OIP Sensor Systems

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SATIRIM 2: Final Presentation 05/09/2024

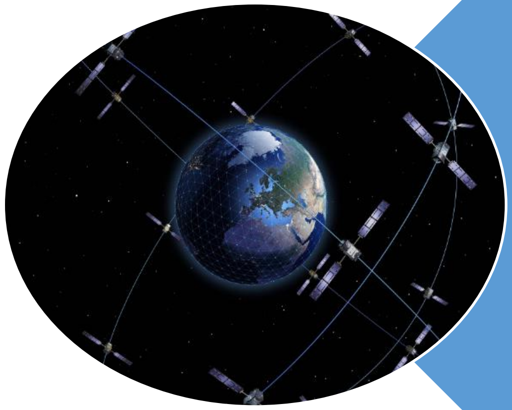
Final Presentation - Contributors

In collaboration with

- VITO (Phase 1 + 2)
- ASL (Phase 1 – Platform requirements)
- OIP (Phase 1 + 2)

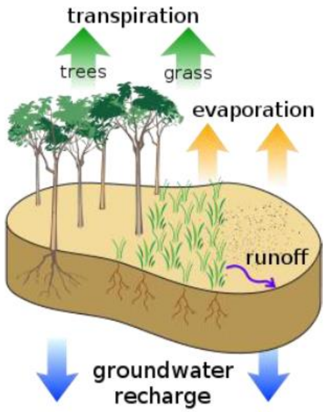
Final Presentation - TOC

Introduction



Need for thermal imaging in space @ low cost

- Measurements in 8-12.5 µm range (LWIR)
- Initial Goal:
  - prepare a thermal IR small satellite IOD (which should lead to a satellites constellation)
  - Altitude ≈ 500 km | GSD 80 m | Swath 80km | 3 spectral filters WL 8-14 µm (LWIR)



Potential use cases:

- Land Surface Temperature (LST) and **Evapotranspiration (ET)** of crops [Primary use case]
- Natural hazards: Volcano activity, wildfires, …
- Monitoring urban environment
- Cryosphere: study of the permafrost areas

SATIRIM 1: Objectives and Results

Objectives

- Determine User Requirements (UR) by VITO
- Develop draft optical design concept for flight
- Selection and evaluation of FPA using a breadboard

Results

- UR formulated, in agreement with existing missions
- Draft System Requirements formulated
- Selected FPA: Uncooled microbolometer PICO 1024 from Lynred (PP 17µm)
- Draft optical concept for flight
  - GSD = 80 m ➔ FL = 108 mm (for given PP)
  - Large aperture needed. F number F/1
- Evaluation revealed slow nature of µ-bolometers (which will cause image smear in orbit)
- Limited temperature accuracy for given UR (i.e. Bandwidth = 0.3 µm)

SATIRIM 1: Proposed Improvements

Proposed Improvements to be investigated during SATIRIM 2

- Increase SNR by:
  - Increase BW to 0.9 µm (which would still give qualitative scientific return)
  - Decrease F number for the same FL (Aperture Ø↑)
- Resolve image smear by:
  - Rotation mirror or other active step and stare mechanism
  - S/C attitude compensation
  - Software compensation

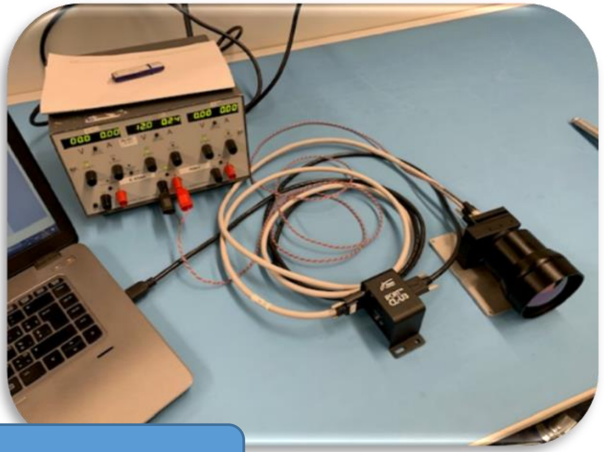
SATIRIM 1: Breadboard Purpose and Components

Purpose

- Evaluate the performance of the PICO1024 microbolometer
- How well can the target temperature be predicted given a pixel bit value?

Components

- COTS components
  - Umicore lens optics (F/1.5 | FL 100 mm | Waveband 8-12 µm
  - Pleora frame grabber
  - Sensor package containing: PICO 1024 | ROE | Shutter
- Custom aperture
- Computer

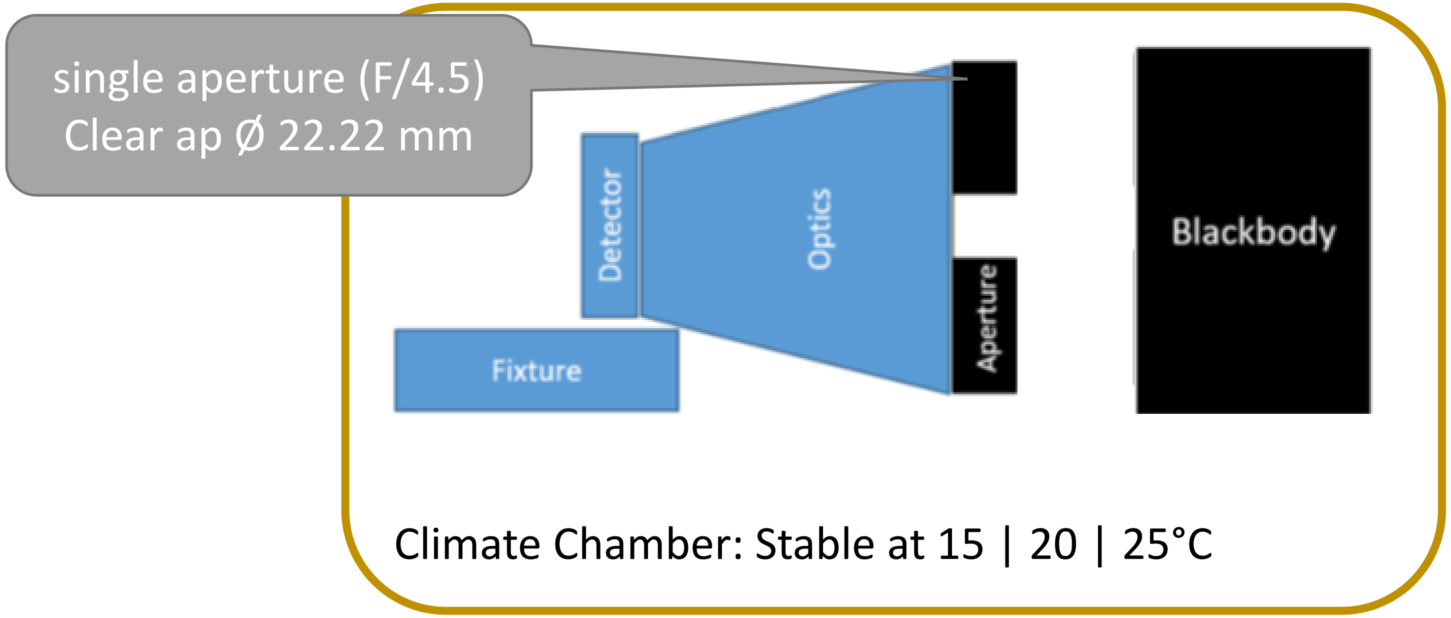


SATIRIM 1 Breadboard

SATIRIM 1: Breadboard Setup

Breadboard Setup

- Camera is exposed to a blackbody (target) over entire FOV
- Entire setup placed in a thermal chamber
- Frames and FPA temperatures captured manually



SATIRIM 2 - Phase 1: Scope

Further elaboration on outcomes of SATIRIM 1

- Trade –Off study selecting feasible methods for image smearing (VITO, TN1)
- Further evaluation of PICO 1024 detector with an improved breadboard (TN2 – TN4)
- Formulating draft Platform Requirements (TN5 + 5A)
- Update Instrument Requirements
- Establish a System Development Plan (TN6)

Results

- Trade –Off study:
  - Stand alone software compensation not sufficient (loss of SNR)
  - S/C attitude compensation excluded: reaction time not feasible + not possible to add other instruments to the same payload
  - Left over options: Rotating mirror or pixel shifting stage
- Evaluation of PICO 1024 detector performed with improved breadboard
  - More info on next slides
- Draft Platform Requirements developed (ASL)
- Instrument requirements updated

SATIRIM 2 - Phase 1: Breadboard Improvements

Possible issues with SATIRIM 1 breadboard:

- Only FPA temperature is known. There is no possibility for controlling thermal equilibrium is reached of the surroundings: Lenses, Optical Holders, ...
- Logging has been executed manually ➔ possible human error

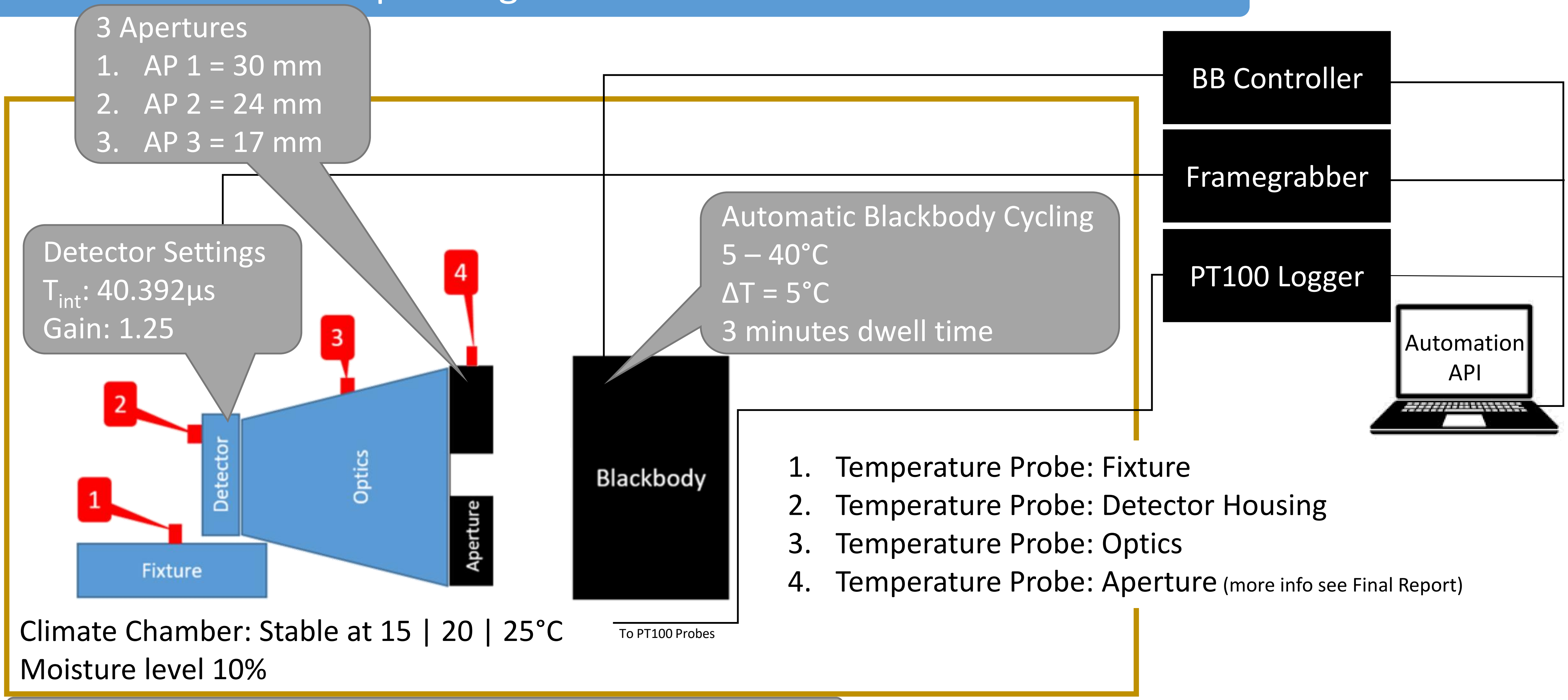
Improvements

- Apertures were foreseen with a low-cost anti reflective paint
- Apertures were enlarged to simulate the increased BW as proposed by SATIRIM 1.
- Improvements for SATIRIM 2:
  - PT100 probes to verify thermal equilibrium
  - Automated data capture (Frame, Timestamp, FPA temperature, PT100 temperatures)
  - Automated blackbody cycling
  - Active control of environmental moisture content, enabling making measurements on lower target temperatures

