



living planet symposium | BONN

23-27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



ESANAV: A HAPS and satellite Earth Observation technology roadmap for low-latency maritime applications

C4.02.1 HAPS – High-Altitude Pseudo Satellites
26.05.22 - 09:15 CEST

Dr. Michael Wilby
Deimos Space UK Ltd.
Patrick Talon, Stefania Cornara
Juan Ignacio Bravo, David Petit, Paulo Rosa





ESA Open Space Innovation Platform Space for the Oceans

ESANAV

Enhanced Surrounding Awareness and
Navigation for Autonomous Vessels

Goals:

- ❑ Feasibility study of **emerging EO technologies** for vessel navigation applications
- ❑ Robust, low-latency **maritime hazard perception & tracking**
- ❑ **Over-the-horizon collision risk identification**
- ❑ Develop & evaluate **near-future system concepts**

→ HOW WOULD YOU USE SPACE TECHNOLOGY TO ENABLE AUTONOMOUS SHIPPING?



Autonomous Surface Vessels (ASVs)



Applications:

Now

- Bathymetric surveying
- Surveillance & support vessels
- Mine clearance



Maersk/Kongsberg - Yara Birkeland

2025

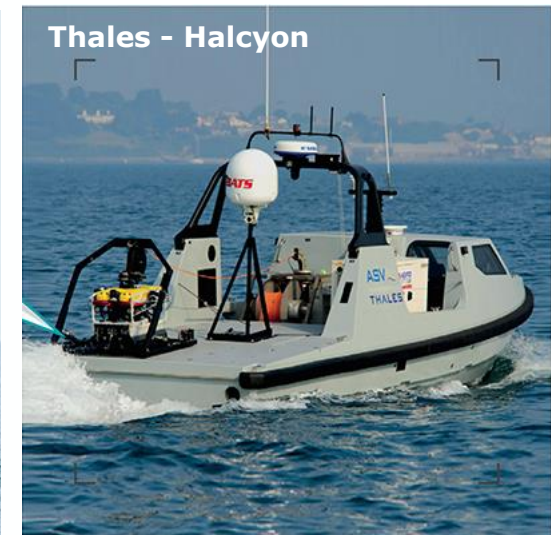
- Short-sea shipping
- Offshore infrastructure logistics



