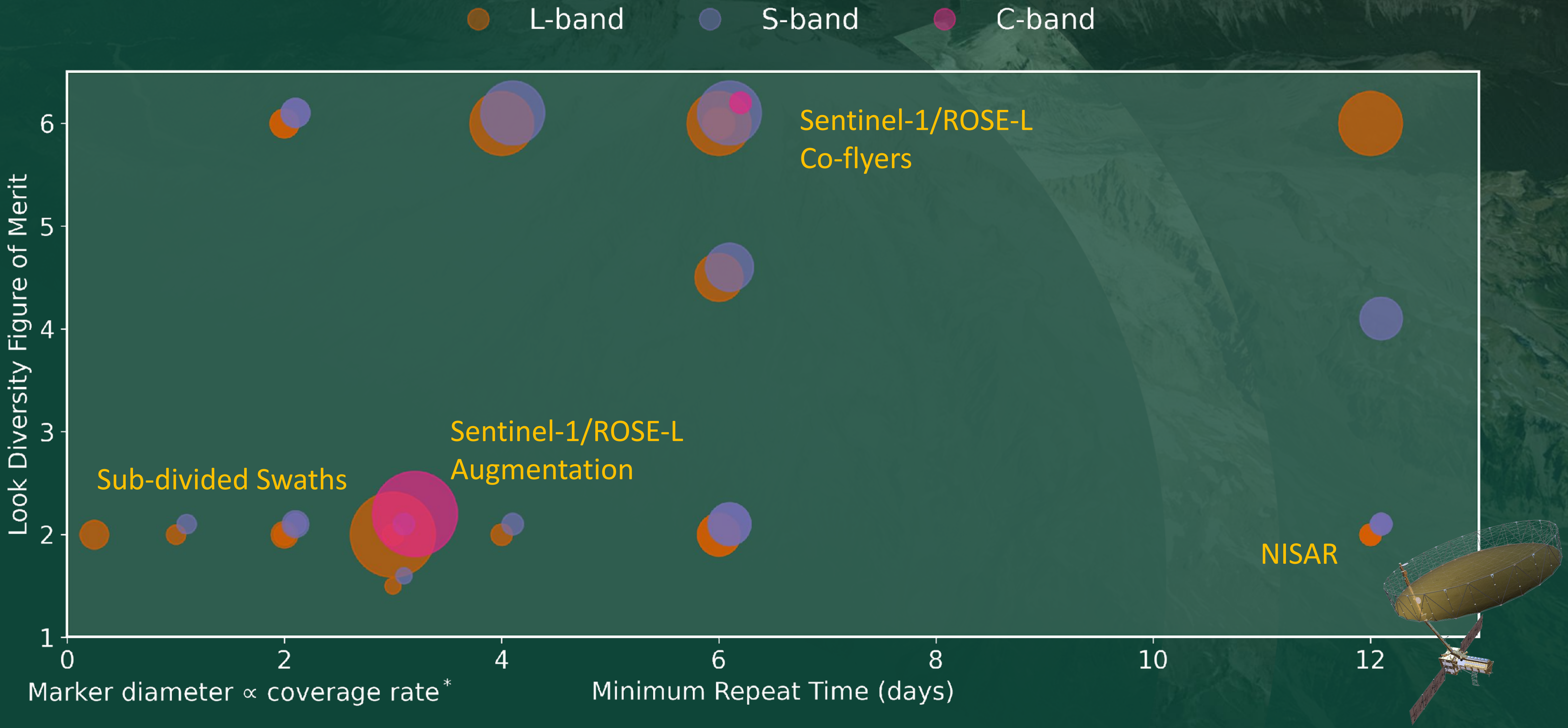
Look Diversity vs. Coverage



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Selected Architectures - Deformation Science Perspective

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Architecture	Characteristic	Continuity	Improved accuracy	Rapid repeat sampling
L1C	*NISAR w/PWV inst.*			
L4A	*2x NISAR w/ROSE-L*			
L5A	*NISAR via 5 Small Sats.*			
L6C	*ROSE-L Active Multi-Squint Co-fliers*			
L6E	*ROSE-L Passive Multi-Squint Co-fliers*			
L8A	*Sub-Daily Repeat*			
L9A	*NISAR via Multi-Squint Co-fliers*			
L12B	*Multi-Baseline Helical Orbit*			
L12C	*Fast Revisit Low Cost per Sat.*			
L18A	*Multi-Squint Low Cost per Sat.*			

Level of Improvement

- Large
- Medium
- Small
- NISAR-like

Selected Architectures – Radiometric-based Science Perspective

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Architecture	Characteristic	Continuity	Improved accuracy	Rapid repeat sampling
L1C	*NISAR w/PWV inst.*	Large	NISAR-like	NISAR-like
L4A	*2x NISAR w/ROSE-L*	Large	Small	Medium
L5A	*NISAR via 5 Small Sats.*	Large	NISAR-like	NISAR-like / Medium
L6C	*ROSE-L Active Multi-Squint Co-fliers*	Large	Small	NISAR-like
L6E	*ROSE-L Passive Multi-Squint Co-fliers*	Large	Small	NISAR-like
L8A	*Sub-Daily Repeat*	Large	NISAR-like / Medium	NISAR-like / Large
L9A	*NISAR via Multi-Squint Co-fliers*	Large	Small	NISAR-like / Small
L12B	*Multi-Baseline Helical Orbit*	Large / Small	Medium	NISAR-like
L12C	*Fast Revisit Low Cost per Sat.*	No Polarimetry	No Polarimetry	No Polarimetry
L18A	*Multi-Squint Low Cost per Sat.*	No Polarimetry	No Polarimetry	No Polarimetry