All COTS components were kept during SATIRIM 2 phase 1

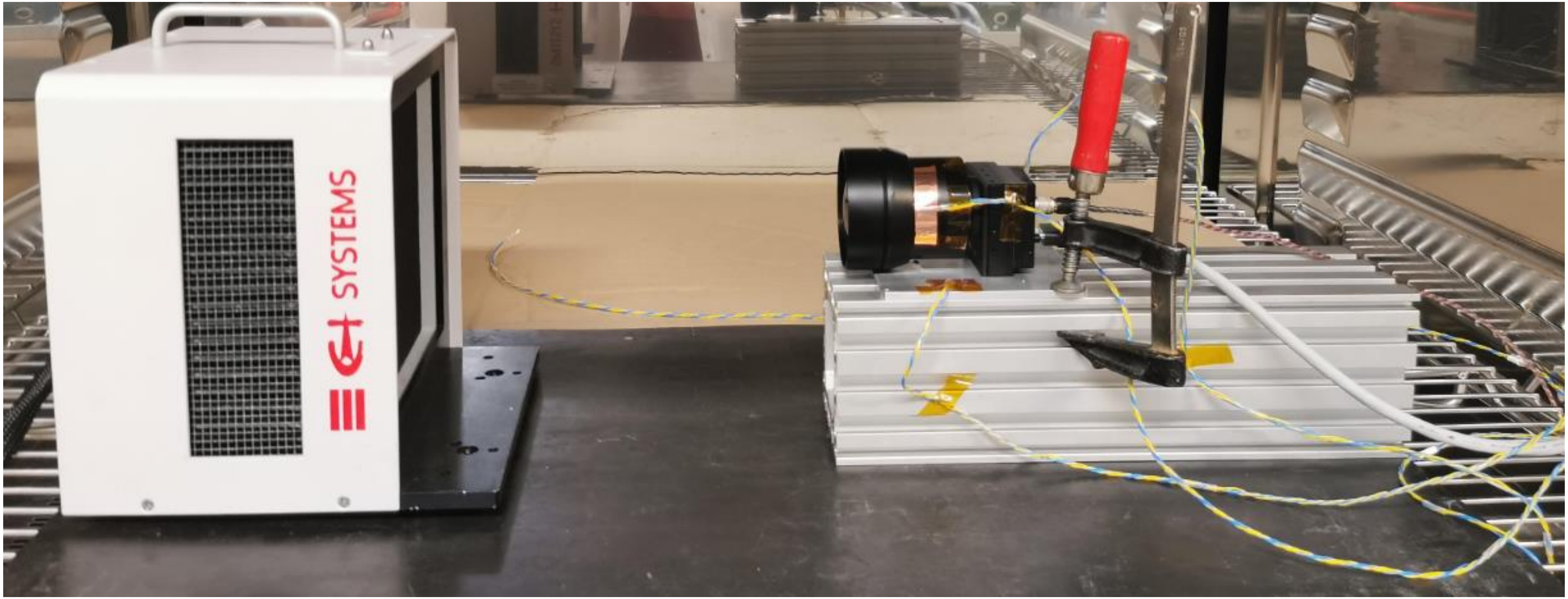
SATIRIM 2 - Phase 1: Breadboard Setup

Setup during SATIRIM 2 – Phase 1



* Frame capture limited to 10 Hz because of limited speed

SATIRIM 2 - Phase 1: Breadboard Setup



SATIRIM 2 - Phase 1: Breadboard Test Results & Conclusions

Results

- Calibration model: $TBB = \alpha\, DN^2 + \beta\, DN + \gamma\, TFPA + \delta$
- Predicted scene T ➔ AP1: < 1.17K | AP2: <1.37K | No AP: <0.25K (Threshold 1.5K @300K)
- NETD: 0.125K (in agreement with Lynred specification, Threshold 0.3K | Goal 0.15K)
- A theoretical instrument noise and spectral response analysis has been made by the university of Leicester

Conclusions

- The FPA shall be temperature stabilized in a range of ±1°C. Passive temperature control is preferred.
- Reference temperature TBD
- Repeatability measurements were performed with good results.
- Predicted scene temperatures are within threshold values (i.e. 1.5K @ 300K) for AP1, AP2 or without aperture
- The aperture reduce the light levels toward the detector as expected. However, they cause an additional offset.

SATIRIM 2 – Phase 1: Platform Requirements

The platform shall accommodate a volume and interfaces for:

- Optical system
- Remote ROE

The remote ROE shall be capable of:

- Communication with proxy ROE and rotation mirror
- Data storage | Data transmission & downlinking
- Capable performing image processing such as frame stacking, ...

The optical consist out of:

- Optical lens system with spectral filter | Detector with proxy ROE → all aligned by dedicated optical holders
- Fast steering mirror with its electronics

Thermal management

- Controlled FPA temperature @ TBD reference temperature, within a range of ±1°C
- Passive temperature control preferred

SATIRIM 2 – Phase 1: Platform Capability

Level 0 data shall be obtained

Operational altitude 500 – 600 km

Max mass instrument allocation for platform 50kg

Volume allocation (Excluding remote ROE): 150x150x350mm | Remote ROE: 250x150x200mm

Payload architecture assumption: the instrument is composed of:

- FPA with proxy ROE
- Optics
- Remote ROE
- Fast steering mirror

ASL platform VSP 150 can contain the SATIRIM instrument (Phase 1)

Thermal control TBD

- Passive control preferred, radiator and feasibility TBD

SATIRIM 2 – Phase 2: Scope

Continuation of SATIRIM 2 – Phase 1: Develop and evaluate proxy ROE

- Formulate Proxy ROE Requirements (TN 7)
- Make a ROE EM detailed design document (TN 8)
- Develop EM ROE Test Plan (TN 9)
- Run tests and report (RP001, TN10)
- Make a final report (TN11)

SATIRIM 2 – Phase 2: ROE EM Requirements

Capabilities:

- Level 0 data capture
- Operate PICO 1024 @ FR 30 Hz
- Adjustable Integration time, Gain, GSK, GFID
- Evaluate performance and compare to COTS ROE

The EM ROE uses 14 bits. The last two are reserved for checksum

Low power supply noise, see picture

Adjustable Gain

GAIN	TIA capacitance (pF)
1.00	5.3 (default configuration)
1.25	4.3
2.30	2.3
4.10	1.3

Power supply noise

The power supplies must be low noise and compliant with the following:

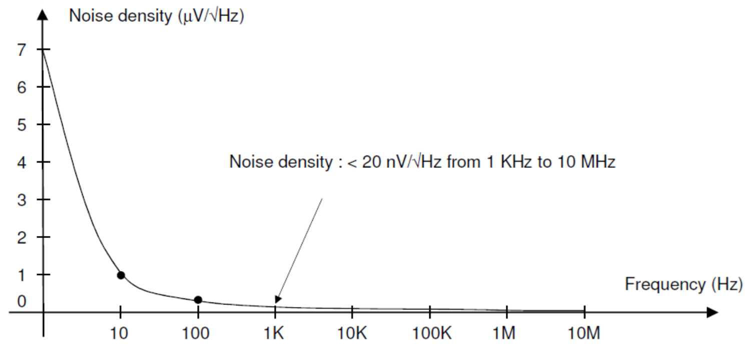
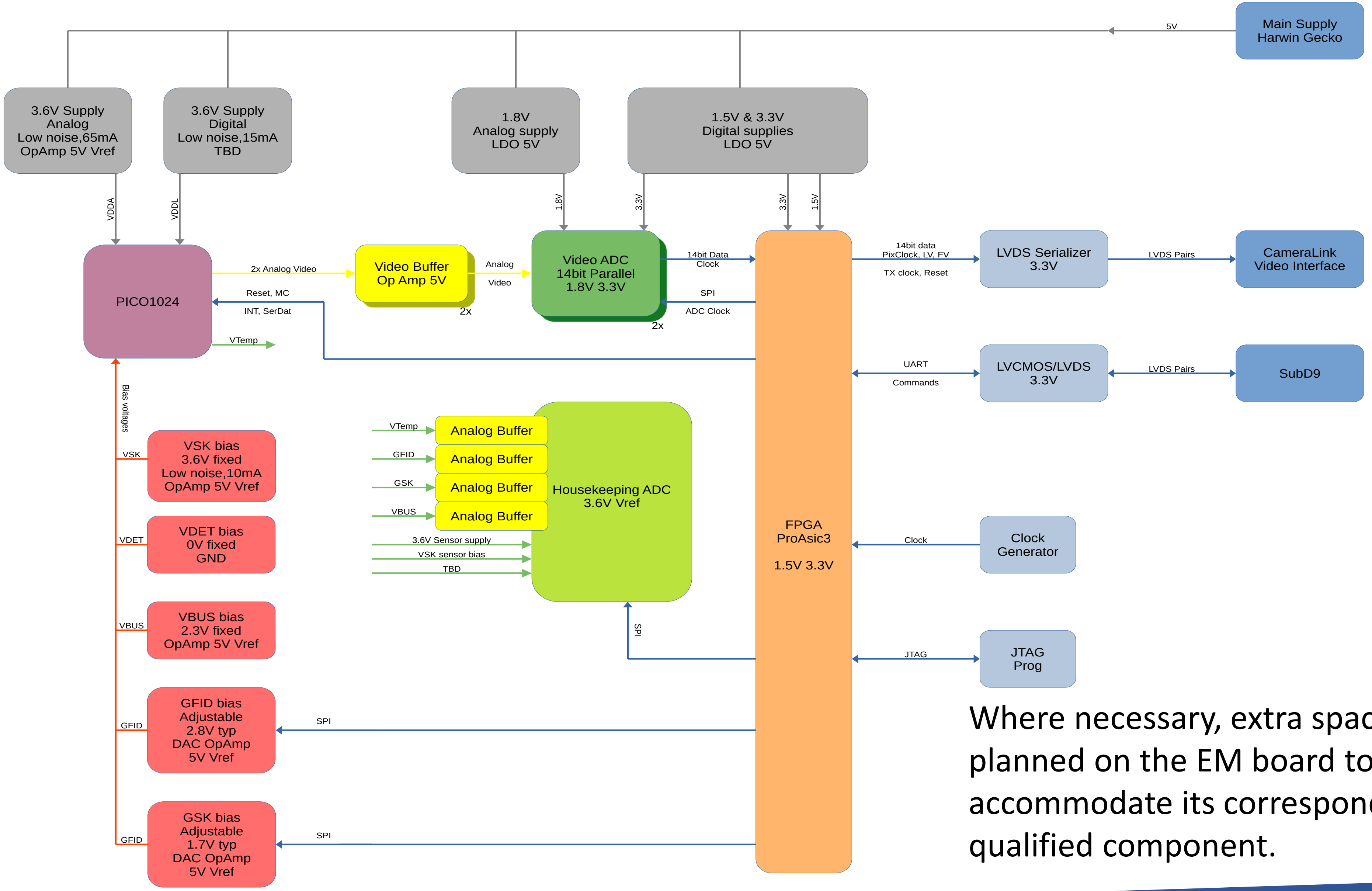


Figure 3.1 – Power supplies - Noise density

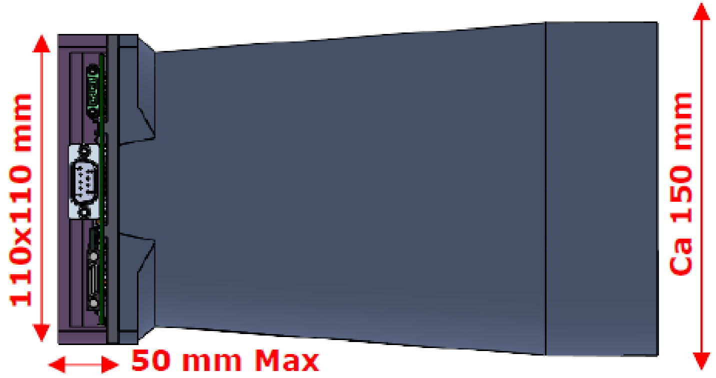
VDET can be connected to ground if the noise between Gfid and Ground is lower than 100µV

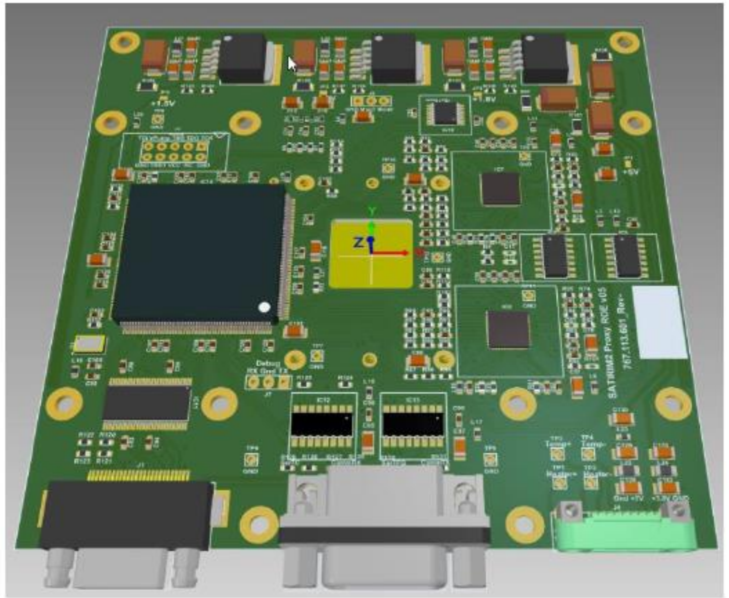
SATIRIM 2 – Phase 2: ROE EM Design

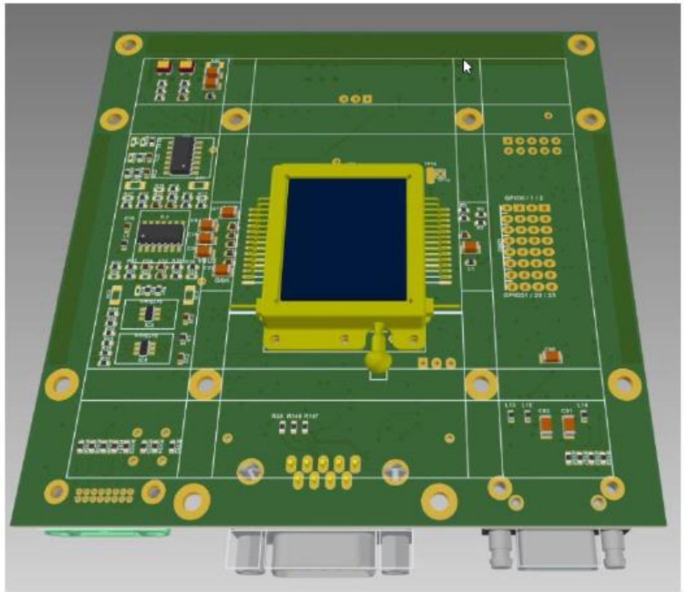


Where necessary, extra space has been planned on the EM board to accommodate its corresponding flight-qualified component.

