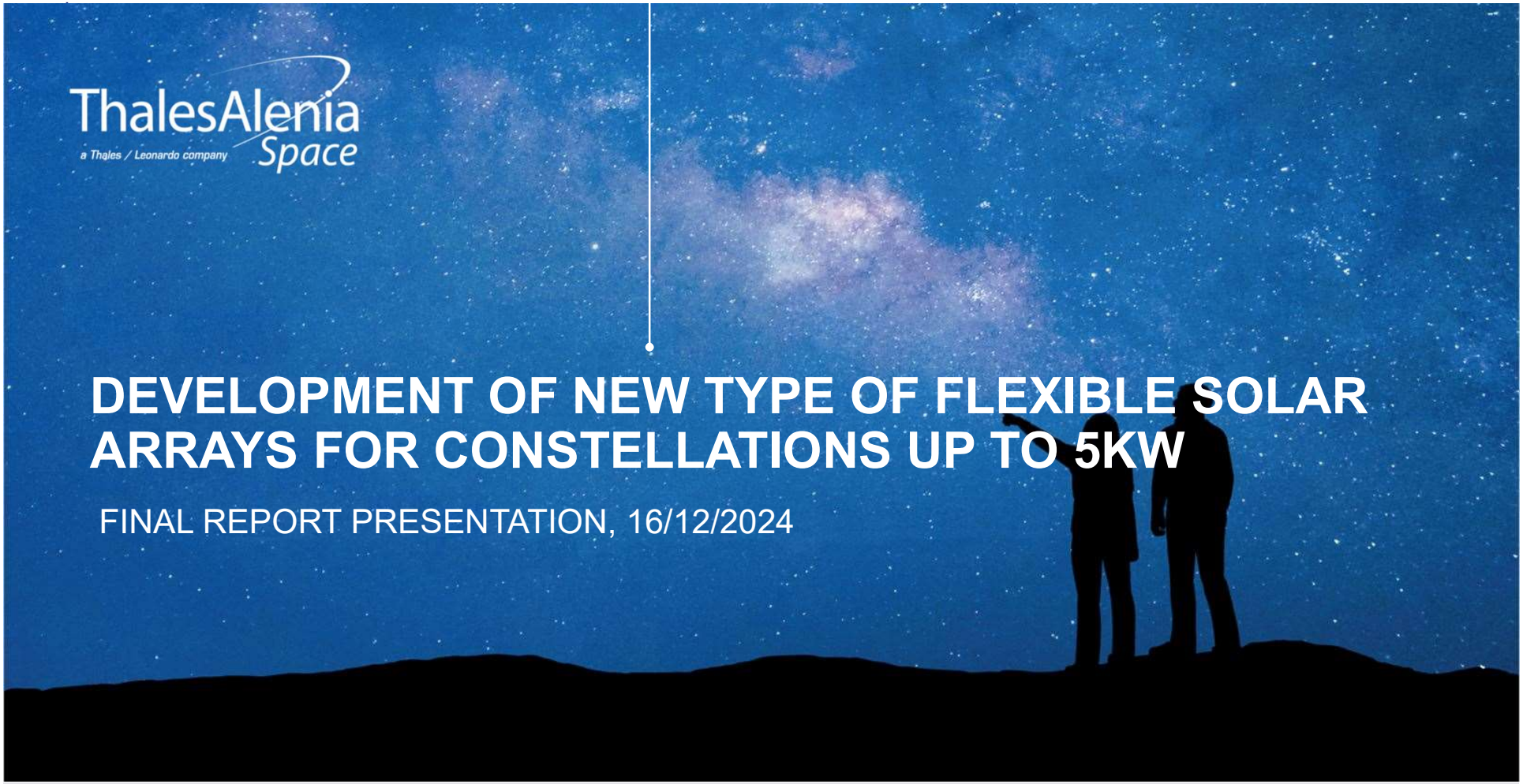

DEVELOPMENT OF NEW TYPE OF FLEXIBLE SOLAR ARRAYS FOR CONSTELLATIONS UP TO 5KW

FINAL REPORT PRESENTATION, 16/12/2024

Date: 16/12/2024
Ref: 0005-0018899372
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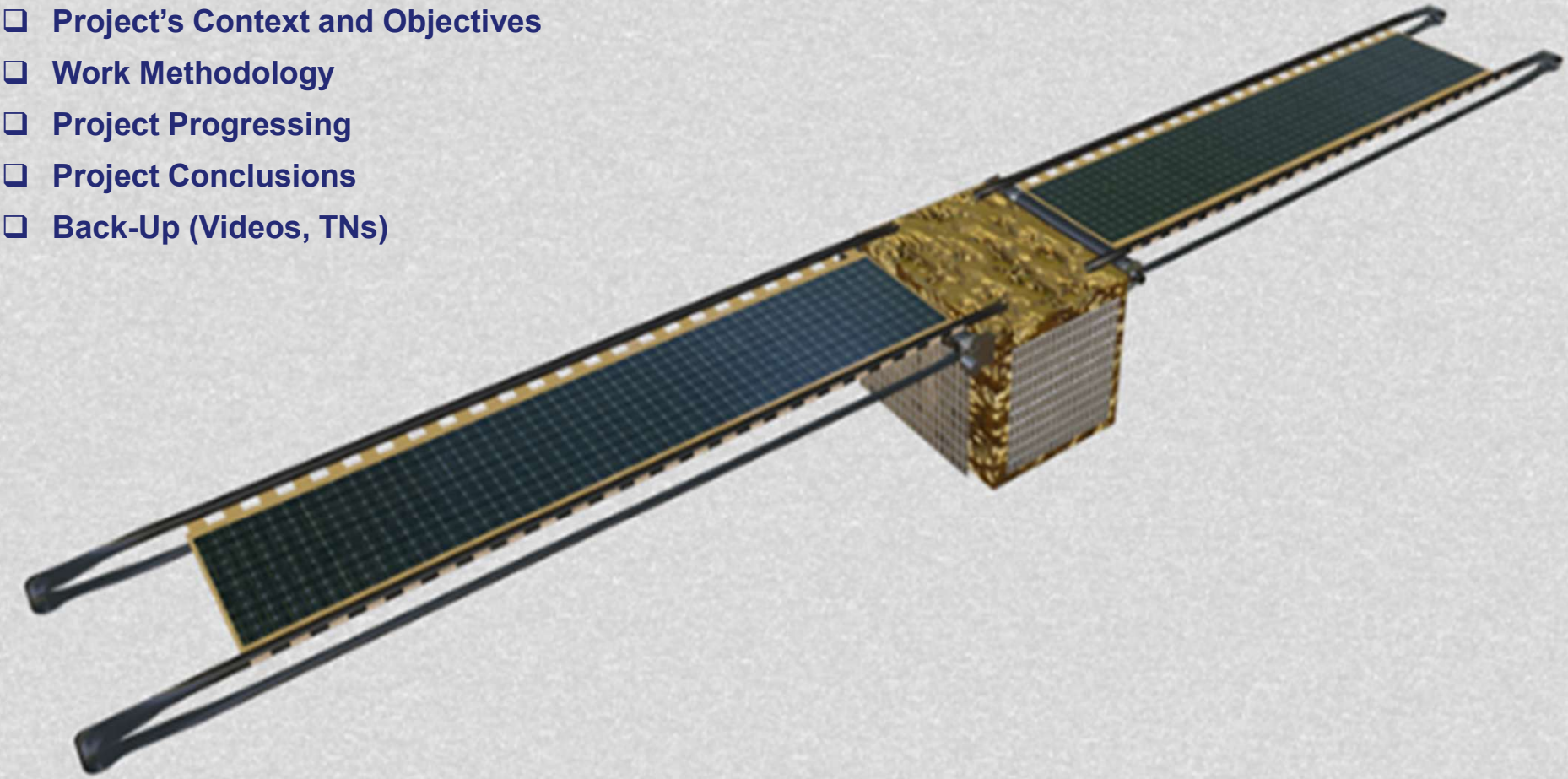
ThalesAlenia Space
a Thales / Leonardo company

- Project's Context and Objectives
- Work Methodology
- Project Progressing
- Project Conclusions
- Back-Up (Videos, TNs)



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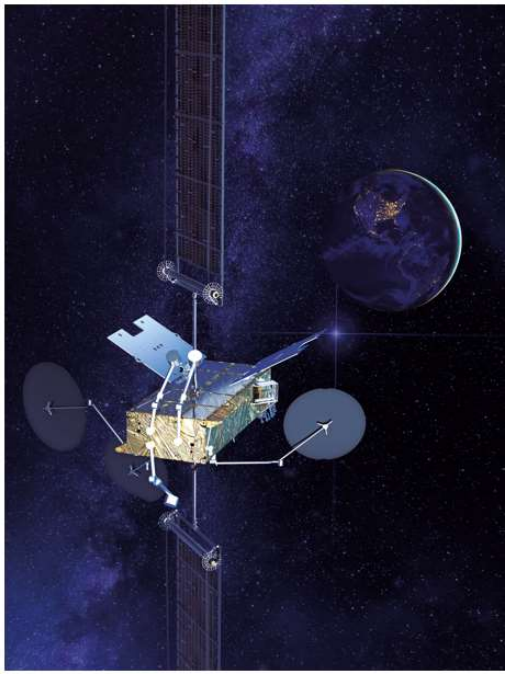
PROJECT'S CONTEXT AND OBJECTIVES

- In recent years, much progress has been made in the development of high performance solar arrays, primarily for GEO applications.
- This study has been performed in order to assess the suitability of the SolarFlex concept for adaptation to LEO constellation applications:
  - with power requirements up to 5 kW.
  - with low cost
  - with the possibility to be packed tightly into limited stowed volumes (target range 25-40 kW/m3).