SEA-KIT - Maxlimer

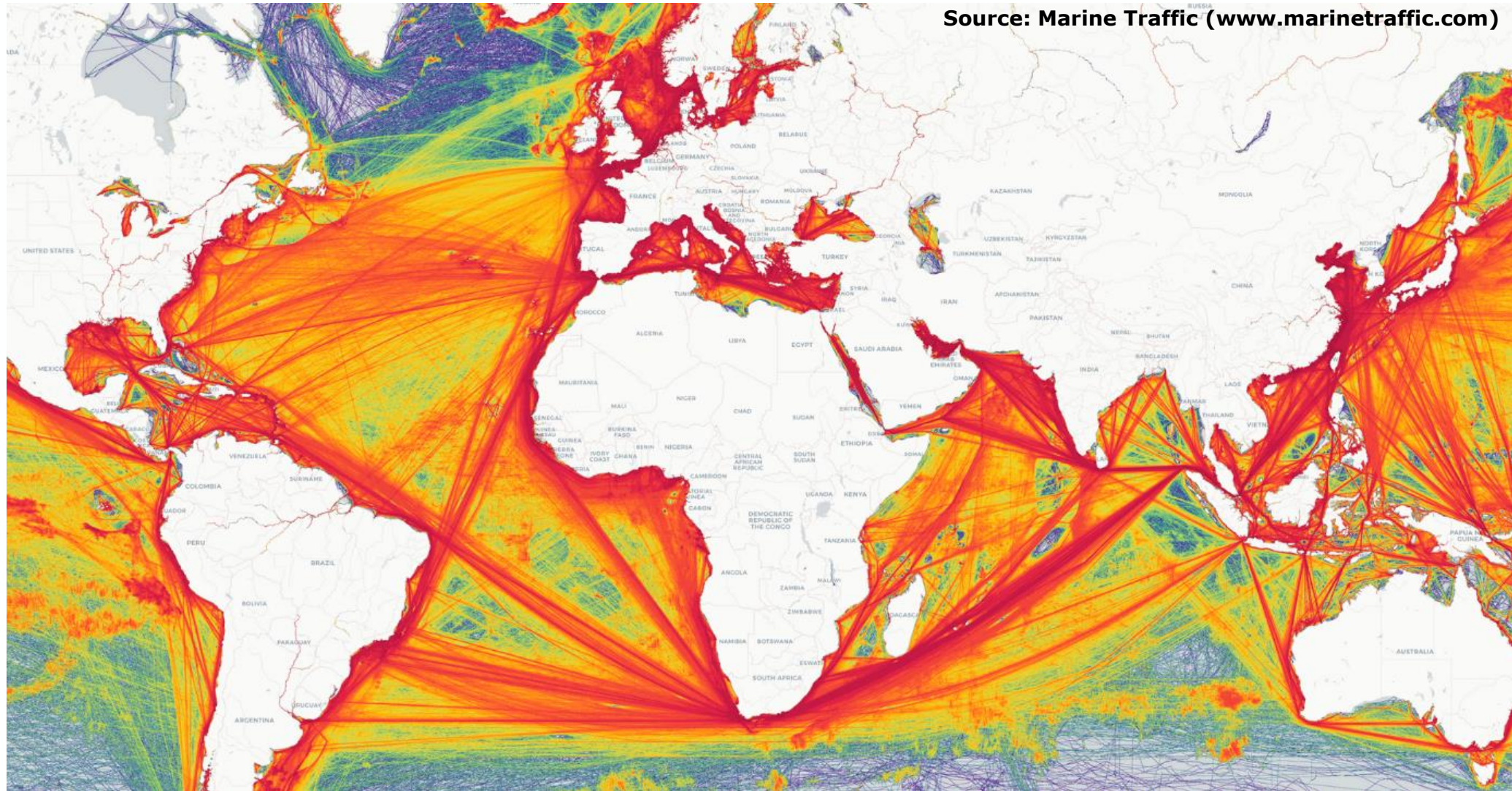
2030+

- Trans-oceanic shipping
- Smart port tugs

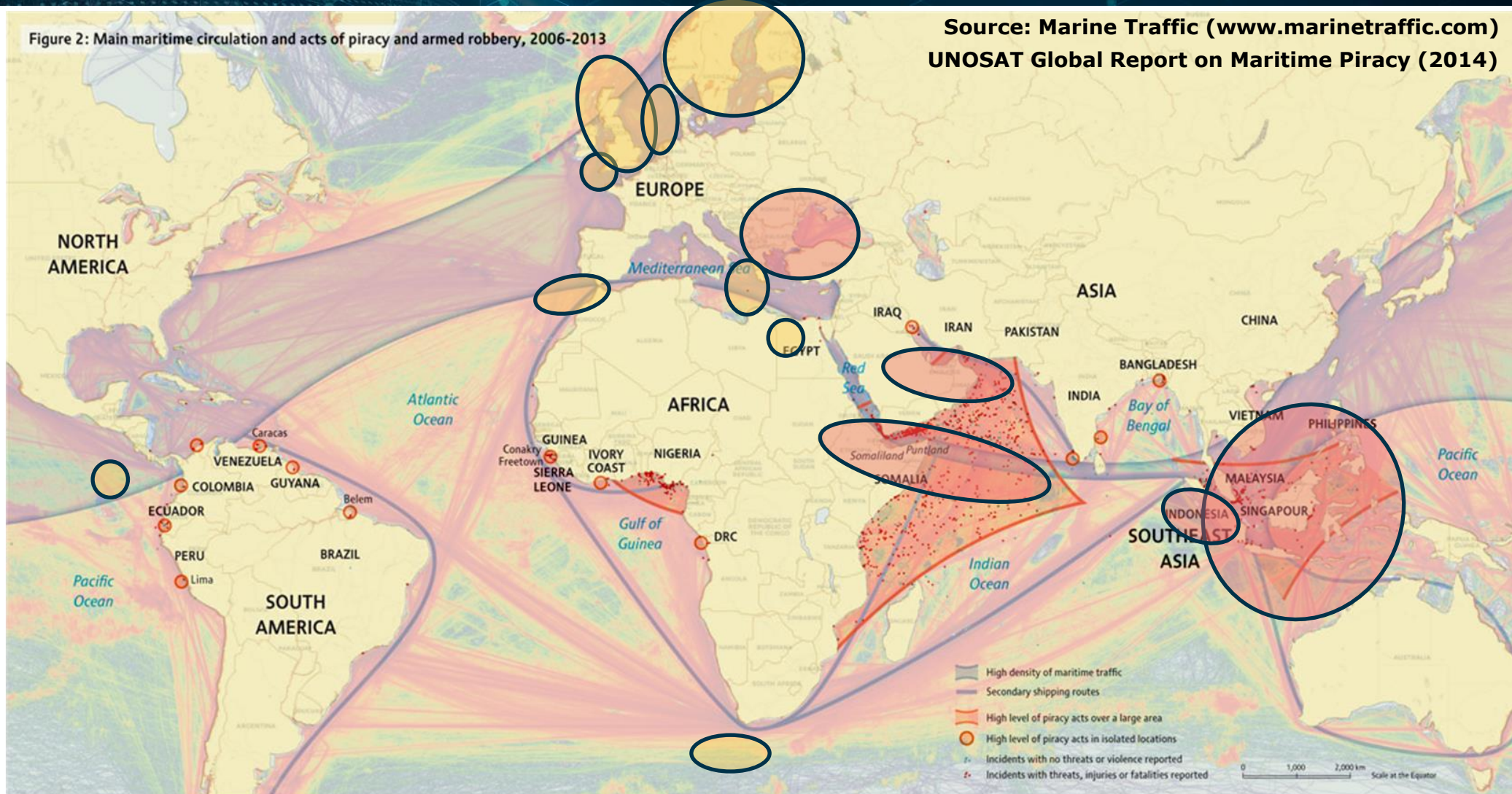


Thales - Halcyon

Global Shipping Density (2020)



Global Risk Hotspots



Service Requirements

- 24/7, all-weather availability
- Collision hazard unique ID & tracking
- Precise positioning & forecasting

AIS information incomplete

- Small vessel & non-vessel collision hazards
- Uncooperative vessels
- Malicious GNSS spoofing & interference

Vessel-mounted sensors

- Range-limited, easily occluded
- Data streaming bandwidth limitations
- Fleet duplication costs

SA timeliness

Sub-minute ←————→ Hourly

	High-Risk	Medium-Risk	Low-Risk
Small-area (<100km ²)	<ul style="list-style-type: none"> • Ports • Chokepoints 		
Medium-area (100 – 1000 km ²)	<ul style="list-style-type: none"> • Coastal Waters • Piracy Hotspots • Conflict Zones 	<ul style="list-style-type: none"> • Inland Waters • Shipping Lanes • Offshore Installations 	
Wide-area (>1000km ²)	<ul style="list-style-type: none"> • Piracy Hotspots • Conflict Zones 	<ul style="list-style-type: none"> • Arctic Waters 	<ul style="list-style-type: none"> • Deep sea

