PROGRAMME OF THE EUROPEAN UNION

co-funded with

7th Sentinel-3 Validation Team Meeting

18–20 October 2022 | ESA–ESRIN | Frascati (Rm), Italy

Fiducial Reference Measurement drifting buoy data for Sentinel-3 SLSTR validation: Progress and future steps

Marc Lucas, CLS

& the TRUSTED Consortium

18th October 2022

Rationale: towards FRM

- Higher quality data needed to enable finer scientific investigations
- To improve satellite data quality:
  - Better instruments
  - Higher quality in situ data for calibration and validation purposes
- Copernicus: set up the TRUSTED project overseen by Eumetsat to get higher quality in situ data for the calibration/validation of the sentinel 3 radiometers

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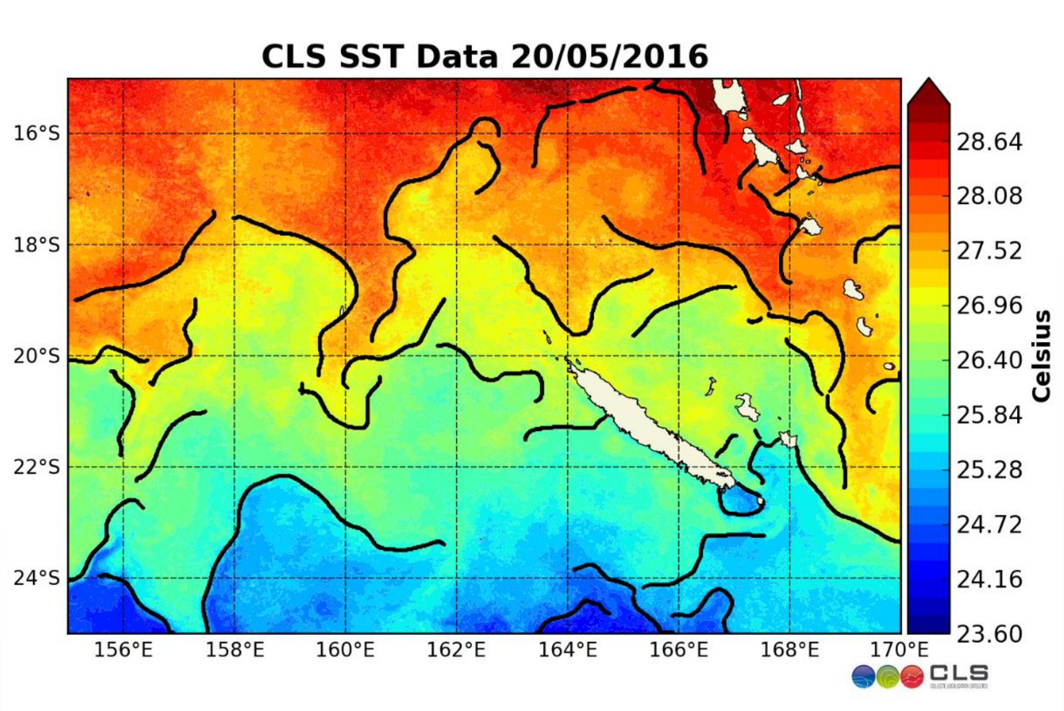
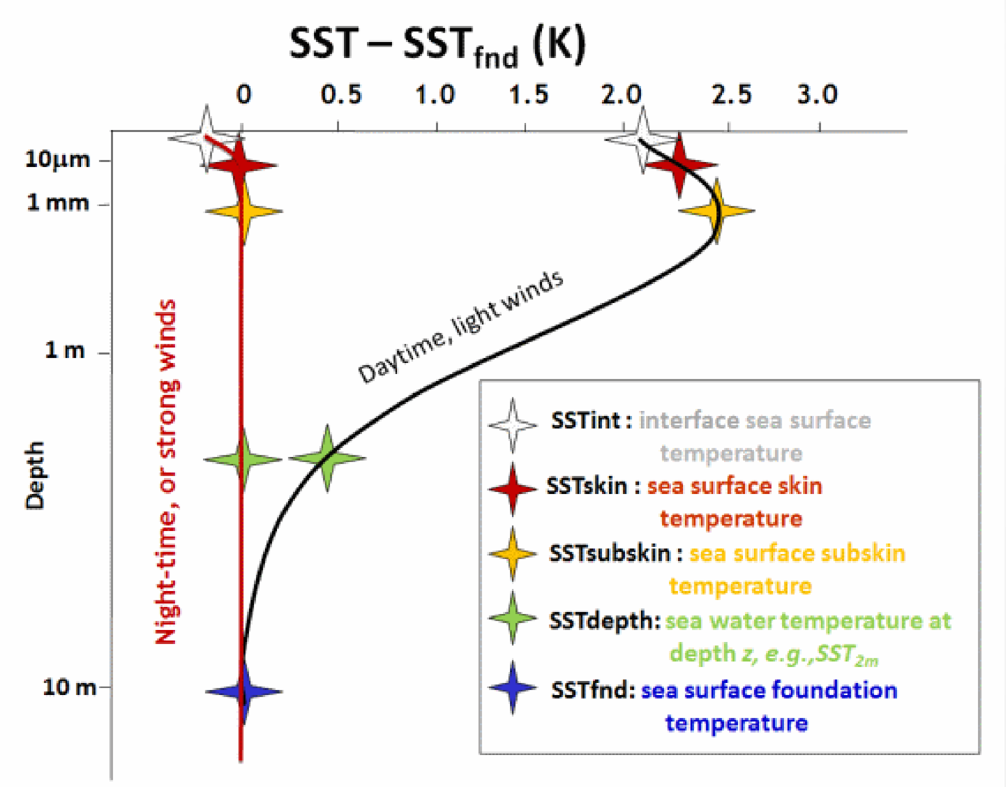
The Sea Surface Temperature: Remote Vs In Situ





