ESA's 2025 Big Data Foundations for Earth Observation Training Course

Introduction to New Satellite Missions & New Space

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European Commission | researchLatvia Value Through Knowledge
Ministry of Education and Science Republic of Latvia
esa academy

Outline

1. New Space – the theory
2. New Space – why, motivation and advantages
3. KappaZeta's 3D-SAR mission
   - purpose and point;
   - main results from the phase 0 study with ESA/ESTEC;
   - status and next steps;

New Space vs Old Space what is the difference?

	New Space	Old Space
Development model	Agile, iterative, rapid prototypes and releases	Waterfall-like, heavy up-front requirements and long design phases
Schedule & cadence	Short development cycles (months → few years); frequent launches	Multi-year programmes (often 5–15+ years to launch)
Cost philosophy	Cost-minimisation, COTS, volume manufacturing, fixed-price ventures	Large budgets, bespoke hardware, cost-plus or conservatively estimated contracts

New Space vs Old Space what is the difference?

	New Space	**Old Space**
Risk tolerance	Higher acceptance of technical/mission risk; **failure used to learn!**	Low tolerance for failure; high redundancy and conservative margins
Design approach	Standardised, modular, software-defined, use of commercial parts	Custom engineering, radiation-hardened components, bespoke interfaces
Testing & qualification	Fast, functional testing; sometimes in-orbit validation	Exhaustive qualification: thermal-vacuum, vibration, electromagnetic-interference, full end-to-end tests

New Space vs Old Space what is the difference?

	New Space	Old Space
Procurement & contracting	Commercial contracts, venture financing, startups	Government procurement, primes and long subcontract chains
Team & culture	Lean, cross-disciplinary teams; rapid decision cycles	Large organisations, formal processes, hierarchical decisions
Technology refresh	Frequent hardware/software refreshes;	Long part lifetimes; slow to adopt un-qualified COTS

New Space – why, motivation & advantages

1. “It has always been done like this” does not mean other ways are not possible.
2. I have seen it many times, when “old farts” trying to protect the status quo.
   - Old telecom gurus opposing why 3G, 4G and 5G “does not work”!
   - Old school mathematicians explaining why deep learning with neural networks is “too complex to work, too many degrees of freedom!”

New Space – why, motivation & advantages

1. Main difference is accepting the risk in New Space.
2. Adopting the concept of “failing forward”.
3. Experiment and testing is often more effective way to develop than trying to foresee, analyse and mitigate all possible risks.
4. Main advantage: being faster and being more competitive, faster to innovate.

Social science question: How to overcome the fear of failure?
How to be more friendly [yet demanding] to each other?

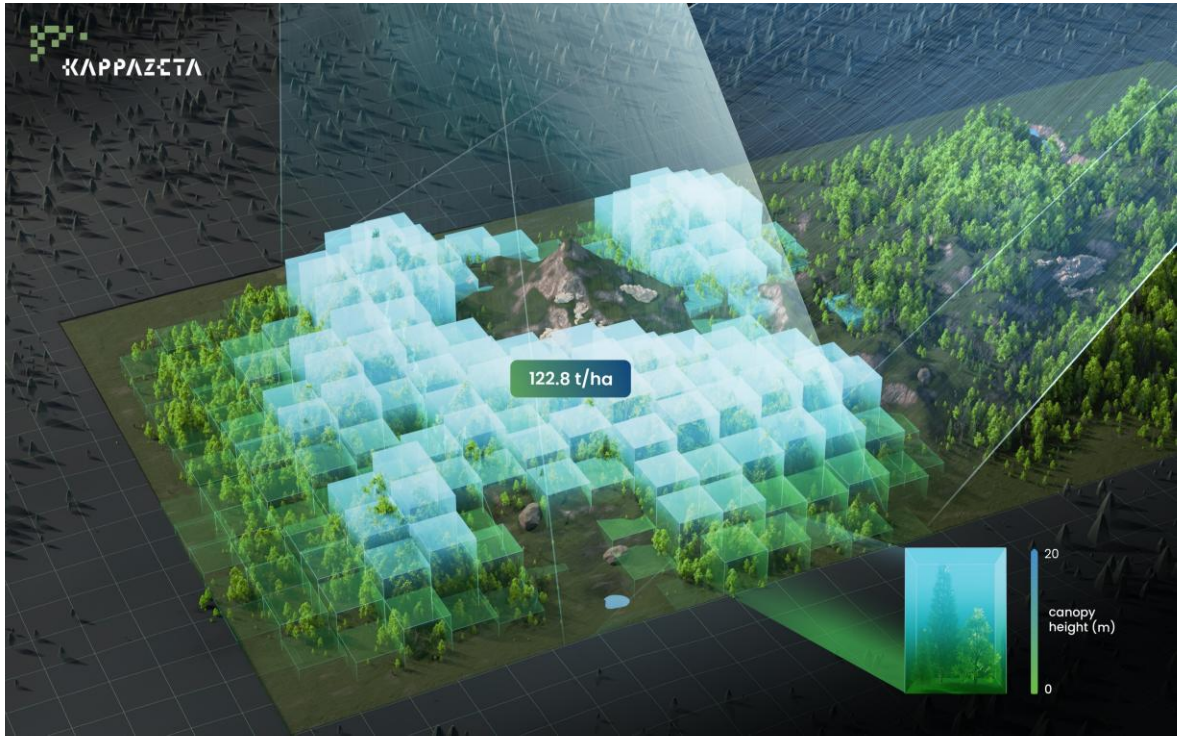
3D-SAR mission - what?