SolarFlex Product of Thales Alenia Space



Fully flexible SA of Thales comprises blankets rolled around a mandrel, onto which the photovoltaic assembly is bonded, deployed by a pair of tape springs on either side

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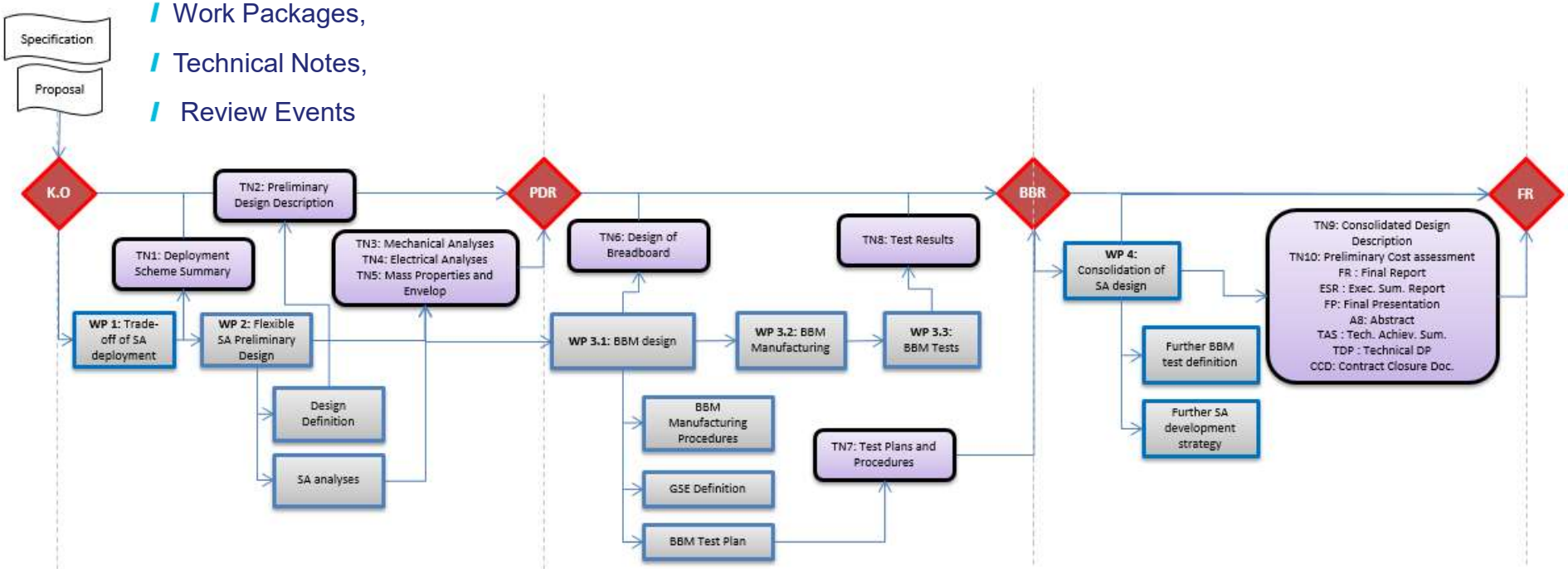
WORK METHODOLOGY

/// Work Logic:

- Work Packages,
- Technical Notes,
- Review Events



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WORK METHODOLOGY - DOCUMENTS DELIVERY/ACCEPTANCE STATUS

Document Identifier and title	Document Reference	Issue	Delivery/acceptance status
TN1- Deployment Scheme Summary	0005-0015797095	01	**Delivered and accepted**
TN2 - Preliminary Design Description	0005-0017470580	01	**Delivered and accepted**
TN3 – Mechanical Analyses	0005-0016711540	02	**Delivered and accepted**
TN4 – Electrical Analyses	0005-0016616955	02	**Delivered and accepted**
TN5- Mass Properties and Envelop	0005-0016699396	01	**Delivered and accepted**
TN6 – Design of Breadboard	0005-0017754749	01	**Delivered and accepted**
TN7 – Test Plans and Procedures	0005-0018693636	01	**Delivered and accepted**
TN8 – Test Results	0005-0018693664	01	**Delivered and accepted**
TN9 - Consolidated Design Description	0005-0018697286	01	**Delivered and accepted**
TN10 – Preliminary Cost Estimation	0005-0018896086	01	To be delivered by mail today 16th December
TDP - Technical Data Package	-	01	To be delivered by mail today 16th December
AB - Abstract	0005-0018906479	01	To be delivered by mail today 16th December
TAS - Technology Achievement Summary	0005-0018905980	01	To be delivered by mail today 16th December
FP – Final Presentation	0005-0018899372	01	To be delivered by mail today 16th December
ESR - Executive Summary Report	0005-0018905811	01	To be delivered by mail today 16th December
FR - Final Report	0005-0018899165	01	To be delivered by mail today 16th December
CCD - Contract Closure Documentation	-	-	To be delivered by mail today 16th December