SATIRIM 2 – Phase 2: ROE EM Design







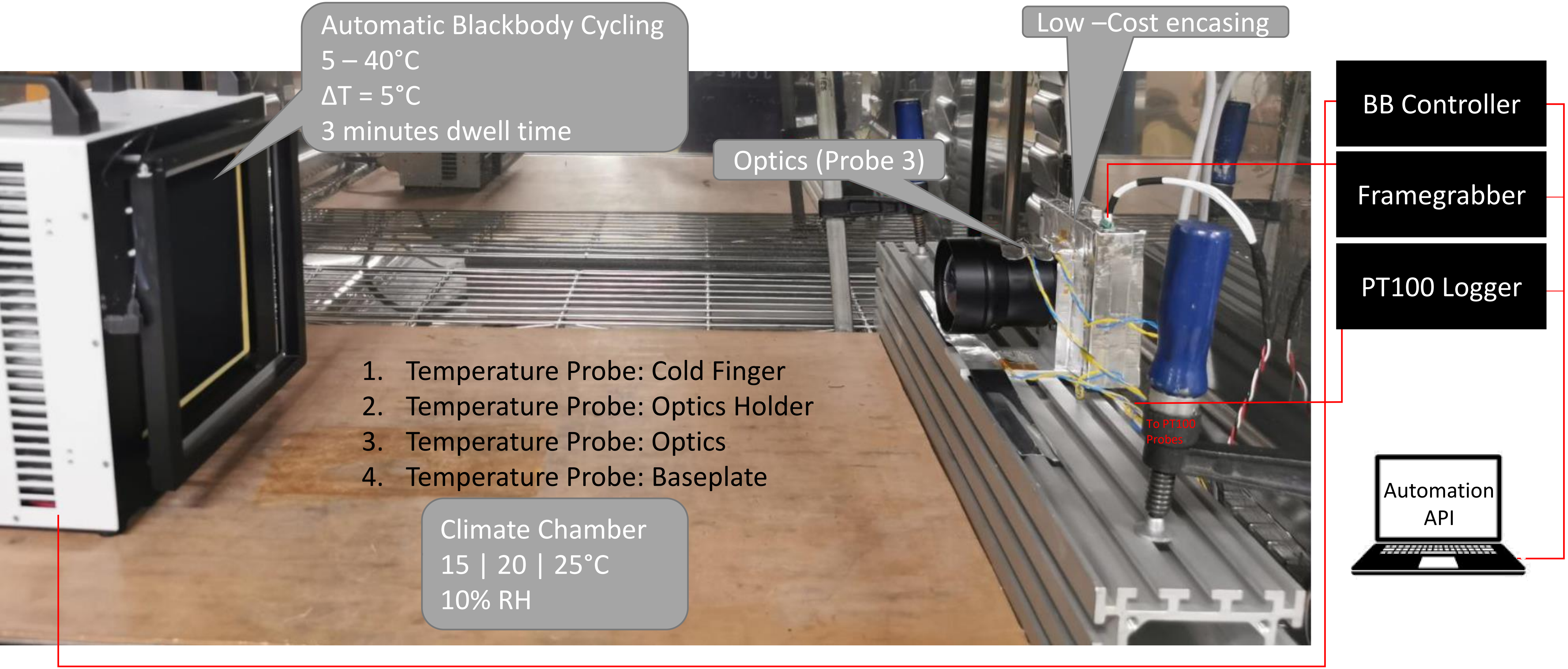
SATIRIM 2 – Phase 2: Test Plan

Stand alone testing of proxy ROE

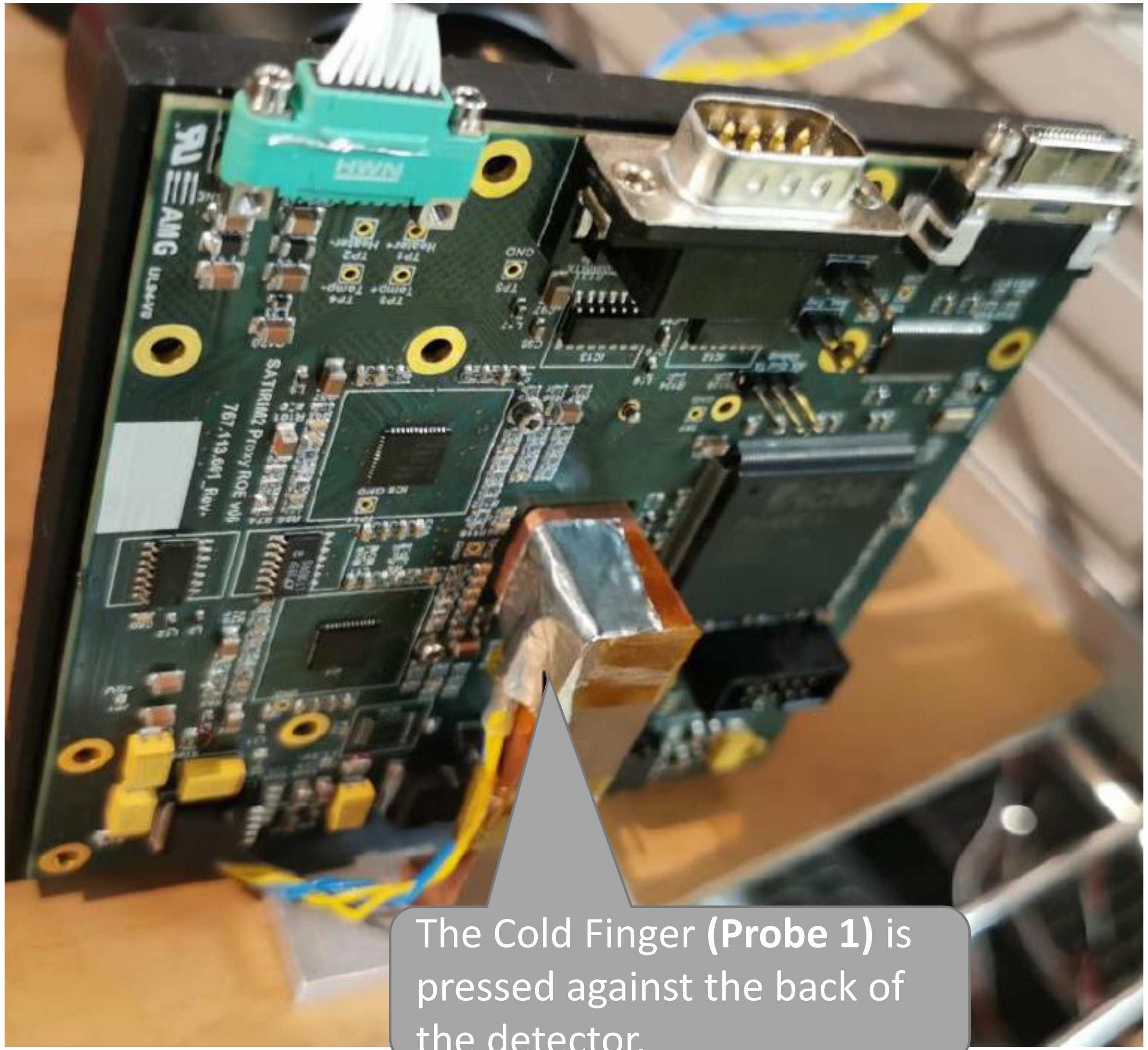
System evaluation

- Evaluate the system performance at different temperatures and gains
  - A noise pattern was observed during SATIRIM 2 Phase 1, which could be caused by the COTS ROE.
- Compare the data with the data from phase 1
- Identify optimal gain settings
- Evaluate repeatability
- An additional test was performed in an EMC chamber:
  - External noise sources will be eliminated or greatly reduced
  - The noise structure will be compared to the ones retrieved in the climate chamber

SATIRIM 2 – Phase 2: Test Setup

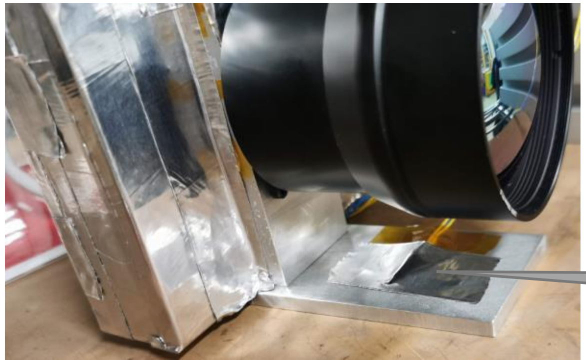


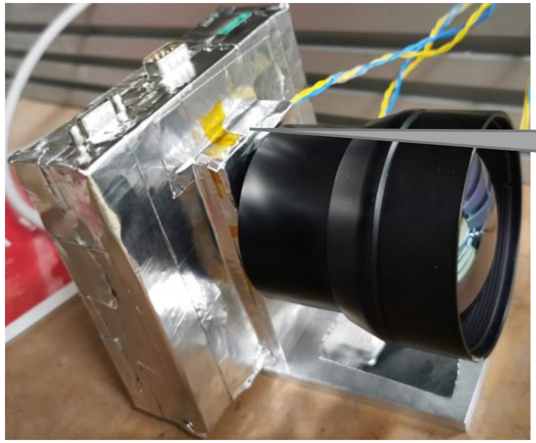
SATIRIM 2 – Phase 2: Test Setup – Cold Finger



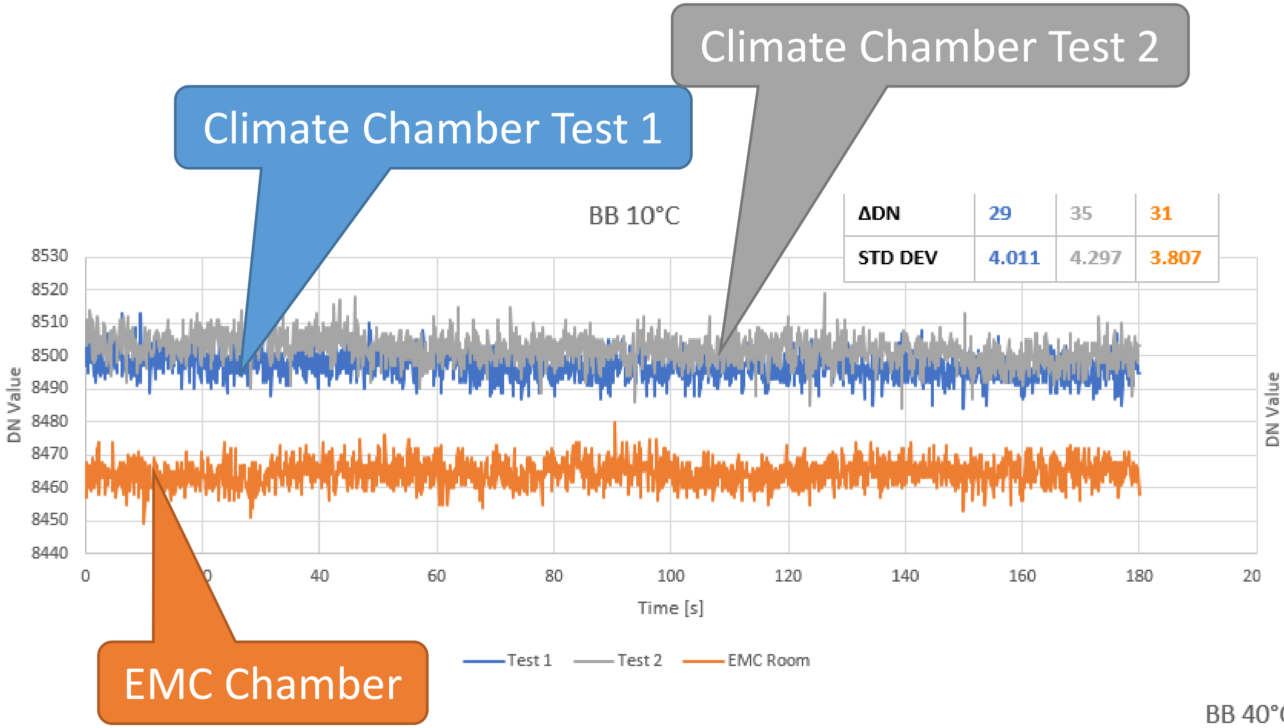
A “Cold Finger” is installed on the back of the detector.

