Rainbow - An innovative approach for a low-cost smart farming mission

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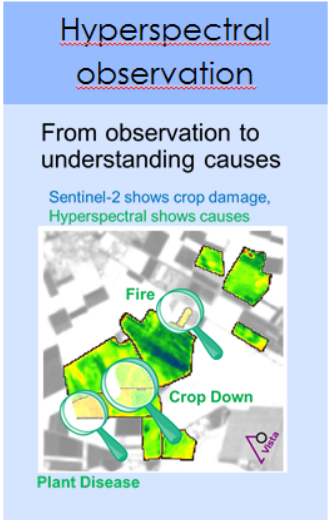
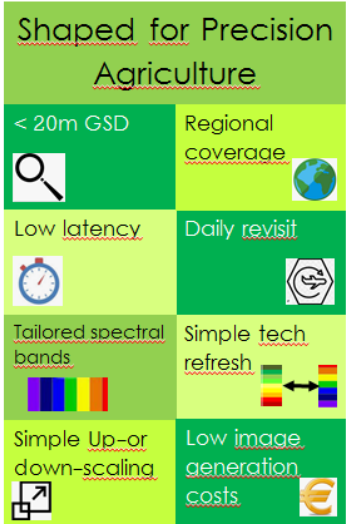
Fraunhofer IST Fraunhofer IOF Vista AIRBUS

Rainbow
An innovative approach for a low-cost smart farming mission

Content





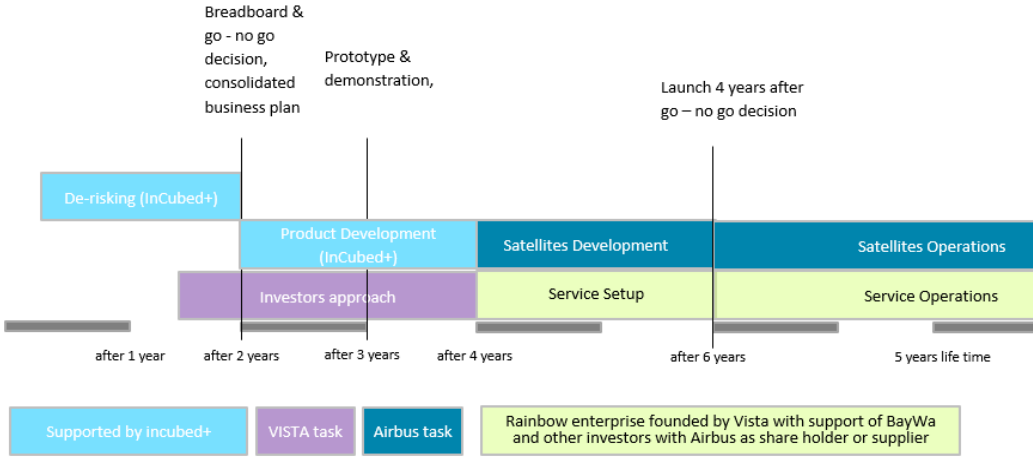
1. Introduction - ESA Incubed+ de risking activity

https://incubed.esa.int/portfolio/rainbow/

- InCubed stands for ‘Investing in Industrial Innovation’ and is a Public Private Partnership co-funding programme run by ESA
- InCubed focuses on developing innovative and commercially viable products and services that generate or exploit the value of Earth observation imagery and datasets.

Incubed+ de-risking phase ongoing for Rainbow

- Demonstrate filter on chip technology for the specific smart farming application
- Define Business Case for smart farming based on a mission scenario with several small satellites equipped with Hyperspectral Instruments based on filter on chip technology



1 Introduction

- Instrument **optimized for agriculture**: Spatial & spectral quality
- **Reduced data volume**: limited number of spectral bands; automated cloud detection
- Satellites **taking advantage from New Space Products**
- Extensive know-how on hyperspectral data pre-processing and analysis for **high-level products**
- **Existing sales channels** to farmers via Vista / BayWa AG
- Fraunhofer contributing to the deriscing for telescope development and filter technology

Institutional Missions

CHIME / EnMap / PRISMA / TRUTH

- Too low spatial resolution for precision farming
- Multipurpose mission not optimized for agriculture
- Large spacecraft and complex instrument

