DAEDALUS CAM
Project Plan

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1. INTRODUCTION

1.1. SCOPE

Through its Open Space Innovation Platform, in August 2019 ESA opened a campaign for novel ideas to address detecting, mapping and exploring lunar caves and lava tubes.

Amongst these ideas, ESA selected the project “Daedalus” to participate in its Concurrent Design Facility (CDF) to study the feasibility and planning the mission. The Mission is planned to last one full lunar day (12+2 contingency), with the possibility to extend the mission time within the cave and to rely on communication with Earth in the following lunar day. The CDF Internal Final Report on Daedalus is now available on request.

The Daedalus robot hosts two payloads, one lidar (responsibility University of Würzburg) and one stereoscopic panoramic camera (Daedalus-CAM, responsibility INAF).

The present document has been issued to describe the Project Plan of the Daedalus–CAM imaging payload.

1.2. ABBREVIATIONS AND ACRONYMS

AIT	Assembly, Integration and Test
AIV	Assembly, Integration and Validation
BPL	Bifocal Panoramic Lens
CAM	Camera
CDF	Concurrent Design Facility
CMOS	Complementary Metal OxideSemiconductor
CNR	Consiglio Nazionale delle Ricerche
DAEDALUS	Descent and exploration in deep autonomy of lunar underground structure
FEM	Finite Element Model
EGSE	Electronic Ground Support Equipment
EM	Engineering Model
ESA	European Space Agency
FM	Flight Model
FPGA	Field Programmable Gate Array
GSE	Ground Support Equipment
IFN	Istituto di Fotonica e Nanotecnologie
IFR	Internal Final Report
IS	Image Sensor
LIDAR	Light Detection and Ranging
MF-SR	Multi Frame Super Resolution
MGSE	Mechanical Ground Support Equipment
OBC	On-Board Computer
OBS	Organization Breakdown Structure
PANCAM	PANoramic-CAMera
PO	Project Office
POLIMI	Politecnico di Milano
QM	Qualification Model
UI	User Interface
WBS	Work Breakdown Structure
WP	Work Package

1.3. Table of Contents

1.4. APPLICABLE DOCUMENTS

ESA CDF Internal Final Report,
"Lunar Caves: Assessment of Robocrane and Daedalus Aiming to Explore Lunar Caves",
ESA CDF Study report #217(A), 421 pages, 2021.

1.5. REFERENCE DOCUMENTS

RD 1 Pernechele, C., "Hyper hemispheric lens", Optics Express, Vol.24(5), pp. 5014-5019, 2016. 10.1364/OE.24.005014

RD 2 Pernechele, C., Dionisio, C., Munari, M., Opromolla, R., Rufino,G., Fasano, G., Grassi, M., Pastore, S., "Hyper hemispheric lens applications in small and micro satellites", Advances in Space Research, doi: 10.1016/j.asr.2018.02.025, 2018.

RD 3 Simioni, E., Pernechele, C., Re, C., Lessio, L., & Cremonese, G.,"Geometrical Calibration for the Panrover: a Stereo Omnidirectional System for Planetary Rover". The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 43, 1151-1158, 2020. 10.5194/isprs-archives-XLIII-B3-2020-1151-2020

RD 4 Coran G., Simioni E. Pernechele C., Lessio, L. "Hyperhemispheric Lens Geometric Calibration", INAF Technical Reports, DOI: 10.20371/INAF/TechRep/174

RD 5 Pozzobon, R., et al., "Marius hill skylight hazard characterization as a possible landing site for lunar subsurface exploration", 52° Lunar and Planetary Science Conference, vol. 2584, #1886, 2021. 10.13140/RG.2.2.29004.74884

RD 6 Borrmann, D., et al., "Lunar caves exploration with the Daedalus spherical robot", 52° Lunar and Planetary Science Conference, vol. 2584, #2073, 2021. 10.1029/2009GL040635

RD 7 Borrmann, D., et al., "Daedalus: a spheric robot for mapping lunar pit and caves", NASA Exploration Science Forum & European Lunar Symposium, 2021.

RD 8 Pernechele, C., et al., "Daedalus-CAM: an immersive stereoscopic camera to explore lunar caves", NASA Exploration Science Forum & European Lunar Symposium, 2021.

2. DAEDALUS MISSION

2.1. DAEDALUS-ROBOT PAYLOAD SCENARIO

While the surface of the Moon has been well-documented with cameras on board several satellite missions, relatively little is known about the presence and nature of subsurface cavities. In volcanic areas of the lunar maria, planetary geologists have identified pits that could be related to the collapse of cavities such as lava tubes – where lava once flowed under the lunar surface (see Figure 1).

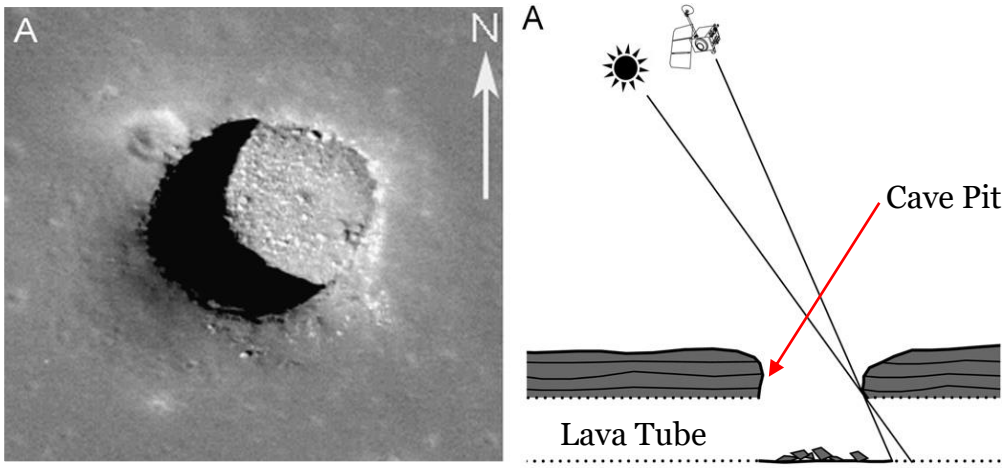

Figure 1: *Lunar cave example (left) and a possible structure (right), although lave tubes are never been observed.*

Exploring and mapping these tubes could provide new information about the Moon's geology, but they could also be an interesting option as long-term shelter for future human visitors to the Moon. They would shield astronauts from cosmic radiation and micrometeorites and possibly provide access to icy water and other resources trapped underground.

Through its Open Space Innovation Platform, in August 2019 ESA opened a campaign for novel ideas to address detecting, mapping and exploring lunar caves and lava tubes. Amongst these ideas, ESA selected the project "Daedalus" to participate in its Concurrent Design Facility (CDF) to study the feasibility and planning the mission. The Mission is planned to last one full lunar day (12+2 contingency), with the possibility to extend the mission time within the cave and to rely on communication with Earth in the following lunar day. The CDF Internal Final Report on Daedalus is now available on request.

The Daedalus is a spherical and transparent robot which hosts (see Figure 2) two payload instruments: a couple of LIDAR (responsibility of the Wurzburg University, DE) and an immersive panoramic camera (Daedalus-CAM) which is under the responsibility of INAF researches (IT). It is worth to note here as another important Italian participation regards the dust mitigation technology for the transparent casing, which is in charge to CIRA (Capua, CE).

The project preliminary scenario has been explored during an ESA CDF study, held in January-March 2021. The Daedalus robot payloads and ancillary sensors architecture is shown in Figure 3 (Daedalus-CAM red framed), while the CDF OBS is shown in Figure 4. The Daedalus payloads with the responsible people are shown here red framed.

This document provides a project plan to trace the roadmap for the realization and validation of the DAEDALUS-CAM. The phase C of the mission is planned to start at the beginning of 2026, while the mission is planned to run in 2031 (TBC).

