

ANSER cluster - Resilience and innovation after one year in orbit

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Presenter:

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Instituto Nacional de Técnica Aeroespacial (INTA)

CubeSat Developers Workshop 2025

(Apr 2025)



Instituto
Nacional
de Técnica
Aeroespacial



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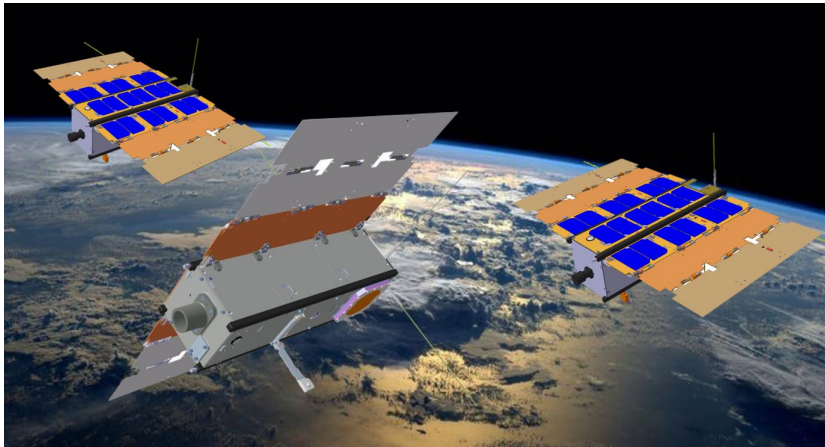
- The Small-Satellite Constellation Programme at INTA
- First Year of ANSER in Orbit
- Conclusions

The Small-Satellite Constellation Programme at INTA

ANSER[®] Programme

Today's talk

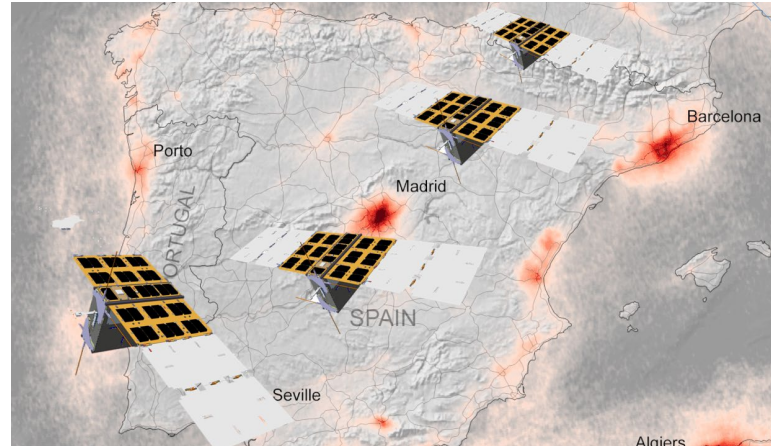
ANSER-WQ → Operational phase



ANSER-WQ (Water Quality)

- Monitoring of inland and coastal water quality
- Cluster of 3 x 3U CubeSats

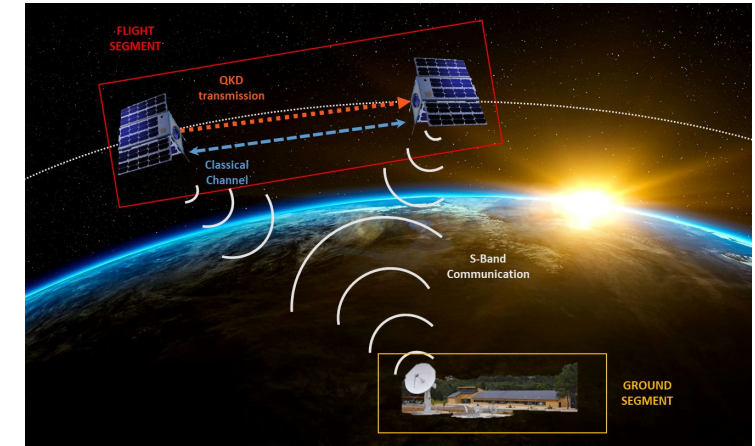
ANSER-AT → CDR phase



ANSER-AT (ATmosphere)

- Monitoring the Earth atmosphere quality
- Cluster of 4 x 6U CubeSats

Q-ANSER → Conceptual phase

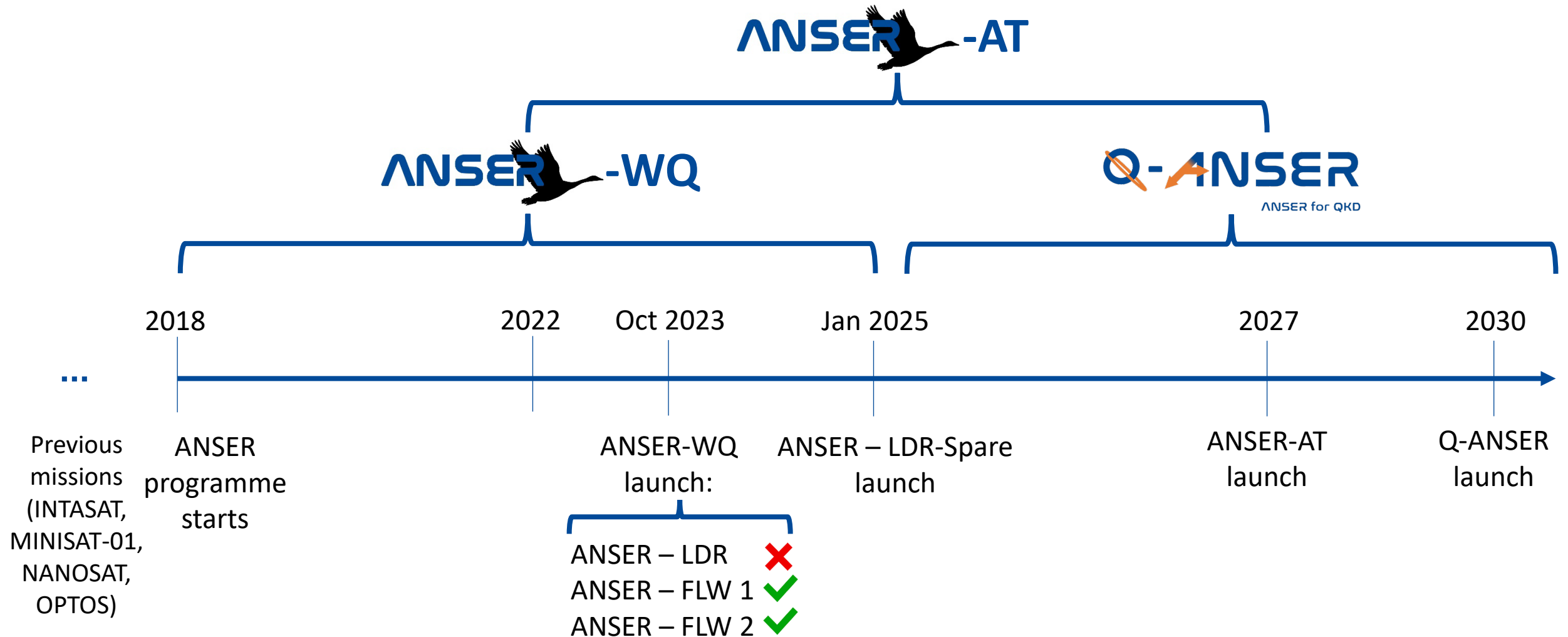


Q-ANSER (Quantum)

