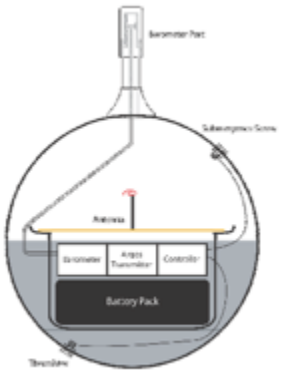
Fiducial Reference Measurements (FRM)



Sea-Bird Argo Float

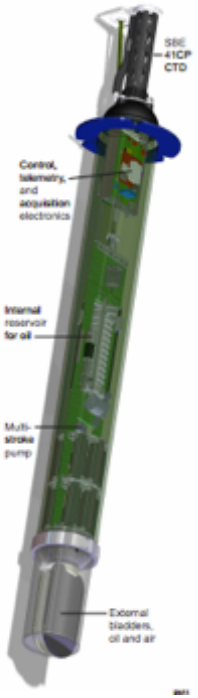
Navis

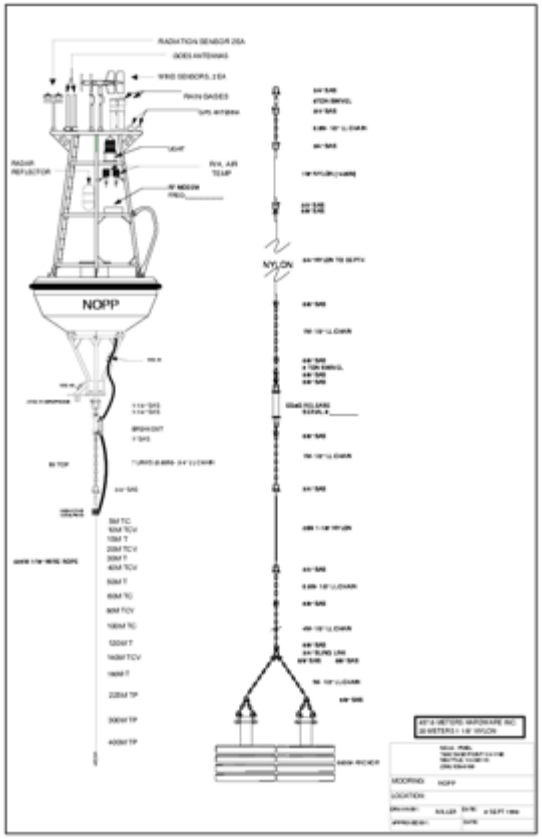
SPECIFICATIONS

Science Data (SBE 41CP CTD)

	Initial Accuracy	Stability
Temperature	± 0.002 °C	± 0.0002 °C/year
Salinity	± 0.002 PSS-78	± 0.001 PSS-78/year
Pressure	± 2 decibars	± 6 decibars

Float Operation Minimum fractional volume change	1.70%
Depth rating	2000 decibars
Communications	Iridium Transceiver 9522B – RUDICS, circuit switched. Nominal transmission time 275 sec for 2000 dbar profile cycle (2 dbar bins of 1 Hz CTD data)
Position	GPS, Garmin 15xL-W, mean acquisition time 20 sec
Park interval	1 - 15 days
Materials	Aluminum hull, seamless natural rubber external bladders
Oil reservoir	300 ml
Ballasting	self-ballasting, 1 day to equilibrate
Weight in air	Less than 17 kg (up to 18 kg initial production)
Box	Stackable, export-compliant
Self-activation	Starts operating automatically on deployment, when pressure reaches user-programmable setpoint
Internal batteries	4 packs of 3 DD lithium sulfuryl chloride cells (IATA certified for shipping). Each pack has open circuit voltage of 10.8 V with 30 AH capacity, yielding 1166 kJ (4664 kJ for 4 packs).
Power Consumption	11 kJ for a 2000-dbar CTD profile cycle
Power Endurance	10 years or 300 2000-dbar cycles
Memory	CTD stores one 2000 decibar CTD profile
Dimensions	Hull diameter 14 cm (5.5 inches) Ring diameter 24 cm (9.5 inches) Total length 159 cm (62.7 inches)