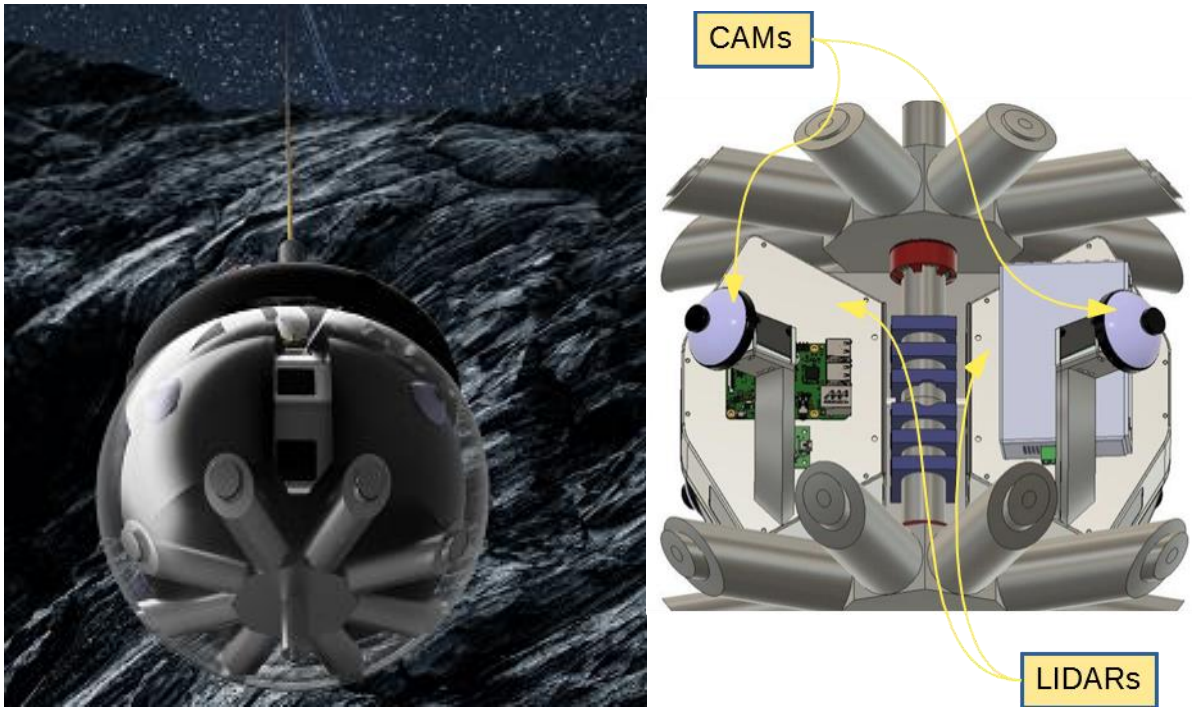

Figure 2:*Daedalus Layout and Payload.*

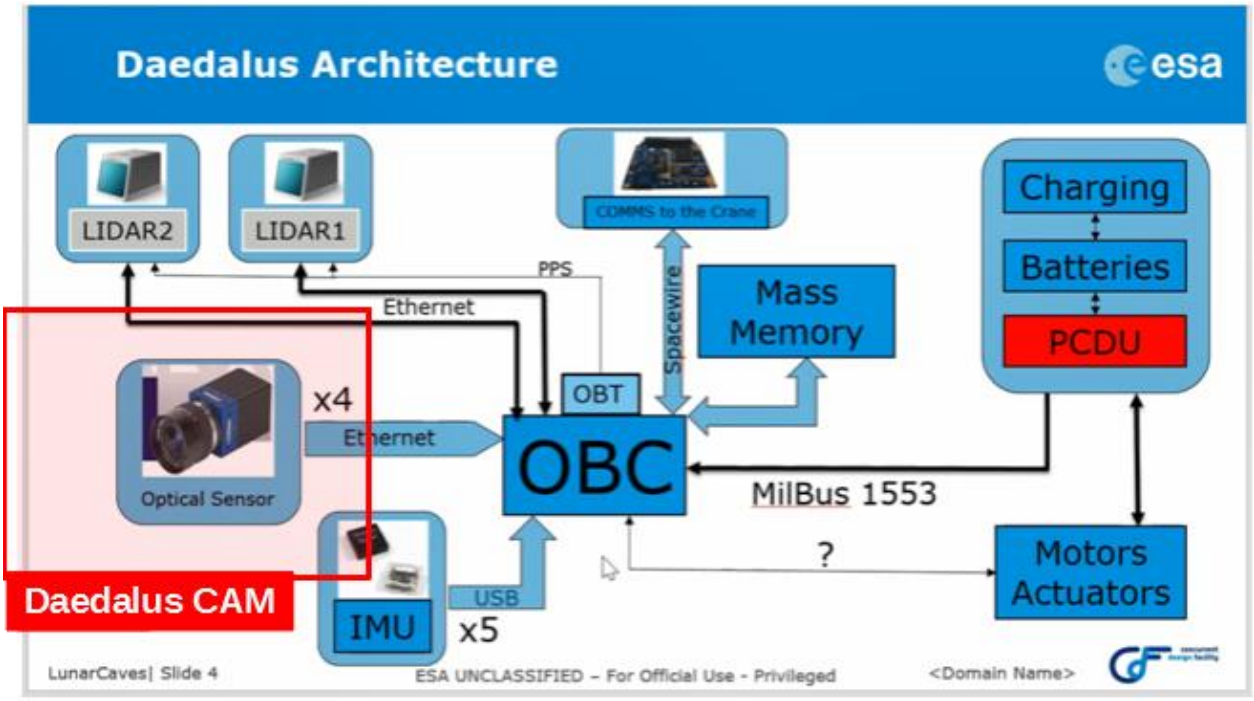

Figure 3: *Daedalus Architecture (from CDF).*

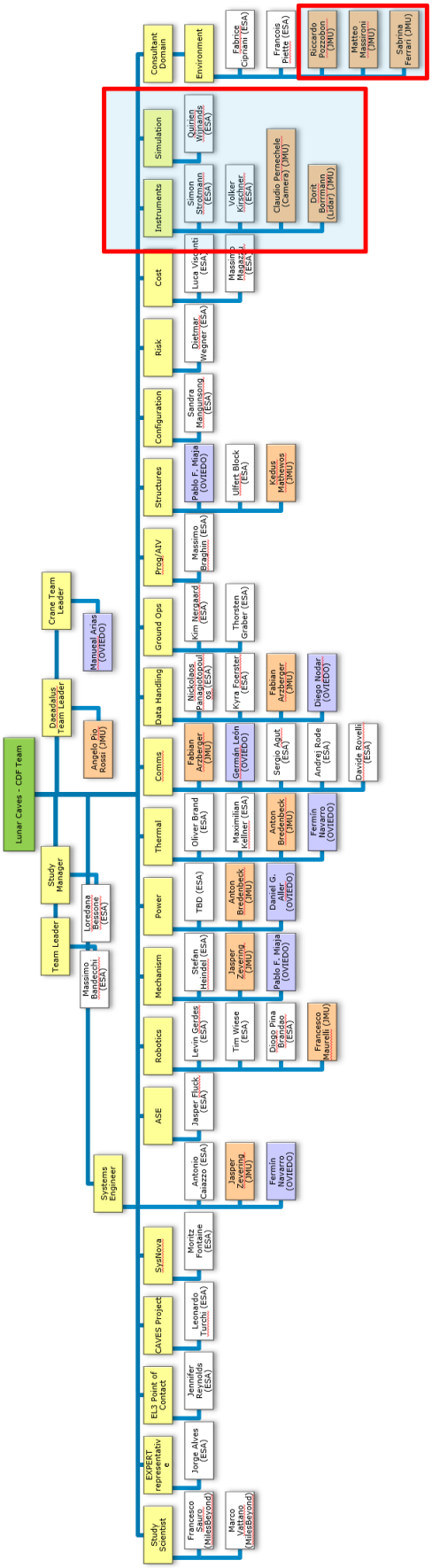

Figure 4: *Daedalus Project OBS (from CDF).*

2.2. DAEDALUS-CAM DESCRIPTION

As visible in Figure 3, the Daedalus On-Board Computer (OBC) is common to both the payload instrumentation and it drive also the series of ancillary sensors such as radiation sensor, thermal sensors, etc.

The DAEDALUS-CAM payload (red framed in Figure 3) consists of four panoramic cameras (PANCAM). Each PANCAM is composed of a bifocal panoramic lens (BPL) and a CMOS chip, a FPGA-based readout electronics and the harness to interface with the common OCB. These four PANCAM systems, together with a scientific analysis software package will be our final deliverables.

In order to validate the acquisition system and the (off-line) software packages (dewarping, stereo imaging [RD 3,RD 4], multi-frame super-resolution imaging, data analysis) a EGSE+MGSE is foreseen, consisting of an on-board computer and its proper power supply.