- It is rigidly connected to the baseplate, which allows it to dissipate heat effectively.
- The system does not have active temperature control

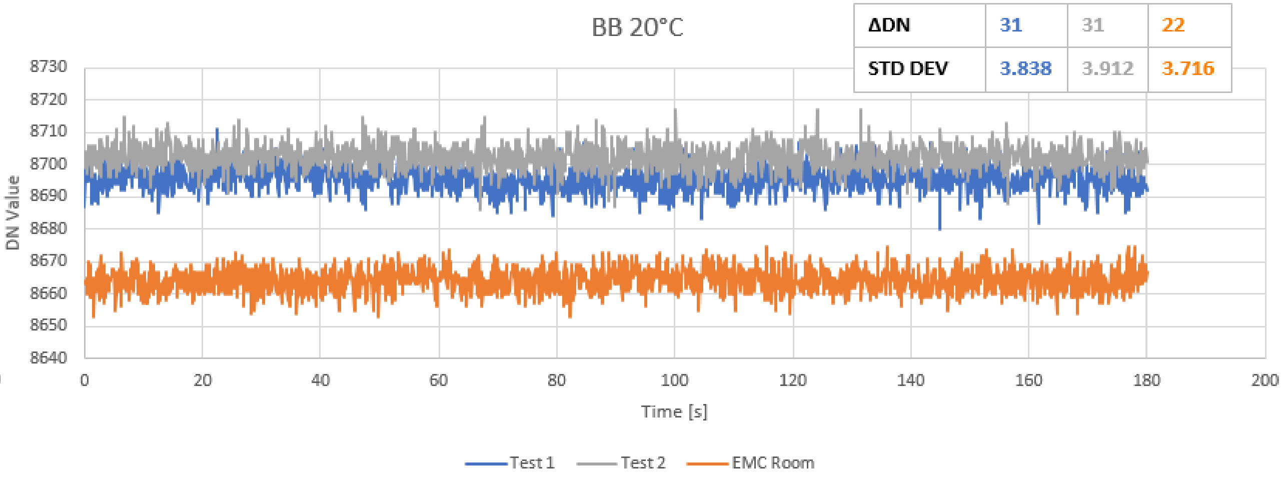




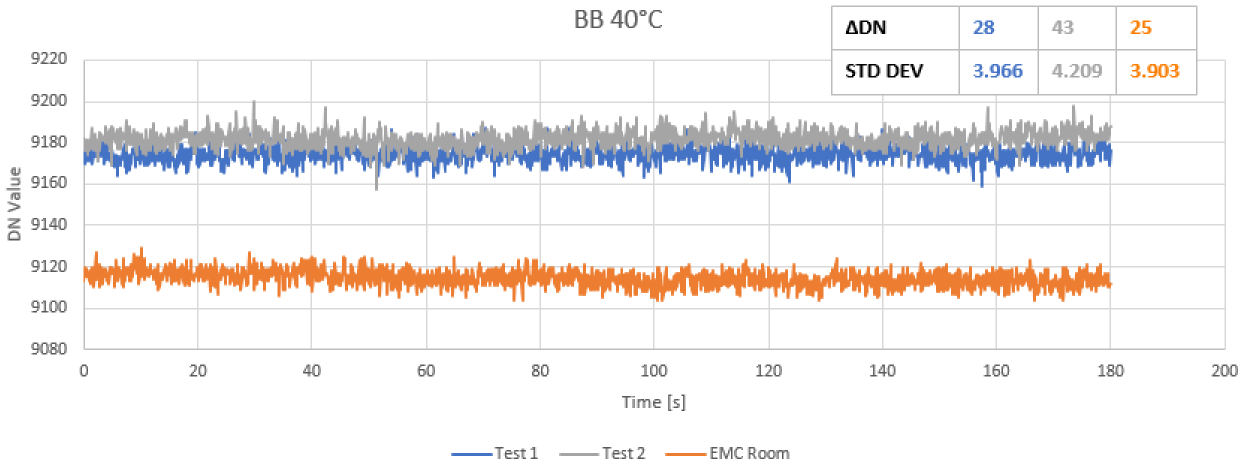
SATIRIM 2 – Phase 2: Test Results – EMC Chamber Test



ΔDN	29	35	31
STD DEV	4.011	4.297	3.807



ΔDN	31	31	22
STD DEV	3.838	3.912	3.716



ΔDN	28	43	25
STD DEV	3.966	4.209	3.903

SATIRIM 2 – Phase 2: Test Results – EMC Chamber Test

EMC chamber test conclusion:

- No significant differences in noise were identified when compared to tests conducted in a climate chamber. This suggests that there are no major noise sources active during climate chamber testing.
- Tests were conducted for baseband temperature (BB T) values of 10°C, 20°C, and 40°C.
- Comparative curves will be presented in the following slide for further analysis and discussion

The EMC chamber does not have active temperature control. Despite this, the temperature managed to remain relatively stable at 22°C.

The test data from the EMC chamber is compared with the data obtained from a climate chamber maintained at 20°C.

SATIRIM 2 – Phase 2: Test Results – Phase 1/2 Performance Comparison

SATIRIM 2 Phase 1

BB T	Phase 1: TCH = 20°C | T_{int} = 40.392µs | Gain = 1.25			
	STD DEV - Central Pixel		STD DEV - Central Pixel: 16 stacked frames	
	STD DEV in ΔDN	STD DEV in ΔT	STD DEV in ΔDN	STD DEV in ΔT
5	16.316	0.173	12.714	0.133
20	21.188	0.224	18.627	0.196
40	15.792	0.167	11.860	0.125

STD DEV at pixel level

STD DEV using frame stacking

SATIRIM 2 Phase 2
Test 1 (Test 2)

BB T	Phase 2 – Test 1 (Test 2): TCH = 20°C | T_{int} = 40.36µs | Gain = 1.25			
	STD DEV - Central Pixel		STD DEV - Central Pixel: 16 stacked frames	
	STD DEV in ΔDN	STD DEV in ΔT	STD DEV in ΔDN	STD DEV in ΔT
5	4.020 (4.142)	0.186 (0.192)	1.659 (1.708)	0.075 (0.077)
20	3.838 (3.912)	0.178 (0.181)	1.412 (1.195)	0.064 (0.054)
40	3.966 (4.209)	0.184 (0.195)	1.313 (1.814)	0.059 (0.082)

SATIRIM 2 – Phase 2: Test Results – Phase 1/2 Performance Comparison

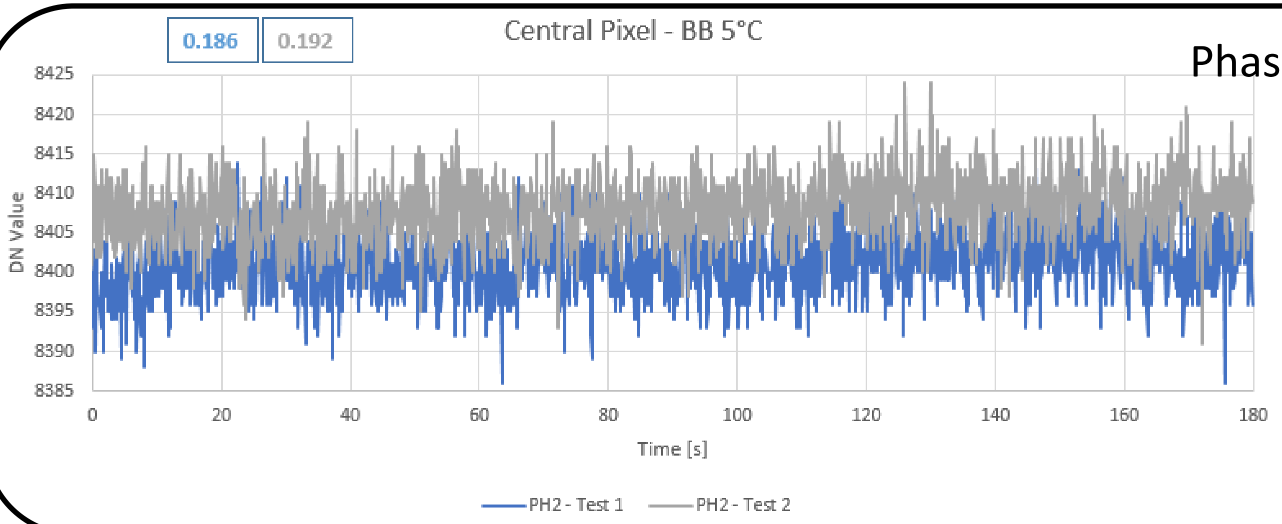
Method	NETD	
	Phase 1	Phase 2 - Test 1 (Test 2)
Central Pixel	0.168	0.181 (0.189)
Central Pixel - 16 Stacked Frames	0.128	0.067 (0.080)

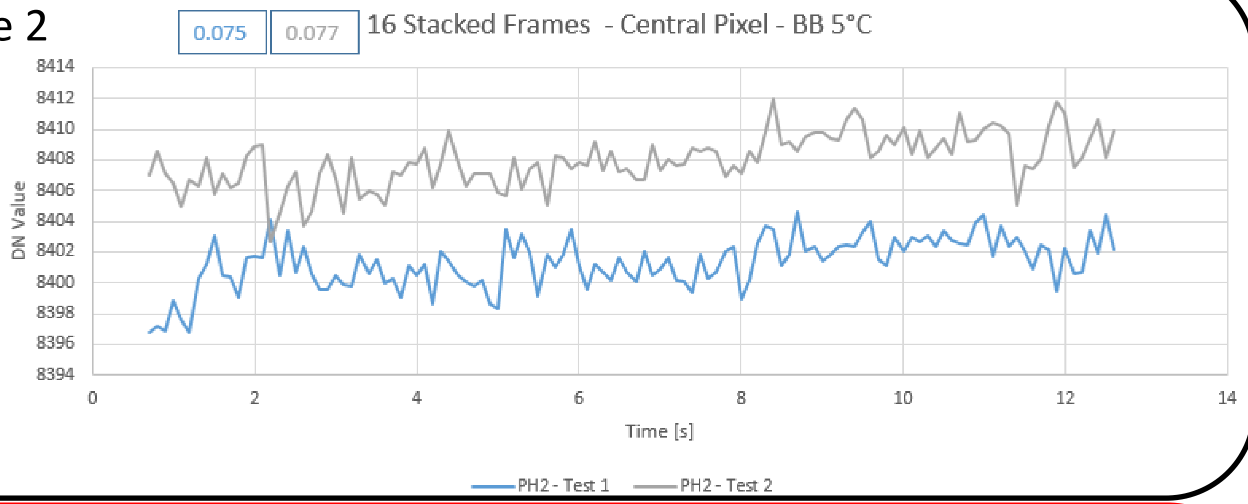
STD DEV at pixel level

STD DEV at pixel level using frame stacking

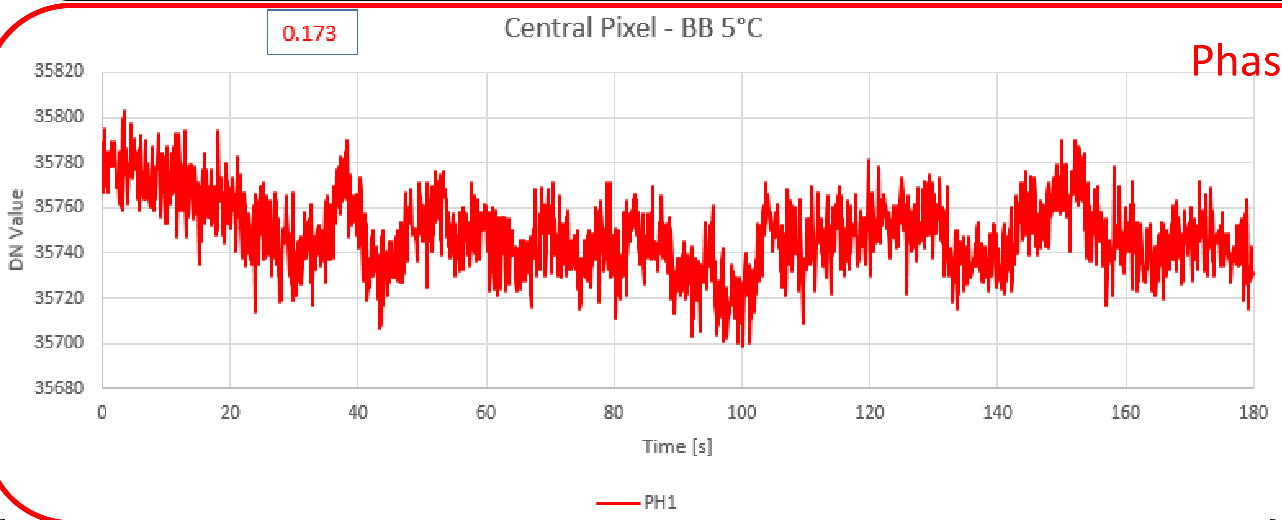
SATIRIM 2 – Phase 2: Test Results – Phase 1/2 Performance Comparison