Commercial Missions

HYPERSCOUT

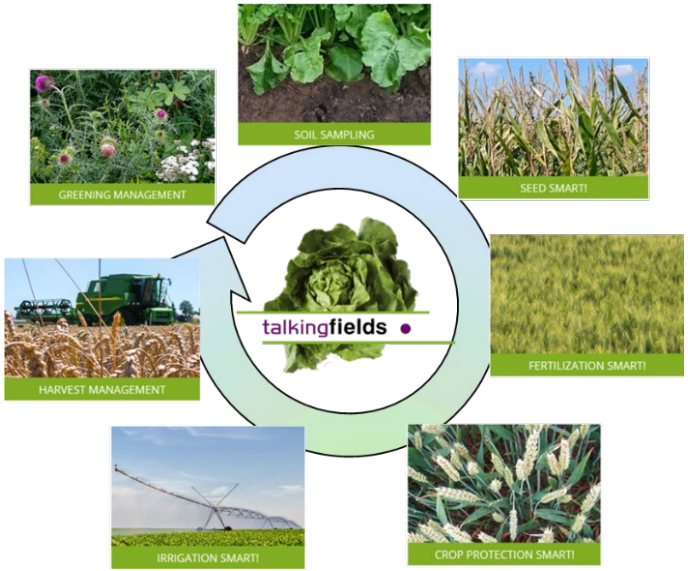
- Typical Small sats (e.g. HyperScout)
- Limitations on spatial resolution (> 30 m)
- Limitations on spectral band (no SWIR)
- Coverage not suitable for farming

2 Market Analysis and Business Plan
Rainbow Products

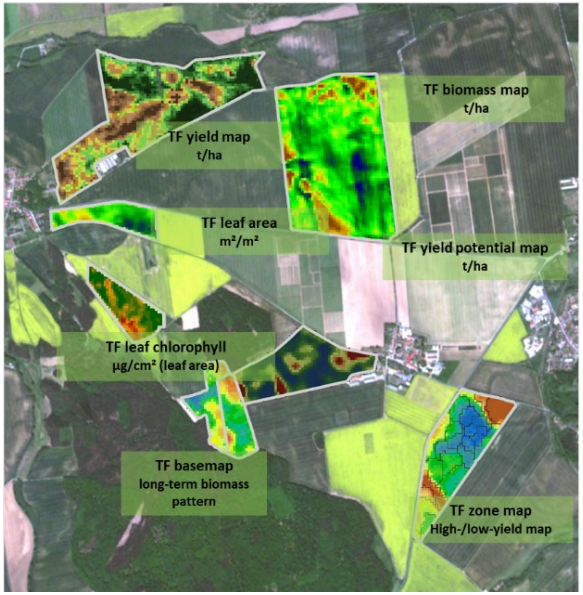
Product/Service Name	Description of the product/service	Seller (owner of the product/service)	Sold to (Customers Segments)
Service: farming data products	Value added products for smart and carbon farming like **fertilizer and irrigation recommendation; soil carbon content map; yield quality map** Smart Farming Industry Globally $ 11.23 bn by 2025* * www.marketsandmarkets.com/Market-Reports/smart-farming-market-522.html	Rainbow enterprise	Farmers, farm advisors, agriculture industry, carbon certification bodies, governmental agencies, NGOs
Service: Hyperspectral Data Cube	Calibrated hyperspectral data	Rainbow enterprise	EO Value adders outside of ag industry

2 Market Analysis and Business Plan
Rainbow Products

Use cases along the agricultural value chain

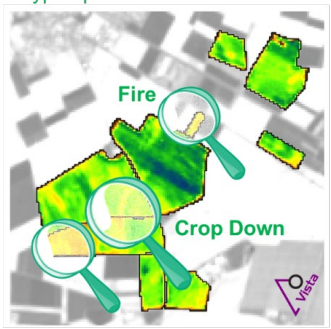


TalkingFields Services for agricultural applications



From observation to understanding causes & from qualitative to quantitative assessment

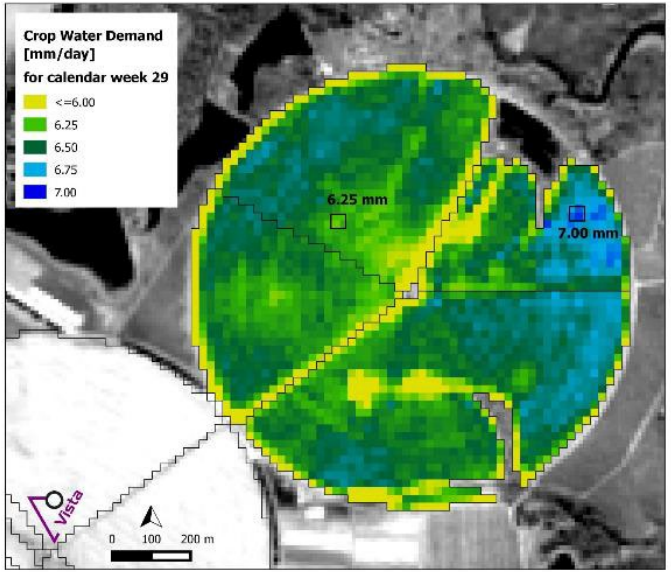
Sentinel-2 shows crop damage,
Hyperspectral shows causes