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Origin: ESA FRM4STS

1. Investigation of requirements for Satellite Surface Temperature calibration requirements
2. Work package dedicated to ocean surface data (led by D.Meldrum)
3. Recommendation formulated on improvements needed to Surface Velocity Profiling (SVP) buoy array
4. the output report ‘Towards SI traceability for non-recoverable SST FRM instruments’

FRM4STS

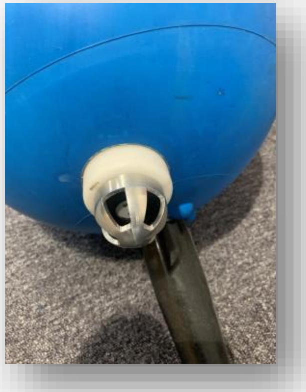
TRUSTED: mission brief

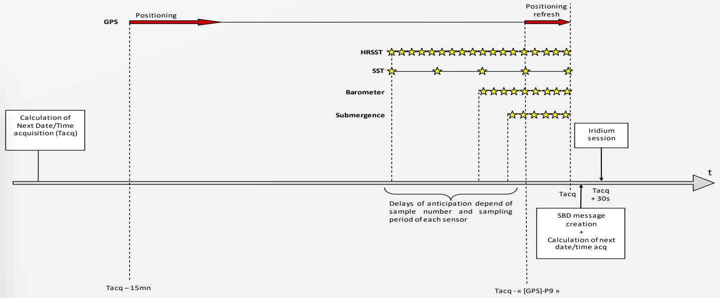
1. Deploy sensors with higher sensitivity and reduced response time
2. Use the highest GNSS positioning accuracy
3. Include 2 sensors for Dual temperature measurement
4. Use of the Bennet/Hoge-2 equation to convert resistance to temperature
5. Include temperature depth measurement though the use of an HP sensor
6. Use Higher sampling frequency (1 second)
7. Improve the metrology procedure for sensor calibration and verification
8. Improve metadata traceability and storage

New Platform: SVP-BRST Design

Design based on the SVP-B:

- DBCP compliant
- 4 sensors: P, SST, HRSST, HP
- GNSS positioning
- Iridium modem





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Metrology: quantification of uncertainties

- A calibration in two steps:
  - MoSens HRSST Sensors Calibration with an uncertainty budget.
  - Verification within the buoys with a final uncertainty budget.

$$U_C = 2\sqrt{u_{tref}^2 + (S_{rep} + u_{bat\,h})^2 + S^2}$$

Uncertainty budget of MoSens calibration	N° 4656 (mK)	N° 4658 (mK)
Reference temperature (u_{tref})	0.9	0.9
Bath stability (u_{Bath})	0.3	0.3
MoSens reproducibility (S)	1.7	0.9
MoSens repeatability (S_{rep})	0.3	0.3
Expended uncertainty (U_C)	4.0	2.8

Le Système international d'unités
The International System of Units
SI

Uncertainty budget of HRSST measurements	N° Y17-07 (mK)	N° Y18-24 (mK)
Reference temperature (u_{tref})	0.9	0.9
Bath stability (u_{Bath})	0.3	0.3
Buoy HRSST reproducibility (S)	2.5	3.4
Buoy HRSST repeatability (S_{rep})	0.5	0.5
Expended uncertainty (U_C)	5.5	7.2

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Metrology: Post Deployment Calibration