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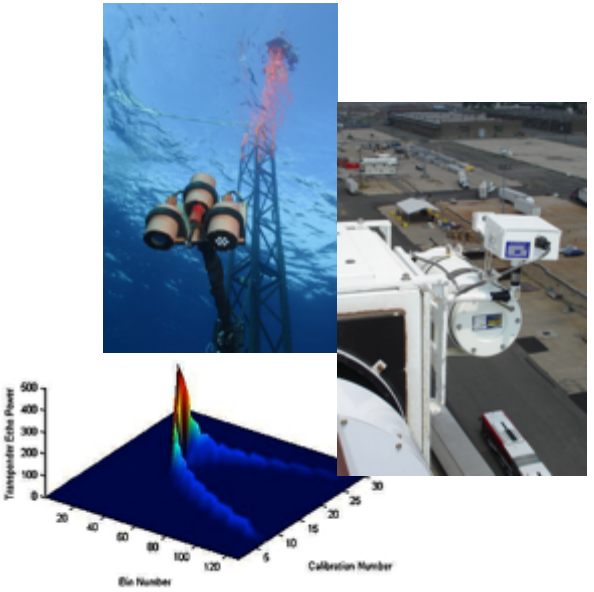
Overview

- What are Fiducial Reference Measurements (FRM)?
- Why do we need them at all?
- Examples of FRM in the context of Sentinel-3
- Summary
- Challenges for this meeting

Fiducial Reference Measurements (FRM)

- **fi·du·cial *(adj)*** *Regarded or employed as a standard of reference, as in surveying.*
  - `[Late Latin fdcilis, from Latin fdcia, trust, from fdere, to trust; seebheidh- in Indo-European roots.]`
- What's wrong with in situ?
  - It means everything to the uneducated
  - It's not tangible to a funding agency
  - It is not precise enough to argue for a validation program
- SST FRM are:
  - Linked to validation activities
  - Based on specific requirements
  - Forward thinking – long-term vision
  - Building on the existing capability
  - Are SI traceable
  - Have an inclusive approach: FRM are not Mission specific (e.g. S3A, B, C, D… S2A, B, C, D…all need ocean colour FRM…, All Altimeters need transponders for range calibration – and Sigma0, SST retrievals from self-calibrating satellite radiometers need validation data)



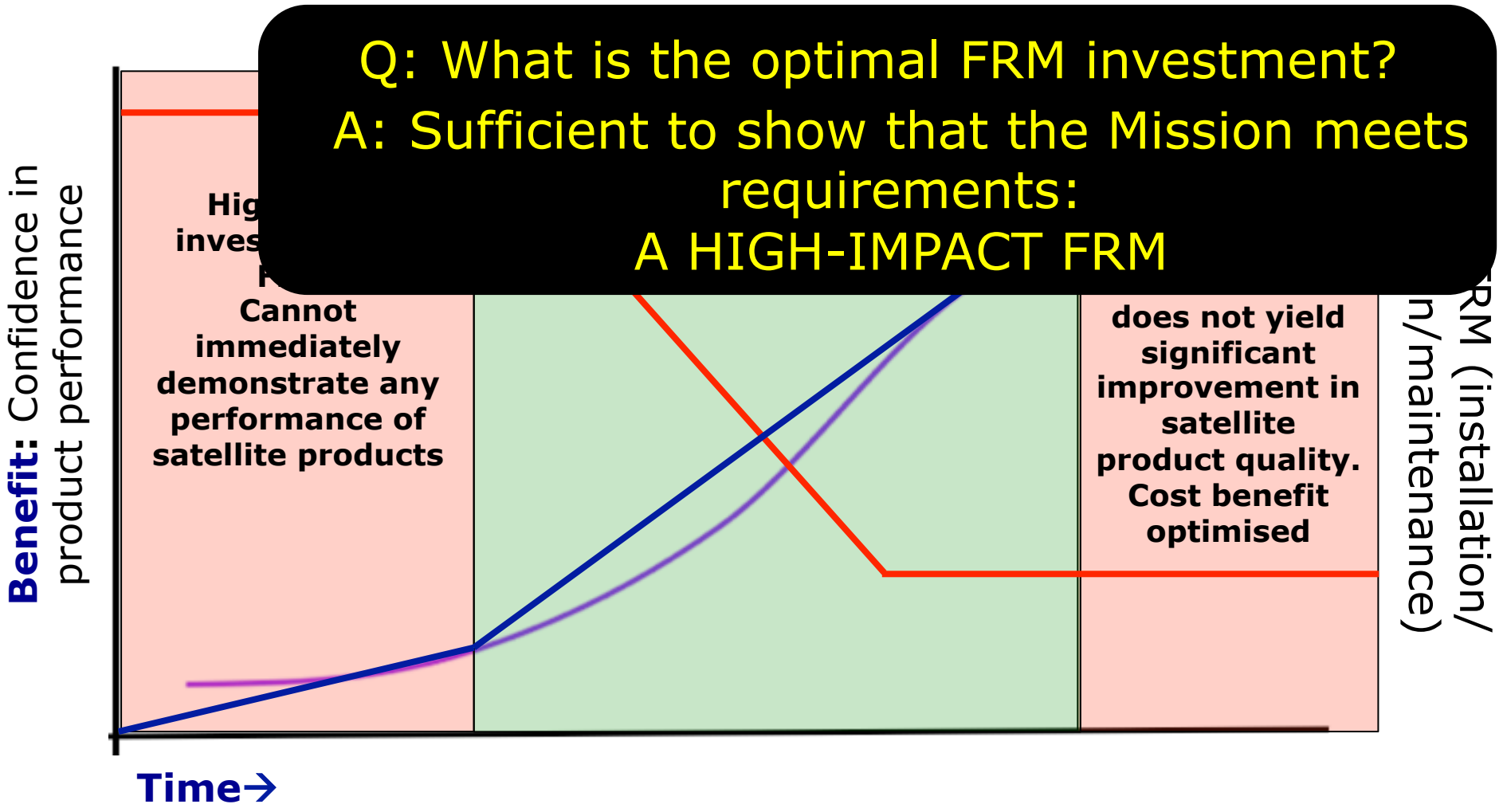
So, what are FRM?