WORK METHODOLOGY – WORK PACKAGE AND TASKS

/// The 4 Work Packages (“WPs”) includes the following tasks:

- *WP1: Flexible SA Concept Trade-off,* focused on the investigation of different deployment schemes.
- WP2: *Flexible SA design and analysis*, focused on the:
  - preliminary design of solar array concept.
  - prediction of electrical performance.
  - mechanical analyses.
  - estimation of mass and inertia.
- WP3: *Flexible SA Breadboard Design & MAIT*, focused on the design, manufacturing and testing of breadboard models.
- WP4: *Flexible SA consolidated design & perspectives,* focused on the conclusions and way-forwards

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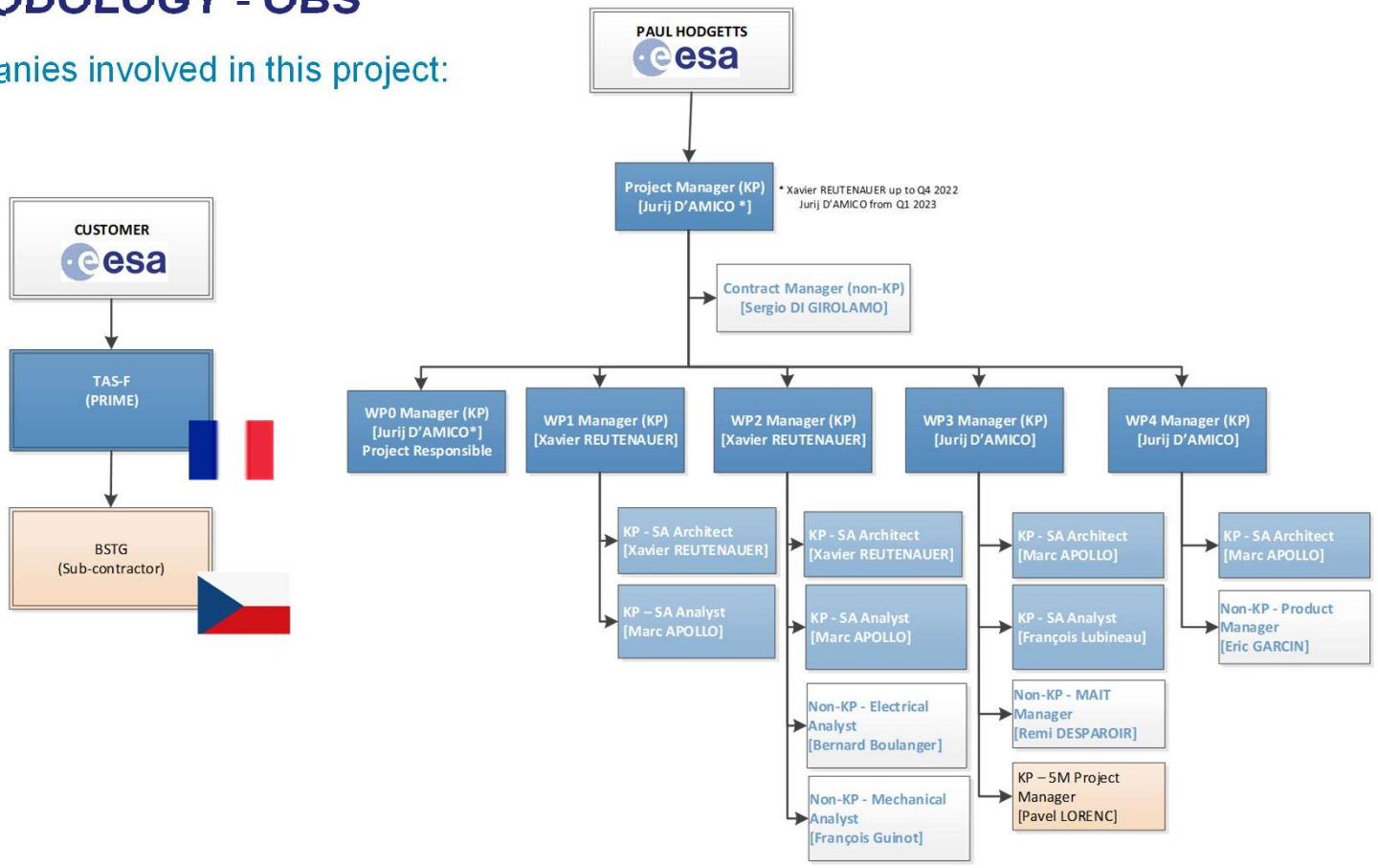
WORK METHODOLOGY - OBS