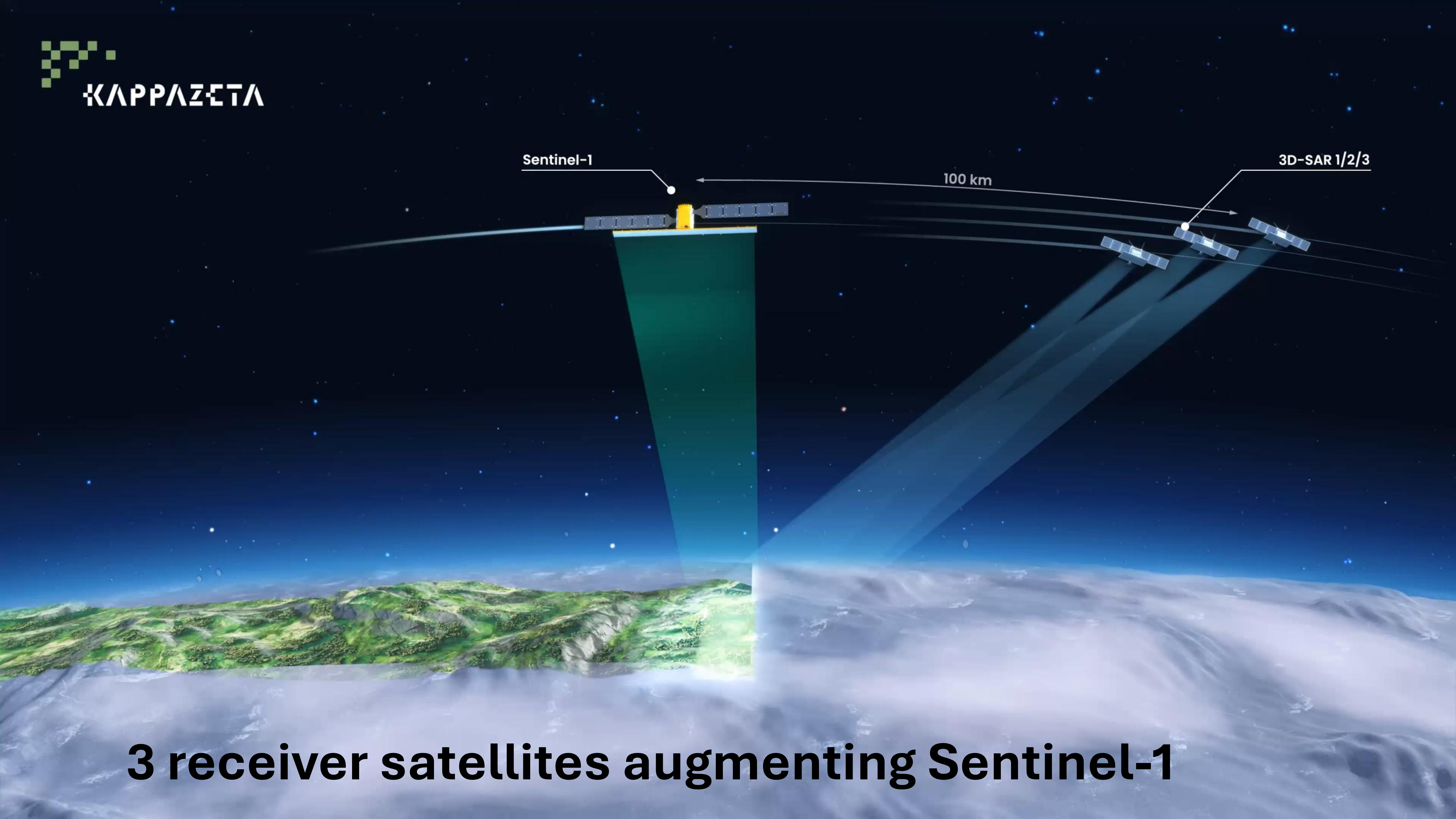
- Sentinel-1, most powerful SAR data source
- Augmenting Sentinel-1 with three formation flying receiver sats
- Receive the signal at different angles = making the data 3D
- Fraction of cost doubling value