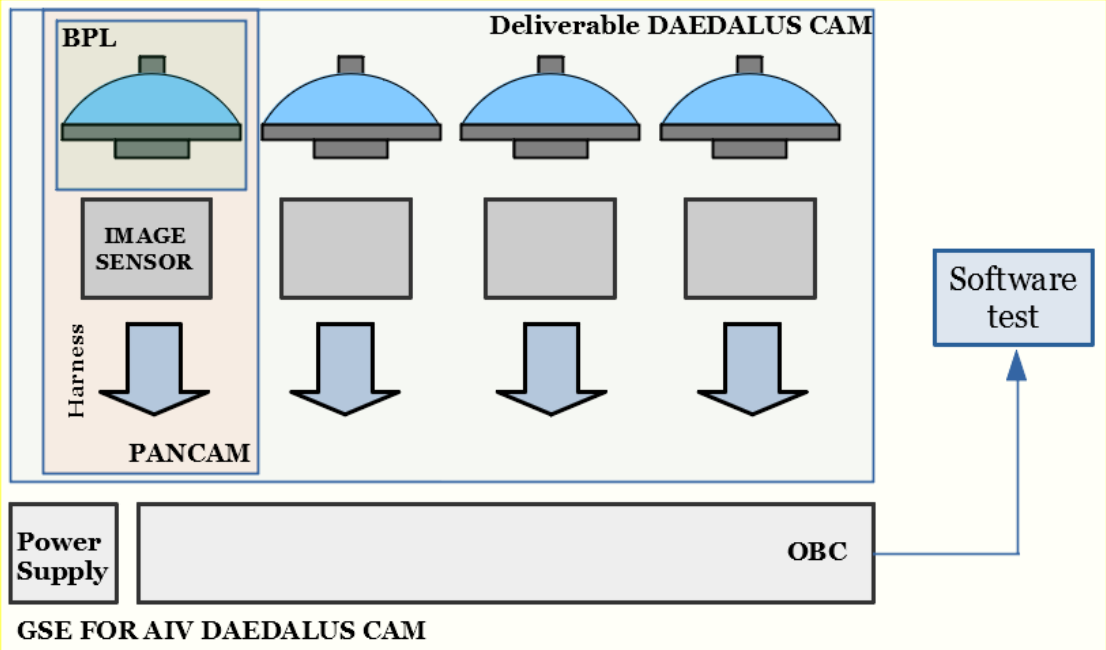

Figure 5:*Daedalus-CAM Architecture & expected deliverables.*

2.3. DAEDALUS-CAM DEVELOPMENT

The ESA/CDF study fixed the Daedalus phase C to start at the beginning of 2026. We describe here the roadmap to realize, test and validate the feasibility of the PANCAM and the analysis software before the starting of the phase C. The Daedalus-CAM architecture has been described in the previous paragraph (see Figure 5) and we briefly summarize here the main aspects. The sub-systems are grouped into:

- the Bifocal Panoramic Lens (BPL),
- the FPGA-based Image Sensor (IS)
- a data analysis software package.

The BPL+IS form a panoramic camera (PANCAM). Daedalus-CAM consists of four PANCAMs. Although the Italian (TBC) deliverable would be the four TRL8 PANCAMs, a

GSE system will be set up in order to test the PANCAMs functionality and validate the analysis software package (which is also under the Italian responsibility).

2.3.1. DAEDALUS-CAM Product tree

- Bifocal Panoramic Lens (BPL)
  - Lenses
  - Filters
  - Mechanics
- Image Sensor (IS)
  - Chip (CMOS)
  - Electronics (FPGA)
  - Mechanics
  - Software (FPGA firmware)
- Ground Segment (GS s/w packages)
  - Dewarping package
  - Stereoscopy package
  - Multi-frame Super-resolution package
- GSE
  - Electronics Ground Support Equipment
  - Mechanics Ground Support Equipment

PANCAM EM, a QM and a FM models are foreseen.

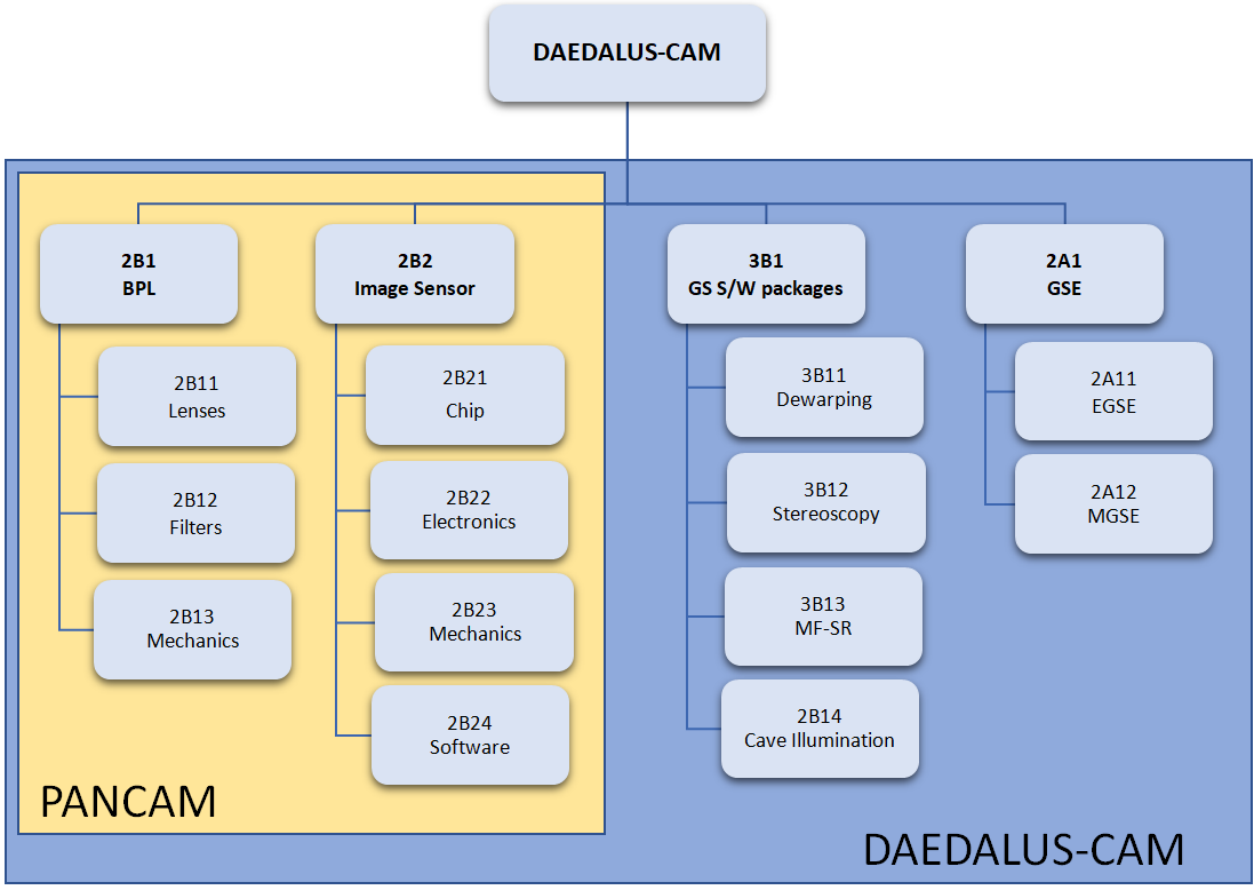

Figure 6: *Daedalus-CAM Product tree.*

2.3.2. DAEDALUS-CAM WBS

In this section are illustrated the sharing of work/responsibilities among the partners involved in the DAEDALUS-CAM provision.

INAF Responsibilities

Systems:

- PI
- PM
- PA
- SE

Design

- Optical (incl. Filters)
- Electric/Electronical Design
- (M)AIV
- GSE

Development

- BPL
- IS
- SW
- GSE

Analysis

- Thermo-mechanical analysis
- SW Data analysis

POLIMI Responsibilities

Subsystems:

- BPL Thermo-Mechanical design
- IS Thermo-Mechanical design
- PANCAM Thermo-Mechanical design
- MAIT/V
- Mechanics procurement

The project is divided into five main blocks:

- Project Office (PO);
- Bifocal Panoramic Lens (BPL) subsystem;
- Image Sensor (IS) subsystem;
- Offline software package;
- Science group management.