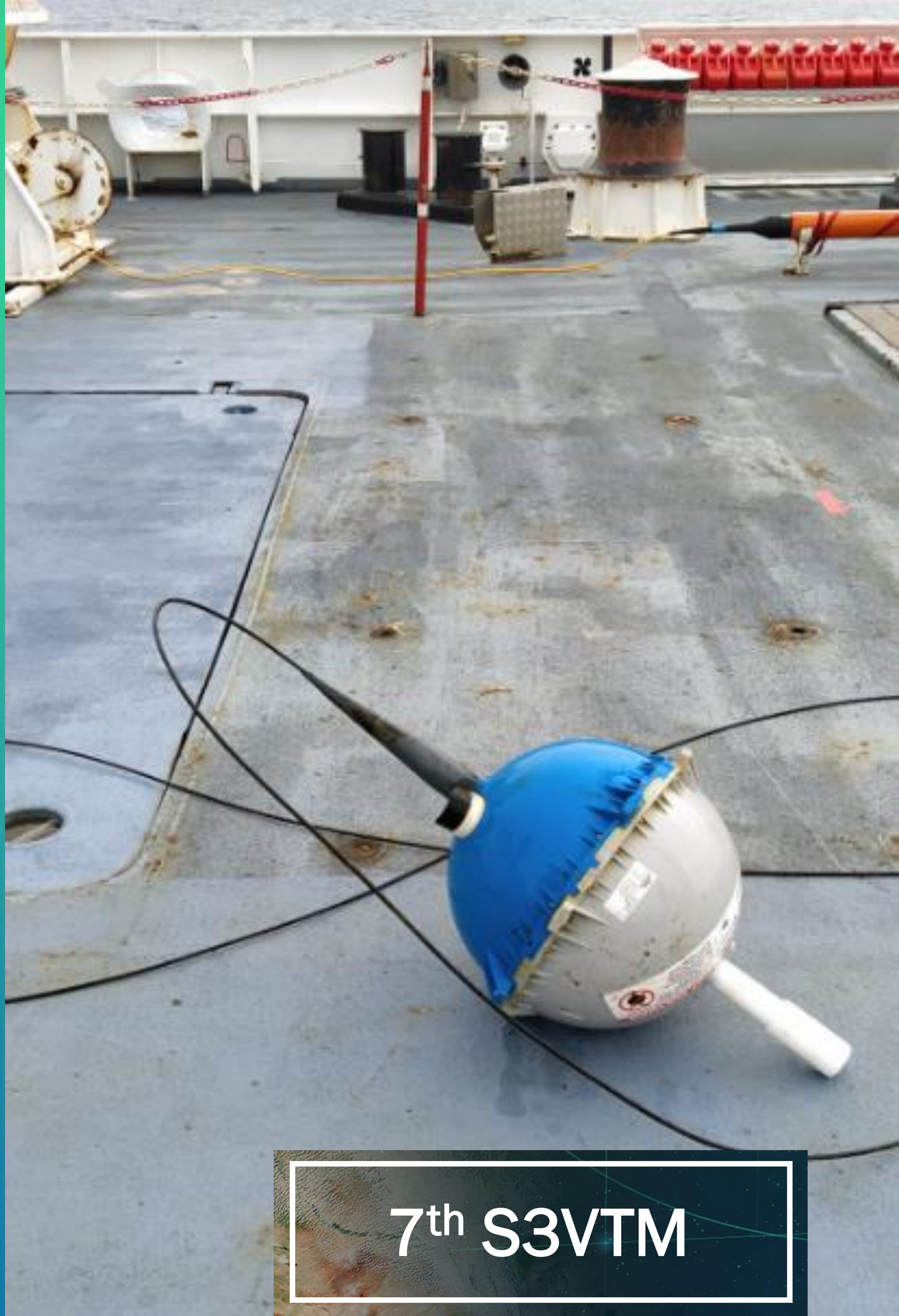
- 3 buoys recovered:
  - 1 onshore Iceland (damaged)
  - 1 east of Iceland (intact)
  - 1 moored in the North Sea

- Quantification of the temperature sensor's drift:

  ≈ 4 mK/year

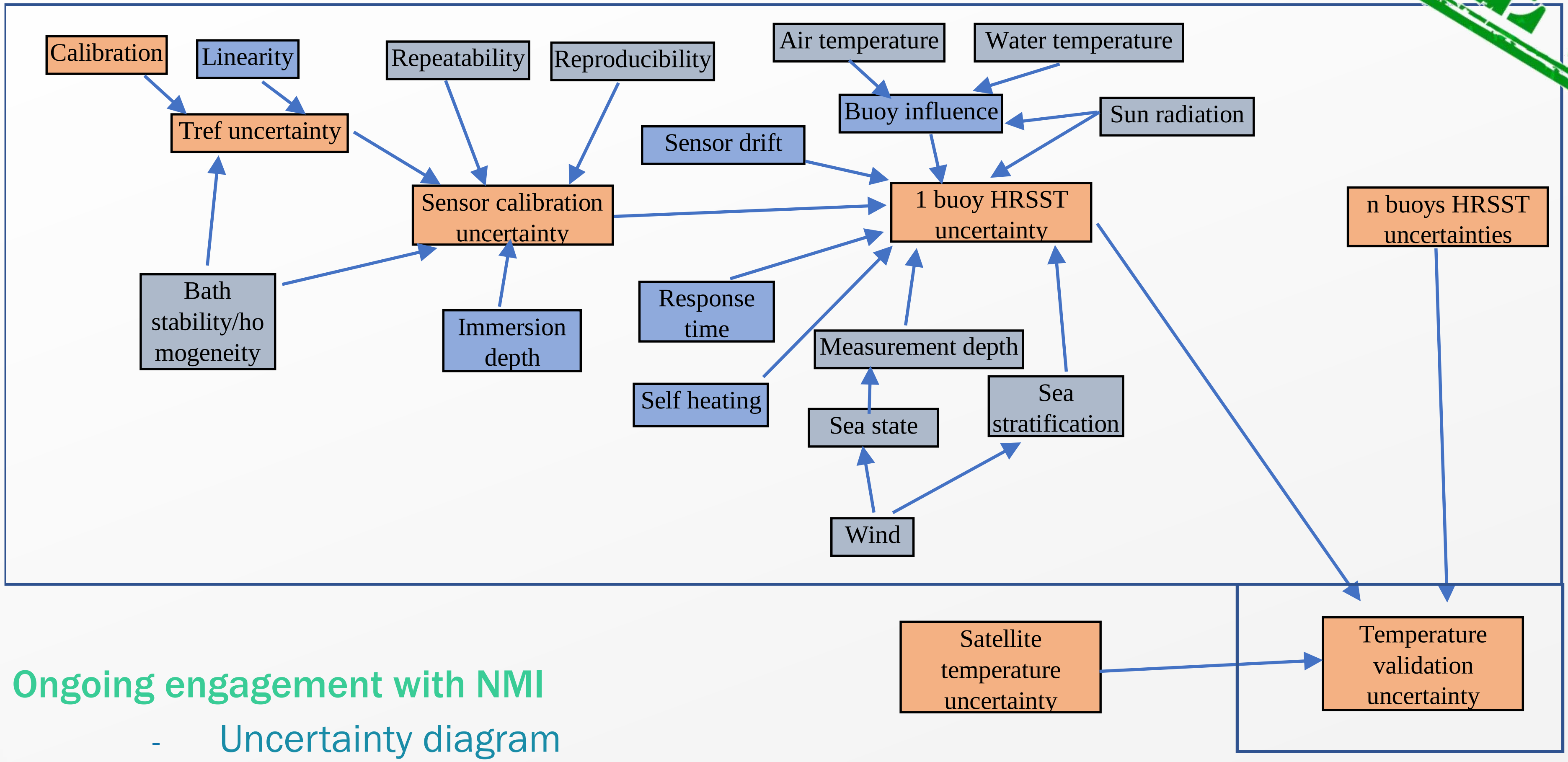
Tref standard uncertainty :	0.001	°C
Bath stability standard uncertainty :	0.000	°C
Reproducibility buoy n° 025 :	0.006	°C
Repeatability buoy n° 025 :	0.001	°C
Verification expanded uncertainty:	0.012	°C