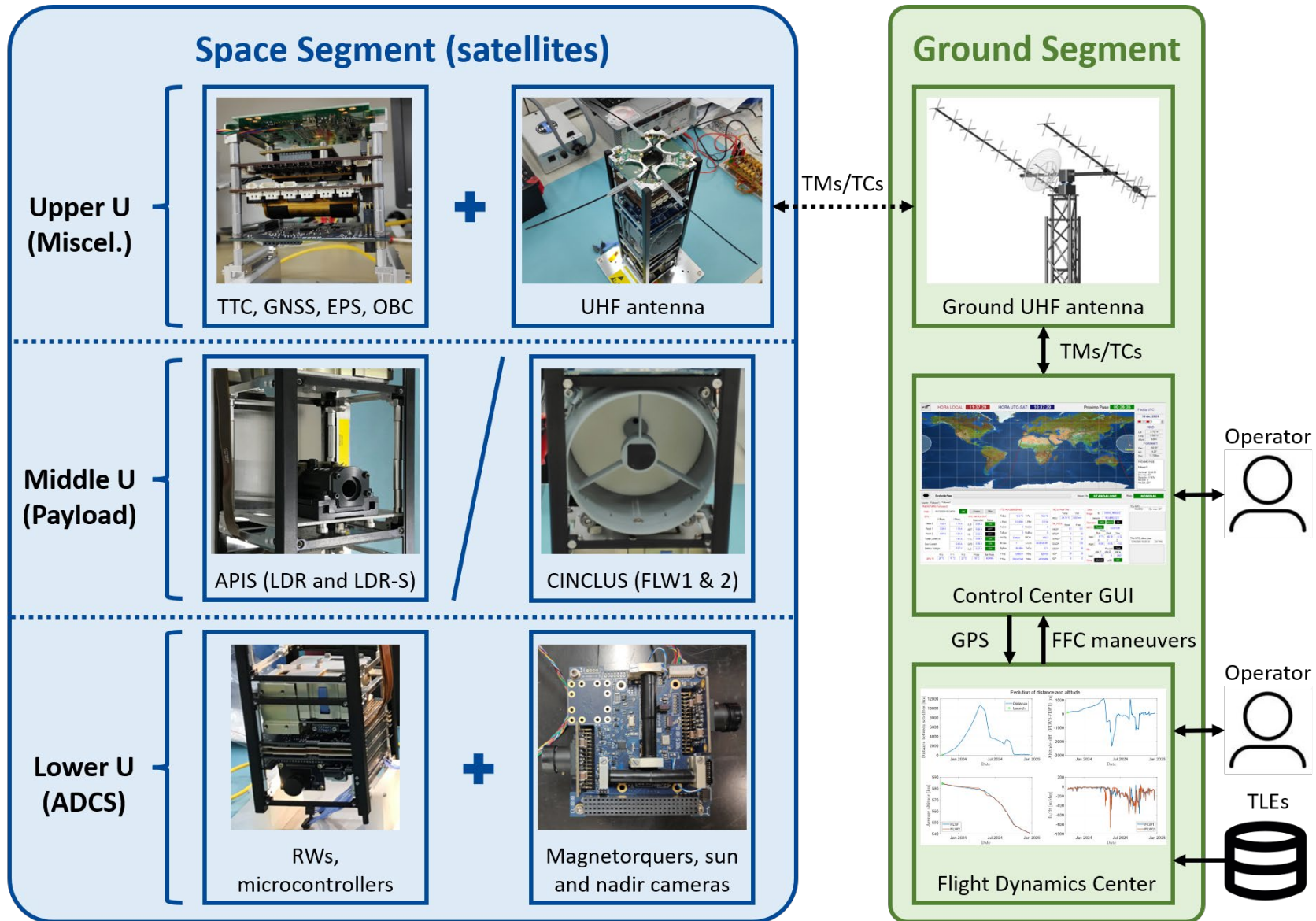
- QKD IOD (Quantum Key Distribution)
- Cluster of 2 x 16U CubeSats

ANSER[®] Programme

Missions calendar



Mission architecture of ANSER-WQ (ANSER)

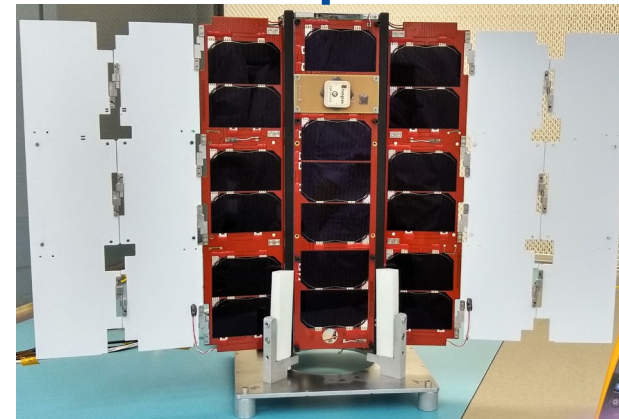
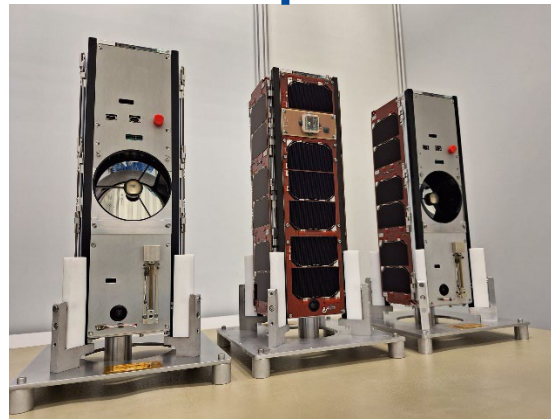