Image: Taavi Torim & European Space Agency

3D-SAR mission - why?

- Global and frequent forest height measurements.
- Enabling accurate stem volume & forest carbon stock estimates.
- No such data source yet!
- Making Sentinel-1 data 3D.
- Accurate, global and comparable forest measurements.





3 receiver satellites augmenting Sentinel-1

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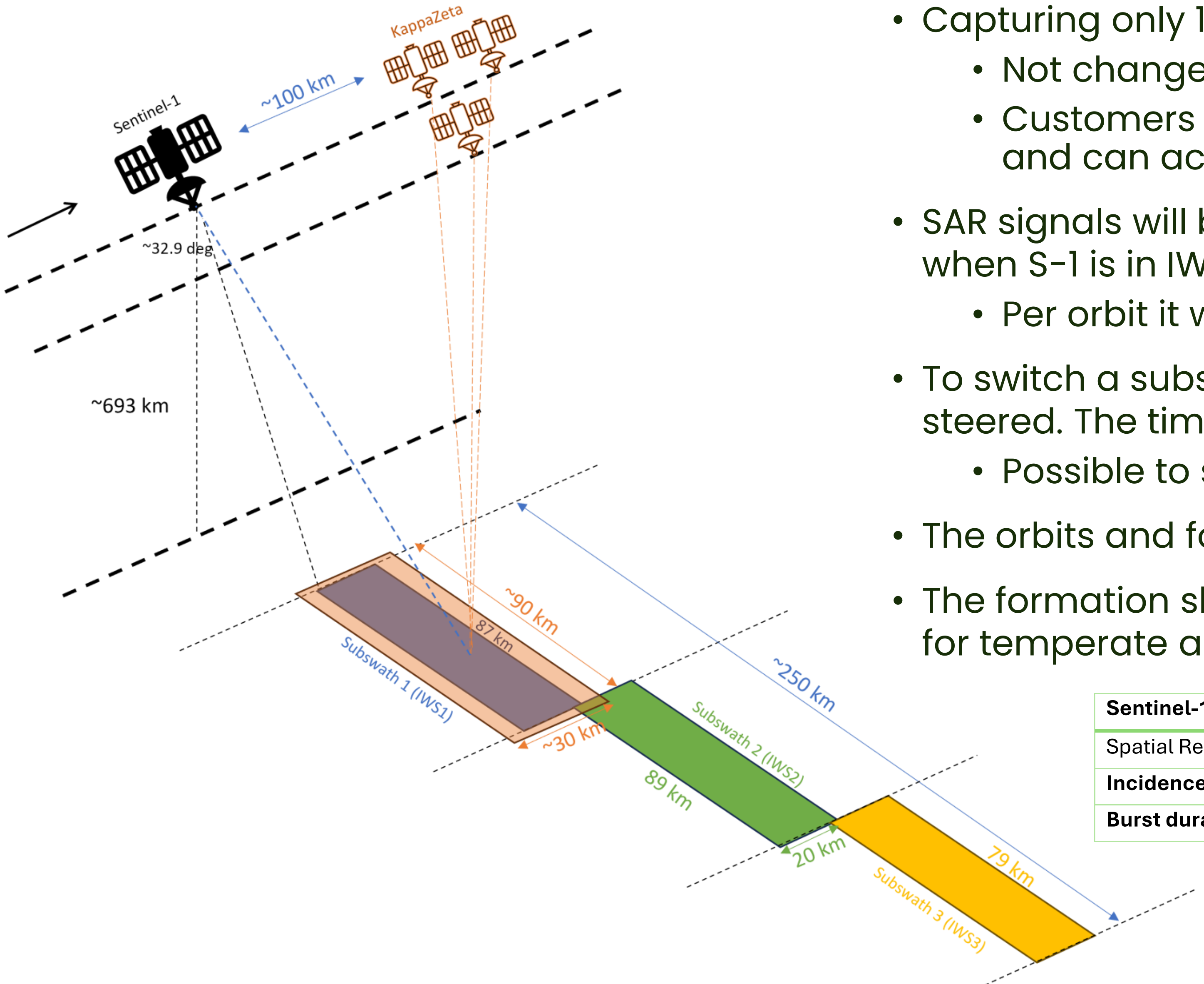
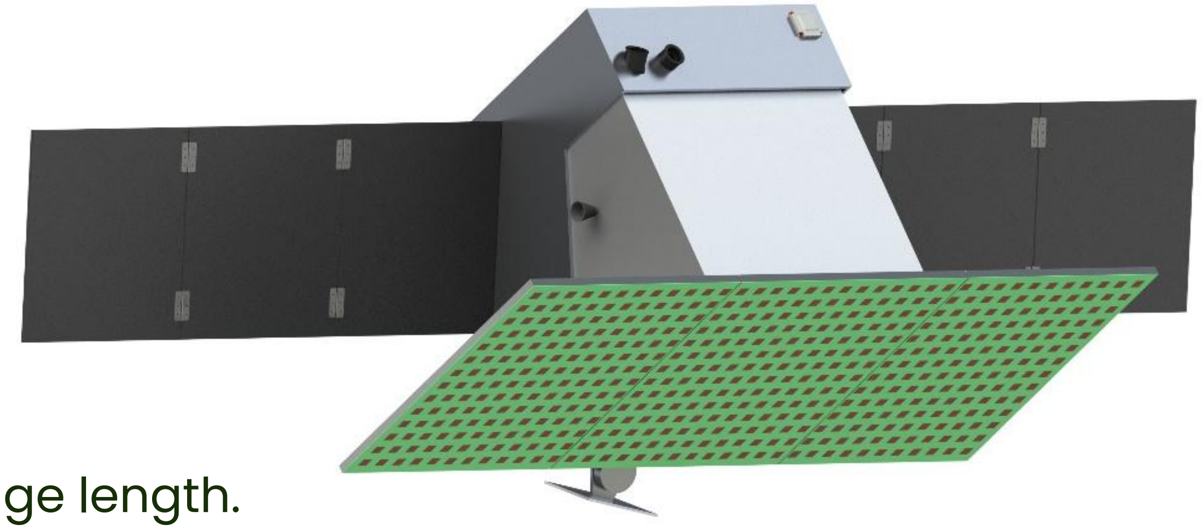
Observation Concept