Maritime Hazard Visibility



Vessel visible/IR detectability

Visible

MWIR

LWIR



	Length (m)	Visible/NIR				TIR				SAR				AIS	
		<1m	1-5m	5-10m	>10m	<1m	1-5m	5-10m	>10m	<1m	1-5m	5-10m	>10m		
Vessel Hazards	Large	>100	*	*	*		*	*	*	*	*	*	*		
	Medium	30-100	*	*	*		*	*	*	*	*	*	*		
	Small	5-30	*	*			*	*		*	*				
	Personal	<5	*				*								
Manmade Hazard	Infrastructure	>10	*	*			*	*			*	*			
	Shipping Containers	5-10	*	*			*	*		*	*				
	Marker Buoys	1-5	*				*								
	Fishing net debris		*				*								
Ice Hazards	Large-area ice	>200	*	*	*	*	*	*	*	*	*	*	*		
	Small Icebergs	15-200	*	*	*	*	*	*	*	*	*	*	*		
	"Bergy bits"	5-15	*	*			*	*		*	*				
	"Growlers"	<5	*				*			*	*				
Misc.	Marine Mammals	>5	*	*			*								
	Sandbars		*	*	*	*									
Imaging Conditions	Night														
	Cloud/Fog														
	Atmosph. extinction														
	Sun Glint														
	Rough Seas		*	*											
	Imaging Artefacts														

Peckham, J. 2019, Thesis, Autonomous real-time infrared detection of sub-surface vessels for unmanned aircraft systems

Key:

- High-confidence detection
- Medium-confidence detection
- Marginal/inconsistent detection
- Undetectable
- No information available
- * identifying features resolvable

VHR EO Constellation Requirements



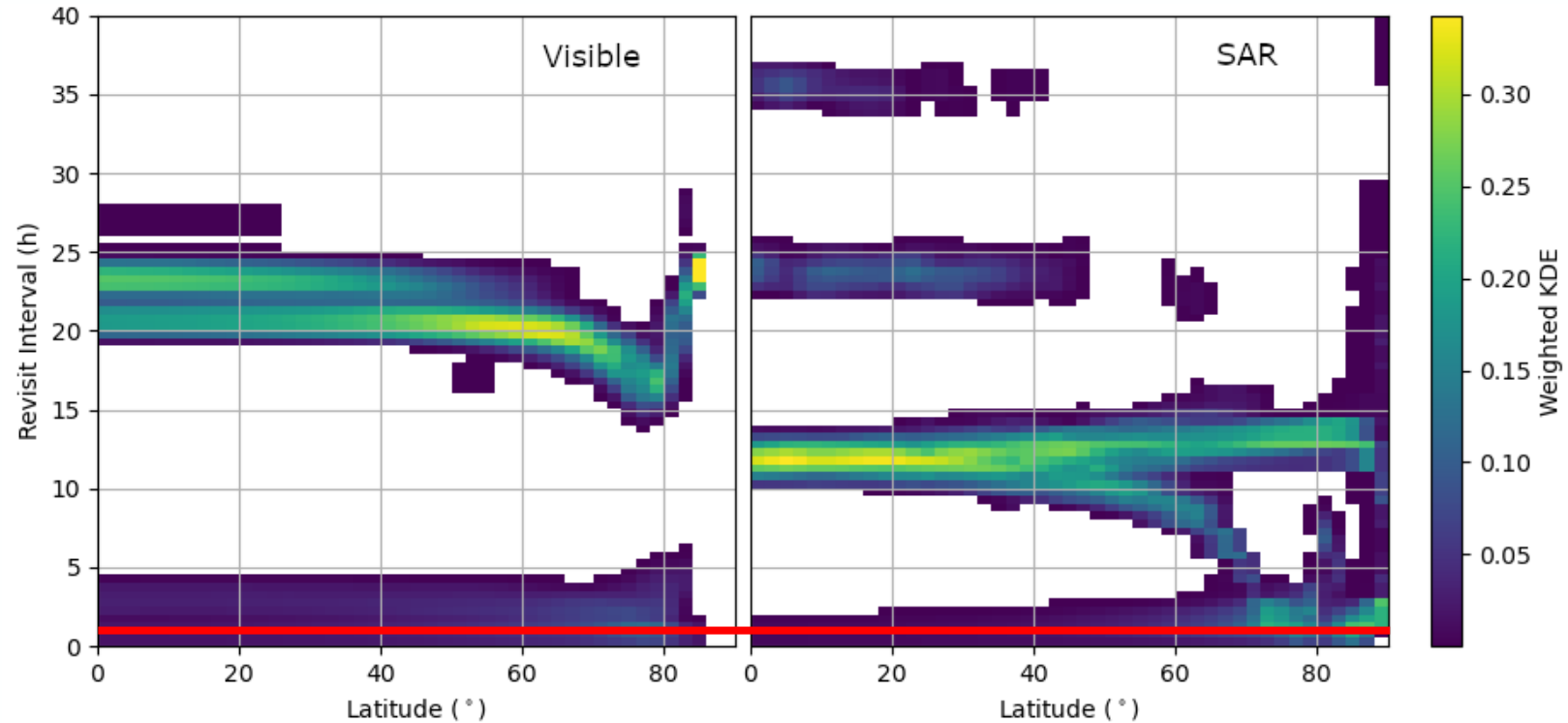
Optical (14)