Tref standard uncertainty :	0.001	°C
Bath stability standard uncertainty :	0.000	°C
Reproducibility buoy n° 017 :	0.005	°C
Repeatability buoy n° 017 :	0.001	°C
Verification expanded uncertainty:	0.011	°C



Metrology: traceability Diagram & engagement

NEW



Ongoing engagement with NMI

- Uncertainty diagram
- Metrology procedure approval

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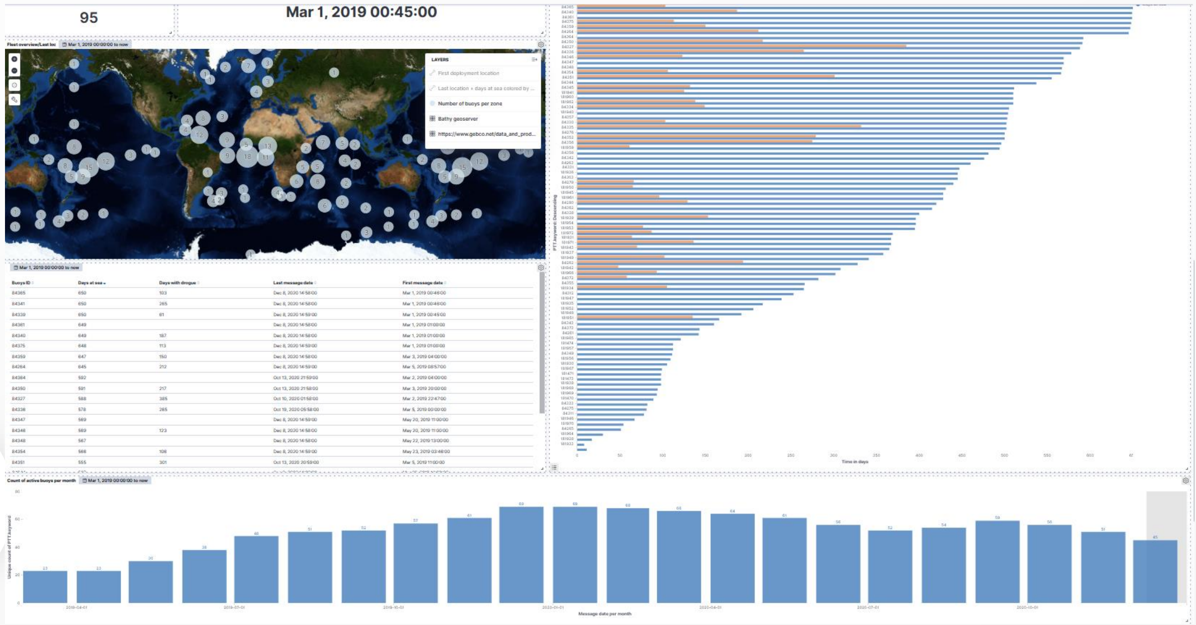
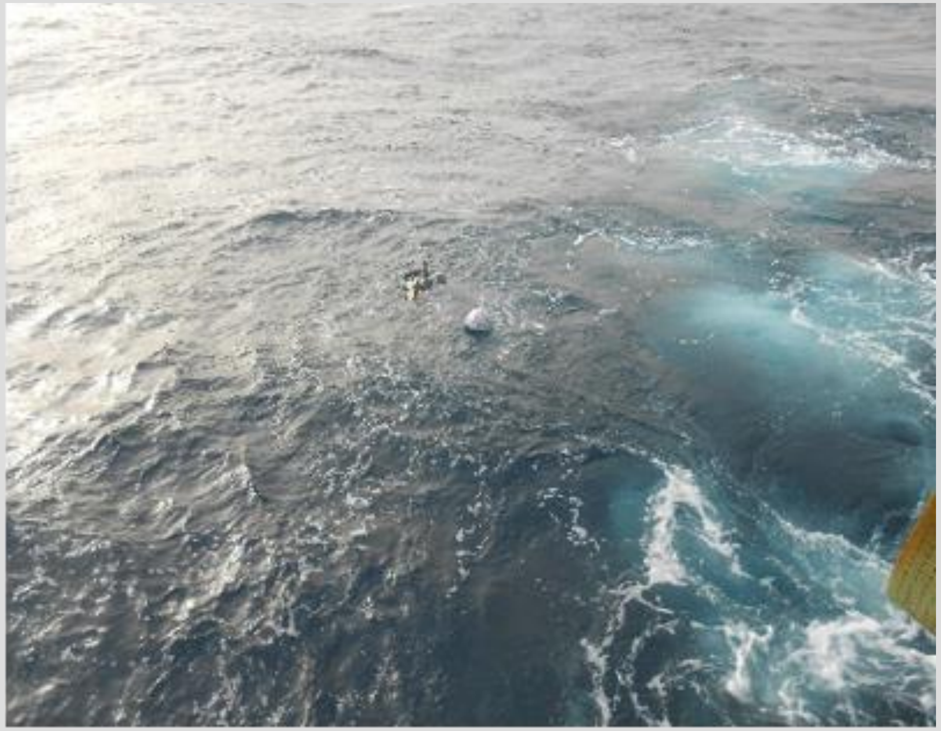
World Wide Deployments