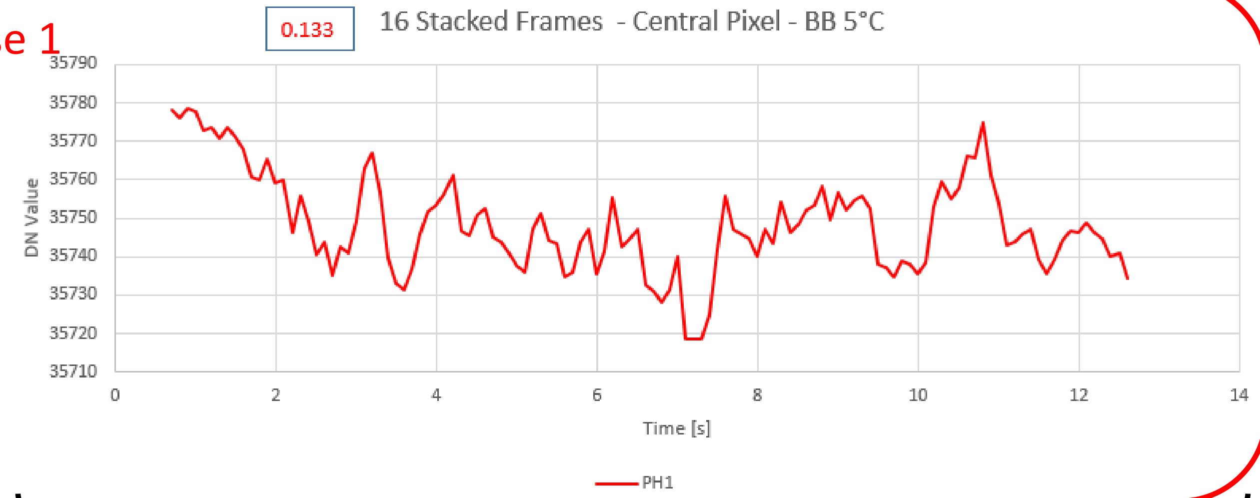
Phase 2





Phase 1



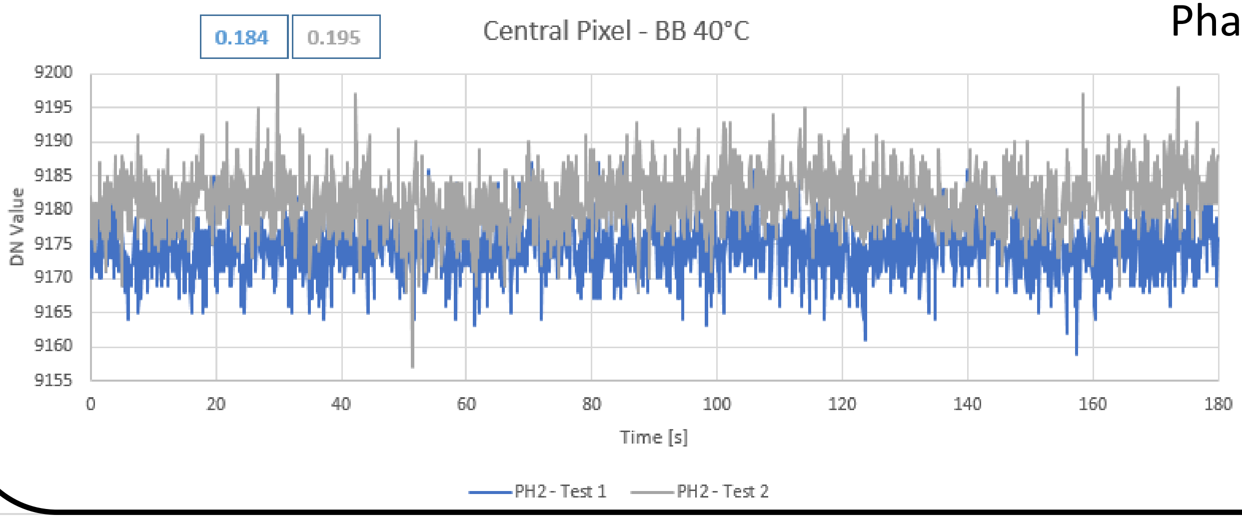


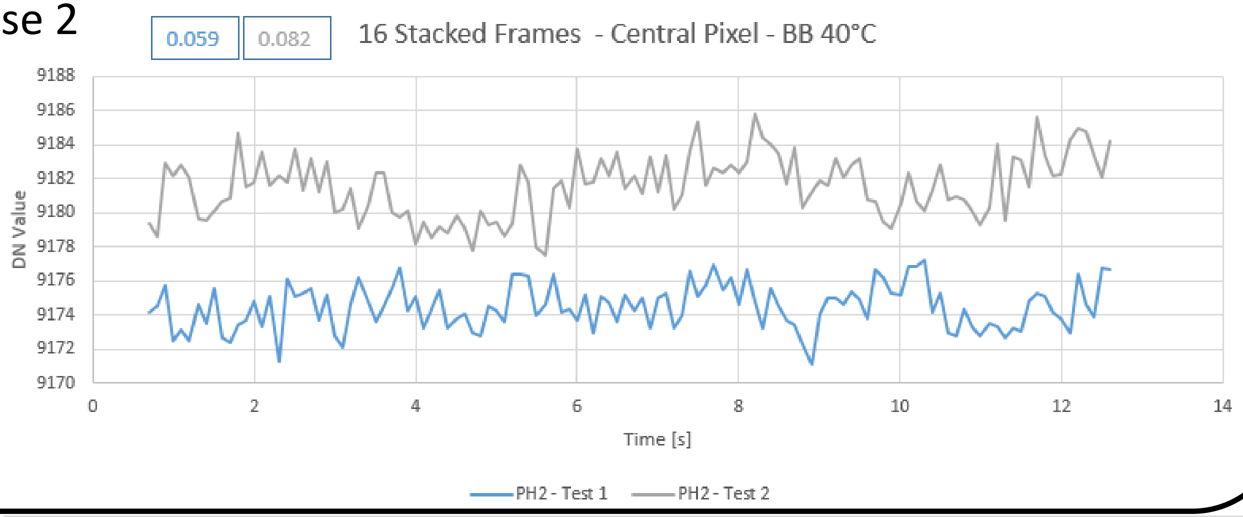
Central pixel

Central pixel using frame stacking

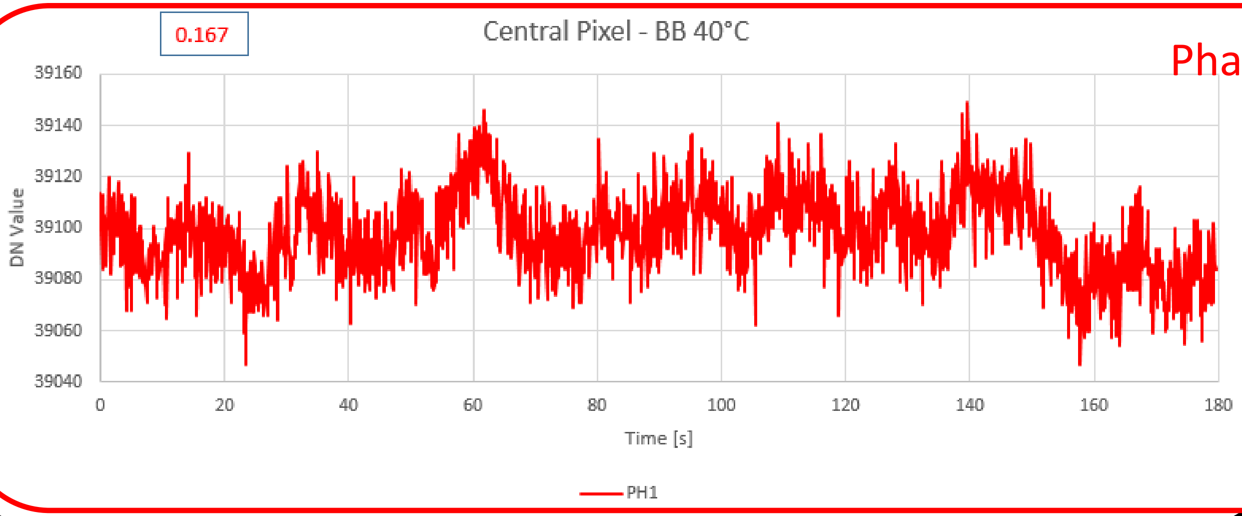
SATIRIM 2 – Phase 2: Test Results – Phase 1/2 Performance Comparison

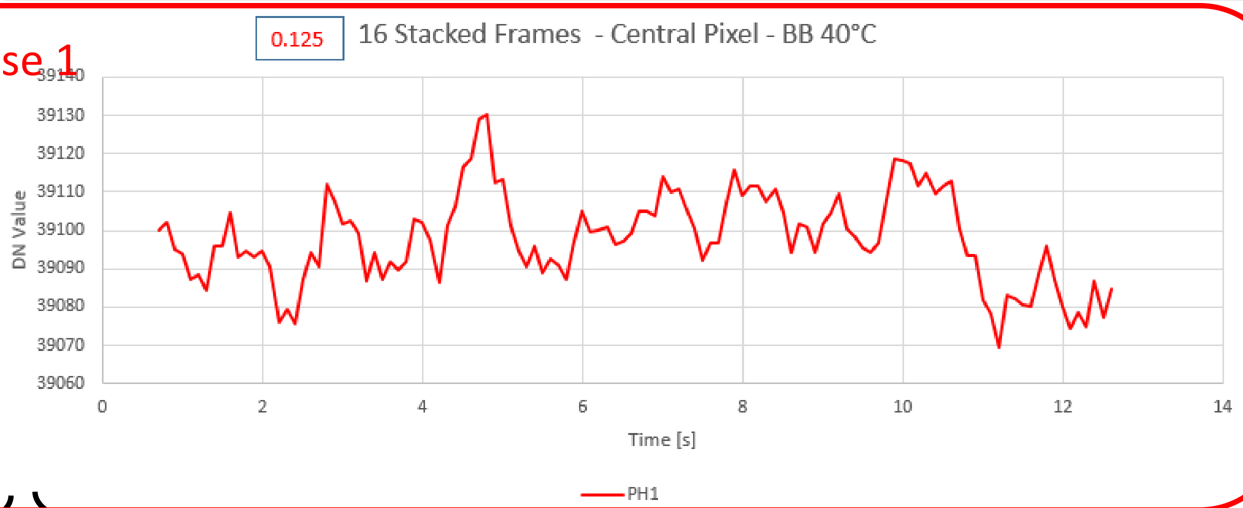
Phase 2





Phase 1





Central pixel

Central pixel using frame stacking

Phase 1/2 Performance Comparison conclusion

- Upon observing the noise signal for a single pixel, the following can be noted:
  - During Phase 2, there is an increase in high-frequency noise, but a decrease in low-frequency noise.
  - This observation leads to a higher standard deviation and a higher Noise Equivalent Temperature Difference (NETD) for Phase 2.
- When frame stacking is applied, the following observations can be made:
  - The noise is significantly reduced for Phase 2 data.
  - The noise remains almost unchanged for Phase 1 data.
  - As a result, the performance during Phase 2 is significantly better than during Phase 1.
  - Since frame stacking will be applied during flight, the Engineering Model Readout Electronics (EM ROE) is expected to perform better.