/// Participating companies involved in this project:



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PROJECT PROGRESSING – REAL TIMELINE

/// The duration of the work is 34 months from kick-off

TDE 5kW Activity	Year	2022												2023												2024												2025					
	Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
	Lead time			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
	KO			KO																																							
	WP1: Investigation Phase																																										
	WP2: Design Phase								SA Design				PDR																															
	WP3.1: Manufacture Phase																						BBM Design & Manufacture									TRR										
	WP3.2: Test Phase																															Test	TRB										
	WP4: Consolidation Phase																																	Consolidation	FR			FP					
	Deployment Scheme Review					DSR																																					
	PDR (Part 1)										PDR (Part 1)																																
	PDR (Part 2)											PDR (Part 2)																																
	PM 1																						PM 1																				
	PM 2																									PM 2																	
	PM 3																												PM 3														
	PM 4																													PM 4													
	TRR																													TRR													
	TRB																															TRB										
	PM 5																																		PM 5								
	FR																																			FR							
	FP																																						FP				

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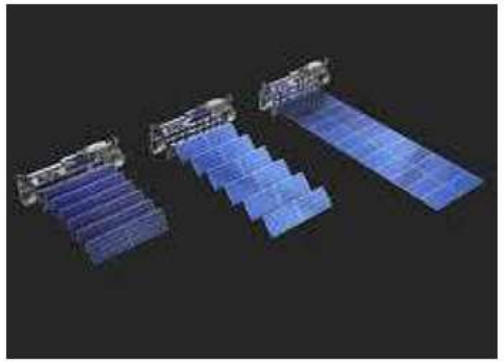
PROJECT PROGRESSING – WP1 MAIN ACHIEVEMENTS

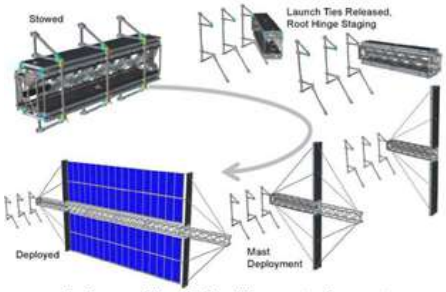
/// This phase has included the following achievements:

- Investigation of the features of the following 4 deployment schemes:
  - Fan folded solar array
  - Accordion SA with central mast deployment on panel rear face
  - Accordion SA with central mast deployment
  - Roll out SA with tape spring for deployment
- Selection of the “Roll out solution” as the most promising architecture for adaptation in terms of cost, low stowage volume, simplicity of release/activation while meeting the power demands of up to 5kW

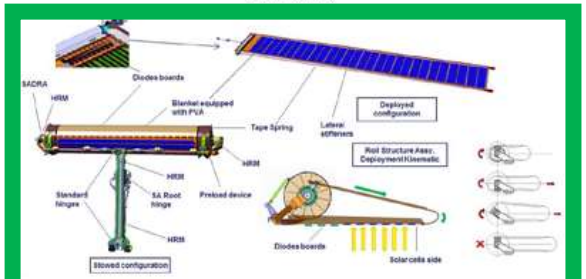
1: Fan folded solar array



2: Accordion SA with central mast deployment on panel rear face



3: Accordion SA with central mast deployment on panel rear face



4: Roll out SA with tape spring for deployment

SELECTED

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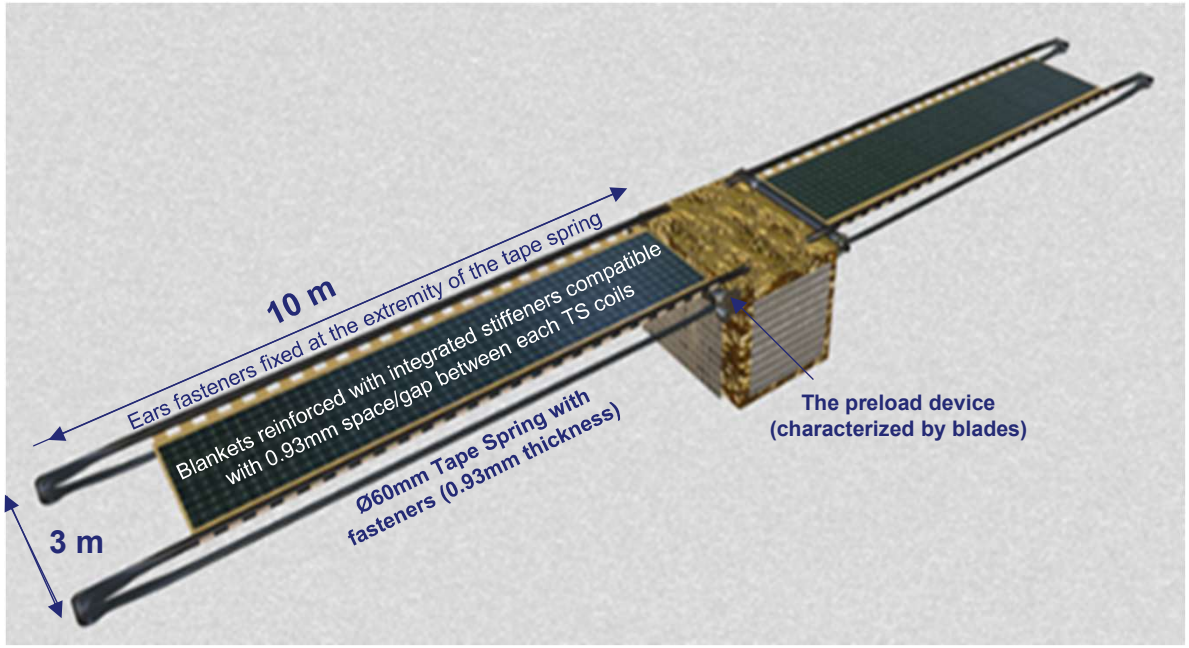
PROJECT PROGRESSING – WP2 MAIN ACHIEVEMENTS