- Capturing only 1 subswath at a time:
  - Not changed during the ~2.75 second S1 burst.
  - Customers do not strongly demand the S1's 12-day revisit and can accept 36–48 days at equator.
- SAR signals will be recorded across all major landmasses when S-1 is in IWS (Interferometric Wide Swath) mode.
  - Per orbit it will be ~1/3 of the <30-minute S-1 duty cycle.
- To switch a subswath, the spacecraft will be mechanically steered. The time to rotate <120 seconds.
  - Possible to switch "on-demand" for customers.
- The orbits and formations shall be relatively stable for InSAR.
- The formation shall prioritize more accuracy in higher latitudes for temperate and boreal forests.

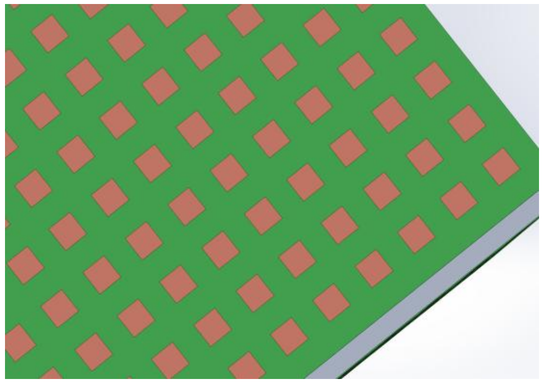
Sentinel-1 Beam ID	IW1	IW2	IW3
Spatial Resolution rg x az m	20.4x22.5	20.3x22.6	20.5x22.6
Incidence angle (center of footprint)	**32.9 deg**	**38.3 deg**	**43.1 deg**
Burst duration	**0.8s sec**	**1.06 sec**	**0.83 sec**

Preliminary Antenna Design



- Aluminium frame for structural support.
- Large PCBs with C-band patches on top, attached via screws.
- Deployable wings with locking mechanism and hold-down-and-release mechanism.