SATIRIM 2 – Phase 2: Test Results – Gain Optimalization

Name	Temperature Settings [°C] Climate Chamber	Temperature Settings [°C] Blackbody	GSK DAC Settings	Relative Gain	S_T	16 Frames S_T	Measured Temperatures [°C] P1 AVG	P1 ΔT	P2 AVG	P2 ΔT	P3 AVG	P3 ΔT	P4 AVG	P4 ΔT	FPA AVG	FPA ΔT	NETD	16 Frames NETD
OPT-0_CH15	15	5	1745	1.25	179.619	71.888	18.629	0.021	16.164	0.024	16.519	0.039	15.906	0.055	21.034	0.121	0.195	0.086
		20	1745	1.25	205.924	112.249	18.652	0.026	16.192	0.029	16.542	0.027	15.924	0.066	21.059	0.047		
		40	1745	1.25	199.498	74.749	18.661	0.023	16.186	0.020	16.542	0.023	15.919	0.021	21.061	0.019		
OPT-0_CH20	20	5	1745	1.25	187.980	76.597	23.561	0.050	21.133	0.085	21.482	0.071	20.917	0.067	25.950	0.149	0.212	0.120
		20	1745	1.25	261.211	196.811	23.616	0.032	21.190	0.037	21.532	0.028	20.914	0.068	25.986	0.000		
		40	1745	1.25	186.955	87.184	23.629	0.021	21.170	0.025	21.523	0.025	20.897	0.026	25.986	0.009		
OPT-0.1_CH25	25	5	1745	1.25	189.836	74.673	28.489	0.059	26.074	0.103	26.422	0.080	25.886	0.088	30.906	0.075	0.214	0.121
		20	1745	1.25	254.375	189.976	28.565	0.044	26.175	0.036	26.526	0.054	25.927	0.034	30.928	0.131		
		40	1745	1.25	197.821	97.650	28.613	0.033	26.211	0.033	26.566	0.040	25.950	0.030	31.050	0.056		
OPT-2_CH15	15	5	1800	2.3	143.911	71.509	18.638	0.021	16.177	0.029	16.529	0.034	15.925	0.052	21.047	0.093	0.150	0.077
		20	1800	2.3	151.224	83.914	18.666	0.027	16.211	0.028	16.559	0.026	15.948	0.050	21.061	0.019		
		40	1800	2.3	154.258	76.655	18.682	0.018	16.210	0.017	16.564	0.029	15.945	0.031	21.062	0.009		
OPT-1_CH20	20	5	1800	2.3	169.297	109.113	23.535	0.051	21.117	0.086	21.464	0.080	20.904	0.075	25.860	0.131	0.189	0.129
		20	1800	2.3	236.816	198.166	23.596	0.031	21.178	0.035	21.521	0.027	20.903	0.076	25.984	0.047		
		40	1800	2.3	160.173	80.718	23.610	0.019	21.156	0.029	21.510	0.021	20.886	0.022	25.986	0.009		
OPT-1.0_CH25	25	5	1800	2.3	173.284	117.382	28.454	0.055	26.053	0.096	26.399	0.095	25.860	0.084	30.862	0.149	0.200	0.146
		20	1800	2.3	257.049	224.139	28.528	0.039	26.130	0.037	26.476	0.036	25.884	0.058	30.911	0.019		
		40	1800	2.3	168.691	96.964	28.556	0.027	26.109	0.028	26.464	0.030	25.862	0.027	30.911	0.019		
OPT-3_CH15	15	5	1831	4.1	123.793	54.380	18.639	0.025	16.174	0.017	16.530	0.023	15.919	0.065	21.048	0.093	0.133	0.065
		20	1831	4.1	139.701	84.993	18.663	0.027	16.204	0.023	16.554	0.034	15.937	0.058	21.060	0.028		
		40	1831	4.1	134.826	56.365	18.675	0.021	16.199	0.024	16.552	0.031	15.932	0.027	21.061	0.009		
OPT-3.1_CH20	20	5	1831	4.1	173.983	133.600	23.565	0.045	21.137	0.076	21.481	0.070	20.919	0.064	25.914	0.149	0.166	0.115
		20	1831	4.1	181.273	140.710	23.614	0.028	21.192	0.032	21.535	0.027	20.917	0.064	25.986	0.019		
		40	1831	4.1	142.301	71.270	23.627	0.022	21.171	0.029	21.522	0.027	20.898	0.030	25.986	0.009		
OPT-2.0_CH25	25	5	1831	4.1	192.244	151.013	28.492	0.058	26.087	0.096	26.434	0.097	25.895	0.085	30.904	0.093	0.185	0.138
		20	1831	4.1	211.363	175.930	28.571	0.039	26.169	0.037	26.518	0.027	25.916	0.061	30.914	0.056		
		40	1831	4.1	150.553	86.433	28.598	0.021	26.147	0.031	26.506	0.031	25.898	0.028	30.934	0.103		

S_T: Standard deviation expressed in Temperature [mK]

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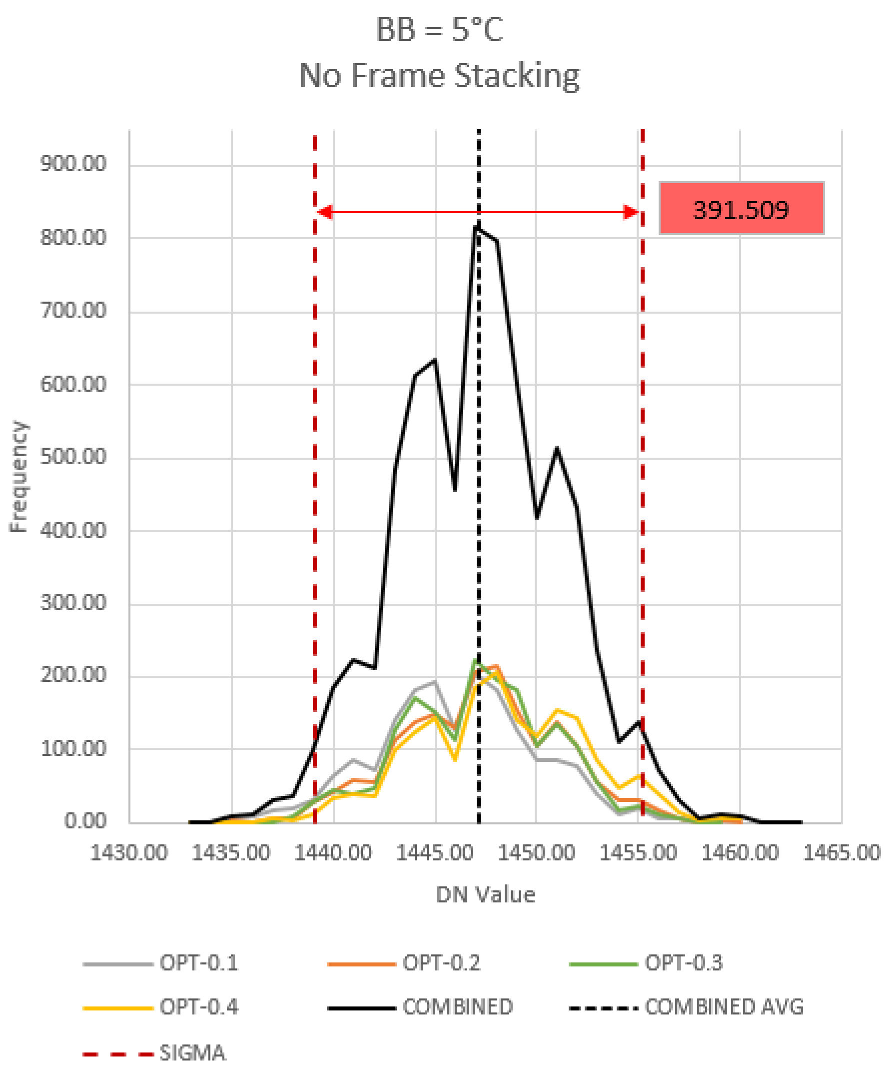
Gain Optimalization conclusion

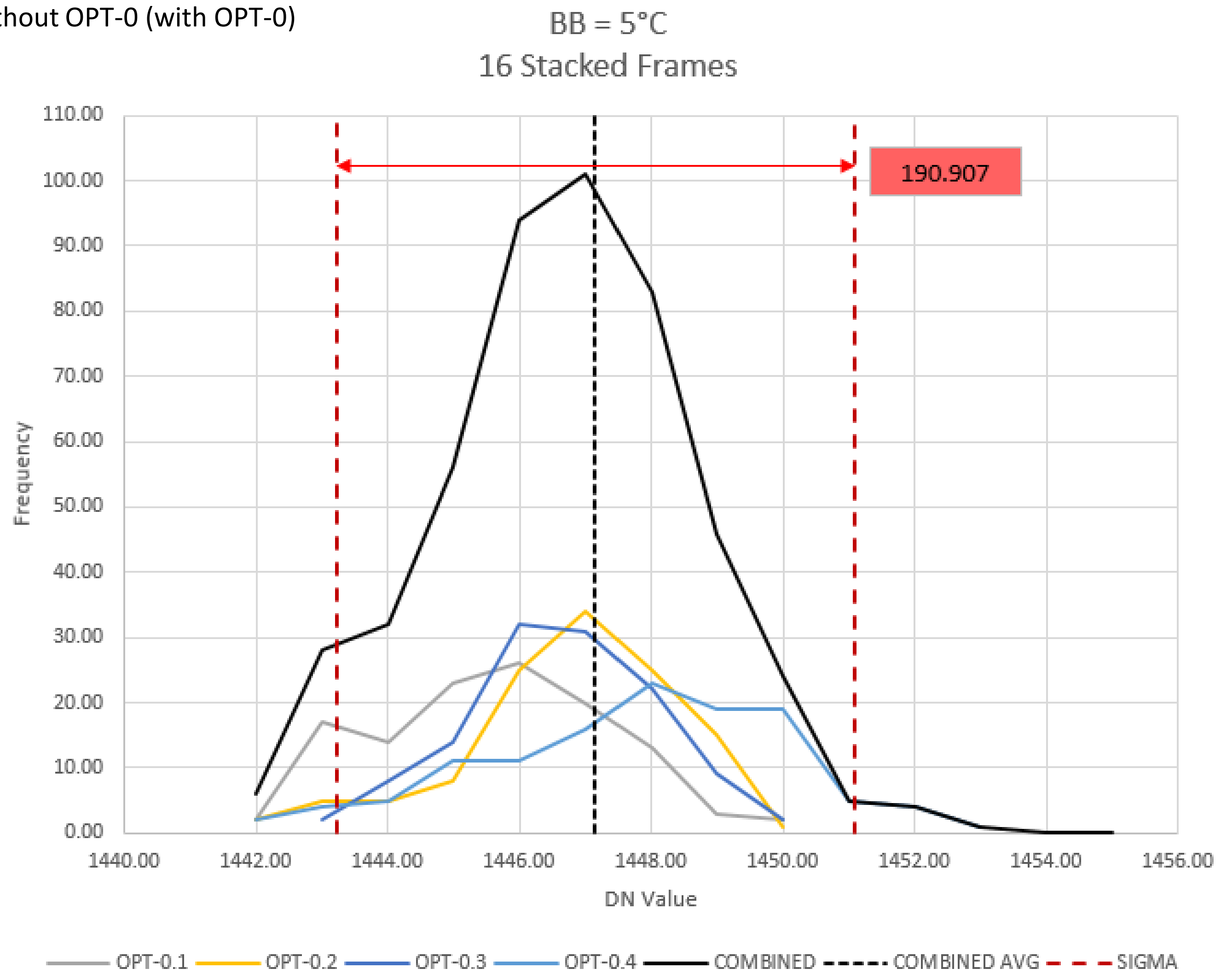
- The NETD is at its lowest across all climate chamber temperatures when a maximum gain of 4.1 is applied.
- The NETD is also at its lowest when the Focal Plane Array (FPA) temperature is at its lowest.
- A heating effect due to the blackbody can be gleaned by observing the PT100 probes: the temperatures increase slightly as the blackbody is set to a higher temperature.
- The temperature increase in the climate chamber (5°C) aligns with the temperature increase observed in the PT100 and FPA.