- Fiducial Reference Measurements (FRM) are
  - the suite of independent ground measurements
  - that provide the maximum Return On Investment (ROI) for a satellite mission
  - by delivering, to users,
  - the required confidence in data products,
  - in the from of independent validation results and satellite measurement uncertainty estimation,
  - over the entire end-to-end duration of a satellite mission.

Why do we need FRM?

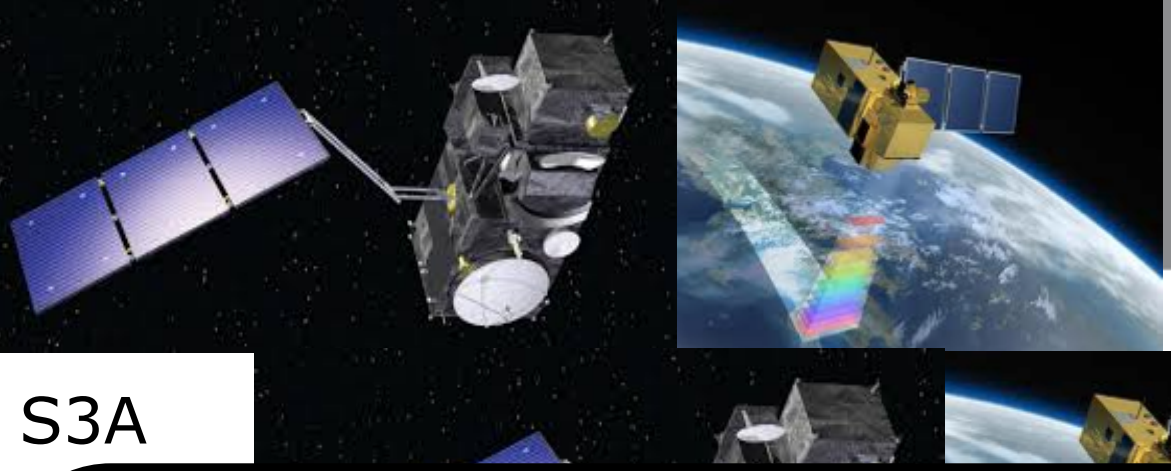
- FRM is the suite of ground measurements that provide the maximum Return On Investment (ROI) for the Mission by **delivering the required confidence in the data products for users.**
  - IF we have **no FRM** then we cannot really use the mission as we have no idea how accurate data products are
  - IF we have **many FRM** this is great scientifically (statistical significance, geographic coverage, robust network…) but incurs additional costs with reducing ROI
- **There is a balance between these two extremes to deliver a satellite mission with a KNOWN product quality that is "fit for Purpose"**

Is a mission product “fit for purpose”?
It depends our knowledge of how “good” it is…



FRM: defining characteristics

- The defining mandatory characteristics of an FRM are:
  - FRM measurements have documented SI traceability via round-robin inter-calibration of instruments.
  - FRM measurements are independent from the satellite SST retrieval process.
  - An uncertainty budget for all FRM instruments and derived measurements is available and maintained.
  - FRM measurement protocols and community-wide management practices (measurement, processing, archive, documents etc.) are defined and adhered to.