SAR (3)

Deimos-2
Pleiades 1A/1B
Superview 1-4
Spot 6/7
Worldview 1-3
GeoEye-1
EROS-B

Radarsat-2
TerraSAR-X
PAZ

- Visible & SAR - maturing**
Planet, Satellogic, ICEYE, Capella Space...
- Thermal Infrared - concept stage**
Satellite Vu, Hydrosat



“Images per day” metric irrelevant - **Uniformity** of revisit is critical

HAPS Capabilities

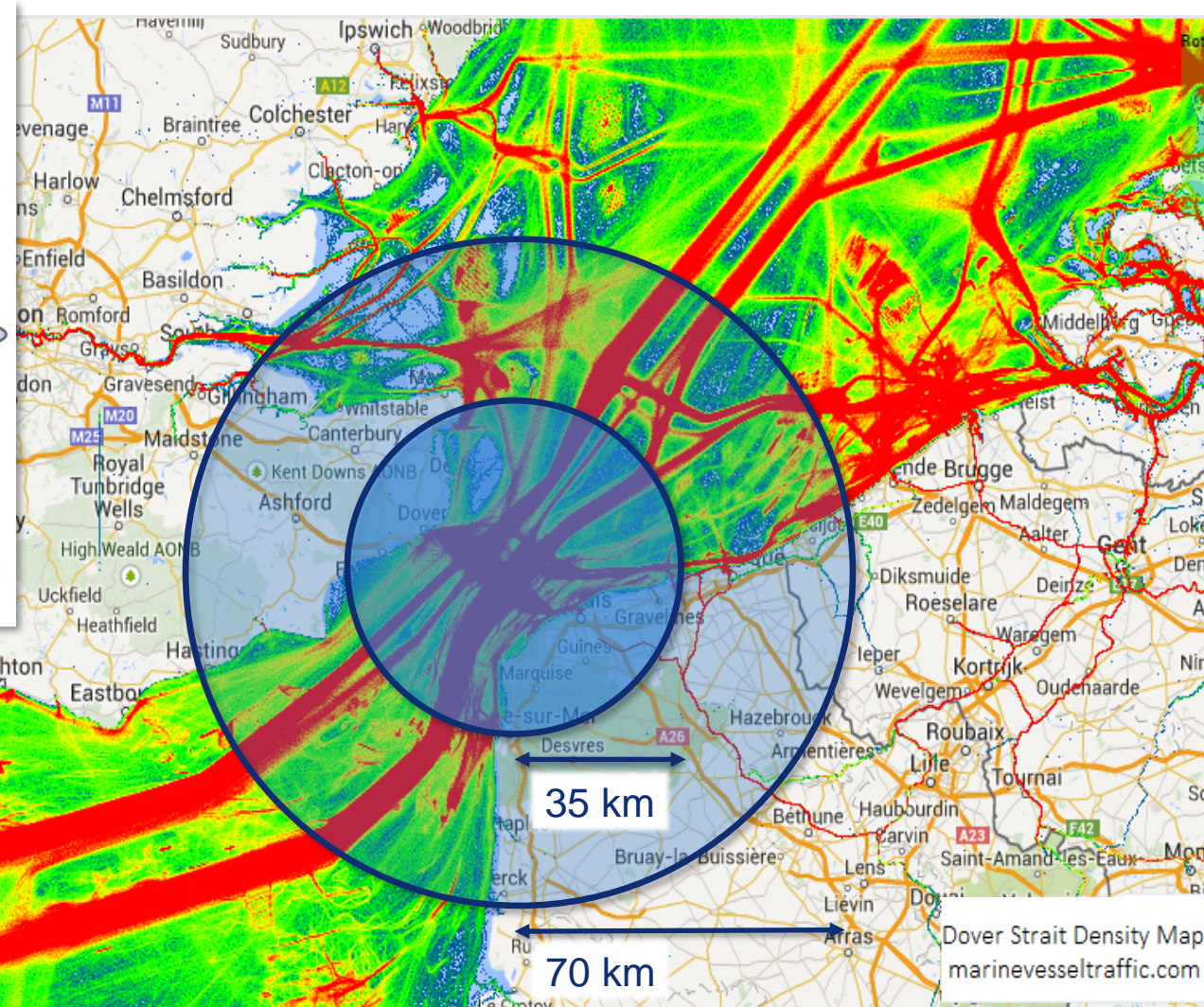
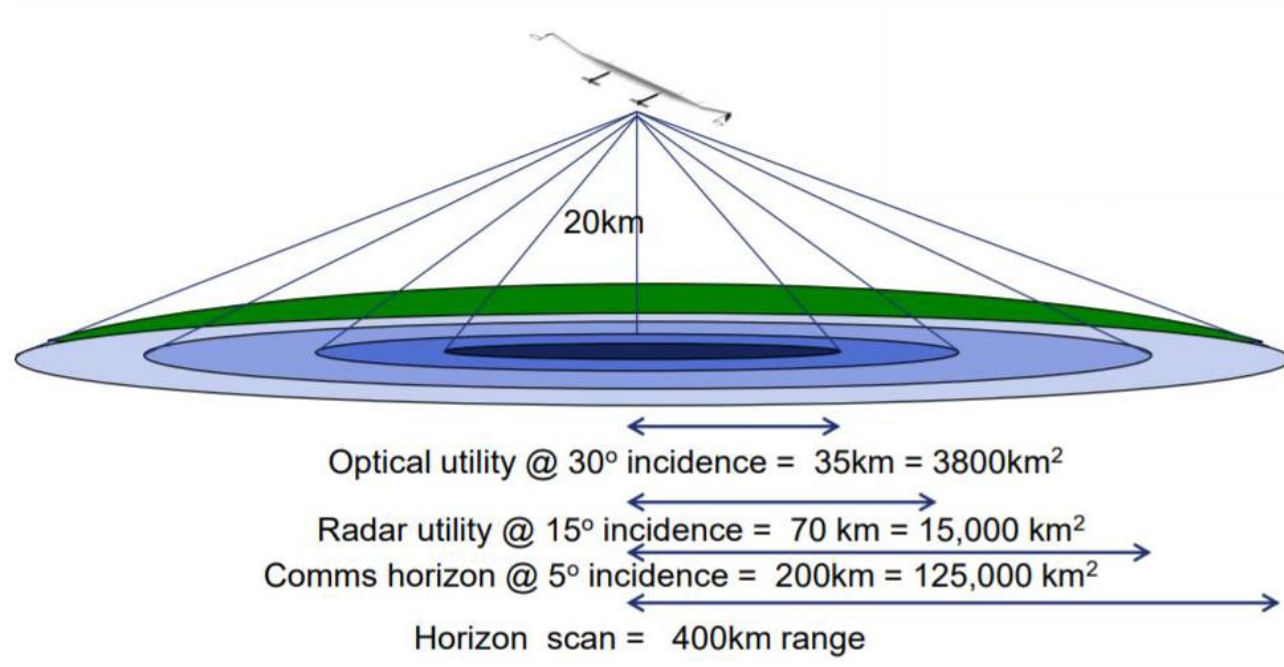