First Year of ANSER in Orbit

ANSER: Validation of enabling technology

1) Commissioning and in-orbit calibration of the ADCS

2) Formation-Flying Control (FFC) through passive aerodynamic forces



4) Launch of the LDR-S to reinstate the lost LDR

3) Inter-Satellite Link (ISL) communications

1) Commissioning of the ADCS

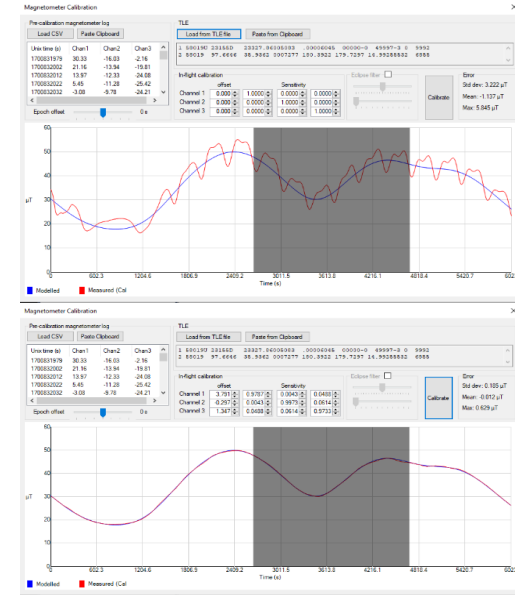
First detumbling with magnetorquers



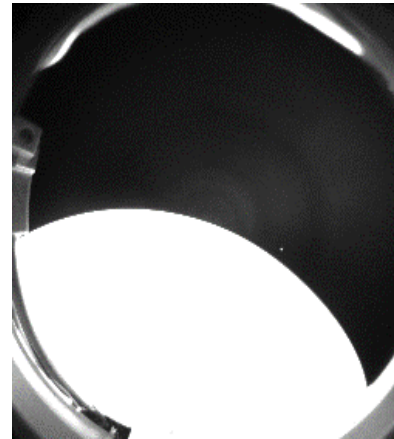
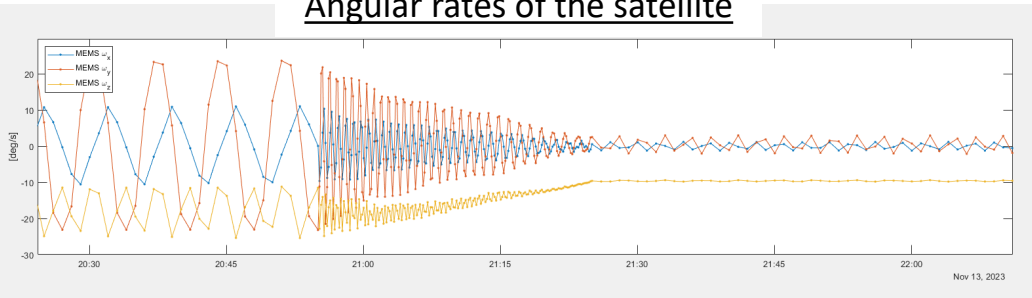
Magnetometer (MGM) deployment



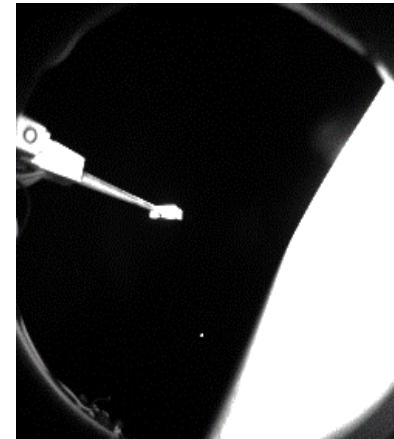
MGM calibration



Angular rates of the satellite



MGM stowed



MGM deployed

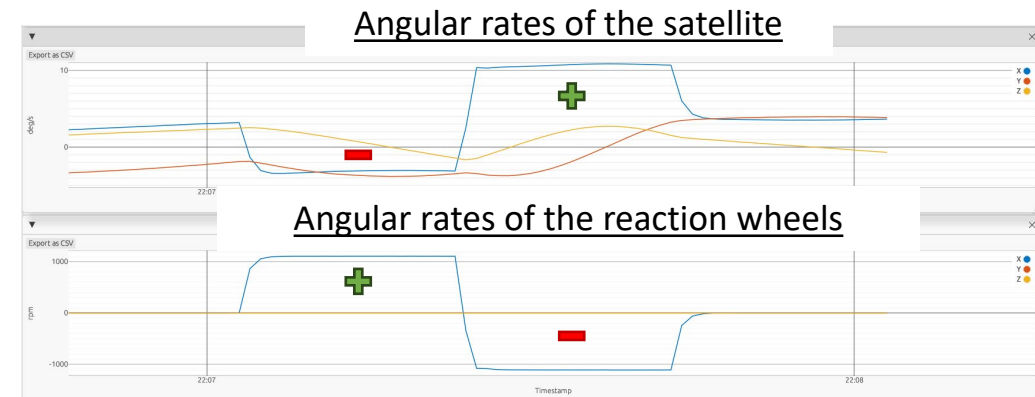
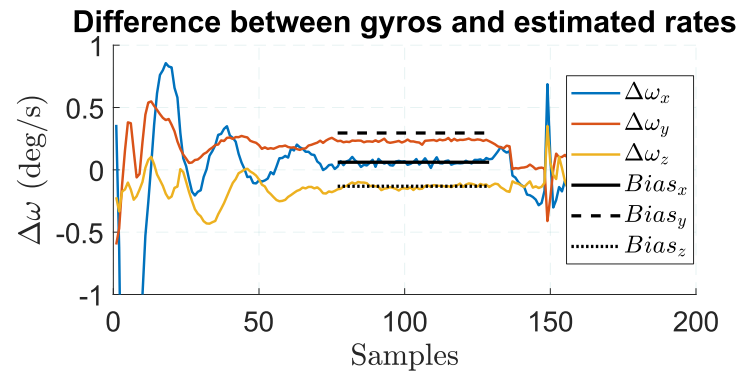
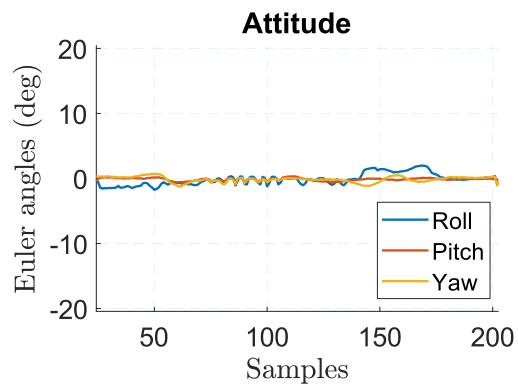
Three-axis control



Gyros calibration



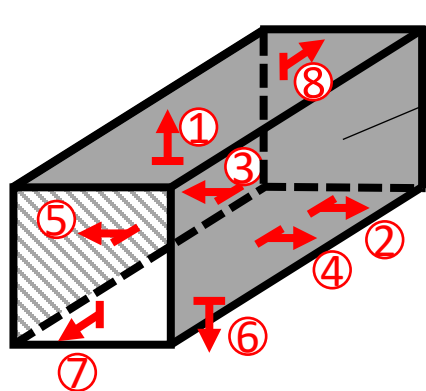
Reaction wheels polarity test



2) Formation-Flying Control (FFC)