- **153 buoys deployed to date:**
    - 138 LF buoys deployed
    - 14 HF buoys deployed
    - longest deployment: 720 days
- **Maximum of 70 at sea simultaneously**
    - Batch 4 delivered end of September
    - Ongoing Deployments





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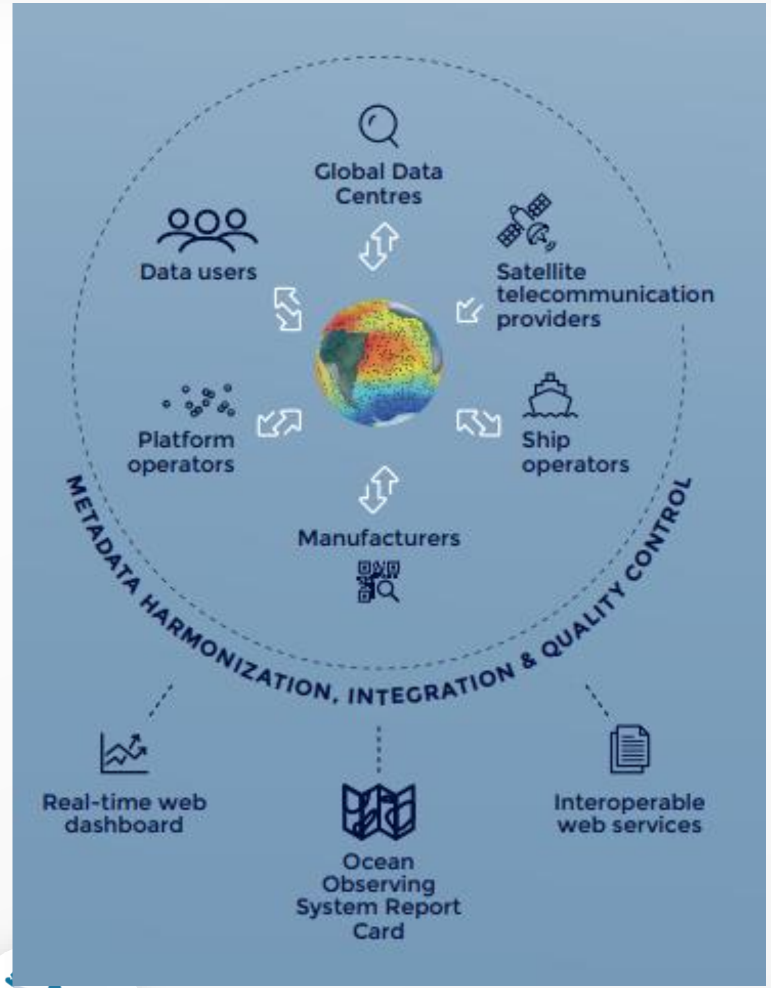
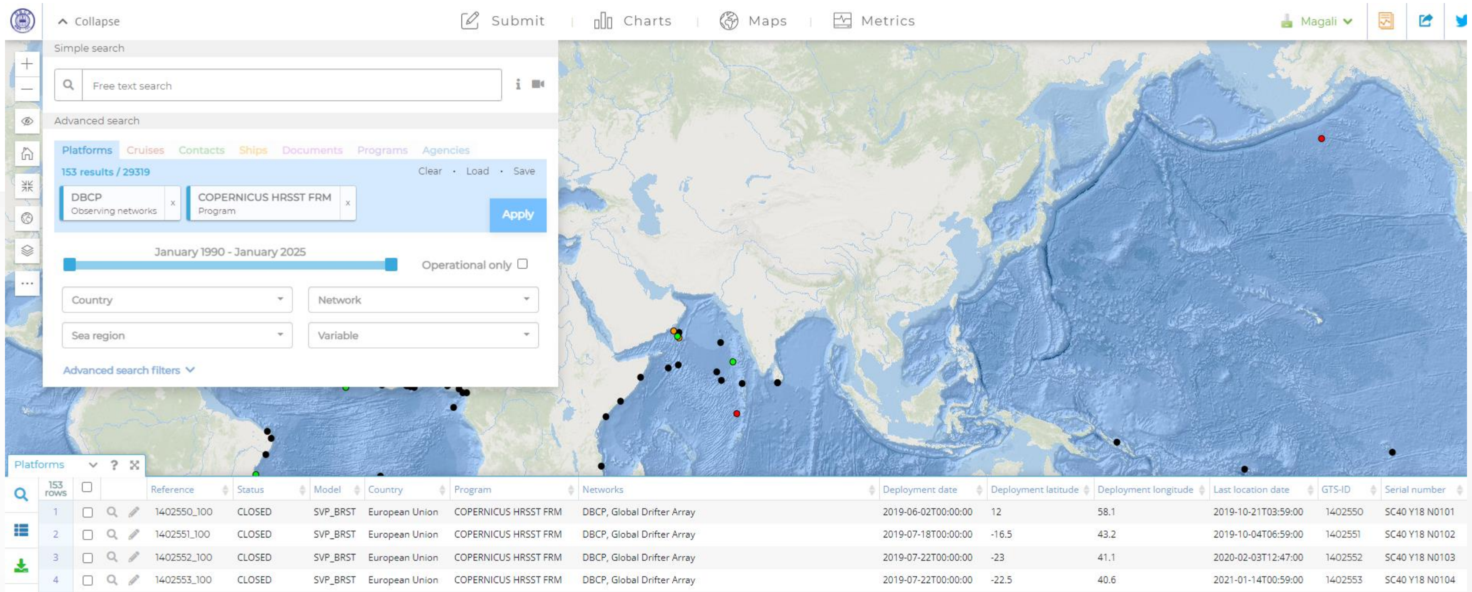
Metadata (OceanOps)