Plant Disease

3. Key Requirements and Mission Concept
Example of user needs

ID	User/customer Need	Source
UN-0100	Need for information services for smart farming measures allowing a more sustainable application of seeds, fertilizer, plant protection and water.	Farmers, farm advisors, ag industry (Smart Farming Services)



Standard irrigation
constant: 8.00 mm/d

Example: Variable Rate Irrigation (VRI)

Sample values of VRI recommendation:
Dense crop: 7.00 mm/d
Medium crop: 6.25 mm/d

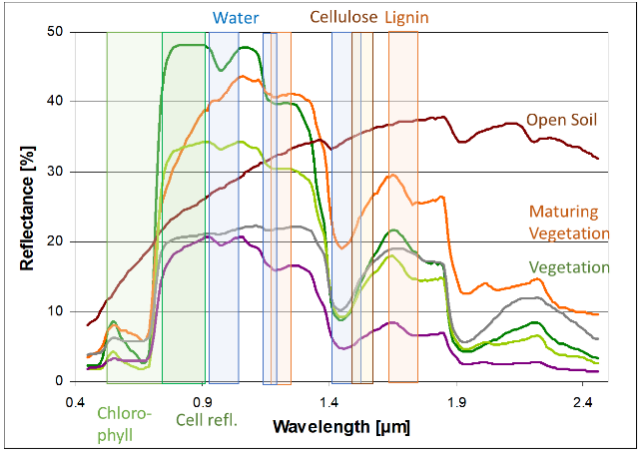
RAINBOW data to increase information depth

⇒ Significant reduction!
⇒ Water savings of 1000 to 1750 m³ possible only for one pivot and one day of irrigation

3. Key Requirements and Mission Concept
Example of user requirements

Req. ID	User/customer Requirement Name	Description	Justification and/or comment	User/customer Need Ref.
UR-SAT - 0200	Spectral: Spectral bands, spectral resolution	Spectral bands shall cover the range from visible to short-wave infrared, approx.. 450 – 1700nm. The spectral resolution shall be high enough to be able to detect the absorption features, i.e. between approx. 20nm and 60nm depending on wavelength range.	Fig. 4 shows the most prominent absorption features that need to be captured with RAINBOW. These are mainly the water absorption features for UR-AG-0100, the red edge for UR-AG-0200 and UR-AG-0300, the cellulose and lignin features for UR-AG-0300 and the VNIR for UR-AG-0400.	UN-0100, UN-0200, UN-0300

Absorption features to be covered:
Chlorophyll 400-700nm;
Water: 940, 1120, 1450nm;
Lignin: 1200, 1690nm;
Cellulose: 1480nm