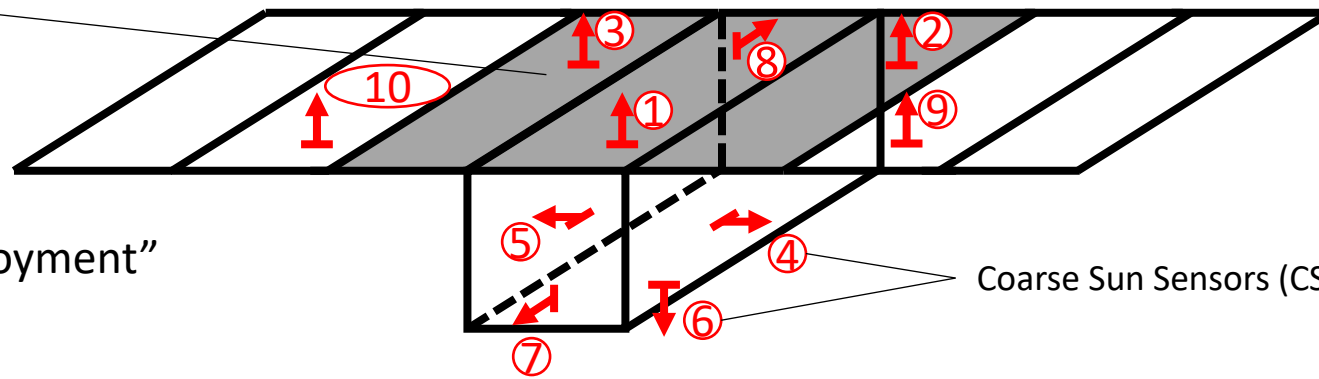
Sun



Solar panels



TC of "flaps deployment"

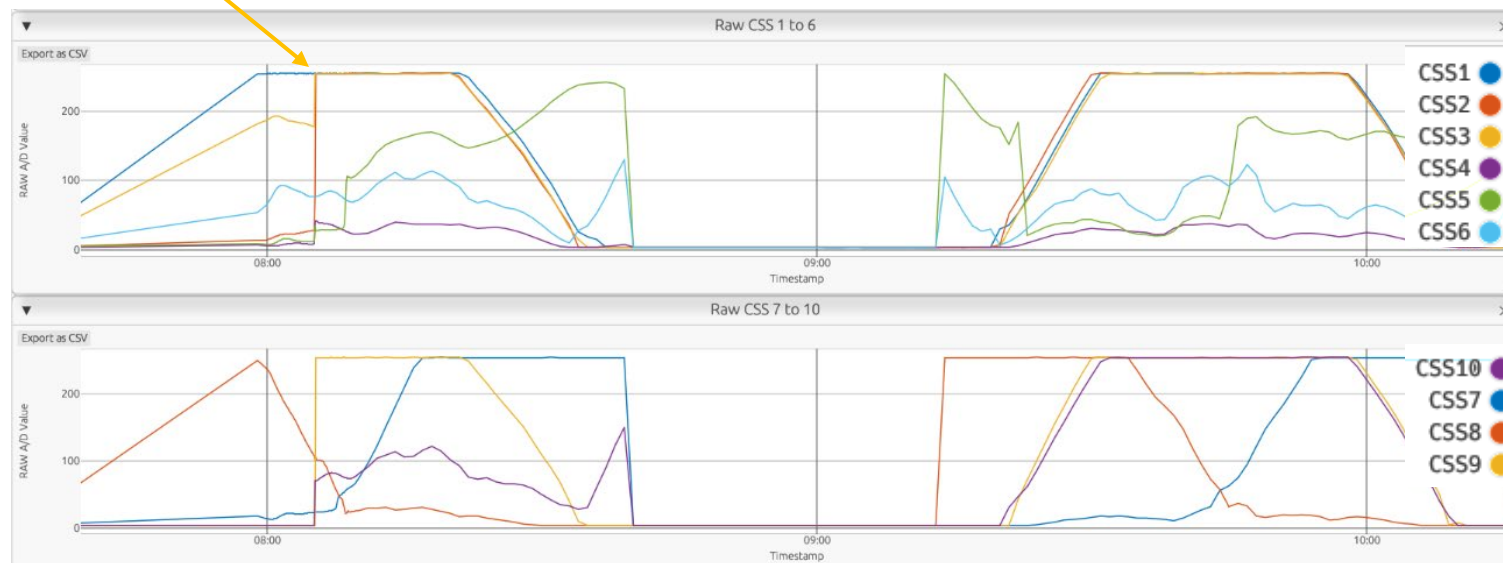
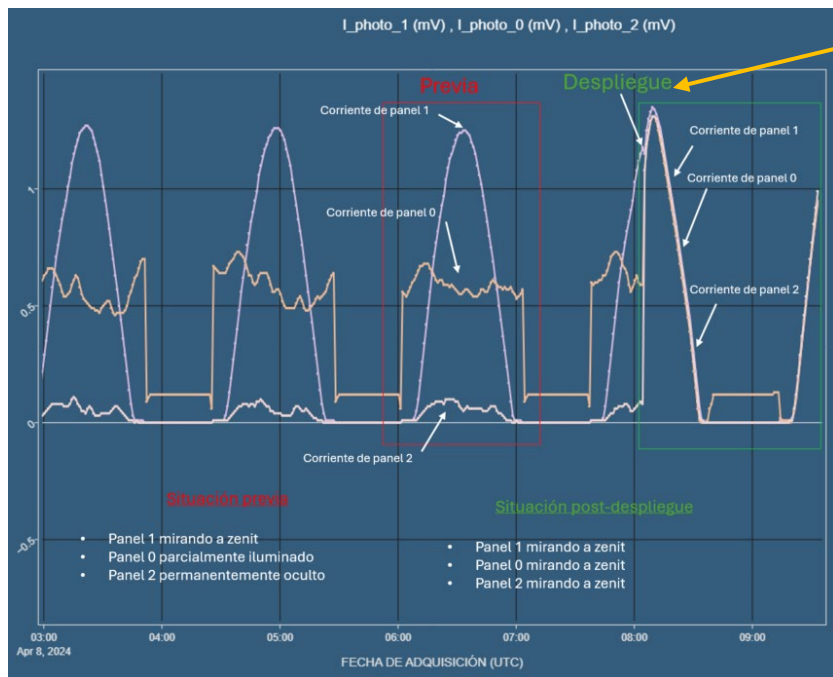


Coarse Sun Sensors (CSS)

Solar panels current

Deployment confirmed!