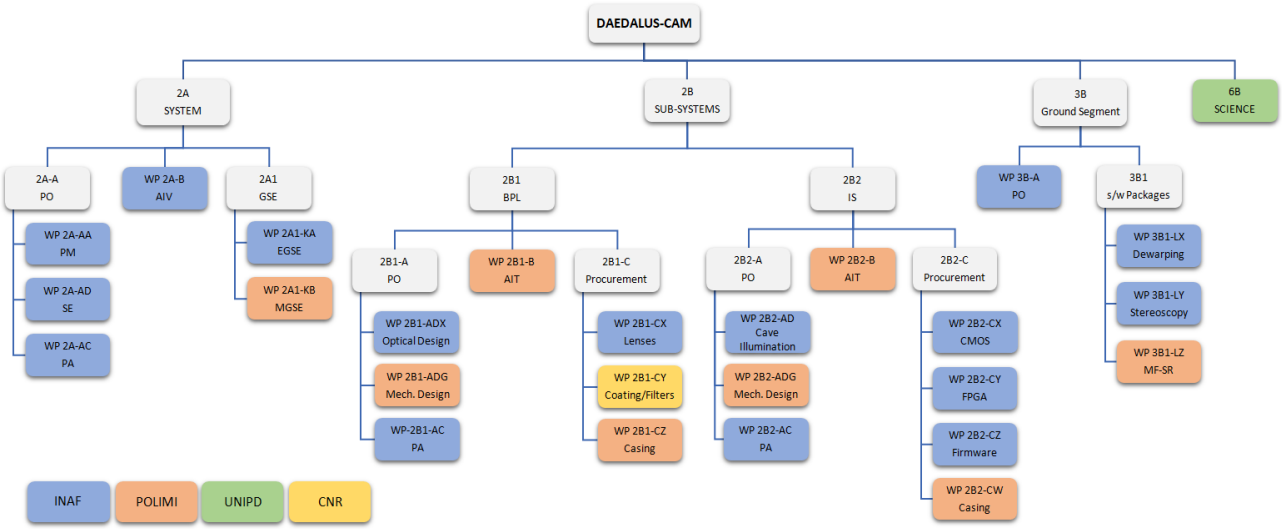

Figure 7:*Daedalus-CAM Work Breakdown Structure.*

PO (2A-A). The project office comprises the project management (WP 2A-AA), the system engineering (WP 2A-AD) and the quality assurance (WP 2A-AC).

GSE (2A1).A EGSE replicating the Daedalus OCB+power supply is foreseen (WP 2A1-KA). Also a mechanical model, replicating the geometry of the BPLs configuration within the Daedalus-CAM will be manufactured (WP 2A1-KB). This MGSE will permit the validation of the off line software package (3B) by acquiring realistic images (using some lunar simulating sites on Earth, such as Etna or Lanzarote island). This will permit also the validation of the image sensor multiple acquisition strategy (FPGA-based) in a relevant environment (WP 2B2-CZ).

AIV (2A-B). The integration of the BPL with the IS will form the PANCAM at a TRL>5 (the right value will depend on the mission environmental condition, not yet fixed); the integration and test will be done at the system level (WP 2A-B).

Subsystem 2B1 (Bifocal Panoramic Lens). Actually a bifocal panoramic lens (BPL) has been developed and validated @TRL4 with earth-based components. To bring it to TRL5 the following steps are necessary: the design of the lens with rad-hard glasses, comprising tolerances, ghost analysis and stray light simulations (WP 2B1-ADX) and the relative thermo-mechanical design (WP 2B1-ADG). Mechanics design will provide safe mounting of the optical system within the thermal and mechanical environments foreseen for the mission. Then the lenses, comprising the antireflection, dichroic and reflective coatings (WP 2B1-CY) and the mechanical casing (WP 2B1-CZ) will be manufactured(WP 2B1-CX). Integration and test @ TRL5 will be the last step (WP 2B1-B).

Subsystem 2B2 (Image Sensor). Due to the strong contrast between the illuminated/shaded pit walls of the lunar cave, we have to design a novel image sensor (IS) with multi-exposure capabilities. The IS consists of a CMOS chip and a FPGA board, all of them available in the COTS market (procurement WP2B2-CX and WP 2B2-CY). The writing of the FPGA firmware code (WP 2B2-CZ) will be strictly driven by the pit illumination simulation (WP 2B2-AD). To prevent minor differences between simulation and real condition (the cave material albedo and its scattering property are not yet well understood) a strategy for fine-tuning of the multiple acquisition stream will be also

studied. A casing for the CMOS+FPGA board integration will be designed (WP 2B2-ADG) and manufactured (WP 2B2-CW). IS AIT to TRL5 (WP 2B2-B) is also foreseen.

Ground Segment: Offline software (3B). A software package to elaborate the data by a ground based operator/scientist is foreseen. This job comprises the s/w analysis also regarding the management of s/w modules (WP 3B-A);three s/w packages are foreseen: one for image distortion correction (WP 3B1-LX), one for stereoscopic analysis (WP 3B1-LY) and the latter for the multi-frame super-resolution retrieving (WP 3B1-LX). Indeed, retrieving of high resolution images from a set of multiple low resolution ones, by means of deep learning/A.I. approach is a modern field of research which is giving promising results in improving image resolution for satellite images of the Earth. We want to explore this very challenging field of research, that would increase the pit cave image resolution.

Table 1:*Working Packages Team.*

WP #	Tasks	Responsibility	WP Manager
2A	PROJECT OFFICE		
2A-AA	PM	INAF-OAPD	E. Simioni
2A-AD	SE	INAF-IASF-ROMA	V. Della Corte
2A-AC	PA	INAF-OAPD	S. Chinellato
2A-B	AIV	-	TBC
2A1-KA	EGSE	-	TBC
2A1-KB	MGSE	POLIMI-DIM	D. Scaccabarozzi
	SUB-SYSTEMS		
2B1	Bifocal Panoramic Lens (BPL)		-
2B1-ADX	Optical Design	INAF-OACT	M. Munari
2B1-ADG	BPL Mechanical Design	POLIMI-DIM	D. Scaccabarozzi
2B1-AC	PA	INAF-OAPD	S. Chinellato
2B1-CX	Lenses Manufacturing	POLIMI-DIM	D. Scaccabarozzi
2B1-CY	Coating Development	CNR-IFN	P. Zuppella
2B1-CZ	BPL Casing	POLIMI-DIM	D. Scaccabarozzi
2B1-B	BPL AIT	POLIMI-DIM	B. Saggin
2B2	Image Sensor (IS)		-
2B2-AD	Cave Illumination Calculation	INAF-OABO	G. Rodeghiero
2B2-ADG	IS Mechanical Design	POLIMI-DIM	D. Scaccabarozzi
2B2-AC	PA	INAF-OAPD	S. Chinellato
2B2-CX	CMOS procurement	INAF-IAPS	A. Melis
2B2-CY	FPGA procurement	INAF-IAPS	A. Melis
2B2-CZ	FPGA Firmware	INAF-IAPS	A. Melis
2B2-CW	IS Casing	POLIMI-DIM	D. Scaccabarozzi
2B2-B	IS AIT	POLIMI-DIM	M. Tarabini
3B	Offline S/W Package		-
3B-A	PO	INAF-OAB	M. Landoni
3B1-LX	Images Dewarping	INAF-OAPD	L. Paoletti
3B-LY	Stereoscopy	INAF-OAPD	C. Re
3B-LZ	A.I. Super resolution	POLIMI-DSTA	TBC
6A	SCIENCE	UNIPD	M. Massironi

Science (WP 6A). The WBS is completed by the scientific group which will participate in the acquisition strategy definition and to the software packages development; it also will exploit the data in the post-processing phase of the mission.

3. DAEDALUS-CAM OVERALL ORGANIZATION

The DAEDALUS_CAM project is entirely under the responsibility of Italy.

The involved Institutes:

- Istituto Nazionale di Astrofisica (INAF)
- Politecnico di Milano (POLIMI)
- Università di Padova
- CNR

Each research entity may make use of industrial partners to fulfill the committed activities.

For communication, the primary points of contact between the involved Institutes are:

- INAF: Claudio Pernechele, DAEDALUS-CAM PI
- POLIMI: Diego Scaccabarozzi, mechanics
- CNR: Paola Zuppella (IFN), lens coating &dichroics
- Università di Padova: Matteo Massironi, science

3.1. DAEDALUS-CAM OBS

The organization of the DEDALUS-CAM team based in research institutes is depicted in **Errore. L'origine riferimento non è stata trovata.**.