153 results / 29319

DBCP – Observing networks

COPERNICUS HRSST FRM – Program

January 1990 - January 2025

153 rows	Reference	Status	Model	Country	Program	Networks	Deployment date	Deployment latitude	Deployment longitude	Last location date	GTS-ID	Serial number
1	1402550_100	CLOSED	SVP_BRST	European Union	COPERNICUS HRSST FRM	DBCP, Global Drifter Array	2019-06-02T00:00:00	12	58.1	2019-10-21T03:59:00	1402550	SC40 Y18 N0101
2	1402551_100	CLOSED	SVP_BRST	European Union	COPERNICUS HRSST FRM	DBCP, Global Drifter Array	2019-07-18T00:00:00	-16.5	43.2	2019-10-04T06:59:00	1402551	SC40 Y18 N0102
3	1402552_100	CLOSED	SVP_BRST	European Union	COPERNICUS HRSST FRM	DBCP, Global Drifter Array	2019-07-22T00:00:00	-23	41.1	2020-02-03T12:47:00	1402552	SC40 Y18 N0103
4	1402553_100	CLOSED	SVP_BRST	European Union	COPERNICUS HRSST FRM	DBCP, Global Drifter Array	2019-07-22T00:00:00	-22.5	40.6	2021-01-14T00:59:00	1402553	SC40 Y18 N0104

Goal 2

Lead metadata standardization and integration across the global ocean observing networks

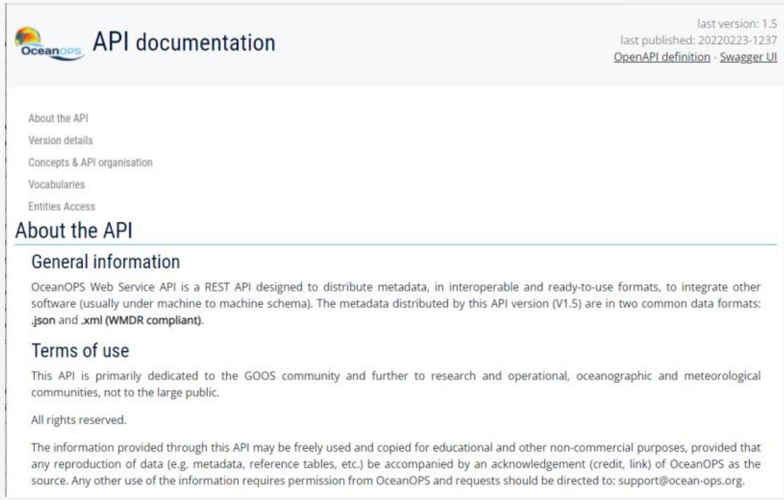
Objective 2.1
Set and disseminate the standards and best practices for metadata harmonization across the OCG networks.

Objective 2.2
Develop the web services required for machine-to-machine metadata exchange and access.

Objective 2.3
Provide a harmonized and high-quality standard of metadata across all OCG networks.

Objective 2.4
Assist users on data access and available data services.

Objective 2.5
Connect OceanOPS services with IOC and WMO international data systems.