Level of Improvement

- Large
- Medium
- Small
- NISAR-like
- No Polarimetry

Relative cost vs. area collected

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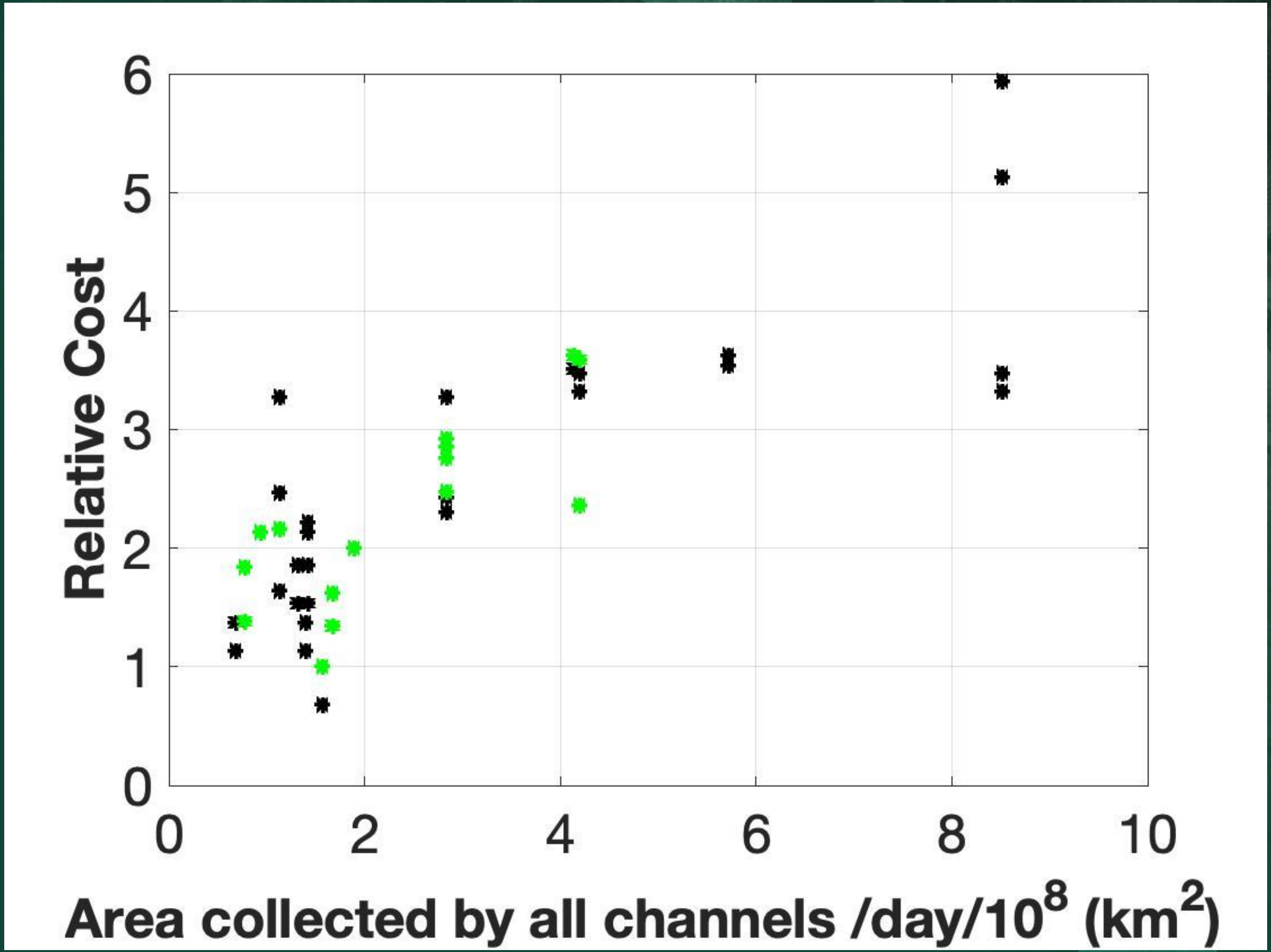

Summary

- We have completed a value framework to quantitatively assess system architectures against a variety of science, applications and programmatic requirements.
- Applied the framework to 40 architectures and selected 10 L-band architectures for further study.
  - We eliminated low-inclination orbits.
  - Remaining architectures span from small satellites to flagships
- Partnerships add significant value to the SDC mission.
- Exploring the specifics of partnerships is becoming important at this point of the study.
  - Engaging with industry in co-development possibilities

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Thank you!

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