Principal Investigator:	Claudio Pernechele,	INAF
Project Management:	Emanuele Simioni,	INAF
System Engineering:	Vincenzo Della Corte,	INAF
Risk Manager:	Emanuele Simioni,	INAF
Product Assurance Manager:	Simonetta Chinellato,	INAF
Optical Engineer:	Matteo Munari,	INAF
Mechanical Engineer:	Diego Scaccabarozzi,	POLIMI
Electronical Engineer:	TBC	
AIV & GSE Engineer:	TBC	
Data Analysis Software Manager:	Marco Landoni,	INAF

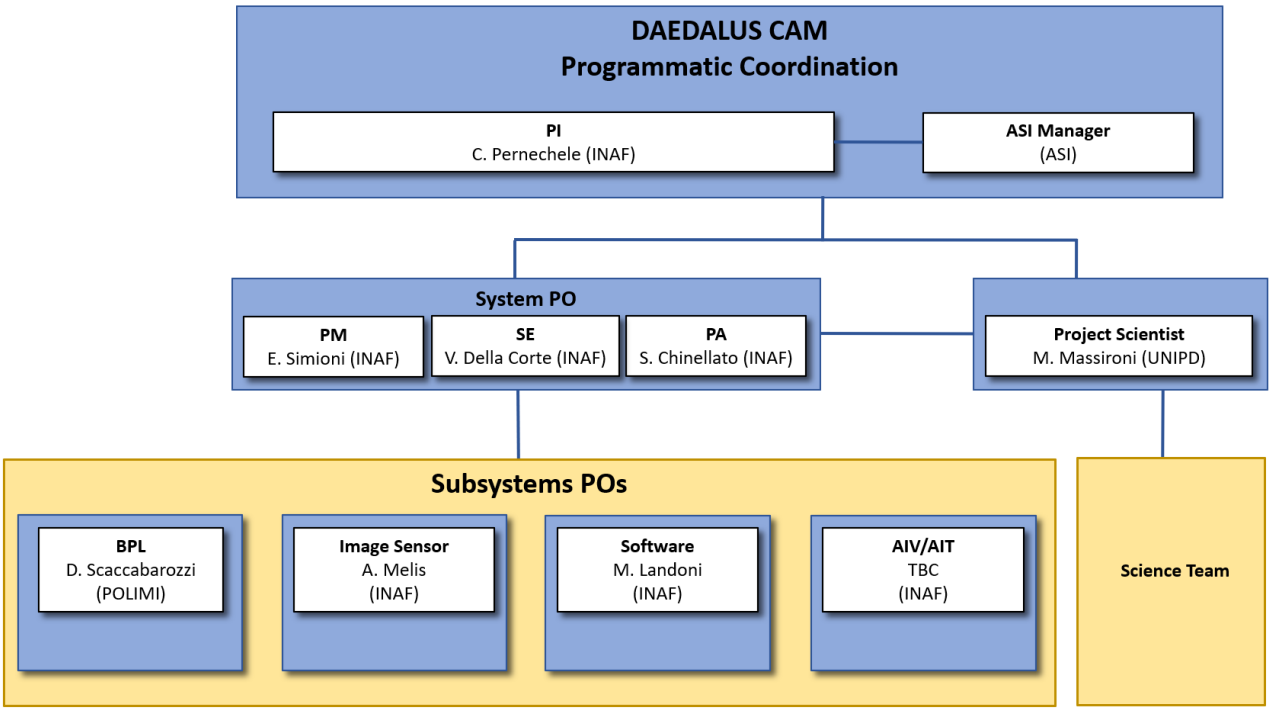

Figure 8: *Daedalus-CAM OBS.*

3.2. DAEDALUS-CAM PEOPLE

Human resources listed by Institute and by WPs are listed below.

Table 2: *People by Institute.*

Institute	Name	Institute role
INAF-OAPD	Claudio Pernechele	Associate Astronomer
	Emanuele Simioni	Technologist
	Simonetta Chinellato	Technologist
	Cristina Re	Technologist
	Daniela Fantinel	Technologist
	Lorenzo Paoletti	Technologist
	Luigi Lessio	Technician
INAF-IAPS	Vincenzo Della Corte	Senior researcher
INAF-OAB	Marco Landoni	Technologist
INAF-OABO	Gabriel Rodeghiero	Technologist
INAF-OACT	Matteo Munari	Technologist
CNR-IFN	Paola Zuppella	Researcher
	Vania Da Deppo	Senior researcher
	Paolo Chioetto	Ph. D. student
POLIMI-DIM	Diego Scaccabarozzi	Associate Professor
	Bortolino Saggin	Full Professor
	Marco Tarabini	Associate professor
POLIMI-DSTA	TBC	
	TBC	

Table 3: *People by Nodes.*

Node	Name
2A	Claudio Pernechele
	Emanuele Simioni
	Simonetta Chinellato
	Vincenzo Della Corte
	Daniela Fantinel
2B1	Diego Scaccabarozzi
	Bortolino Saggin
	Marco Tarabini
	Paola Zuppella
	Vania Da Deppo
	Paolo Chioetto
	Matteo Munari
	Luigi Lessio
	Simonetta Chinellato
2B2	Andrea Melis
	Gabriele Rodeghiero
	Simonetta Chinellato
3B	Marco Landoni
	Cristina Re
	Lorenzo Paoletti
	TBD
	TBD

3.3. DAEDALUS-CAM TIMELINE

The Daedalus B2 to D phases have been planned during the ESA CDF study. The phase B2 is planned to start in the first quarter of 2026, while the mission is planned to be operative in the mid of 2031 (bottom panel in Fig. 8).

PANCAM is currently at TRL4, and we plan three years to take it @TRL>5 (phase B1) (upper panel in Fig. 8). To bring the BPL (WPs 2B1) and the IS (WPs 2B2) up to TRL5 requires 2 years of work, while one more year is required to integrate the PANCAM (BPL+IS) and test it @TRL>5, TBD when the environmental condition will be fixed.

WPs 2B1: The WP starts with the optical design (WP 2B1-ADX) based on the configuration developed during the design of the actual TRL4 BPL. The thermo-mechanical design (WP 2B1-ADG) is planned to start after 2 months. Once concluded the opto-mechanical design (KO+8), stray light simulation (WP 2B1-ADX) and lenses manufacturing (WP 2B1-CX) will start. A further WP 2B1-CY is dedicated to the lenses coating (antireflection, dichroic and reflective). Then the mechanics is manufactured (WP 2B1-CZ) and the lenses are assembled (KO+20). AIV will provide a mockup of the BPL to be tested in the representative environment (WP 2B1-B). The qualified BPL @TRL5 will be delivered as well as the testing report and the final design report.

WPs 2B2: The image sensor design starts with the CMOS and FPGA procurement. There are many models available in the space COTS market and we plan to identify the optimum models (for both) in 4 months (WP 2B2-CX, WP 2B2-CY) . In the meantime the simulation of the cave illumination, to find the exposure time of the camera, will run (WP 2B2-AD, KO+10) and then this algorithm will be implemented on the FPGA (2B2-CY, KO+20). Based on the COTS selected models of the chips (both CMOS and FPGA) a thermo-mechanical casing design will start in parallel (WP 2B2-ADG). Once the CMOS, FPGA and casing have been assembled (WP 2B2-B), a validation in the thermal and mechanical environment is foreseen. At this stage, in two years from KO, an image sensor @TRL5 is obtained.

WPs 3B: The software packages are expected to run all along the project timeline. Continuous feedback with optics and sensor developers is necessary to optimize the s/w codes. A least three independent packages are foreseen: image distortion correction (WP1B3-B), stereoscopic information retrievement (WP1B3-C) and multiframe super-resolution deep-learning algorithm (WP1B3-D). All the packages will be integrated into a user interface (WP1B3-A) to make them all available to the scientific final user.

WP1A-B: Once the BPL and IS @TRL5 have been manufactured (KO+2 years), their integration is expected to produce and validate the PANCAM (WP1A-BA). This work will last 1 years and the PANCAM @TRL8 will be ready to be delivered for the integration into the Daedalus robot. In the meanwhile, a mockup of the Daedalus-CAM architecture (not space qualified) will be also built up. This mockup will help to acquire realistic immersive images in a relevant environment (such as caves in Lanzarote or Etna sites) in order to test the developed s/w packages.