API documentation

last version: 1.5
last published: 20220223-1237
OpenAPI definition - Swagger UI

- About the API
- Version details
- Concepts & API organisation
- Vocabularies
- Entities Access

About the API

General information

OceanOPS Web Service API is a REST API designed to distribute metadata, in interoperable and ready-to-use formats, to integrate other software (usually under machine to machine schema). The metadata distributed by this API version (V1.5) are in two common data formats: **.json** and **.xml (WMDR compliant).**

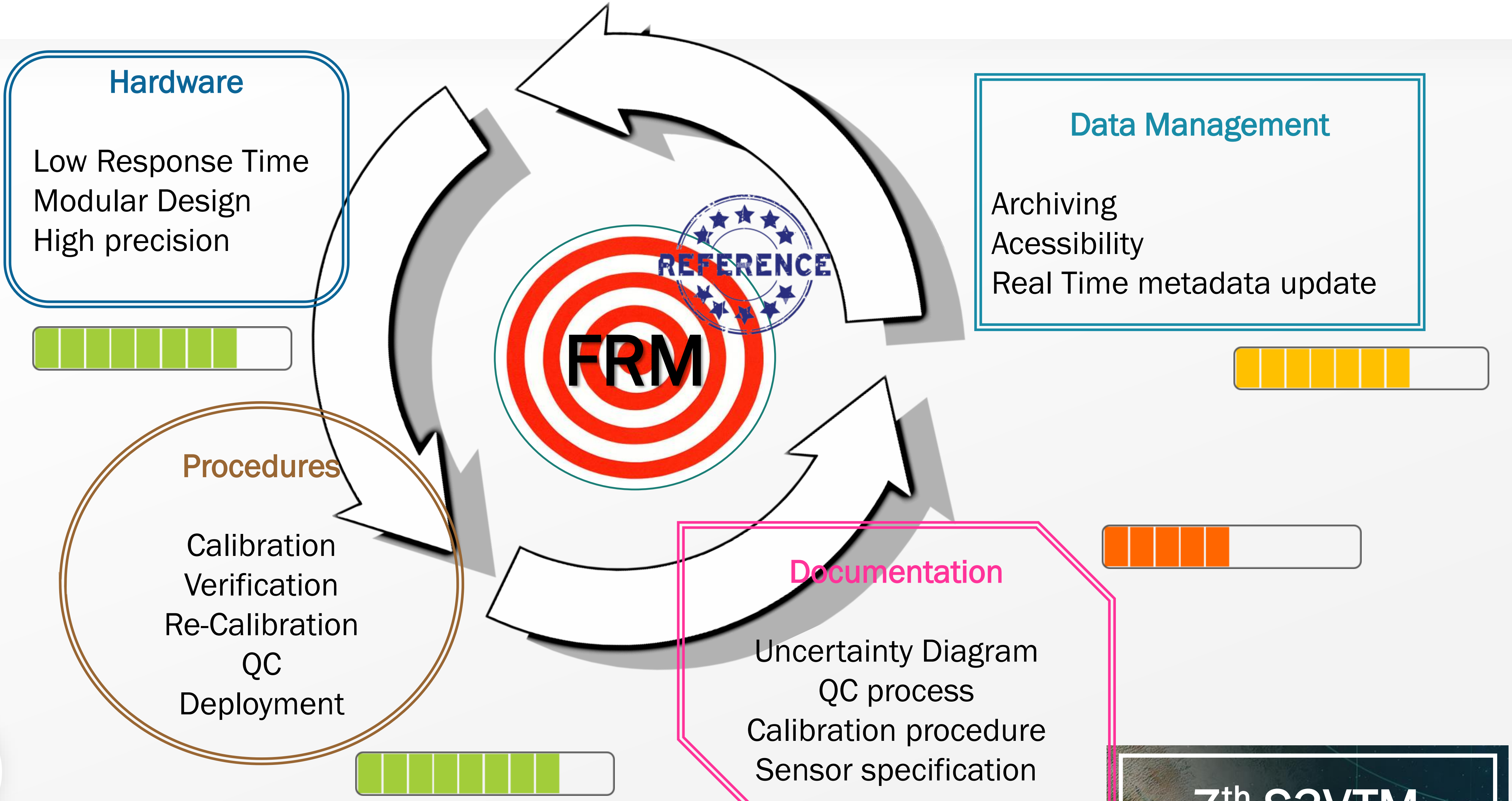
Terms of use

This API is primarily dedicated to the GOOS community and further to research and operational, oceanographic and meteorological communities, not to the large public.

All rights reserved.

The information provided through this API may be freely used and copied for educational and other non-commercial purposes, provided that any reproduction of data (e.g. metadata, reference tables, etc.) be accompanied by an acknowledgement (credit, link) of OceanOPS as the source. Any other use of the information requires permission from OceanOPS and requests should be directed to: support@ocean-ops.org.

SST FRM in TRUSTED



Hardware

Low Response Time
Modular Design
High precision

Data Management

Archiving
Acessibility
Real Time metadata update

Procedures

Calibration
Verification
Re-Calibration
QC
Deployment

Documentation

Uncertainty Diagram
QC process
Calibration procedure
Sensor specification

IST data Gap

- Lack of observation in sea-ice
- Harsh condition
- sea-ice in situ measurements critical for developing and validating new operational Copernicus Sentinel-3 sea-ice Surface Temperature products
- Snow effect is a big obstacle (1m thermistor pole)
- What can be done to bring down the cost to increase sampling

https://www.sams-enterprise.com/services/autonomous-ice-measurement/

IST platform specifications

- Collect requirements
    - Science
    - Manufacturing & procurement
    - Metrology
    - Deployment
- Analyse requirements
- Produce specification document
- Start design process (2023)