Image Credit: Airbus, HAPS4ESA 2019

- ✓ 20 km altitude, multi-month persistence
- ✓ Sub-metre optical & SAR payloads
- 1st generation HAPS limited to low latitudes (<35°) or summer operation



C-SAR payload: sub-metre imaging with ~1 minute integration

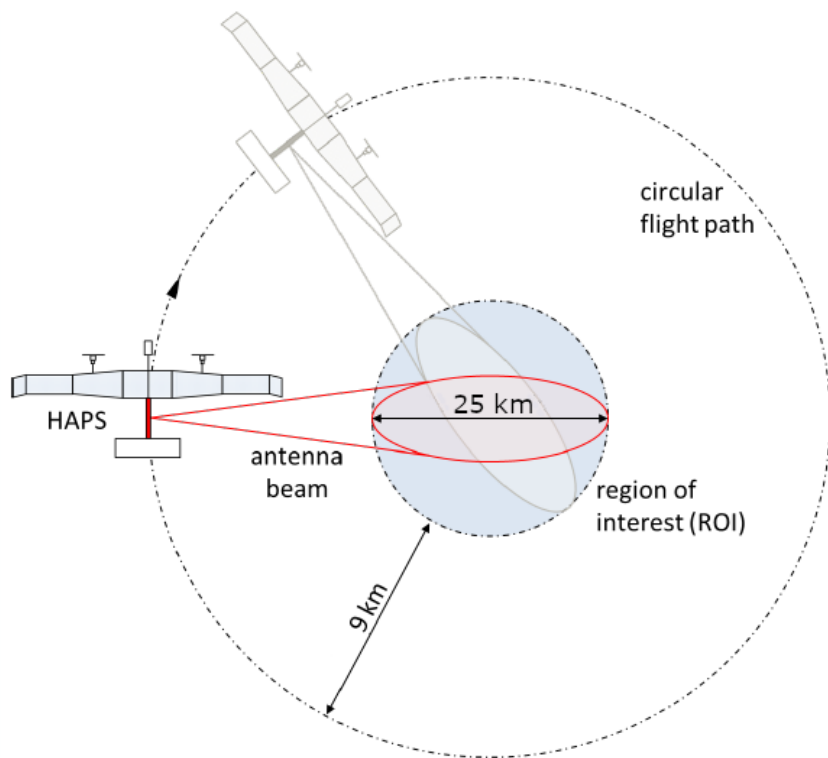
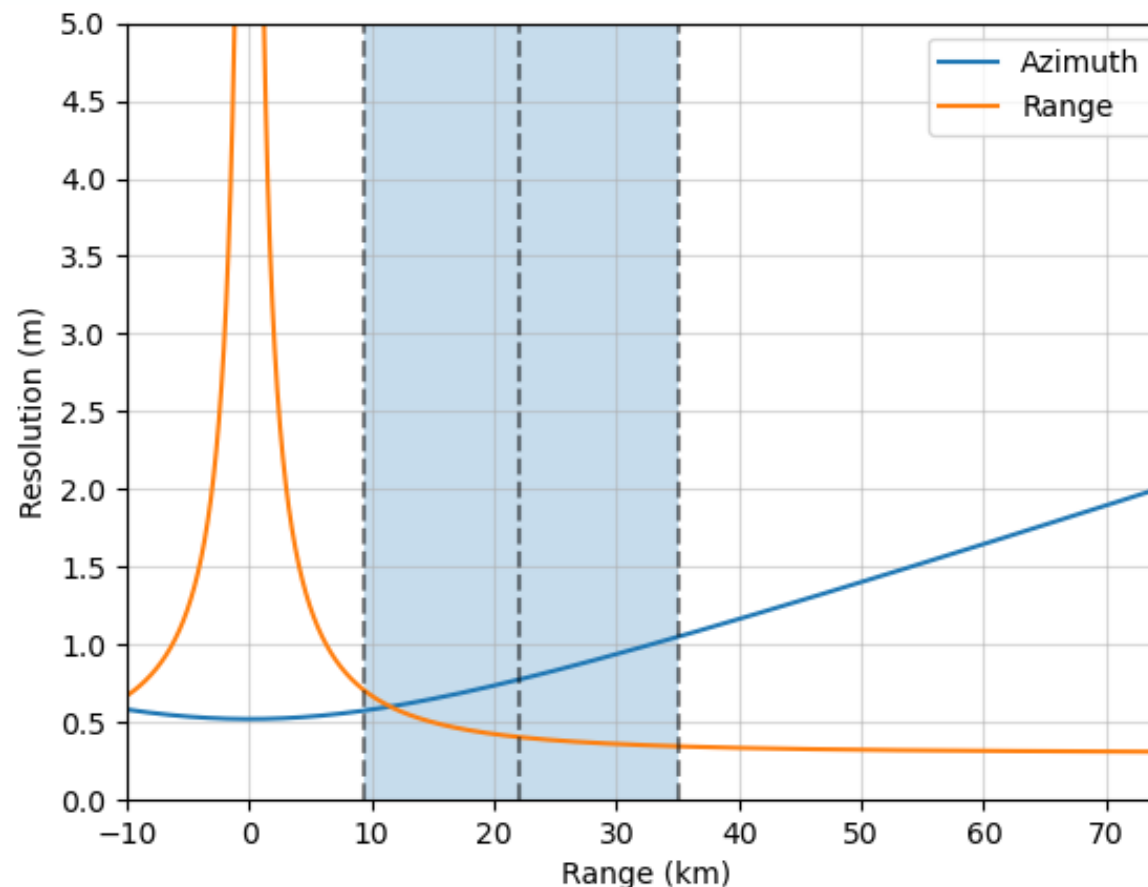
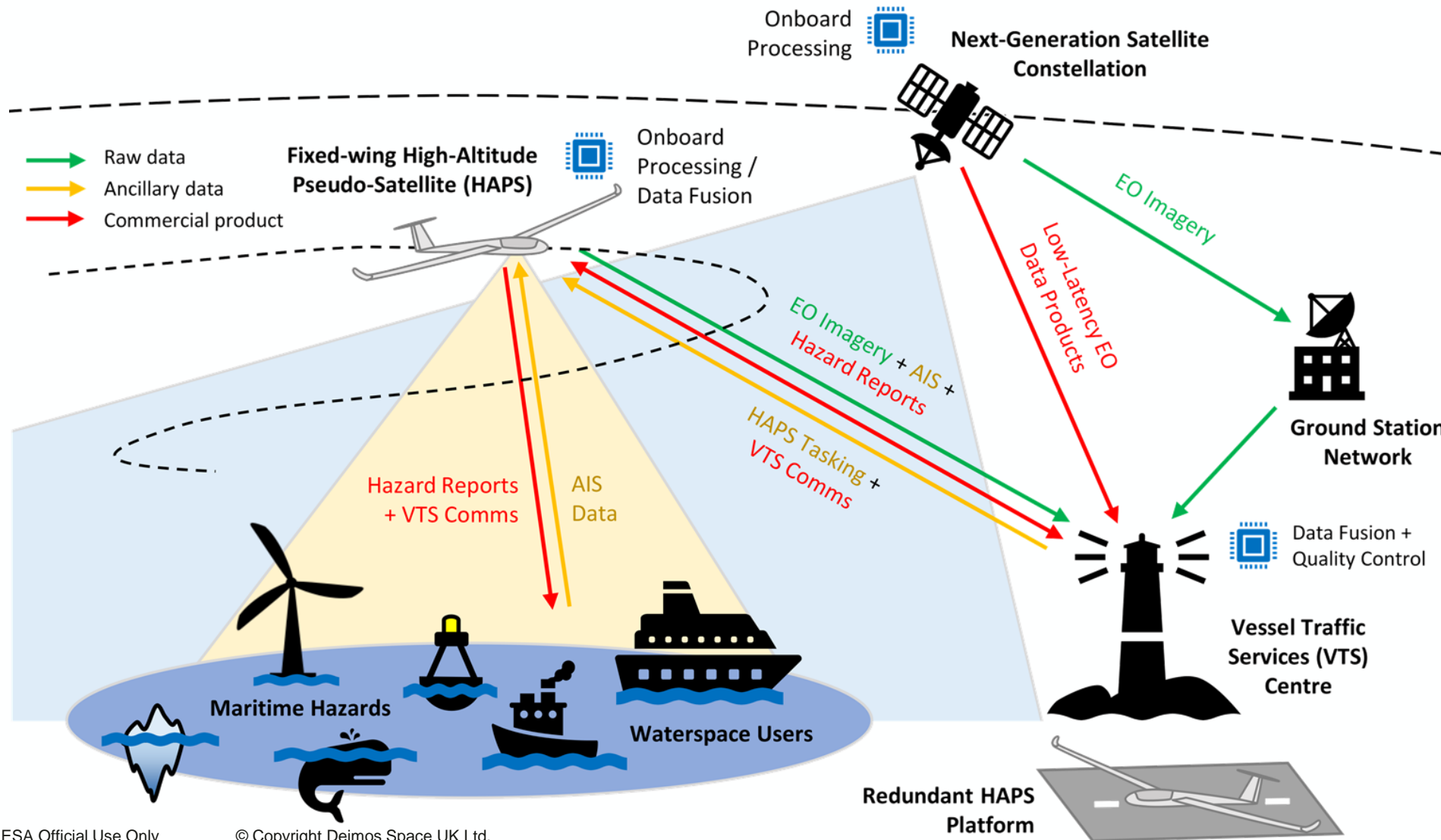