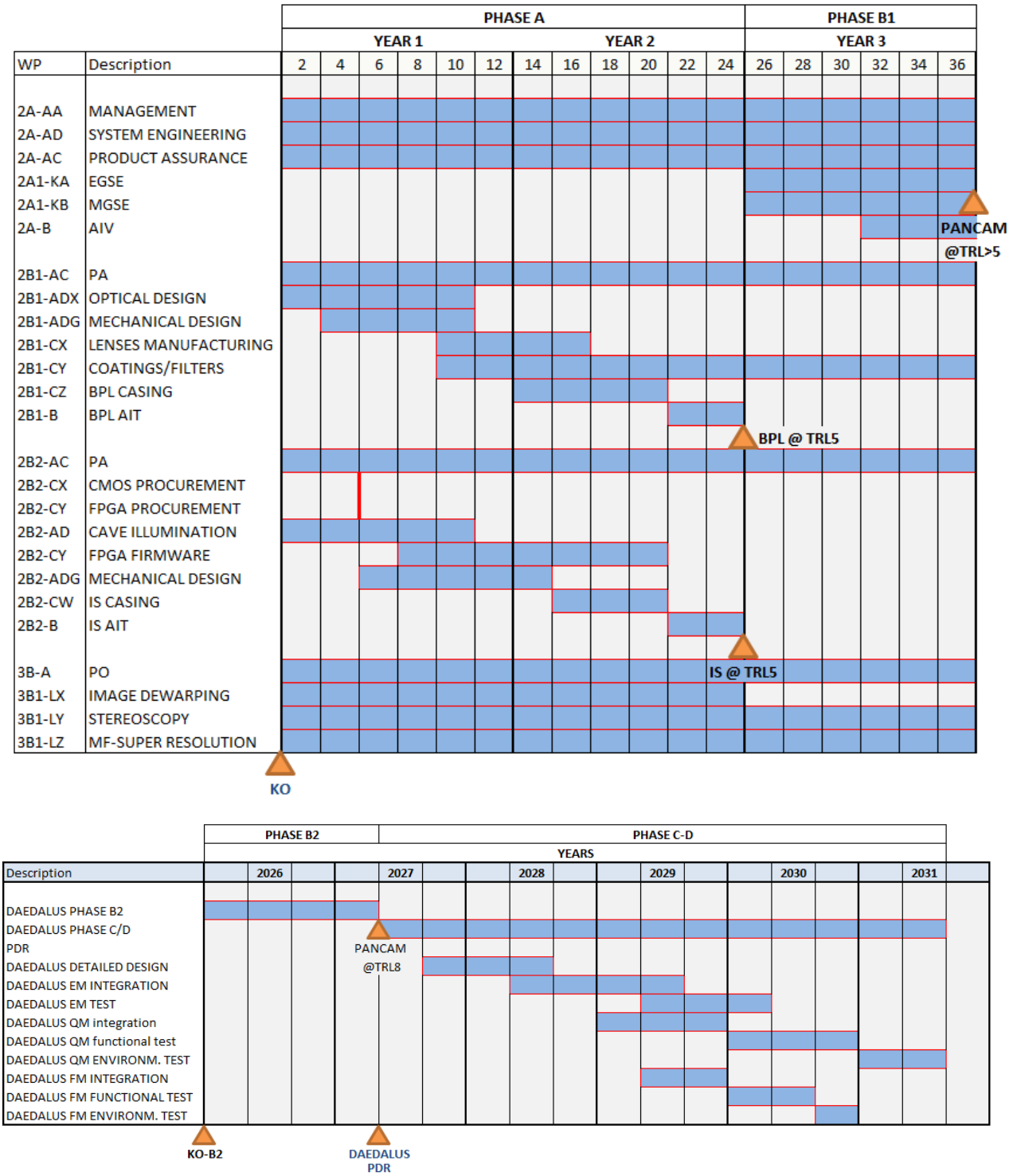

Figure 9: *Timeline for the A-B1 phases (3 years, top) and the B2-D phases (6 years, bottom, from ESA CDF study).*

3.4. DAEDALUS-CAM COST BREAKDOWN

The project Daedalus received 120 k€ funds from ESA (EXPRO+ program) for the CDF study. Daedalus-CAM has benefited of the 12% of that, then 14.4 k€. This concluded the preliminary part of the phase 0 study (overall mission feasibility).

The development costs for the A-B1 phases is estimated in 3125 k€.

The costs for the A-B1 phases (3 years), divided per node blocks, are as in the table:

PHASE A-B1			ASI	Cofin	Total
2A	INAF	Research grant (AIV)	70		
		EGSE procurement and assembly (OBC, …)	250		
		MGSE procurement and manufacturing	140		
		AIV activities	85		
		Staff		180	725
2B1	POLIMI	Research grant	70		
		Consumption	20		
		BPL Thermomechanical design	50		
		Mechanical achievement	80		
		BPL AIT	25		
		Lenses procurement (set 8x)	120		
		Staff		150	
	CNR	Research grant	105		
		Consumption	30		
		Samples achievement for feasibility	70		
		A/R and dichroic coatings deposition	110		
		Coatings AIT	80		
		Staff		80	990
2B2	POLIMI	Research grant	35		
		Consumption	15		
		Thermomechanical design IS	30		
		Mechanical achievement	60		
		IS AIT	20		
		Staff		130	
	INAF	Research Grant	70		
		Consumption	20		
		CMOS & FPGA procurement	130		
		Support sviluppo firmware	30		
		Firmware development	210		
		Staff		140	890
3B	INAF/POLIMI	Research Grants (3x)	315		
		Consumption	45		
		Staff		300	660
6B	UNIPD	Research Grant	105		
		Staff		140	245
all	all	Missions Italia, ESA, Germany	60		60
		Total	**2450**	**1120**	**3570**

The costs for the B2-C-D(6 years) phases are estimated as in the following table:

	PHASE B2-D	ASI	Cofin	Total
B2 (1 year)	Research grants (5x 1 anno)	210		
	Contract PA/QA 1x 1 anno	35		
	RTDA	150		
	Consumption	35		
	Miscellaneous	50		
	Missions Italia, ESA, Germany	60		
	Staff		480	1020
C-D (5 years)	PANCAM EM items (lens, coating, casing)	250		
	PANCAM EM AIV	220		
	PANCAM FM/FS items (lens, coating, casing)	250		
	PANCAM FM/FS AIV	440		
	EGSE manufacturing	300		
	IS (FPGA+CMOS)	400		
	EGSE + FM characterization	300		
	Contract PA/QA 1x 5 anni	175		
	Research grant opto-mechanics engineer	175		
	Research grant system engineer	175		
	Research grant electronic engineer	175		
	Research grant software engineer (3x)	525		
	Research grant o RTDa science (2x)	350		
	Missions Italia, ESA, Germany	180		
	Staff		1600	5515
	Total	**4455**	**2080**	**6535**

Table 4: Daedalus-CAM overall project costs estimation.

Phases	Duration (years)	Project costs (k€)	ASI costs (k€)	Cofin (k€)
A-B1	3	3570	2450	1120
B2-D	6	6535	4455	2080
Total	9	10005	6905	3200

3.5. DAEDALUS-CAM DELIVERY ITEMS

The Daedalus-CAM final delivery from INAF/ASI will consist of:

- 4x FM PANCAM,
- Analysis s/w package.

3.6. DAEDALUS-CAM WORK PACKAGES

Below details on the project work packages.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 06-07-2021	issue: 1
WP title	**Project Office: Management**	**WP ID.: 2A-AA**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: T0	
End event:	PANCAM @TRL>5	End date: T0+36	
WP manager:	Emanuele Simioni	Sheet 1 of 1	

Inputs

- Daedalus Mission ESA-CDF study
- Scientific requirements
- Mission requirements

Activities

- Management of formal relations with the PI/PM/SE/PA Managers, the Project Scientist, Tech. team and Sub-Contractors for programmatic and technical aspects.
- Prepare and maintain the Project Management Plan and other project management documentation.
- Interface with the customer and subcontractors with emphasis on performance and schedule.
- Overall Action Item management.
- Perform risk management.
- Assessment and handling of contractual issues.
- Organize meetings, prepare and perform reviews.
- Perform project progress and cost control.
- Review and approve documentation.
- Perform lower level reviews.
- Prepare progress reports, establish and maintain project schedule.
- Establish and maintain compliance to Product Assurance Plan.
- Configuration and Documentation Management of all involved hardware, software, including test software, simulators and test data, documentation, problem reports, change requests, actions, critical issues.