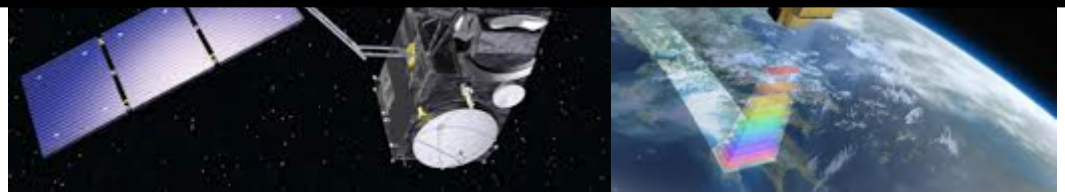
S2A

S3A

In Europe, we have a lot of Copernicus infrastructure in preparation – will we be able demonstrate its performance?

Can we demonstrate we have met requirements?

Are products "fit for purpose" within Copernicus?



S3D

Example FRM: S3 SLSTR

- Ship-borne radiometers provide skin SST traceable to International standards.
- Drifting buoys provide wider geograph coverage and measure sub-surfa (more complex validation) h ally traceable.
- Moorings provid face SST – better temporal co ut poor spatial covera be partially traceable
- floats: Provide vertical profiles erate coverage but not fully traceable…

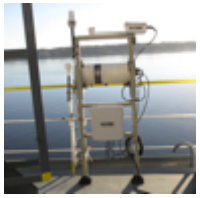
Which one is a high impact FRM?

What makes an FRM an FRM?

- Standards Traceability via round-robin inter-calibration of instruments?
- Independence?
- An Uncertainty budget?
- Published papers?
- Good management?
- Maintenance of infrastructure and calibration?
- A good site? (atmosphere, gradients…)
- A long lime series?
- “Because this is what was done in the past”?
- Good protocols (measurement, processing, archive, documents…)?
- Availability (data sharing)?
- Provides evidence that we meet mission requirements?

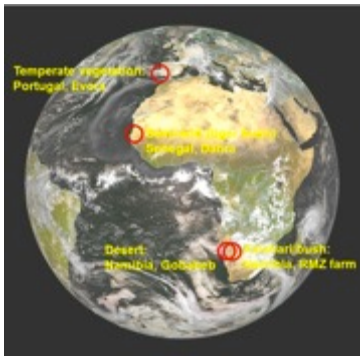
Fiducial Reference Measurements for Thermal Infrared Satellite Validation (FRM4-CEOS)

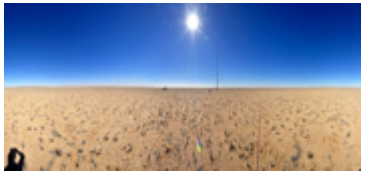
- FRM4-CEOS: ESA ITT for FRM TIR radiometer validation and investigation of routes to SI traceability for other SST measurements
- ~400K ITT in Summer 2014



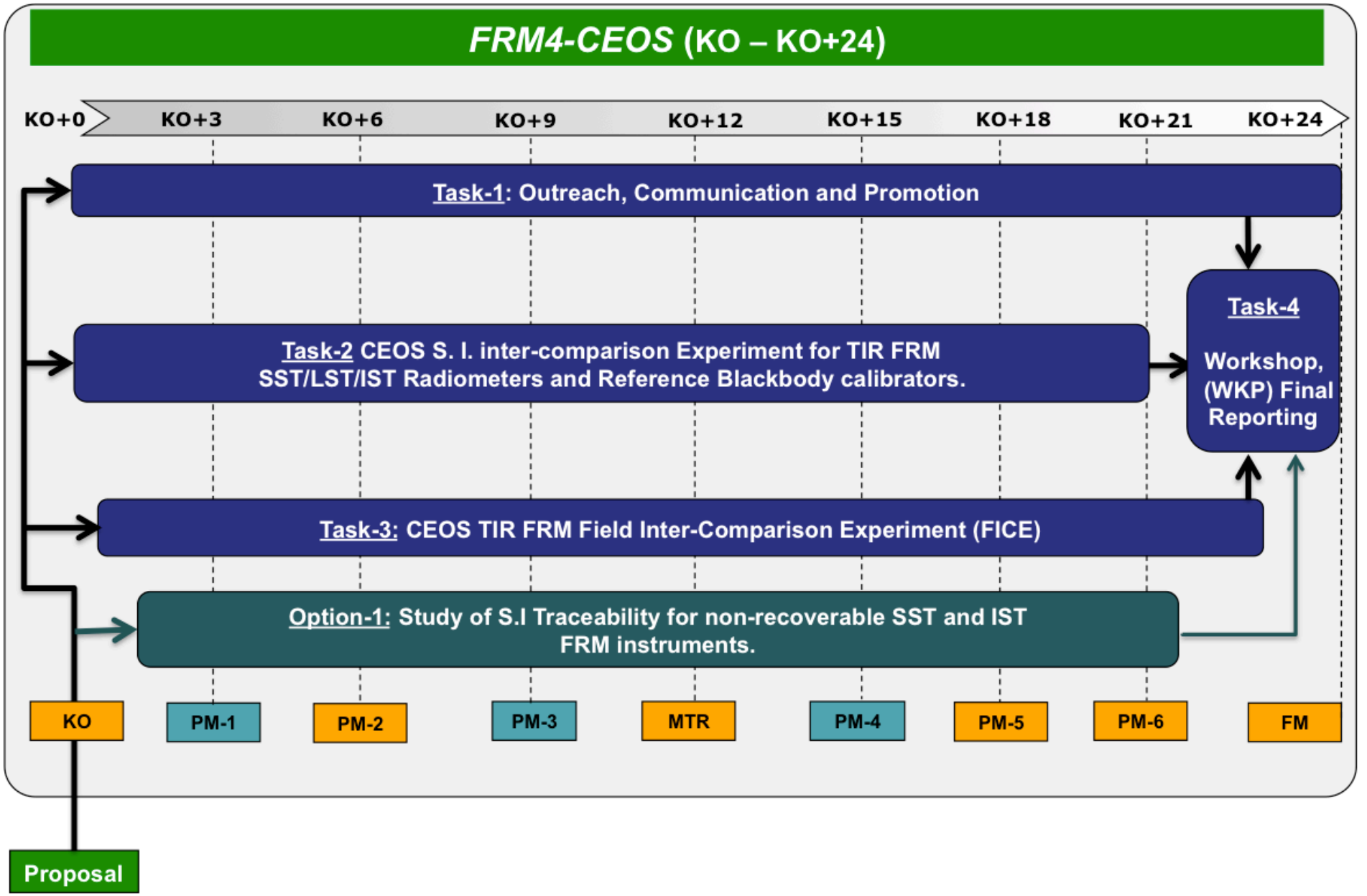
FRM4-CEOS: (SST and LST)