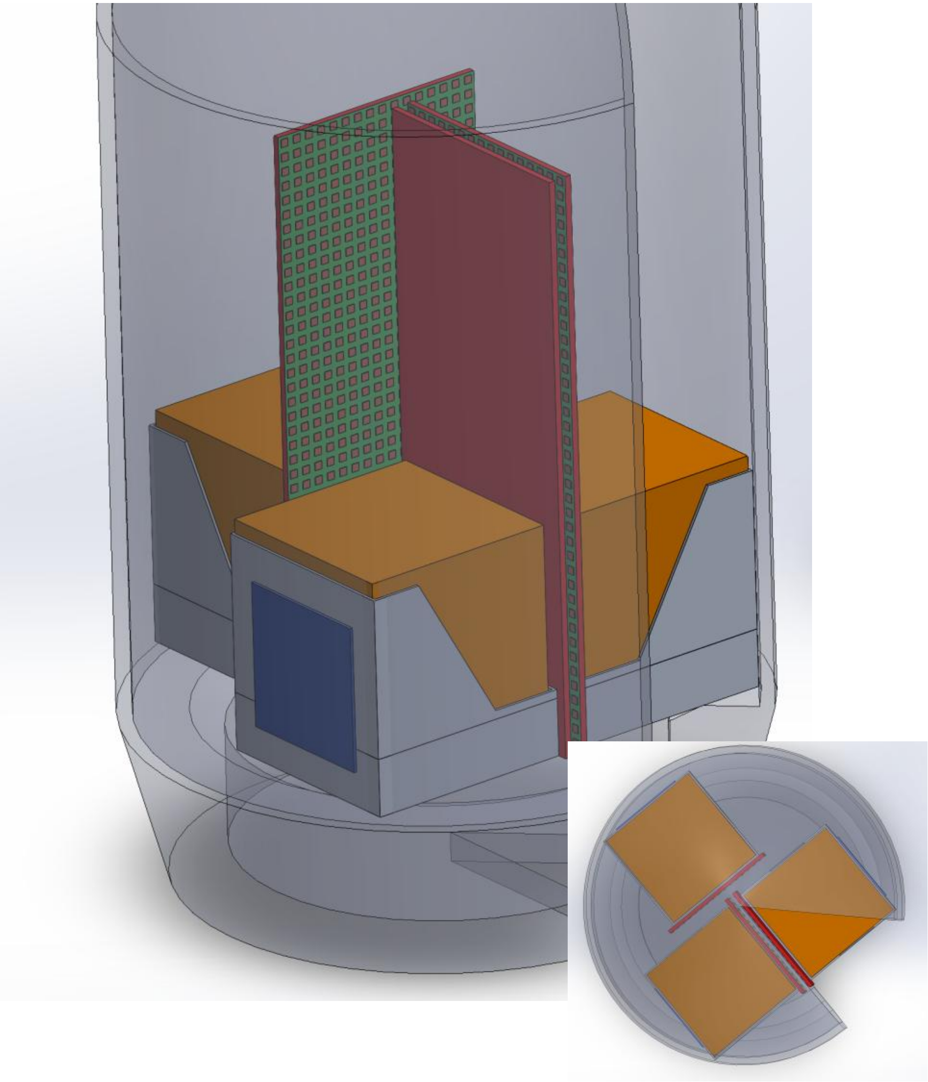
- Each C-band patch is a square with 2.77 cm edge length.
- The distance between patches is half the wavelength.
  - *In reality, the patches would not be perfect squares and distances between patches would be >wavelength/2.*
  - *Sentinel-1 wavelength is 5.5466 cm.*