Outputs

- Project management documentation.
- Contracts and confirmations.
- Progress reports and project schedule.
- Minutes of meetings.
- Other management reports and documentation.
- Project Schedule.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**Project Office: System Engineering**	**WP ID.: 2A-AD**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:	PANCAM @TRL>5	End date: To+36	
WP manager:	Vincenzo Della Corte	Sheet 1 of 1	

Inputs

- ICD Daedalus robot
- Daedalus Mission ESA-CDF study
- Scientific requirements
- Mission requirements
- Management Plan
- Instrument Requirement Specification

Activities

- System, subsystem requirements Definition
- Preparation of the Development Plan
- Development of the Architecture and Detailed Design
- Technical coordination of the activities related to the design and manufacturing of the sub-systems
- Coordination of the System and sub-System generation of technical documentation
- Interface control documents
- Definition of the mechanical, thermal, electrical and communication interfaces
- Collection and integration of the input to the Design Report
- Generation and maintenance of the tech budget (mass, power, telemetry)
- Verification of sub-system in order to make them available for the system integration
- Preparation of the project reviews
- Contribution to the Acceptance Data Package preparation
- Management of the criticalities of design
- Bench integration supervision

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**Project Office: System Engineering**	**WP ID.: 2A-AD**	
Outputs • System requirements • Engineering Development Plan • Design Report • Mass, Power and Telemetry Budget • Sub-systems ready to the System Integration • Mechanical, thermal, electrical and communication ICDs • Presentations at conferences and team meetings • Support the documentation of the DAEDALUS-CAM • Contribution to periodic reports to CAS and LFA.			

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**Project Office: PA**	**WP ID.: 2A-AC**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:	PANCAM @TRL>5	End date: To+36	
WP manager:	Simonetta Chinellato	Sheet 1 of 1	

Inputs

- Product Assurance Requirement Documents
- Scientific requirements
- Mission requirements
- Management Plan
- Development Plan

Activities

- Interface PI/LFA Manager, Sub-Contractors, Technological Team for what concern safety and quality aspects
- Monitoring and control of all internal and external production, integration and testing activities
- Generation of the PA plan
- Application of the PA Plan
- Approval and check regarding structure and completeness of the technical documentation
- Configuration control and approval of changes
- Certification of test results
- Calling of dedicated meetings in case of quality and safety problems
- Perform of all needed analysis on the reliability aspects in order to meet requirements
- Material, EEE parts and processes list and of the relevant export control
- Perform all needed Safety Analysis

Outputs

- PA Plan
- Certificates of conformity and NCR
- System Reliability Analysis
- Material, EEE parts and Processes list
- Safety Analysis
- Verification Control Document
- presentations at conferences and team meetings
- Support the documentation
- Contribution to periodic reports to CAS and LFA

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**PANCAM AIV**	**WP ID.: 2A-B**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO phase B1	Start date: T0+24	
End event:	I-FAR	End date: T0+36	
WP manager:	TBD	Sheet 1 of 1	

Inputs

- Interface Control Document
- System requirements
- Management Plan
- Development Plan
- PA Plan
- ICDs
- IS @TRL5 (2B2)
- BPL @TRL5 (2B1)

Activities

- Integration of BPL and IS
- Thermo-vacuum tests
- Vibrational test

Outputs

- PANCAM at a TBD TRL (>5)

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**EGSE**	**WP ID.: 2A1-KA**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO phase B1	Start date: T0+24	
End event:		End date: T0+36	
WP manager:	TBD	Sheet 1 of 1	

Inputs

- General Design Requirements
- Environmental Design Requirements
- Mechanical design Requirements
- Interface Requirements and ICDs
- Quality Assurance Requirements

Activities

The activity consists of an equipment (electric and electronics housed in a box) that interfaces cameras with a PC, running specific software, allowing the following operations:

- visualization of images acquired from 4 cameras via 4 HDMI interfaces (TBC)
- control of cameras parameters
- monitoring of the status registers of the cameras

Here is the list of activities:

- Detailed hardware architecture design
- Selection and dimensioning of active and passive components (industrial range will be used)
- Development of electrical schemes
- Mechanical design of boards
- Development of printed circuits
- Signal integrity simulation for “High speed” sections (if needed)
- Procurement of active (i.e. FPGA) and passive components
- Board mounting and electrical testing

- Development of hardware/software interface document
- Development of VHDL code for the programmable logic
- Clock domain management
- Testbench development
- Functional simulations
- Definition of timing and electrical constraints for the implementation on the programmable logic
- Implementation of the project

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**EGSE**	**WP ID.: 2A1-KA**	

- Logical synthesis
- Mapping and PAR
- Bitstream generation
- Specific PC software developing to test of the camera subsystem and to emulate processor board of the system.

Outputs

- subsystem technical specs
- Manufacturing dossier
- Electrical Drawings, Assembly L.C. e L.S.
- Project files for the PCB developed with CAD tool
- Gerber files
- Mechanical drawing (XDF and 3D STEPS formats)
- Results of simulations (if needed)
- C/C++ source code
- Software user manual

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**MGSE**	**WP ID.: 2A1-KB**	
Supplier:	**POLIMI**	Country: Italy	
Start event:	KO	Start date: T0+18	
End event:	Launch	End date: T0+36	
WP manager:	Diego Scaccabarozzi	Sheet 1 of 1	

Inputs

- Interface Control Document
- System requirements
- Management Plan
- Development Plan
- PA Plan
- Calibration Plan
- ICDs
- BPL
- IS
- harness
- Test procedures

Activities

- Preparation of the MGSE specs
- Preparation of the MGSE User Manual
- MGSE hardware procurements
- Generation of test/simulation data
- Instrument configuration control and commanding

Outputs

- MGSE specs
- MGSE User Manual
- MGSE object

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL PO: Optical Design**	**WP ID.: 2B1-ADX**	
Supplier:	**INAF**	Country:Italy	
Start event:	KO	Start date: To	
End event:		End date: To+10	
WP manager:	Matteo Munari	Sheet 1 of 1	

Inputs

- Interface Control Document
- Daedalus ESA CDF final report
- Optical requirement
- Environment specs

Activities

- BPL optical design using radiation hardness glasses
- Optical effects simulation of the Daedalus robot transparent shell
- Tolerance calculations
- Ghost analysis
- Stray light analysis

Outputs

- BPL optical design
- As-to-build tables for each lens in the optical train
- Lenses coating specifications.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL PO: Mechanical Design**	**WP ID.: 2B1-ADG**	
Supplier:	**POLIMI**	Country:Italy	
Start event:	KO	Start date: T0+2	
End event:		End date: T0+10	
WP manager:	Diego Scaccabarozzi	Sheet 1 of 1	

Inputs

- BPL optical design (WP2B1-A)
- Daedalus ESA CDF final report
- Environment specs

Activities

- Thermal and mechanical requirements review from Daedalus mission analysis;
- BPL thermo-mechanical design using numerical method (FE analyses and thermal analyses);
- CAD models realization

Outputs

- BPL thermo-mechanical design report
- Mechanical drawings of the BPL assembly with the as-to-built mechanics.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL PO: PA**	**WP ID.: 2B1-AC**	
Supplier:	**INAF**	Country:Italy	
Start event:	KO	Start date: To	
End event:		End date: To+36	
WP manager:	Simonetta Chinellato	Sheet 1 of 1	

Inputs

- Product Assurance Requirement Documents
- Scientific requirements
- Mission requirements
- Management Plan
- Development Plan

Activities

- Interface PI/LFA Manager, Sub-Contractors, Technological Team for what concern safety and quality aspects
- Monitoring and control of all internal and external production, integration and testing activities
- Generation of the PA plan
- Application of the PA Plan
- Approval and check regarding structure and completeness of the technical documentation
- Configuration control and approval of changes
- Certification of test results
- Calling of dedicated meetings in case of quality and safety problems
- Perform of all needed analysis on the reliability aspects in order to meet requirements
- Material, EEE parts and processes list and of the relevant export control
- Perform all needed Safety Analysis

Outputs

- PA Plan
- Certificates of conformity and NCR
- System Reliability Analysis
- Material, EEE parts and Processes list
- Safety Analysis
- Verification Control Document
- presentations at conferences and team meetings
- Support the documentation

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL Procurement: Lenses manufacturing**	**WP ID.: 2B1-CX**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: T0+8	
End event:		End date: T0+12	
WP manager:	Matteo Munari	Sheet 1 of 1	

Inputs

- As-to-built tables for each lens (WP 2B1-)
- Coatings specification (WP 2B1-).

Activities

- BPL Lenses manufacturing

Outputs

- BPL Lenses train

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL Procurement: Lenses coating deposition**	**WP ID.: 2B1-CY**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To+8	
End event:		End date: To+12	
WP manager:	Paola Zuppella	Sheet 1 of 1	

Inputs

- BPL lenses train (WP 2B1-ADX)
- Coatings specification.