SATIRIM 2 – Phase 2: Test Results – Repeatability



<u>BB = 5°C: 2σ values</u>

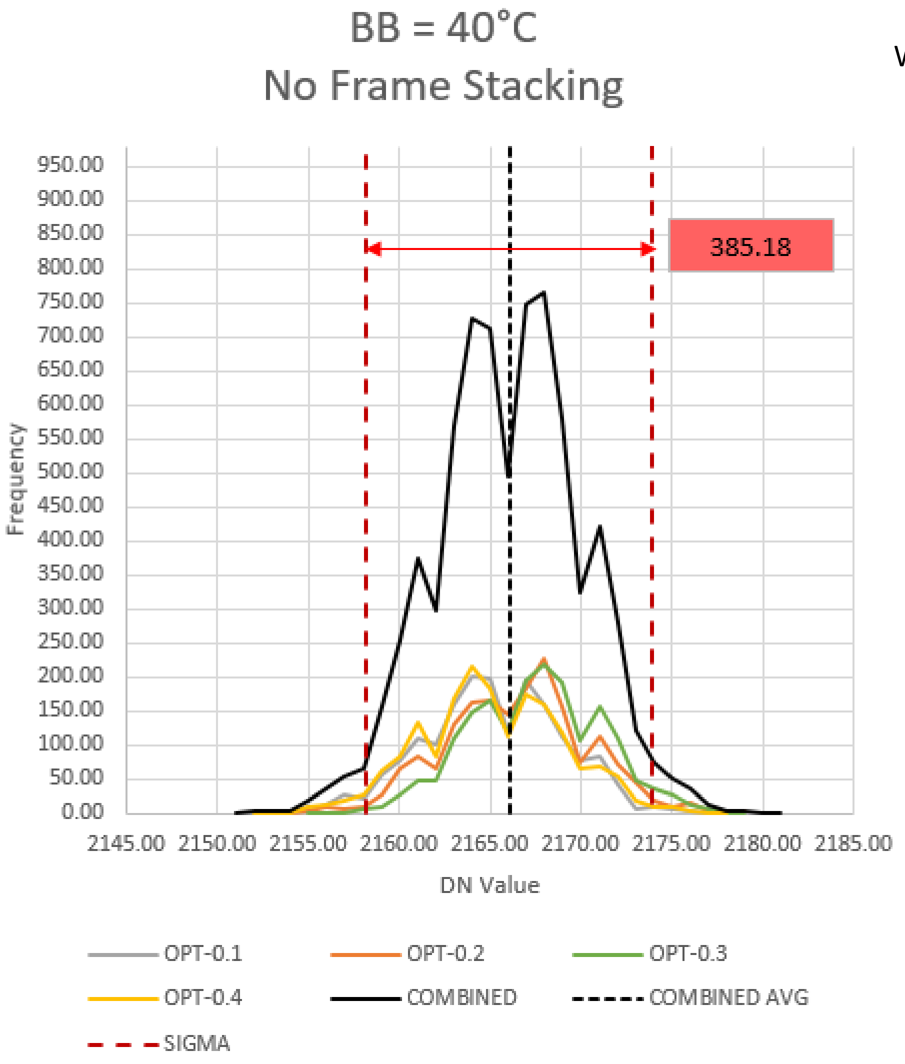
Without OPT-0 (with OPT-0)

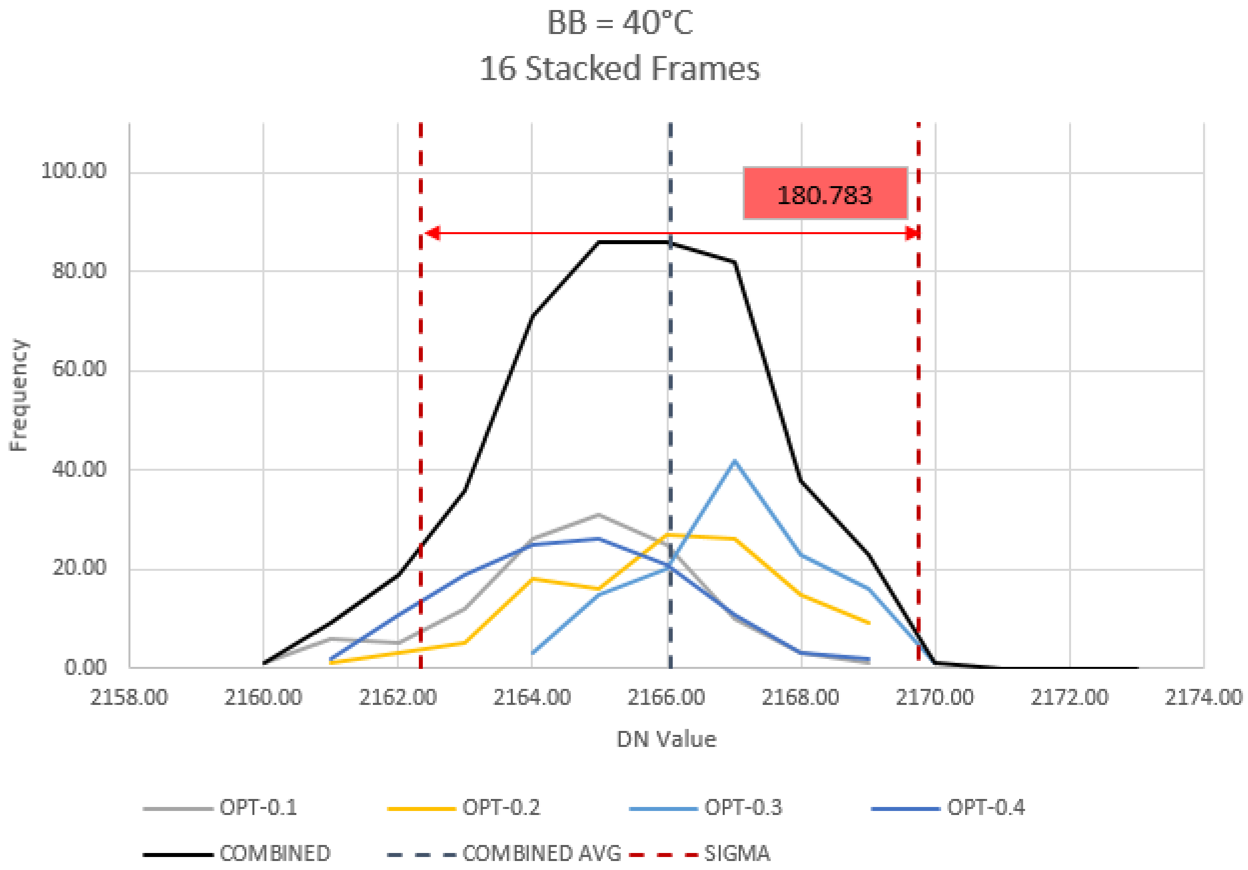


- Central Pixel: ΔT = 391 mK (423 mK)
- Central Pixel with frame stacking: ΔT = 191 mK (250 mK)

SATIRIM 2 – Phase 2: Test Results – Repeatability

BB = 40°C: 2σ values
Without OPT-0 (with OPT-0)





- Central Pixel: ΔT = 385 mK (398 mK)
- Central Pixel with frame stacking: ΔT = 181 mK (211 mK)

SATIRIM 2 – Phase 2: Test Results – Repeatability

Repeatability conclusion

- The maximum 2σ repeatability for a single pixel is 0.554°C.
- When frame stacking is applied, the maximum 2σ repeatability for a single pixel improves to 0.436°C.
- Both maximum repeatabilities were observed at TCH = BBT = 20°C, although this was anticipated to occur at BBT = 40°C.
- Distorted histograms were observed. The cause of this distortion is to be investigated during the next phase.
- Despite these issues, the repeatability remains within acceptable limits.

SATIRIM 2: Other Documents

Two additional documents were made during this SATIRIM 2 project:

Instrument Specification

- For more detailed information, please refer to the next slide.

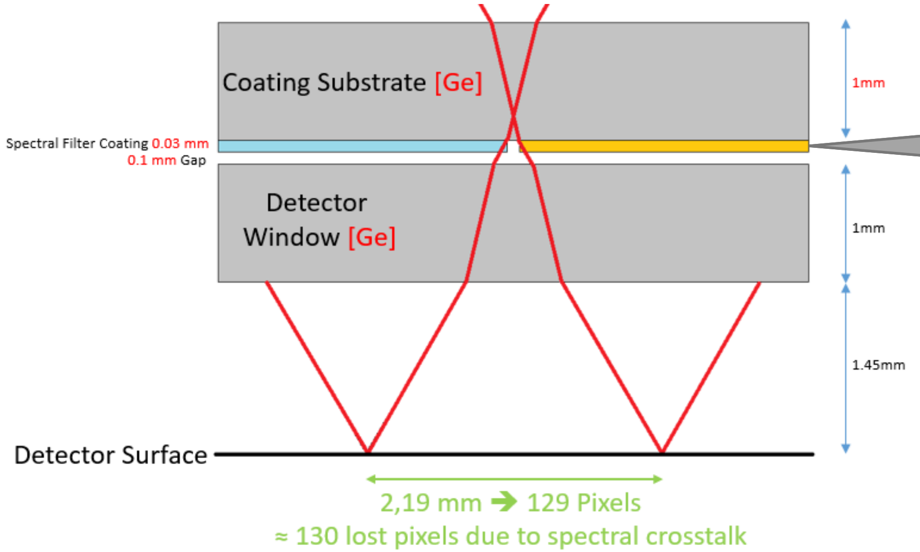
Theoretical Instrument Noise and Spectral Response Analysis

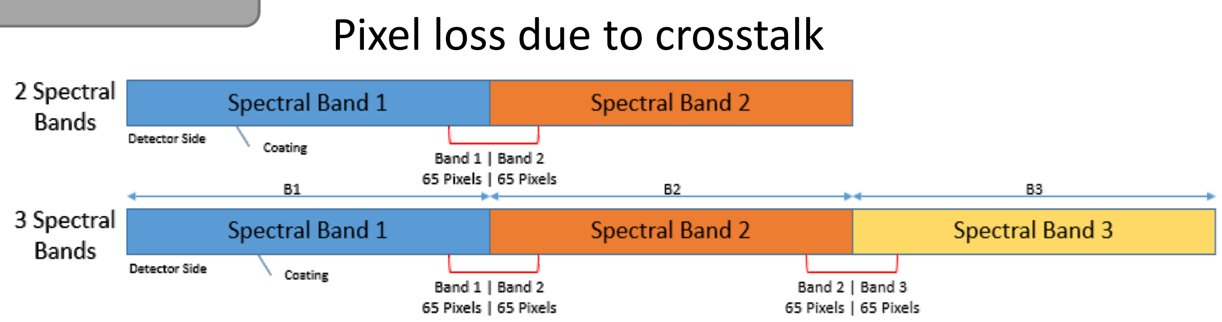
- Analysis conducted by Leicester University
- Selection of spectral filters (bandwidth and wavelength)

SATIRIM 2: Other Documents – Instrument Specification

Optical Concept Baseline

- **Detector:** PICO 1024 (Pixel Pitch = 17 µm) | GSD (Ground Sample Distance): 80m (goal) ➔ Focal Length (FL): 108 mm
- **Spectral Window:** To be placed on top of the detector window.
- **Unusable Pixels Due to Crosstalk:**
  - 2-Band System: Each band loses 65 pixels.
  - 3-Band System: Outer bands lose 65 pixels each.
  - Middle band loses 2x65 pixels.





Flight altitude within treshold limits: 495 – 635 km

SATIRIM 2: Overall Conclusion

- PICO 1024 Evaluation & Noise Signals
  - It has been confirmed that the target temperature can be accurately predicted within threshold limits
  - The camera system temperature shall be stabilized within at least ±1°C
  - Additionally, the dedicated ROE has successfully demonstrated improved performance through the use of frame stacking.
  - Switching off and on of the camera system is not recommended
  - The detector NETD agrees with the Lynred specification for a F/1 optical system (0.125K)
- Spectral Bands
  - A theoretical spectral analysis was conducted by Leicester University, confirming that a 0.9µm bandwidth should be sufficient.
- There can be concluded that all threshold requirements are met
  - 1.5K @ 300K | RMS value 300mK | NETD 0.5K

SATIRIM 2: Recomendations for next phase

Main Tasks

Spectral Filter:

- A 2-band spectral filter shall be manufactured for further fine tuning of the calibration model.

Calibration Model Development in TVAC Chamber:

- Calibration models shall be further developed in a Thermal Vacuum (TVAC) chamber.
- A blackbody with minimal dimensions of 7x7 inches (180x180mm) is recommended.
- The system shall be wrapped in MLI to reduce thermal effects to the environment.

Development of Dedicated Optical Holder and Housing:

- A dedicated optical holder and detector/ROE housing will be developed and machined to ensure stability and accuracy during testing.
- This structure shall be capable of holding and accurately aligning the detector (including proxy ROE) and optics, including the spectral window.
- The housing shall facilitate for monitoring the FPA temperature and shall be held stable to TBD °C ±1°C.

Further Automation of testing:

- **Test Execution:** Thermal stabilization is time-consuming, so all data should be captured automatically to improve efficiency.
- **Test Data Analysis:** An analysis should be performed for at least TBD pixels, both with and without frame stacking applied. This entire process shall be automated to ensure consistency and accuracy.

SATIRIM 2: Recommendations for next phase

Flight Model Development

Optical Design Refinement:

- The current optical design is still in its draft stage. This design will be fine-tuned and optimized during the next phase to ensure it meets the stringent requirements for flight.

Fast Steering Mirror (FSM) Risk Mitigation:

- Needed for step and stare: framestacking and counteract image smear
- One of the major open risks is the Fast Steering Mirror (FSM). To address this, the FSM will be derisked through a demonstration in the next phase, ensuring its reliability and performance in the final flight model.