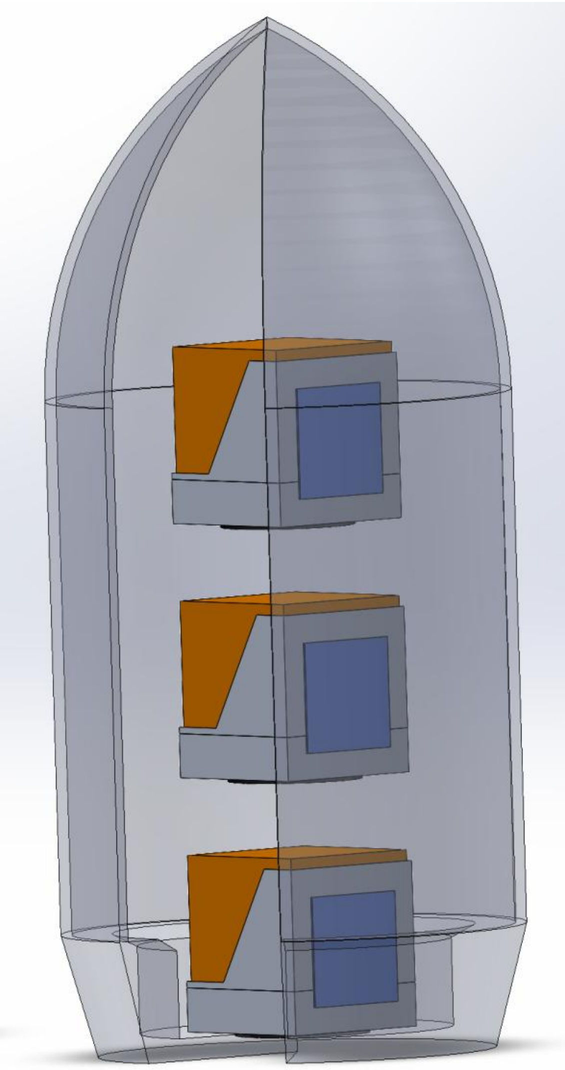


However, the following antenna options are still open and will be investigated further in Phase-A:

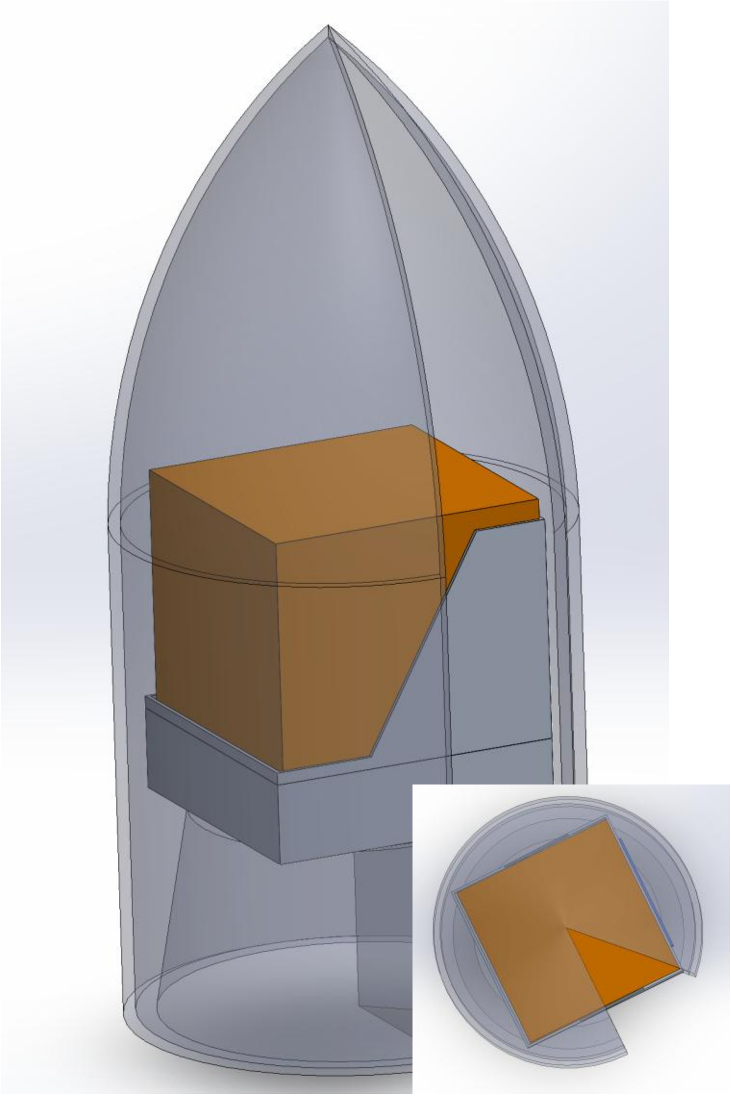
- SESAME-like dual spaced antenna solution.
- Smaller antenna (25-50cm height instead of 80 cm).