Signal from CSS 1 – 10



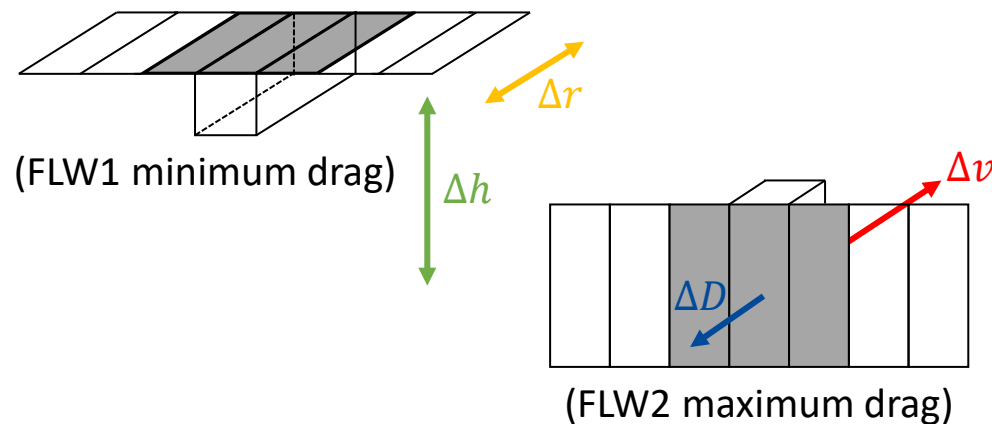
2) Formation-Flying Control (FFC)

Methodology

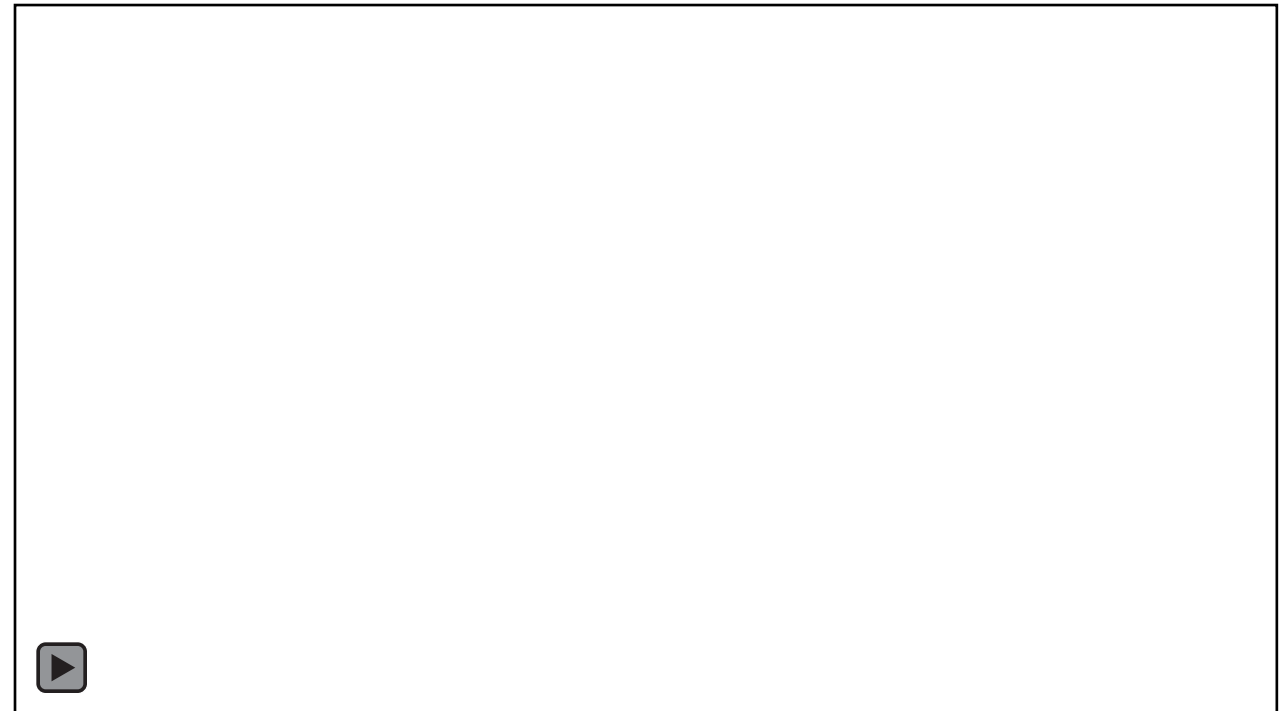
- Using differential aerodynamic forces of Drag & Lift to control the relative position between the FLW1 and FLW2, avoiding a propulsion system (complex and expensive)
- Differential drag → In-plane maneuvers
- Differential lift → Out-of-plane maneuvers (not tested yet)

Differential drag (ratio of frontal areas 21:1)

- 1) Difference in altitude
- 2) Difference in orbital velocity
- 3) Control of the relative position