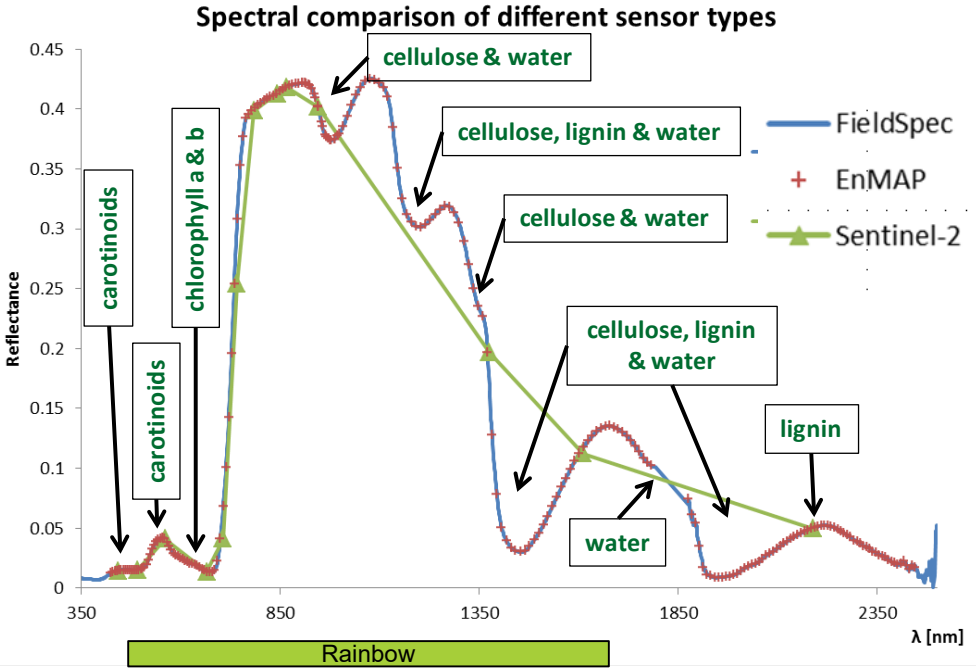


RAINBOW requirement: Spectral coverage 450-1700nm, spectral resolution 20nm-60nm

3. Key Requirements and Mission Concept
Available detector technology limits number of channels

- Xenix - Cheetah package
  - Detector Typ: Thinned InGaAs 640x512 pixel
  - Sensitivity 400nm up to 1700nm
  - Operational Temp -20°C (TBC)

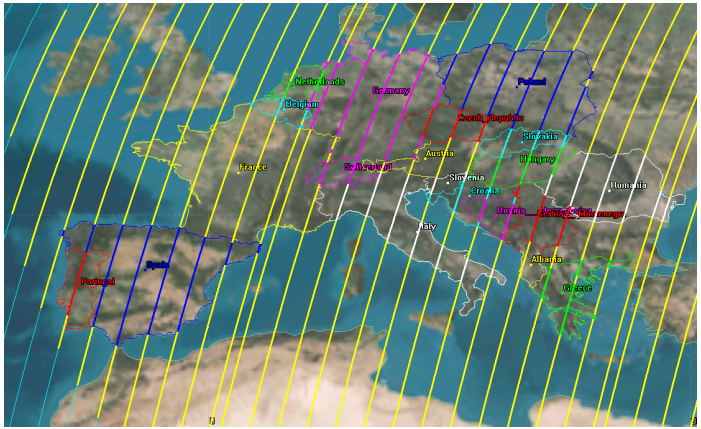
- Limited number of pixel and required binning limits number of channels < 50
  - Sentinel-2 channels are used for cross calibration
  - Position of remaining channels optimized for smart farming application



3. Key Requirements and Mission Concept
System Level Considerations

Mission/System Requirements

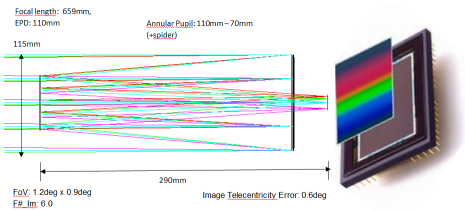
- ❑ Coverage of Europe within 15 days with <20 m spatial resolution
- ❑ Global coverage
- ❑ Preliminary candidate orbit @ 538 km
  - 28 day repeat, close to 14 days
  - 120 km distance between adjacent ground tracks @ Europe



Country	Number of access	total duration s	average / path s
Albania	2	75,100	38
Austria	9	181,367	20
Belgium	6	74,435	12
Bosnia-Herzigovina	4	104,440	26
Croatia	9	140,834	16
Czech Republic	6	176,950	29
France	20	1255,768	63
Germany	19	888,813	47
Greece	9	217,469	24
Hungary	7	196,378	28
Italy	14	509,097	36
Netherlands	5	91,146	18
Poland	16	735,105	46
Portugal	3	147,516	49
Romania	10	523,485	52
Serbia-Montenegro	6	188,452	31
Slovakia	6	114,777	19
Slovenia	3	43,094	14
Spain	15	963,393	64
Switzerland	5	116,798	23

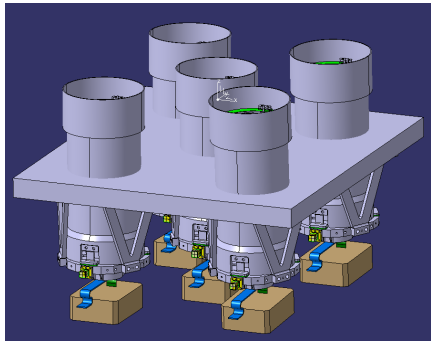
System Design with focus on minimum lifecycle cost