https://www.sams-enterprise.com[illegible]es/autonomous-ice-measurement/

NEW

ID	Requirement 2022-06-03 postPM1	Description	Priority (High/ mid/ Low	Comment / justification
RU-IST-01	The measuring height shall be NO less than 50cm.	The height of the top sensor must be larger than the max snow depth. E.g. Natural snow depth in the Arctic is rarely larger than 50 cm.	high	Th[illegible]ng heig[illegible]exc[illegible]d the snowp[illegible]h, in[illegible]ildup around the [illegible]w drif
J-IST-02	The vertical resolution shall be less than 5cm.	The vertical resolution of the thermistors is less than 5cm.5cm.	high	This is preferable to be[illegible]hat will make the identification of the of skin-sensor easier and more accurate snow depth estimate Many sensors is a challenge (NKE). Prototype must be is high resolution (AOC)
T-10	The buoy is designed for dual use of IST and SST	Sea-ice and Sea application buoys -i.e. both sea-ice and sea deployment is desired i.e. facility to transform to float, measure and transmit SST after ice melt.	Low	Will add to battery weight (NKE) Hence, not a high priority requirement anymore.
	Pitch Roll Azimuth	PNI (pitch, roll,~~azimuth~~) to determine orientation of thermistors.	mid/low*	*depending on design. A minimum requirement is information regarding buoy orientation correct or not. However a tilt angle will be preferable.
	able platform nsor	The buoy shall be ready for reuse e.g. easy to change the battery package and/or external sensors	low	The aim is to make the platform relatively cheap. At this stage we focus a solution and design. For now, reusability is Niceto-have
	st	The buoy must be easy to deploy by non-scientists with a maximum weight of 30 kg including packing. (30kg is aximum allowed luggage ht in passenger s.)	high *low for prototype	An important parameter wide spread distribution– and production in large numbers
		cturing costs low to allo		n. f too

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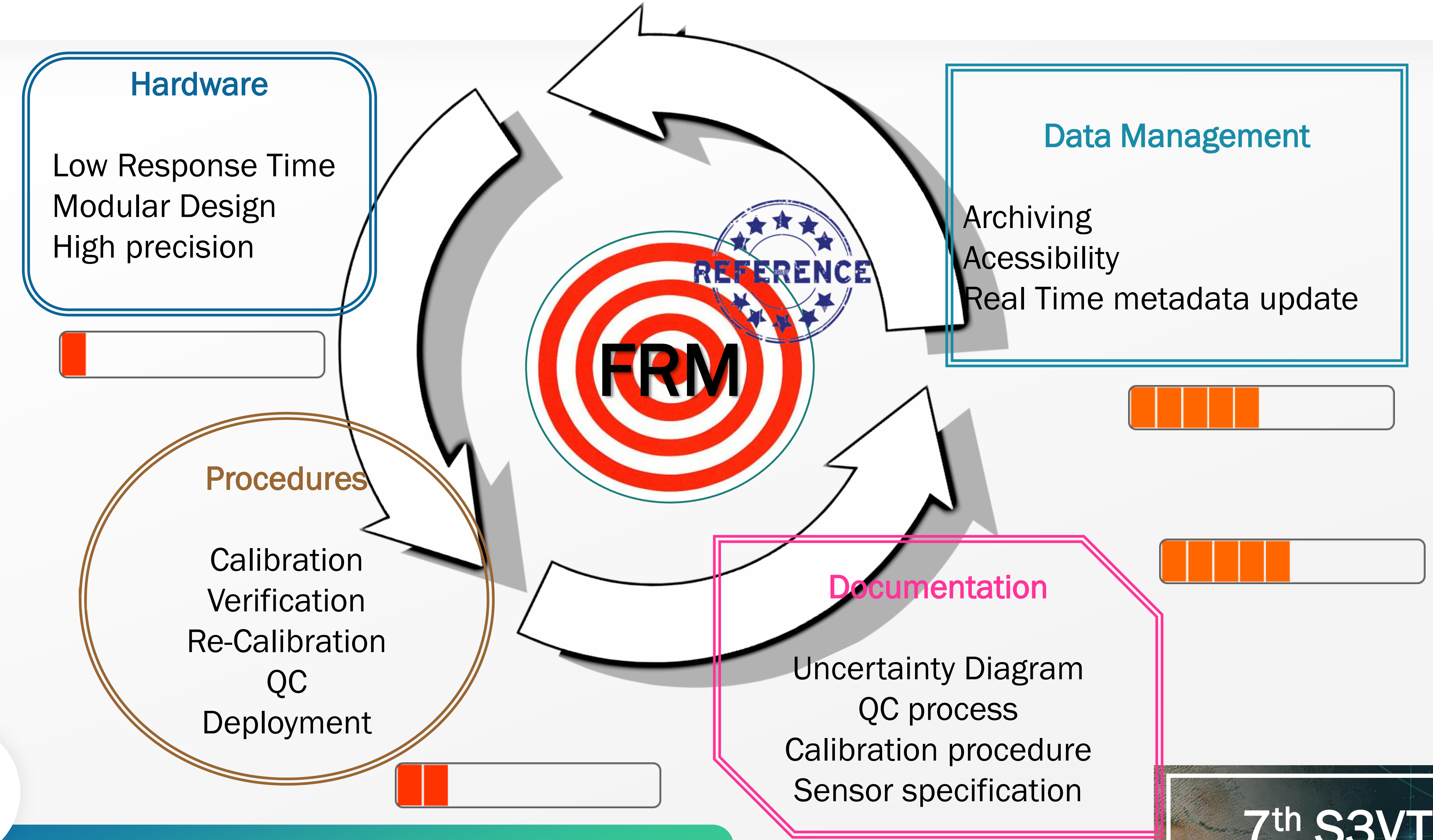
IST FRM in TRUSTED



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Thank You

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