Image Credit: Baumgartner, S. et al. (DLR), HAPS4ESA 2017
<https://elib.dlr.de/113651/>



Hybrid Maritime Monitoring System



Need for Onboard Processing



European Maritime Safety Agency

Downlink & Processing Latency

STANDARD PRODUCT		VALUE-ADDED PRODUCT <small>Credit: EMSA CMSS</small>	
EO Image		<ul style="list-style-type: none"> Vessel Detection Service (VDS) Feature Detection Service (FDS) Oil Spill Detection 	<ul style="list-style-type: none"> Enriched Vessel Service (EVS) Enriched Feature Service (EFS) Wake Detection Service (WDS) Activity Detection Service (ADS)
SAR*	25 min	20 min	30 min
Optical*	30 min	40 min	50 min

Onboard processing offers significant advantages in latency, bandwidth use and delivery mode flexibility

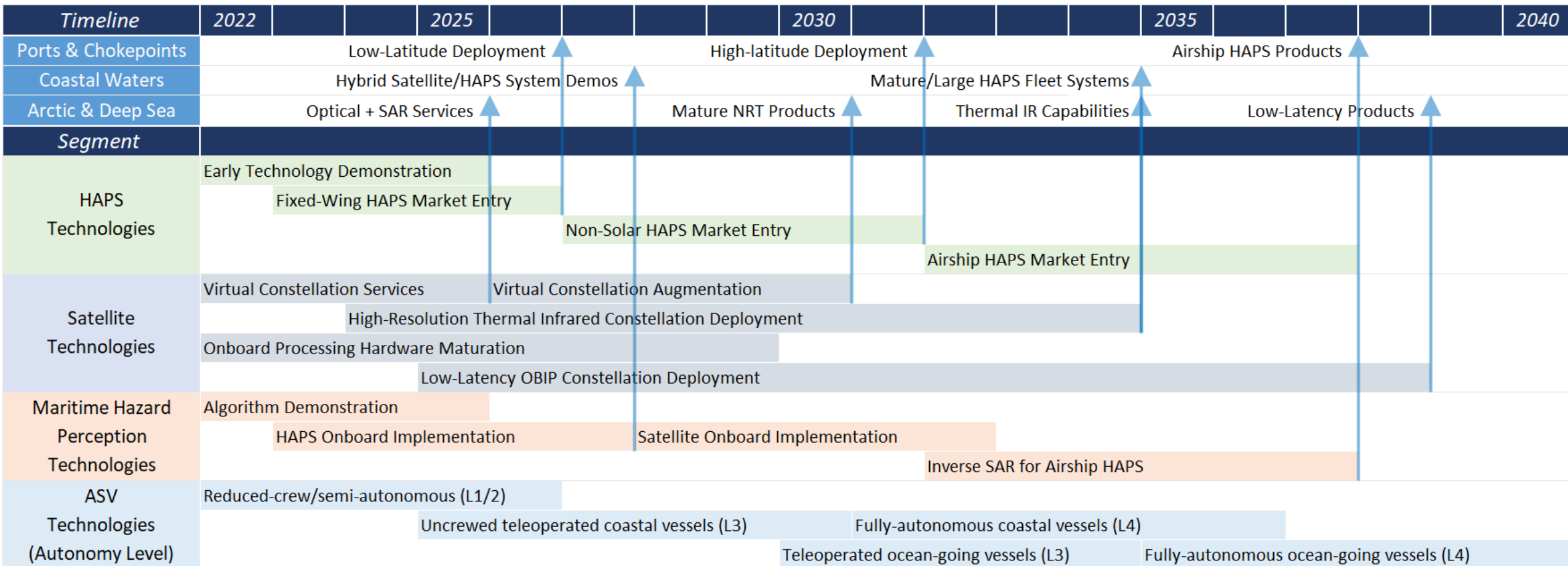
Payload comm bandwidth limitations for raw data streaming

	Deimos-2 (PAN)	TerraSAR-X (stripmap)	HAPS (RGB)	HAPS (SAR)
Coverage	12 km swath	30 km swath	20 km radius	25 km swath
GSD	1 m	4 m	2 m	0.5 m
Image / Pulse Frequency	Continuous (pushbroom)	4000 Hz	0.3 FPS	2400 Hz
Repeat cycle	1.5-hour orbit	1.5-hour orbit	1-minute scan	1-minute integration
Raw data rate (Mbps)	890	480	310	1900
Contact time per cycle	8 min (4x GS)	8 min (4x GS)	Continuous	Continuous
Est. downlink needs (Mbps)	5000	1400	160	480
Payload capability (Mbps)	160	300	~100	~100