SATIRIM: Added Value

Observational gap: TIR based applications with sufficient spatial resolutions and short revisit time

- Hence strong interest in SATIRIM camera for Smallsat constellations
- TIR camera can be used on institutional EO and SSA missions, both for civil and defense applications
- Interest from New Space companies to use OIP solutions:
  - Aerospacelab
  - ConstellR
  - Aistech
  - Orora Tech

Source: vito remote sensing

Satellite	Thermal bands	Revisit time	Spatial Resolution
Aster	5	16 days	90m
MODIS	16	Daily / 2-daily	1 km
LANDSAT 8	2	8 – 16 days	100 m
METEOSAT SG	8	15 minutes	3 km
SENTINEL-3 SLSTR	2	Daily	1 km

Satellite	Thermal bands	Revisit time	Spatial Resolution
SATIRIM	Threshold 2 Goal 3	Threshold 7 days Goal 1 days	80m

Use Cases: TIR for Space Situational Awareness

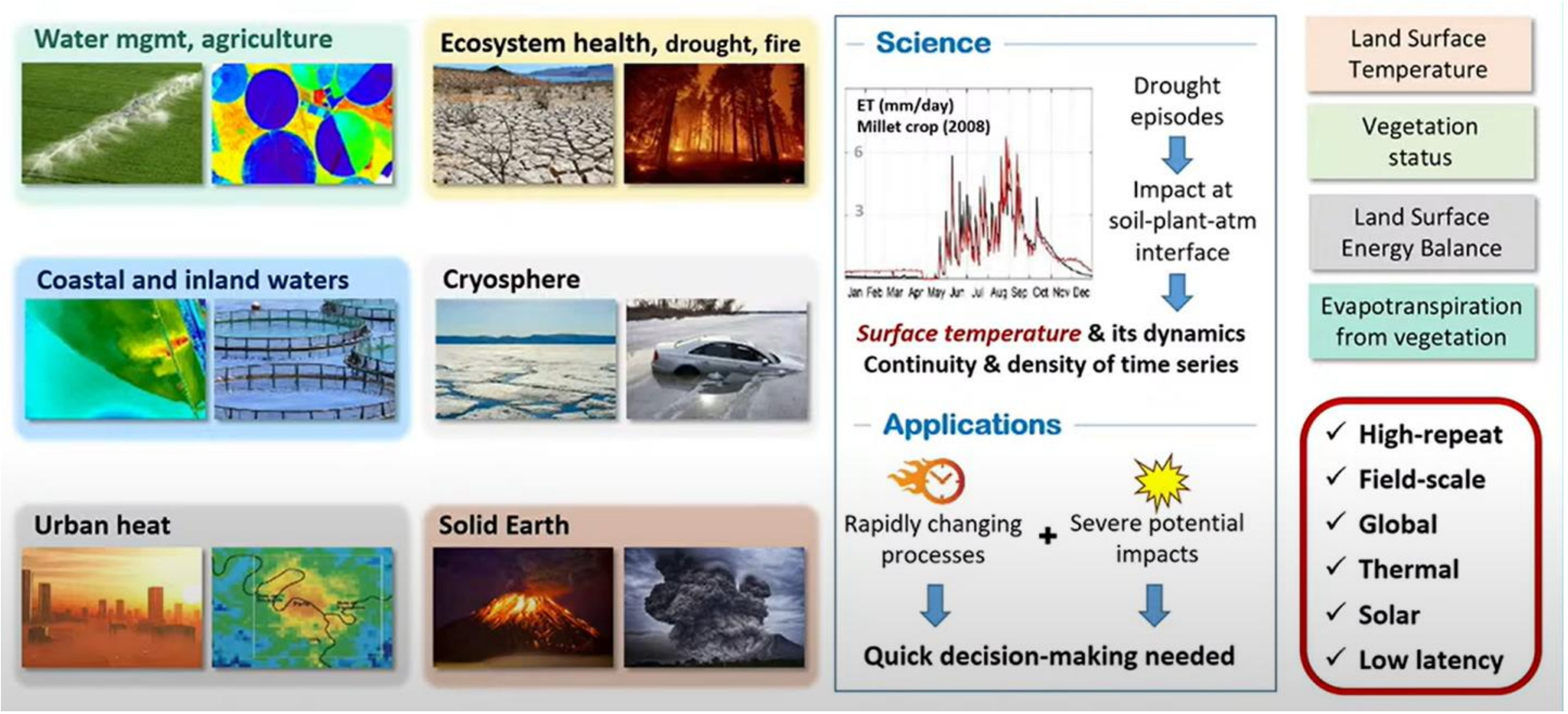
- Growing strategic importance of Space Situational Awareness (SSA)
  - Detection and characterization of Near-Earth Objects (NEOs) and space debris
  - Protection and resilience of strategic space assets

- Strategic initiatives at different levels
  - NATO Overarching Space Policy (2019)
  - EU Space Strategy for Security and Defense (2023)
  - Capability development within EDF and EDA Captech Space
  - ESA Vision 2025 (2021)
  - Belgium: relevant space based SSA contribution with national sensors

- Space based SSA needs TIR capabilities
  - Detection during night conditions
  - Detection of hot spots
  - Detection of exhausts

Use Cases: TIR for Earth Observation

- Large need for thermal data in multiple application domains, reinforced by changing climate
  - Strong interest at the ESA International Workshop on High-Resolution Thermal EO (2023)



Source: P. Gamet, CNES (Thermal EO conference 2023)

Use Cases: TIR for Earth Observation

Increased interest to monitor the Earth in the thermal window at high spatial resolution (<100m) for different applications:

Source: vito remote sensing

Applications Topics	Spatial resolution	Temporal resolution	Accuracy
Agriculture	< 50 m	Daily	1 K
Forestry / Vegetation	< 80 m	Daily	1 – 1.5 K
Water applications	< 100 m	Daily	1 K
Natural hazards			
- Wild fires	100 m	Daily	-
- Coalmine fires	<100 m	weekly	-
- Thermal anomalies	>500 m	monthly	< 1 K
Permafrost	50 m	Weekly – monthly	1 K
Urban Heat Island	50 m	Daily -monthly	1-2 K

Dynamic range: 270 to 350 K, with extension to 248 K for cryosphere

OID Mission Plan – Timeline Objectives

Objective

- Develop a thermal infrared camera to enable Earth observation with a focus on land surface temperature monitoring, agricultural health assessment, and environmental monitoring.

Development Duration

- 2 years
- Phase B2 – 8 Months
- Phase C/D – 16 months

Project Phases: B2 /C/ D

- Conceptual Design, Development, Integration, Testing, Launch, and Operation.

Approach

- OIP Tailored ESA ECSS methodology, optimized for New Space development.

SATIRIM for IOD – continuation contract

- **Objective:** Our aim is to engineer a compact and cost-effective Thermal Infrared (TIR) camera, adhering to the "New Space" principles, for deployment in small satellite constellations. This camera will be utilized in In-Orbit Demonstration (IOD) missions.

- **Work Plan:**

  - **WP 1x00:** Comprehensive design and analysis of the TIR camera, which includes:
    - Optical Design
    - Mechanical Design
    - Thermal and Structural Design
    - Electrical and Firmware Design
  - **WP 2000:** Engineering Model (EM) Development
  - **WP 3000:** Proto-Flight Model (PFM) Development
  - **WP 4000, 5000, 6000:** System Engineering, Product Assurance, and Project Management

SATIRIM for IOD – continuation contract

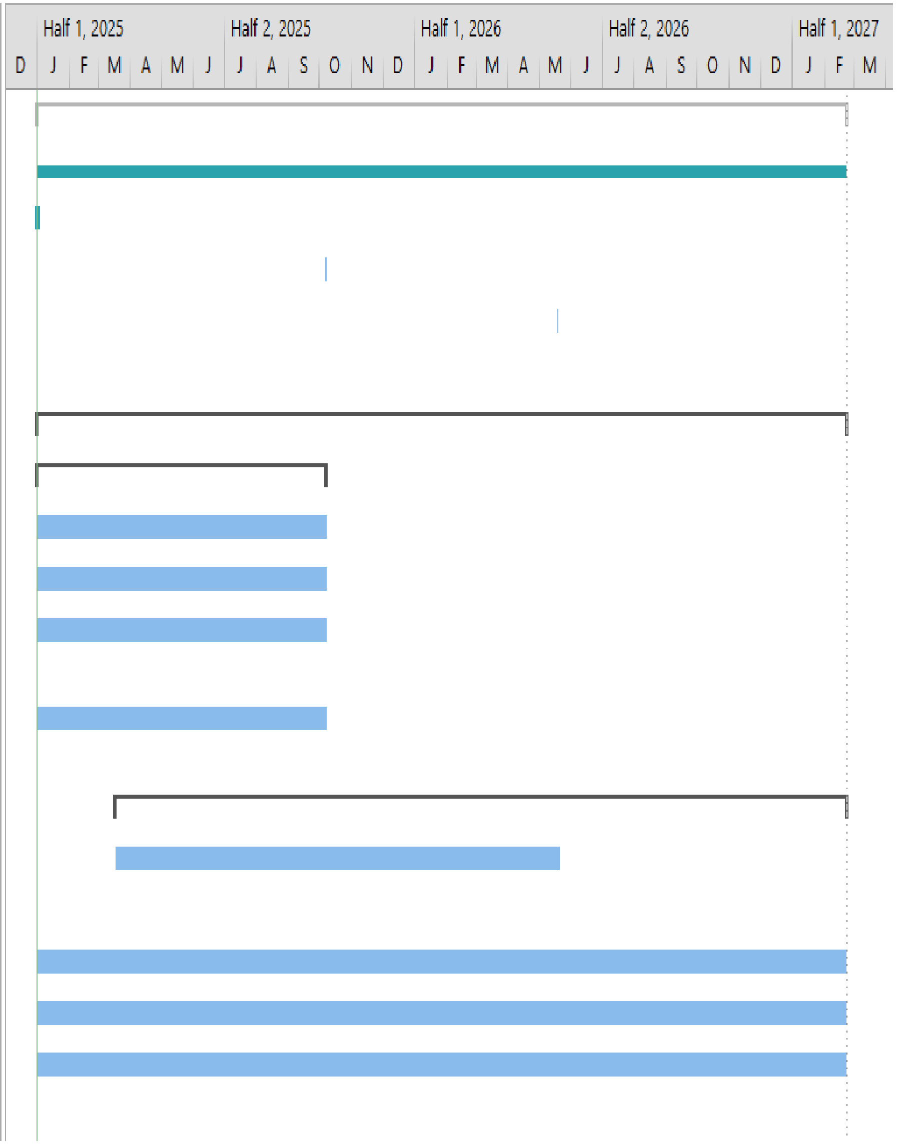
- **Key Assumptions:**
    - The development will follow the New Space approach (details to be determined).
    - Major technical risks will be mitigated during an additional phase under a Contract Change Notice (CCN).
    - The baseline design will be derived from the current SATIRIM2 project phase.

- **Budget and Costing:**
    - The Rough Order of Magnitude (ROM) budget is estimated to be discussed. This is subject to the New Space tailoring approach and will be finalized in agreement with the European Space Agency (ESA).
  - **Exclusions:** The budget does not cover the IOD Spacecraft (S/C) platform, launch, and ground processing.
  - **Inclusions:** The budget includes a service contract for VITO, which covers requirements definition and test & calibration support.
  - **Subcontractors:** There is no requirement for subcontractors in this project.

SATIRIM IOD – Timeline continuation contract

GANTT CHART

	WBS	Task Mode	Task Name	Start	Finish
0	**0**		**SATIRIM2 IOD Timeline**	**Wed 1/01/25**	**Mon 22/02/27**
1	**1**		**Milestones**		
2	1.1		Kick-off	Wed 1/01/25	Wed 1/01/25
3	1.2		PDR	Mon 6/10/25	Mon 6/10/25
4	1.3		CDR	Mon 18/05/26	Mon 18/05/26
5	1.4		FAR	Mon 22/02/27	Mon 22/02/27
6	**2**		**Tasks**	**Wed 1/01/25**	**Mon 22/02/27**
7	**1000**		**Design and Analysis**	**Wed 1/01/25**	**Mon 6/10/25**
8	1100		Optical design	Wed 1/01/25	Mon 6/10/25
9	1200		Mechanical design	Wed 1/01/25	Mon 6/10/25
10	1300		Therman and structural design	Wed 1/01/25	Mon 6/10/25
11	1400		Electrical and firmware design	Wed 1/01/25	Mon 6/10/25
12	**2000**		**Development and test**	**Mon 17/03/25**	**Mon 22/02/27**
13	2100		EM development and test	Mon 17/03/25	Tue 19/05/26
14	2200		PFM development and test	Mon 22/02/27	Mon 22/02/27
15	3000		System Engineering	Wed 1/01/25	Mon 22/02/27
16	4000		Product Assurance	Wed 1/01/25	Mon 22/02/27
17	5000		Project Management	Wed 1/01/25	Mon 22/02/27



Proposed development schedule:

- **Kick-off: January 2025**
- **PFM delivery: February 2027**
- **Launch IOD mission: end-2027 (TBD)**

Thank you for your attention

For more information:

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