3D-SAR Spacecraft with Launcher Fairings





Firefly – Alpha (2m diameter) -> Isar, RFA, MaiaSpace



Rocket Lab - Electron

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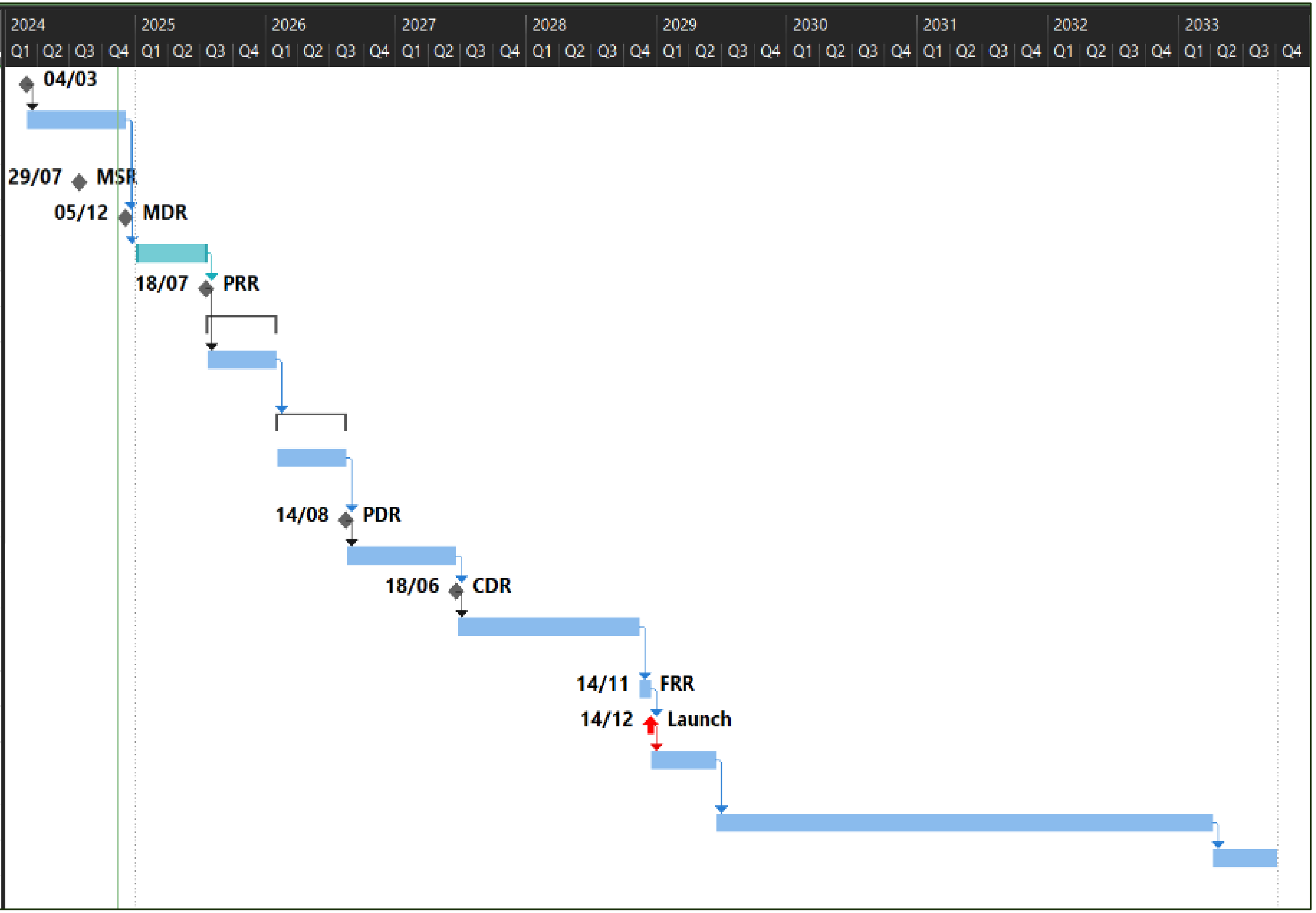
Schedule, Project Timeline