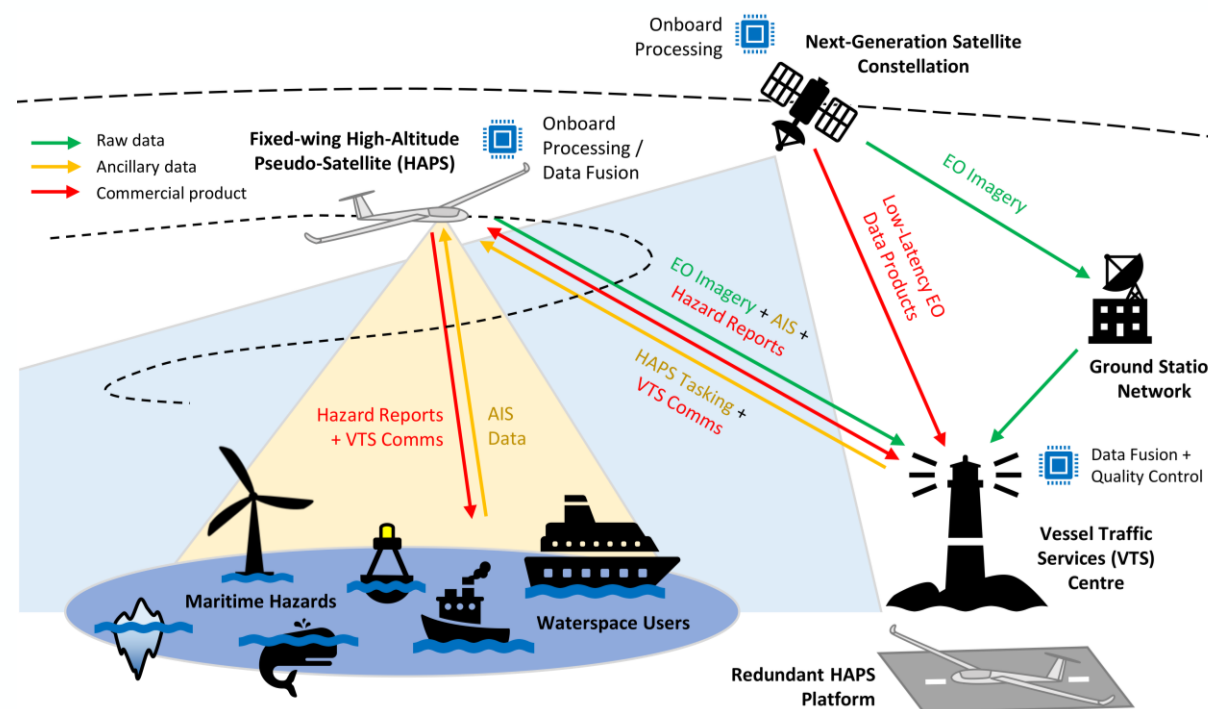
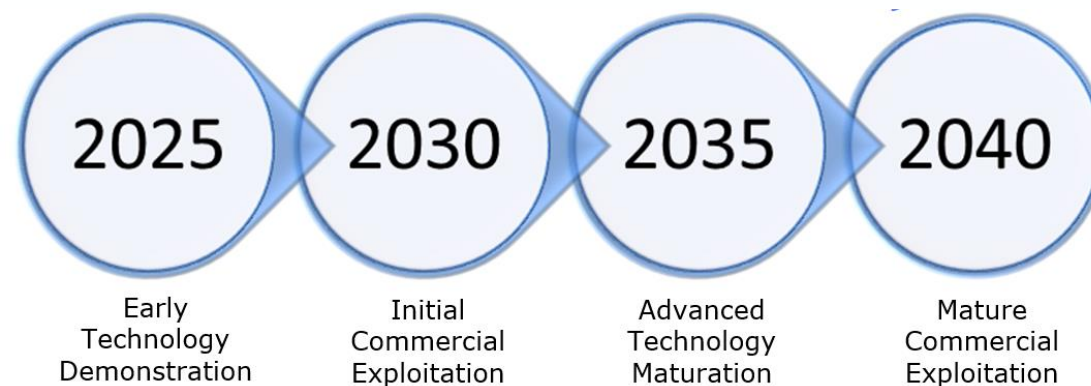
Multidisciplinary Roadmap



Low-hanging fruit – but cross-sector initiatives & system certifiability key for autonomous vessel applications



- Maritime navigational service applications have significant need for **24/7, sub-metre, sub-minute EO imagery** products
- Hybrid solutions **fusing LEO and HAPS VHR data** promising for **dynamic coverage of up to ~500km² regions**
- Application of **third-party data services for safety-critical autonomous decision making** requires extensive system performance & robustness certification
 - **BUT:** roadmap opens many opportunities for **intermediate non-safety-critical NRT applications.**
- Focus needed on **robust detection, tracking and forecasting algorithms for non-AIS-broadcasting hazards**

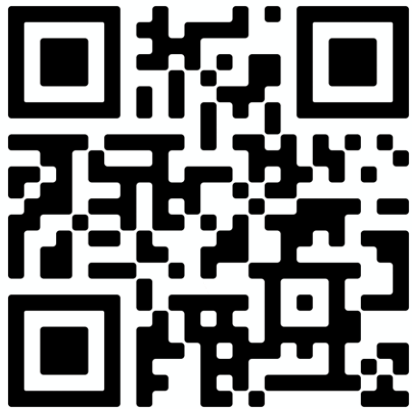


Find out more about Deimos' activities



sat4EO
insight4EO
services4EO

services4eo.com



Onboard intelligence for EO applications:

sat4EO+	E1.05.1, Fri 11:10 (Berlin)
EOALERT	E1.02.1, Fri 14:15 (H1-01)

Visit us at Booth #6





living planet symposium

BONN
23-27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



ESANAV: A HAPS and satellite Earth Observation technology roadmap for low-latency maritime applications

C4.02.1 HAPS – High-Altitude Pseudo Satellites
26.05.22 - 09:15

Dr. Michael Wilby
Deimos Space UK Ltd.
Patrick Talon, Stefania Cornara
Juan Ignacio Bravo, David Petit, Paulo Rosa