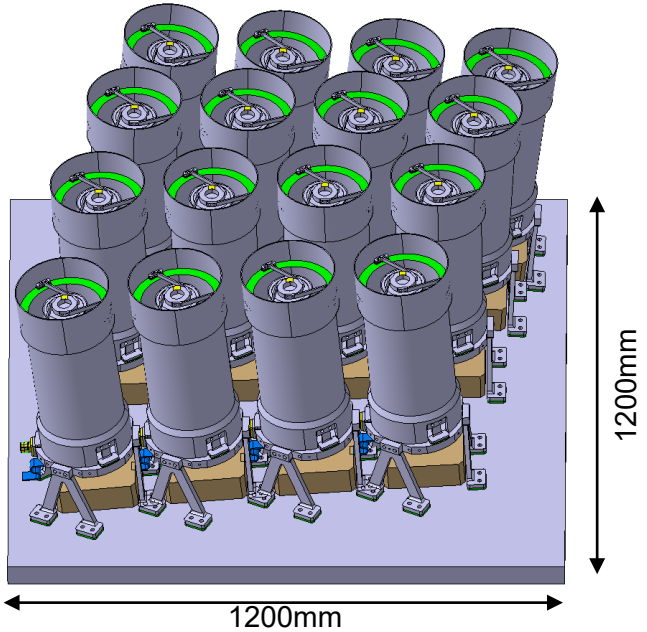
- ❑ Trade-off: number/size of satellites
  - Small Sats cons:
    Live time, operations cost, total investment cost
  - Small Sat pros:
    distributed investment cost, revisit in case of agility; marketing;



4 Candidate Implementation Scenarios
Instrument accommodation

- For full swath coverage in the order of 16 instruments are required (driven by current detector technology)
- Min. 1.2x1.2m2 Instrument Panel required
- Additional thermal control measures necessary
- Total mass <200kg

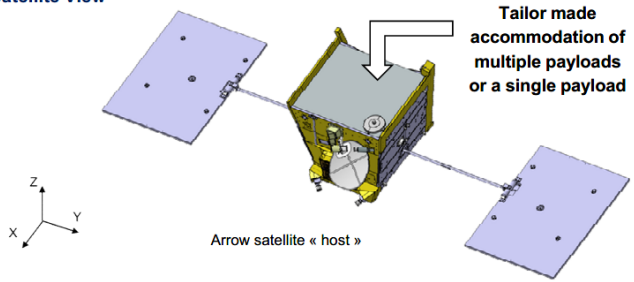




4 Candidate Implementation Scenarios
Taking advantage of NewSpace – e.g. Platform based on OneWeb

ArrOW Mk 1 (GEN1-like) Mission as a Service

Satellite View



Concept Description

- **Turnkey satellite system solution including delivery in space and payload connectivity**
- **Airbus accommodates any kind of payloads as a service**
- **Payload is provided by the customer as Customer Furnished Item**
- **Accommodation is tailor made and included in the service price**

Payload Capacity (Overall)	Power	• 170 Watts Orbit Average Power (orbit dependent) • 700 Watts peak power for 5 minutes
	Mass	• Up to 80 kg
	Volume (typical)	• Earth deck : 850 (Y) x 750 (X, Min) x 200 (Z) mm^3 • +/- Y Side walls (internal footprint): 0,8 m^2
Spacecraft mass	Max 200 kg	
Orbit Range	Altitude: 500 – 1200 km (110 to 60 deg minimum inclined orbits)	
Mission Data	Uplink 28 kbps; Downlink: 50 kbps (low rate) / 420 kbps (high rate)	
Slew rate	0.5 deg/s (roll/yaw); 1.5 deg/s (pitch)	
Pointing Control	< 0.10 deg (1σ) / 0.07 deg (1 σ) after in-flight calibration	
GPS accuracy	Position 10 m; Velocity 0.02 m/s; time 50 ns (1σ)	
Batteries	Li-ion	
Bus Voltage	22 – 38 V non-regulated	
Encryption	AES 256	
Propulsion	Electric (Xenon HET)	
Max Delta-V	> 800 m/s	
Launch vehicles	Arianespace Soyuz, Falcon 9 rideshare, others (TBC)	

5 Summary

Smart farming business case

- ❑ Promissing business case
- ❑ >15 M€/year revenue with smart farming in Europe estimated by Vista

Hyperspectral Instrument based on filter on chip technology

- ❑ Instrument baseline enables compact instrument optimized for the technical sweet spot of the use case
- ❑ Enabled by filter-on-chip technology

Incubed+ de-risking phase ongoing

- ❑ Demonstrate filter on chip technology for the specific smart farming application
- ❑ Define Business Case assuming a mission based on several small sat‘s
  (e.g. 2-3 OneWeb satellites with in total >15 instruments)

Thank‘s for your attention

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Rainbow

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