- The **aim** of the ***FRM4-CEOS*** project is to:
- ***Establish and maintain S.I. traceability of Fiducial Reference Measurements (FRM) for satellite derived surface temperature product validation.***
  - CEOS TIR FRM Radiometer and Reference Blackbody SI Inter-comparison experiment,
  - CEOS TIR FRM Field Inter-Comparison Experiment (FICE) (**SST and LST**)
  - Workshop and Final Reporting.
  - Option-1: Study of SI Traceability for SST, LST and IST measurements collected using instruments other than FRM TIR radiometers.





Schedule


FRM4-CEOS (KO – KO+24)
KO+0
KO+3
KO+6
KO+9
KO+12
KO+15
KO+18
KO+21
KO+24
Task-1: Outreach, Communication and Promotion
Task-2 CEOS S. I. inter-comparison Experiment for TIR FRM SST/LST/IST Radiometers and Reference Blackbody calibrators.
Task-4
Workshop, (WKP) Final Reporting
Task-3: CEOS TIR FRM Field Inter-Comparison Experiment (FICE)
Option-1: Study of S.I Traceability for non-recoverable SST and IST FRM instruments.
KO
PM-1
PM-2
PM-3
MTR
PM-4
PM-5
PM-6
FM
Proposal

Expected Benefits

- Establish and document protocols and best practice for FRM TIR radiometer and reference blackbody inter-comparisons for future use.
- Establish community best practises for SST, LST and IST FRM TIR radiometer deployments,
- Evaluate and document differences in IR radiometry primary calibrations and performances under a range of simulated environmental conditions,
- Establish and document formal SI-traceability and uncertainty budgets for participant blackbodies and radiometers,
- Evaluate and document protocols and best practice to characterise differences between FRM TIR radiometer measurements made in field (land, ocean, ice) operational conditions,
- Follow QA4EO principles and in particular Guidelines
- Establish and document the best route to potential SI-traceability and uncertainty budgets for drifting buoy SST and other in water SST devices

Summary

- The term “in situ” measurement brings fear to some eyes… costs are potentially enormous
- A refined process is required to move on from where we are – your S3VT sub-group chairs have a responsibility to “make it happen” – me included!
- A requirements-based (justified) and prioritized (cost-benefit) suite of measurements is obviously required to demonstrate that S3 products are “fit for purpose”
- The concept of Fiducial Reference Measurements (FRM) may be one way to develop a more palatable case in the long term
- Care is needed to define FRM appropriately
- Europe needs to build a secure FRM base of its own to provide the required confidence in EO measurements and fully realise the Return on Investment (ROI) for Sentinels
- ESA, With CEOS WGCV and SST-VC, will run a project to enable FRM for SST and LST

Thank you - any questions?

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