/// Based on a preliminary array design and representative breadboard models, the Thales team has demonstrated the feasibility of the development of a fully flexible variant of SolarFlex product:

1 wing	Silicon cells	AsGa cells
Power EOL [kW]	2.85	4.9
Volume [kW/m3]	33	57
Power/Mass [W/Kg]	57	98

Three-dimensional concept of the miniaturized flexible SA for LEO constellations



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PROJECT PROGRESSING – WP3 MAIN ACHIEVEMENTS

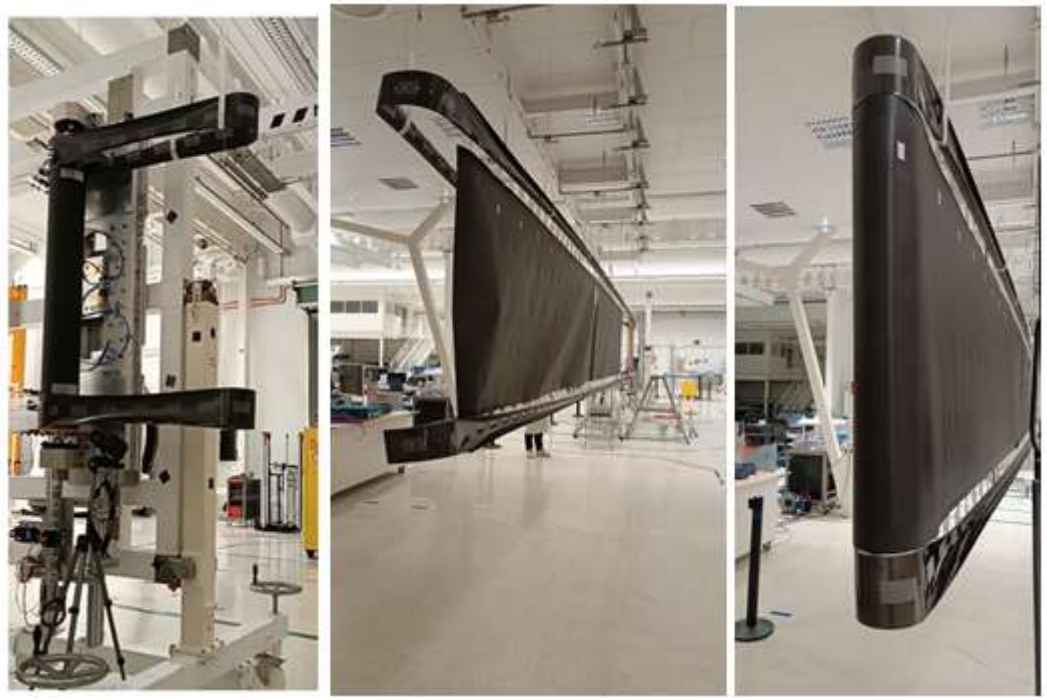
/// The miniaturized architecture has been manufactured and tested in order to verify its deployment capability.

The act of motorizing and bringing GS BB from stowed to deployed configuration is successfully performed

/// An high confidence on the suitability of the proposed innovative technologies for deployment has been built. It is the case of preload devices characterized by blades, synchronization and deployment devices based on fasteners and pins.

/// However to overcome visible anomalies on the blankets (folds during deployments and through the bulb passage) design optimization and additional tests are recommended, in order to improve the tensioning and flatness of the blankets and co-alignments of the tapes springs.