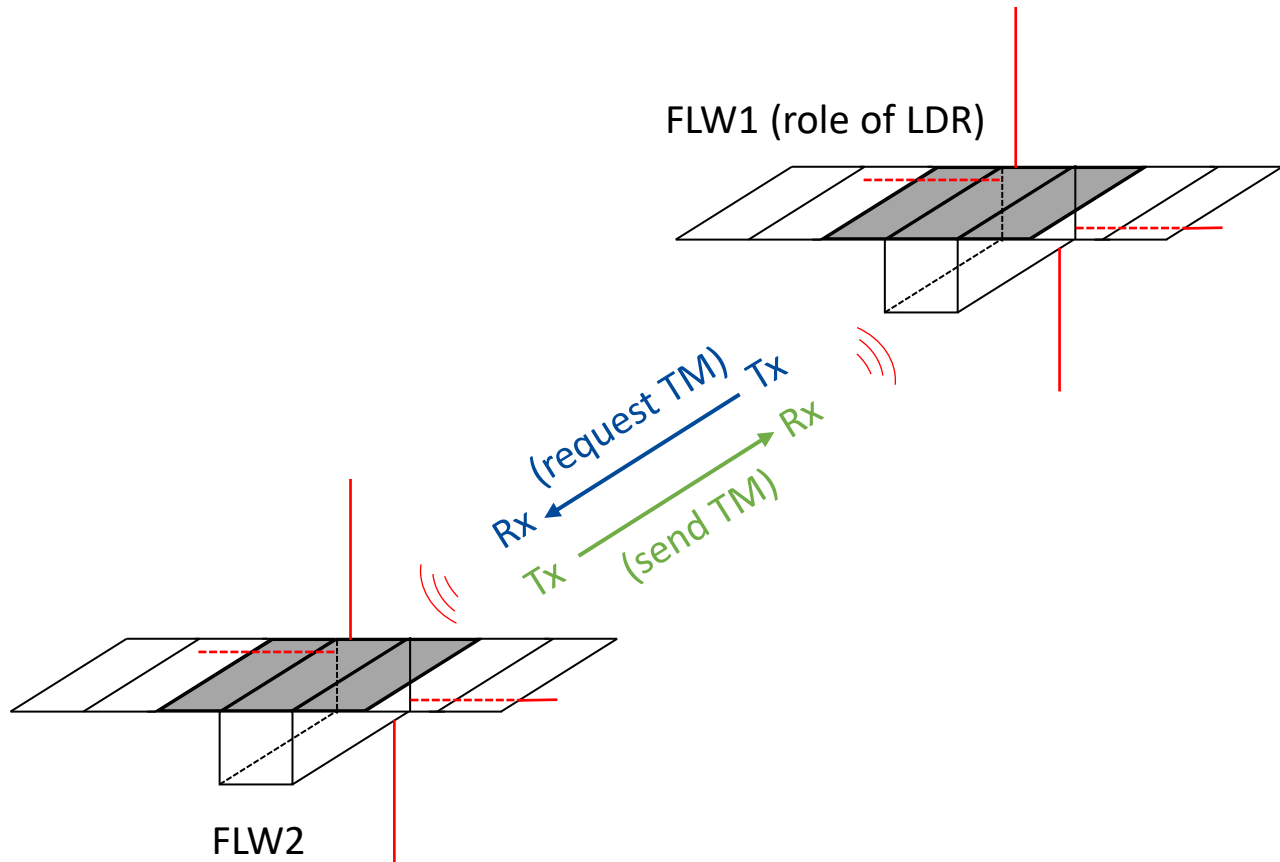


In-orbit change of attitude for FFC (FLW2)



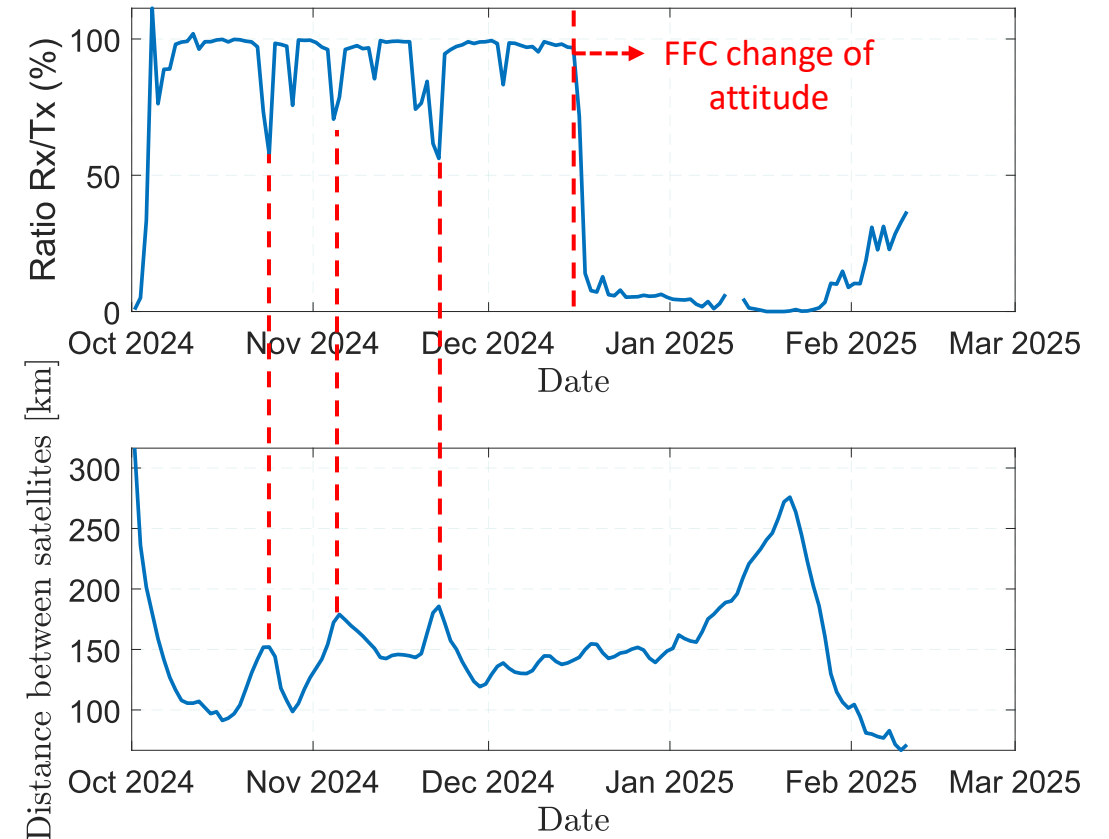
3) Inter-Satellite Link (ISL) communications

ISL concept:

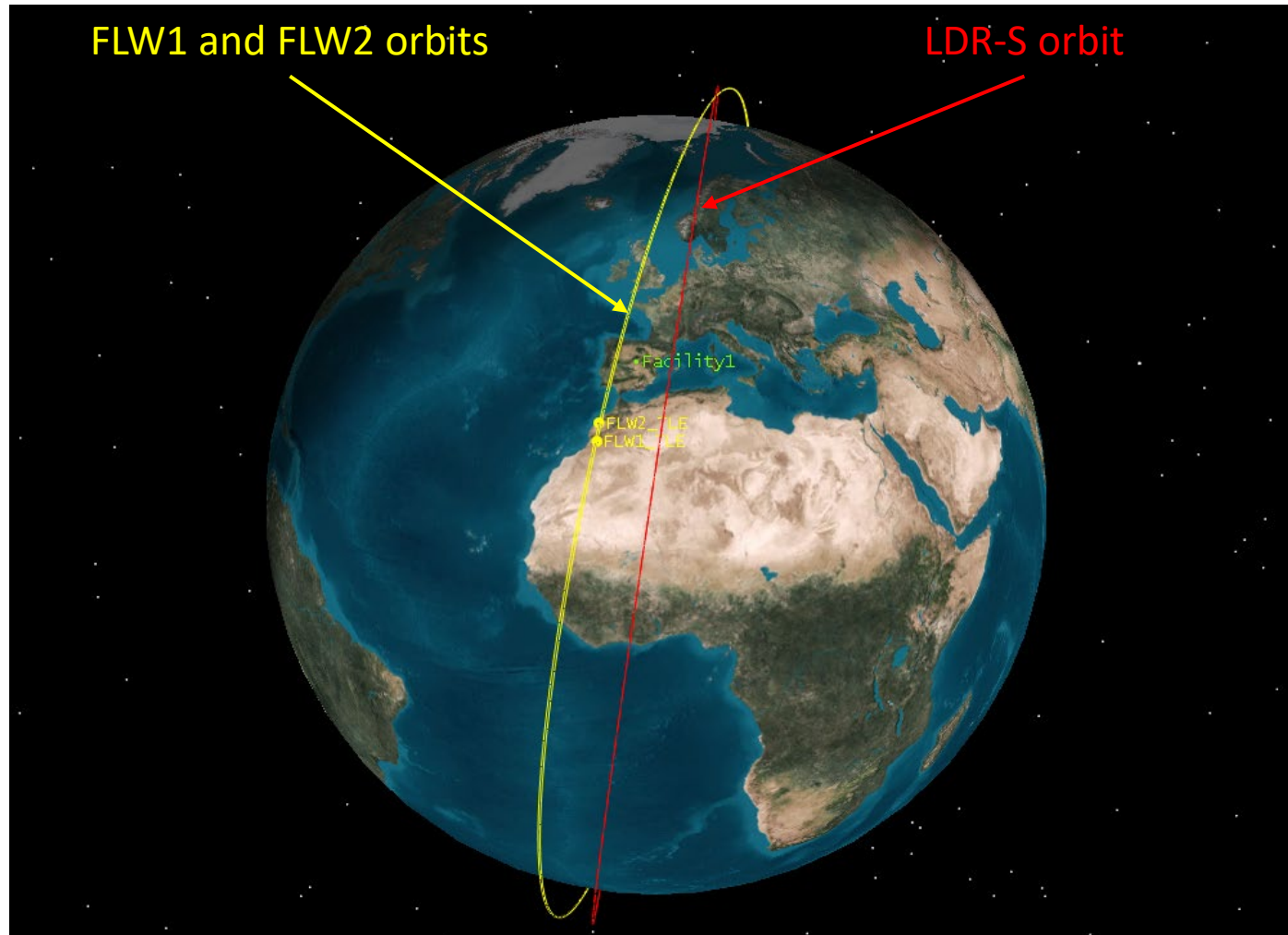


ISL results:

- Validated for distances between satellites < 200 km
- Key technology for the autonomous FFC in future missions



4) Launch of the LDR-S to reinstate the lost LDR



Remarks:

- Preparation and launch of the spare Leader (LDR-S) in about 1 year
- Ongoing commissioning phase (ADCS, flaps...)

Next steps:

- Formation-flying control in the along-track direction (ISL comms between LDR-S and FLWs in the two orbit crossings)
- Attempt orbital plane change with differential lift ($h < 450$ km)

Conclusions

Conclusions

Goals accomplished during the first year of ANSER mission:

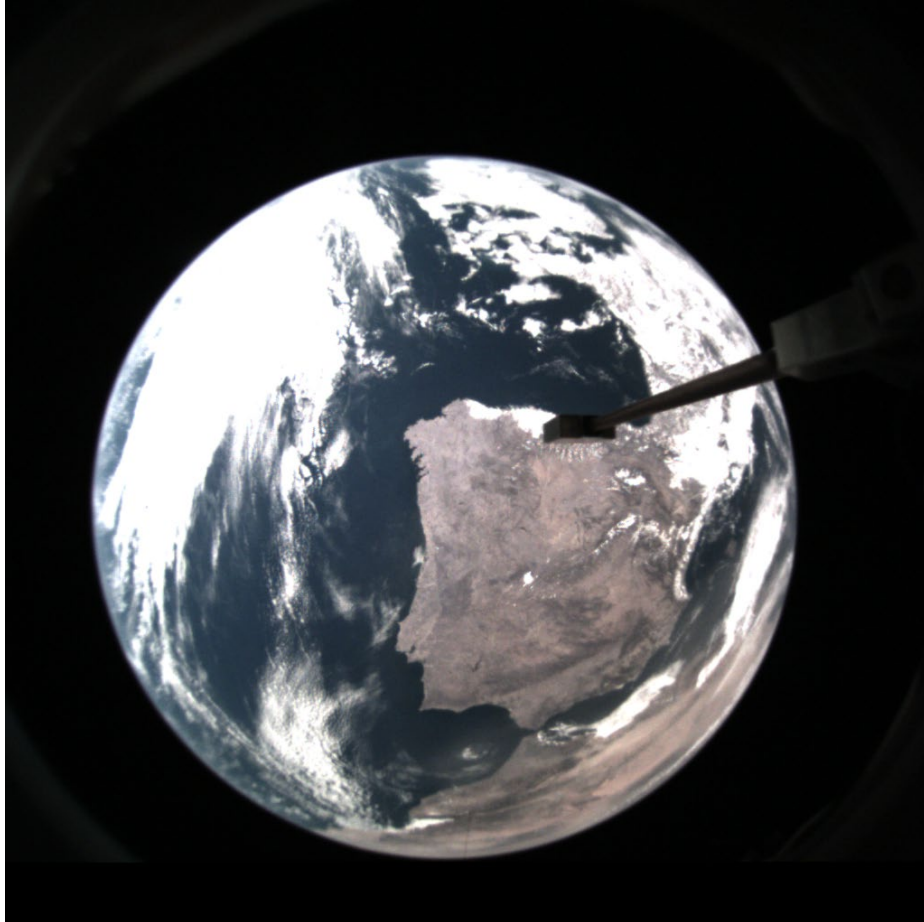
- Validation of the attitude control (ADCS), formation-flying (FFC) and inter-satellite comms (ISL)
- Demonstration of robustness and flexibility of multi-platform missions → reinstatement of the LDR-S
- Routine scientific operation with CINCLUS spectrometer (out of the scope of this presentation)

Future works:

- Complete the commissioning of the LDR-S
- FFC between the LDR-S and the FLWs
- Work on the next missions → ANSER-AT and Q-ANSER

Photos with the nadir camera from space

Iberian peninsula



Anular eclipse (14 – Oct – 2024)



ANSER TEAM



Acknowledgements

The small-satellite constellation programme (ANSER) has been self-financed by the Spanish Institute of Aerospace Technology (INTA). The launch was financed by the European Commission through its programme IOD/IOV.



Thank you for your attention!

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Backup slides

1) Commissioning of the ADCS

Commissioning modes → Y-Thomson e Y-Momentum

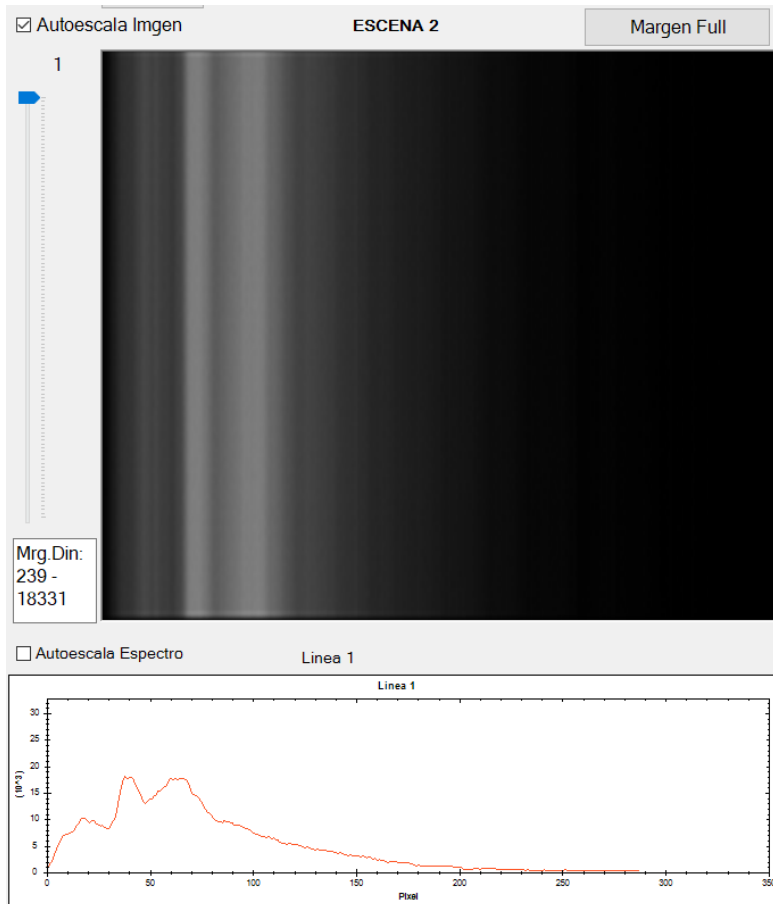


Remarks:

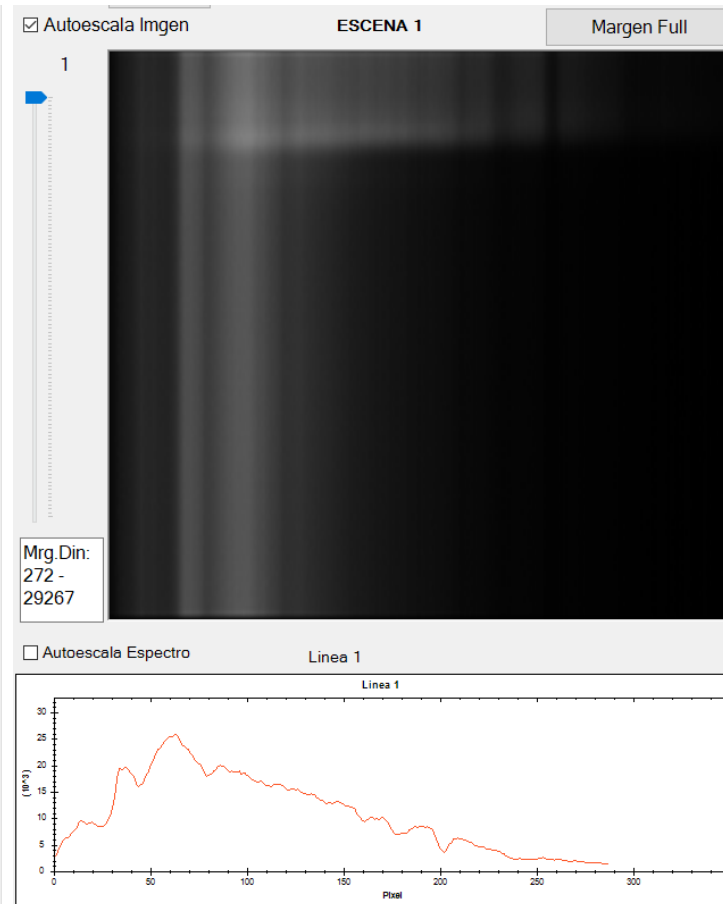
- Visualización de datos en órbita (vel. x500) con VTS (CNES)
- Estabilización por giro mediante Modo Y-Thomson (1 deg/s)
- Navegación de bajo consumo con Modo Y-Momentum (solo rueda Y)
- FLW1 y FLW2 se comportan similar (incluidas las oscilaciones en Y-Momentum)

Operación científica (espectrómetro CINCLUS)

Espectros de agua



Transición tierra-agua



Comentarios:

- Espectrómetro CINCLUS validado: espectros esperados para tierra y agua
- X: Longitud de onda (380 – 850 nm)
- Y: Tiempo o distancia (110 tomas)
- Se barren ~35 km en dirección along-track



Otros aspectos clave de la misión

Software de vuelo (in-house)

- Resiliencia y flexibilidad (capacidad de actualización)
- Fault Detection, Isolation and Recovery (FDIR)

Leader*	Followers		
File ID	Timestamp (UTC)	Operational State and Mode	Event ID
113	2025-02-09 23:10:40	Nom - MAINTENANCE	OBT_Updated_Report
113	2025-02-10 00:10:40	Nom - MAINTENANCE	OBT_Updated_Report
113	2025-02-10 00:24:06	Nom - GND_COMMS	GNDCOMMS_Communication_Started_Successfully
114	2025-02-10 00:27:25	Nom - GND_COMMS	GNDCOMMS_TC_Exec_Successfully
114	2025-02-10 00:27:25	Nom - GND_COMMS	OBT_Updated_Report
114	2025-02-10 00:27:27	Nom - GND_COMMS	TM_Pool_Is_Empty
114	2025-02-10 00:27:27	Nom - GND_COMMS	GNDCOMMS_TC_Exec_Successfully
114	2025-02-10 00:27:30	Nom - GND_COMMS	TM_Pool_Is_Empty
114	2025-02-10 00:27:30	Nom - GND_COMMS	GNDCOMMS_TC_Exec_Successfully
114	2025-02-10 00:27:33	Nom - GND_COMMS	GNDCOMMS_TC_Exec_Successfully
114	2025-02-10 00:27:42	Nom - GND_COMMS	TM_Pool_Is_Empty
114	2025-02-10 00:27:42	Nom - GND_COMMS	GNDCOMMS_TC_Exec_Successfully
114	2025-02-10 00:27:45	Nom - GND_COMMS	GNDCOMMS_TC_Exec_Successfully
114	2025-02-10 00:28:11	Nom - GND_COMMS	FDIR_Detected_Ground_Communication_Error
114	2025-02-10 00:29:31	Nom - GND_COMMS	GNDCOMMS_Communication_Finished_Successfully
114	2025-02-10 00:29:31	Nom - GND_COMMS	COMMT_Entry_Exec_Successfully
114	2025-02-10 01:10:40	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 02:10:40	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 03:10:40	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 03:19:08	Nom - MAINTENANCE	FDIR_Detected_Error
114	2025-02-10 03:19:08	Nom - MAINTENANCE	FDIR_Detected_Failure
114	2025-02-10 03:19:14	Nom - MAINTENANCE	GPS_Disable_Operation_Successfully
114	2025-02-10 03:19:50	Nom - MAINTENANCE	GPS_Enable_Operation_Successfully
114	2025-02-10 03:19:50	Nom - MAINTENANCE	FDIR_Recovery_Actions_Finished
114	2025-02-10 03:19:56	Nom - MAINTENANCE	FDIR_Detected_Error
114	2025-02-10 04:19:54	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 05:19:54	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 06:19:56	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 07:19:55	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 08:19:55	Nom - MAINTENANCE	OBT_Updated_Report
114	2025-02-10 09:19:55	Nom - MAINTENANCE	OBT_Updated_Report

Filter Real time Lost time

Comunicaciones intersatelitales (ISL)

- Validadas a partir de los 200 km de distancia entre satélites
- Tecnología clave para el control de vuelo en formación autónomo en futuras misiones