	Task Name	Duration	Start	Finish
1	Kick-off	0 days	Mon 04/03/24	Mon 04/03/24
2	Phase 0: Concept Exploration	199 days	Mon 04/03/24	Thu 05/12/24
3	MSR	0 days	Mon 29/07/24	Mon 29/07/24
4	MDR	0 days	Thu 05/12/24	Thu 05/12/24
5	Phase A: Feasibility Study	140 days	Mon 06/01/25	Fri 18/07/25
6	PRR	0 days	Fri 18/07/25	Fri 18/07/25
7	Phase B	140 days	Mon 21/07/25	Fri 30/01/26
8	Phase B1: Preliminary Definition 1	140 days	Mon 21/07/25	Fri 30/01/26
9	SRR	140 days	Mon 02/02/26	Fri 14/08/26
10	Phase B2: Preliminary Definiton 2	140 days	Mon 02/02/26	Fri 14/08/26
11	PDR	0 days	Fri 14/08/26	Fri 14/08/26
12	Phase C: Detailed Definition	220 days	Mon 17/08/26	Fri 18/06/27
13	CDR	0 days	Fri 18/06/27	Fri 18/06/27
14	Phase D: Assembly, Integration & Testing	366 days	Mon 21/06/27	Mon 13/11/28
15	FRR	23 days	Tue 14/11/28	Thu 14/12/28
16	Launch	0 days	Thu 14/12/28	Thu 14/12/28
17	Phase E1: Launch & Early Operations	130 days	Fri 15/12/28	Thu 14/06/29
18	Phase E: Full operations	992 days	Fri 15/06/29	Mon 04/04/33
19	Phase F: Disposal	130 days	Tue 05/04/33	Mon 03/10/33



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Phase A+B1

Estonian RPA proposal recommended by ESA

Formulated consortium:

KappaZeta (EE): Systems engineering and mission management, roadmap, payload electronics

TU Delft (NL): SAR simulations, formation flying, L1 SAR product

Rantelon (EE): antenna and SAR receiver design

Kongsberg NanoAvionics (LT): Satellite bus and ops ground segment roadmap, PA/QA

Serco Services (DE): Mission Operations and planning consultancy

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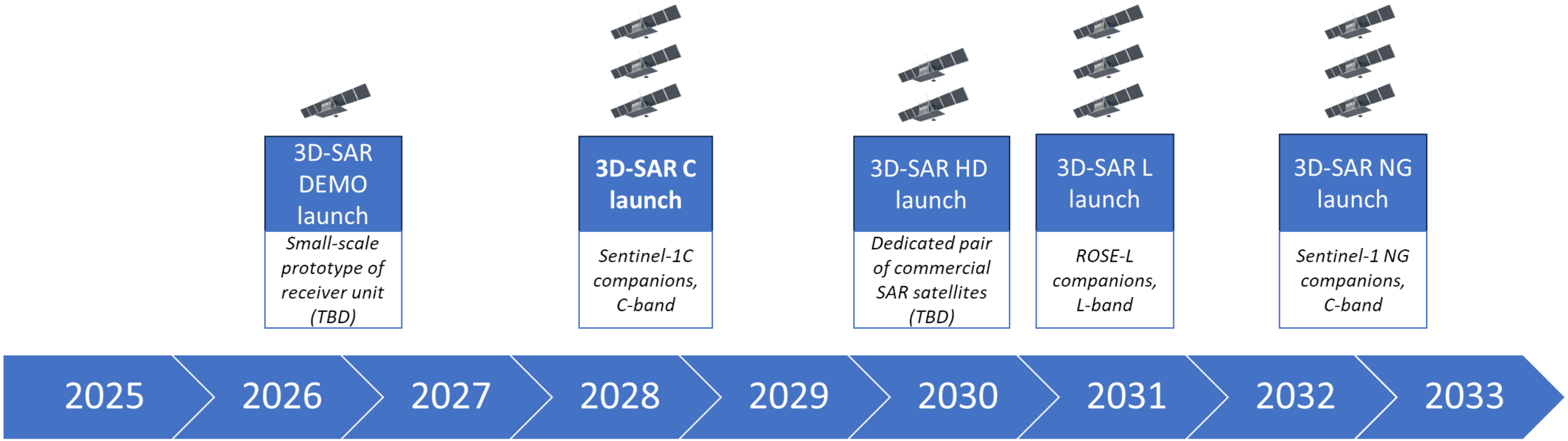
KappaZeta's long-term vision

- **Transparent and reliable information about our forests' status and health – globally and continuously**
- **Foreseen mission impact >100M€ per year**



Thank you!

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Questions?

Photo: Indrek Sünter 2021