SA BB deployment test (integrated on 0G trolley placed in the clean room under rails)



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PROJECT PROGRESSING – WP4 MAIN ACHIEVEMENTS

/// The final task has allowed to update the risk register for next activities.
/// A preliminary cost estimation of the risk mitigation plan is defined for rapid implementation (650,000 EUR is the estimated cost to achieve the TRL5

Risk	Point	Domain	Problem Description	Mitigation strategy
Risk 1 / Risk 12	Point 1	Flexible GS BBM Integration/Assembly	Difficulties were encountered during BBM assembly process in stowed configuration (misalignments and synchronization problem between BBM components along the thickness and through the deployment axis)	Integration/Assembly in deployed configuration seems mandatory, including rigid stiffeners in the assembly process
Risk 1	Point 2	Flexible GS BBM Synchronization System Functioning	Operation problem was encountered during the assessment of the synchronization systems functioning (for back side) (misalignments between TS holes and pins locations due to TS manufacturing defects)	Control of the TS drilling plan based on better TS thickness prediction
	Points 3 and 4	Flexible GS BBM Fasteners developments	Space material for fasteners is not available. Consequently a development is needed. Sizing of fasteners is simply based on preliminary experimental de-risking test done at TS level. Incompatibility with stiffeners positioning.	Consolidation of the fasteners development strategy based on suitability with numbers and positions of external rigid stiffeners (see problems 4 and 5).
	Point 5	Flexible GS BBM deployment (TS positioning during deployment)	Deployment problem of the TS observed from the unsuitable positioning of the GS (not controlled spacing between TS)	Replacement of stiffeners integrated/embedded in the blanket with external rigid stiffeners including an optimal BBM integration plan.
	Point 6	Flexible GS BBM deployment (Blanket positioning during deployment)	Deployment problem of the blanket observed through the bulb passage (Blanket folds appears)	
	Point 7	SA positioning during rolling	Rolling problem of the GS observed from the unsuitable synchronization of the TS and insufficient effort on preload system	Improvement of synchronization system (with pins) and preload devices (with additional rollers).
	Point 8	SA Global Architecture	Integrated Y stiffeners in blankets and blanket ears are not suitable to avoid problem during deployment (see points 5 and 6).	The integration of external rigid stiffeners is essential as long as the critical evaluation of their compatibility with fasteners and other possible impact on the design for their fixation

Example of risk management tool to identify potential setbacks within the project

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CONCLUSIONS

/// The suitability of the SolarFlex concept for adaptation to LEO constellation applications can be confirmed based on the following advantages:

- An extremely compact design (possibility to be packed tightly into stowed volumes range 33-57 kW/m3.
- Compliant power capacity per wing (range 2.85 - 4.9 kW)
- A proven deployment functioning
- A budget less than 1 MEUR is envisaged to increase the TRL up to 5.

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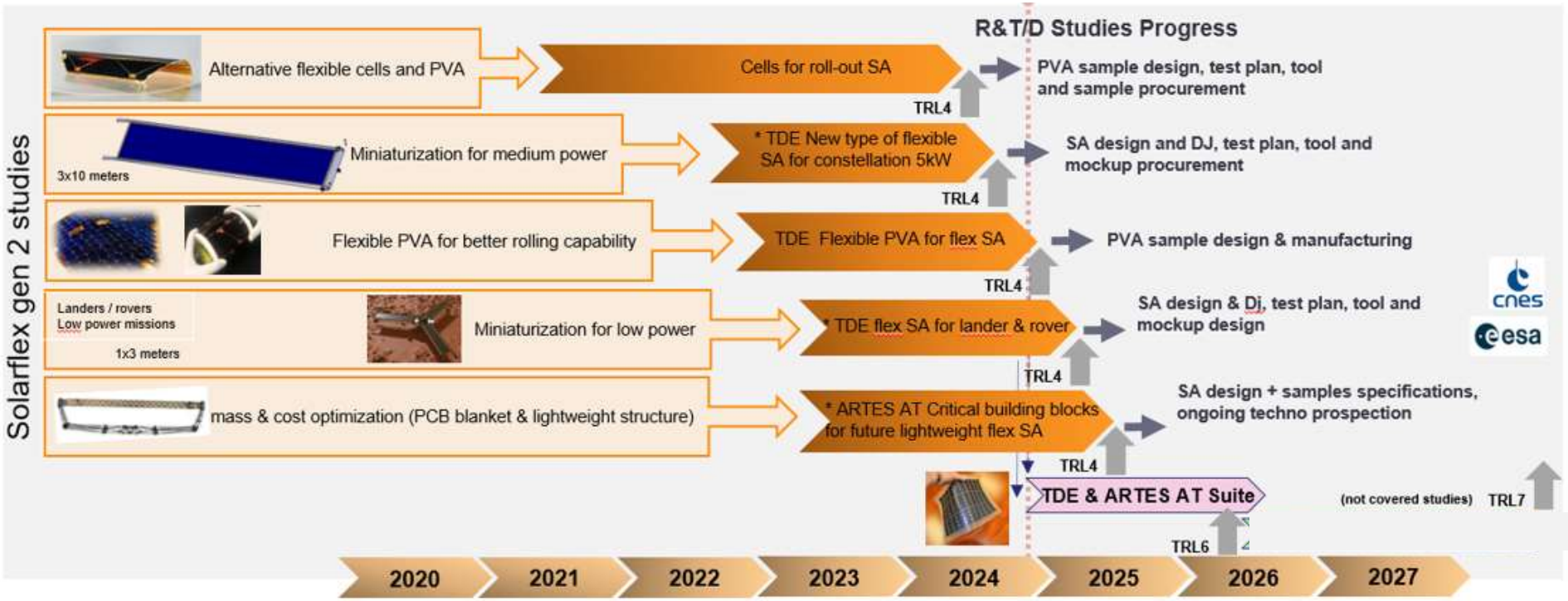
BACK-UP - STRATEGY



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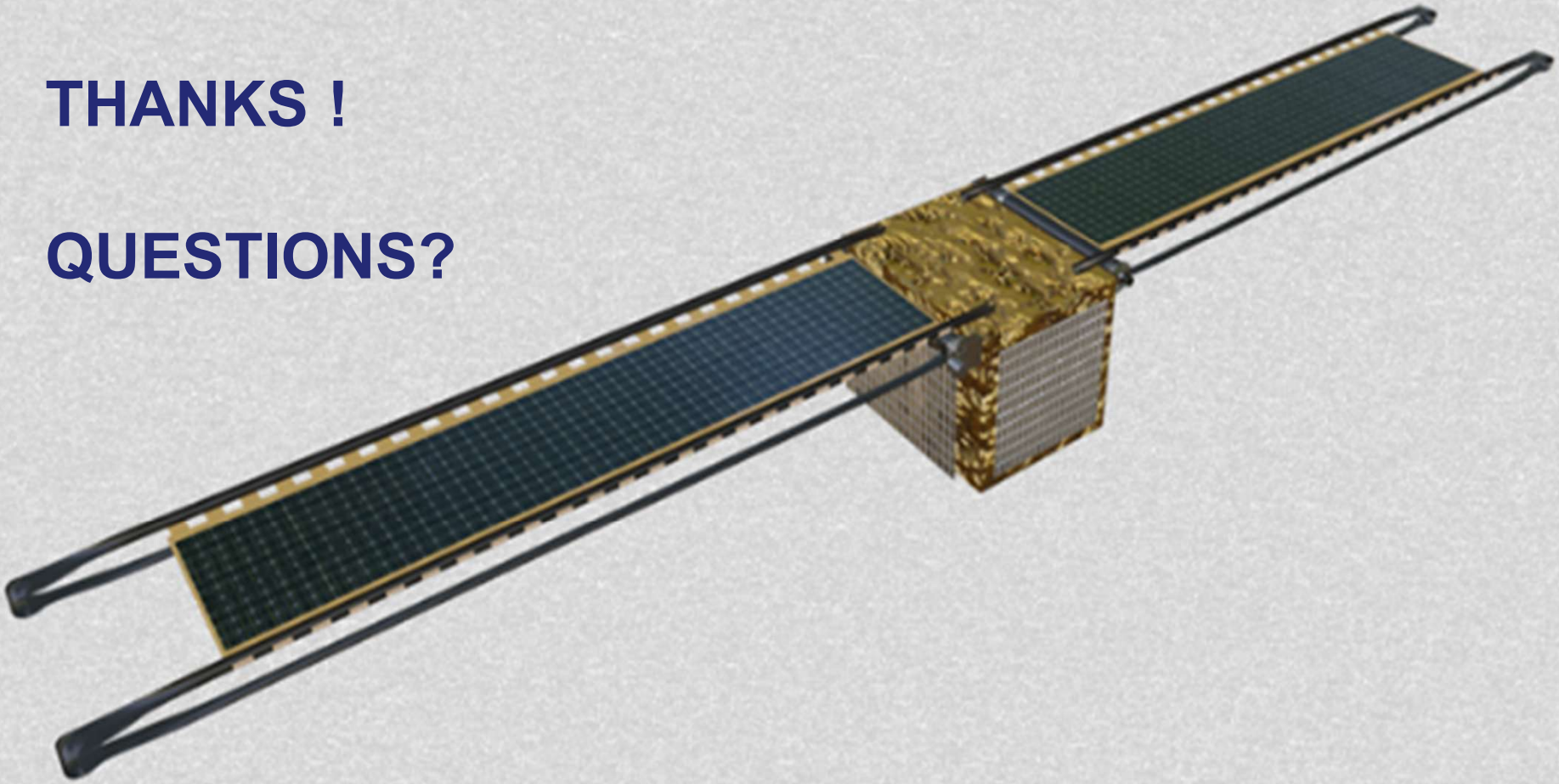
THANKS !

QUESTIONS?



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