Activities

- Coating design
  - BPL A/R coating
  - BPL reflective coating
  - BPL dichroic filter
- Coating deposition
  - BPL A/R coating
  - BPL reflective coating
  - BPL dichroic filter
- Coating qualification and test
  - BPL A/R coating
  - BPL reflective coating
  - BPL dichroic filter

The tests will be carried out in co-engineering activities with the selected company. A qualification test plan will be fixed and the performance measurements settled. Reflectivity and roughness measurements will be performed at the CNR-IFN labs.
Other activities:

- periodic meeting
- progress report
- conferences

Outputs

- BPL coated lenses train
- Qualification report

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL Procurement: BPL Casing**	**WP ID.: 2B1-CZ**	
Supplier:	**POLIMI**	Country: Italy	
Start event:	KO	Start date: T0+8	
End event:		End date: T0+12	
WP manager:	Diego Scaccabarozzi	Sheet 1 of 1	

Inputs

- BPL mechanical design report (WP 2B1-ADG)
- Mechanics drawings (WP 2B1-ADG)

Activities

- Mechanical manufacturing
- Anodization and/or coatings
- Thermal and mechanical testing plans

Outputs

- Manufacturing report
- Thermal and mechanical test plan
- BPL Mechanics

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**BPL AIT**	**WP ID.: 2B1-B**	
Supplier:	**POLIMI**	Country:Italy	
Start event:	KO	Start date: T0+20	
End event:		End date: T0+24	
WP manager:	Bortolino Saggin	Sheet 1 of 1	

Inputs

- Thermal and mechanical tests plan
- Manufactured lenses + coatings
- Manufactured mechanics

Activities

- Lens and mechanics assembly
- Thermo-vacuum tests
- Vibrational tests

Outputs

- Thermal and mechanical testing report
- Final design report of the BPL@TRL5
- BPL @ TRL5

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS PO: Cave illumination**	**WP ID.: 2B2-AD**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+10	
WP manager:	Gabriele Rodeghiero	Sheet 1 of 1	

Inputs

- Environmental condition from Daedalus ESA CDF final report
- Filters passband from Daedalus ESA CDF final report
- Mission profile from Daedalus ESA CDF final report
- Optical design

Activities

- Software simulating solar irradiance during the mission profile
- Sterance / radiance from the pit/floor/lava tube calculation
- Exposure time calculation for the illuminated/shaded pit wall.

Outputs

- Exposure time table for illuminated/shaded wall at different solar illumination condition (mission profile).
- Exposure Time Algorithm
- Exposure Time Algorithm Description Document

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS PO: Mechanical Design**	**WP ID.: 2B2-ADG**	
Supplier:	**POLIMI**	Country: Italy	
Start event:	KO	Start date: T0+4	
End event:		End date: T0+10	
WP manager:	Diego Scaccabarozzi	Sheet 1 of 1	

Inputs

- CMOS mechanical characteristic/constraints
- FPGA mechanical characteristic/constraints
- Environmental condition from Daedalus ESA CDF final report
- BPL Optical design report
- BPL thermo-mechanical design report

Activities

- IS thermal and mechanical requirements review
- IS casing thermo-mechanical design
- IS casing 2D drawings

Outputs

- Thermo-mechanical design IS report
- As-to-built tables for the IS casing mechanical pieces.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS PO: PA**	**WP ID.: 2B2-AC**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+36	
WP manager:	Simonetta Chinellato	Sheet 1 of 1	

Inputs

- Product Assurance Requirement Documents
- Scientific requirements
- Mission requirements
- Management Plan
- Development Plan

Activities

- Interface PI/LFA Manager, Sub-Contractors, Technological Team for what concern safety and quality aspects
- Monitoring and control of all internal and external production, integration and testing activities
- Generation of the PA plan
- Application of the PA Plan
- Approval and check regarding structure and completeness of the technical documentation
- Configuration control and approval of changes
- Certification of test results
- Calling of dedicated meetings in case of quality and safety problems
- Perform of all needed analysis on the reliability aspects in order to meet requirements
- Material, EEE parts and processes list and of the relevant export control
- Perform all needed Safety Analysis

Outputs

- PA Plan
- Certificates of conformity and NCR
- System Reliability Analysis
- Material, EEE parts and Processes list
- Safety Analysis
- Verification Control Document
- presentations at conferences and team meetings
- Support the documentation

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS Procurement: CMOS procurement**	**WP ID.: 2B2-CX**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+4	
WP manager:	Andrea Melis	Sheet 1 of 1	

Inputs

- General Design Requirements
- Environmental Design Requirements
- Mechanical design Requirements
- Interface Requirements and ICDs
- Quality Assurance Requirements

Activities

- Detailed hardware architecture design
- Selection and dimensioning of active and passive components (industrial range will be used)
- Development of electrical schemes
- Mechanical design of boards to fit equipment requirements
- Development of printed circuits
- Signal integrity simulation for “High speed” sections (if needed)
- Procurement of active CMOS and passive components

Outputs

- CMOS chip.
- Manufacturing dossier
- Electrical Drawings, Assembly L.C. e L.S.
- Project files for the PCB developed with CAD tool
- Gerber files
- Mechanical drawing (XDF and 3D STEPS formats)

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS Procurement: FPGA procurement**	**WP ID.: 2B2-CY**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+4	
WP manager:	Andrea Melis	Sheet 1 of 1	

Inputs

- General Design Requirements
- Environmental Design Requirements
- Mechanical design Requirements
- Interface Requirements and ICDs
- Quality Assurance Requirements

Activities

- Detailed hardware architecture design
- Selection and dimensioning of active and passive components (industrial range will be used)
- Development of electrical schemes
- Mechanical design of boards to fit equipment requirements
- Development of printed circuits
- Signal integrity simulation for “High speed” sections (if needed)
- Procurement of active FPGA and passive components

Outputs

- FPGA chip.
- Manufacturing dossier
- Electrical Drawings, Assembly L.C. e L.S.
- Project files for the PCB developed with CAD tool
- Gerber files
- Mechanical drawing (XDF and 3D STEPS formats)

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS Procurement: FPGA Firmware Development**	**WP ID.: 2B2-CZ**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: T0+6	
End event:		End date: T0+20	
WP manager:	Andrea Melis	Sheet 1 of 1	

Inputs

- CMOS
- FPGA
- Environmental Design Requirements
- Exposure Time Algorithm (WP 2B2-AD)
- Exposure Time Algorithm Description Document (WP 2B2-AD)

Activities

- CMOS sensor interface
- VIDEO framing transmitted with SPICEWIRE interface as physical layer
- SPI interface for sensor management
- GSE interface
- “Image algorithm”

Here is the list of activities:

- Development of hardware/software interface document
- Development of VHDL code for the programmable logic
- Clock domain management
- Testbench development
- Functional simulations
- Definition of timing and electrical constraints for the implementation on the programmable logic
- Implementation of the project
  - Logical synthesis
  - Mapping and PAR
  - Bitstream generation

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS Procurement: FPGA Firmware Development**	**WP ID.: 2B2-CZ**	

Outputs

1. FIRMWARE: bitstream for programmable logic configuration concerning implementation of all interfaces.

   DOCUMENTATION concerning implementation of all interfaces:

   - Hardware/software interface document
   - VHDL source code
   - Testbenches
   - Implementation project environment with all the files needed for the generation of the binary file for the configuration of the programmable logic.

2. FIRMWARE: bitstream for programmable logic configuration concerning implementation of overall functions included “Image algorithm”.

   DOCUMENTATION concerning implementation of overall functions included “Image algorithm”:

   - VHDL source code
   - Testbenches
   - Implementation project environment, with all the files needed for the generation of the binary file for the configuration of the programmable logic

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS Procurement: Casing**	**WP ID.: 2B2-CW**	
Supplier:	**POLIMI**	Country: Italy	
Start event:	KO	Start date: T0+10	
End event:		End date: T0+16	
WP manager:	Diego Scaccabarozzi	Sheet 1 of 1	

Inputs

- IS thermal and mechanical requirements review
- IS casing thermo-mechanical design
- IS casing 2D drawings

Activities

- IS mechanical manufacturing
- IS testing plan

Outputs

- IS mechanics
- IS testing plan report.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**IS: AIT**	**WP ID.: 2B2-B**	
Supplier:	**POLIMI**	Country: Italy	
Start event:	KO	Start date: T0+20	
End event:		End date: T0+24	
WP manager:	Marco Tabarini	Sheet 1 of 1	

Inputs

- IS testing plan report

Activities

- Integration of the electronics into the mechanical housing
- Integration between system HW components, the PC software and the programmable logic
- Execution of acceptance tests and finalization of the activities within the scope of the application

Outputs

- AIT Test procedure
- AIT Test report
- Final system design report

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**Ground Segment PO**	**WP ID.: 3B-A**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+36	
WP manager:	Marco Landoni	Sheet 1 of 1	

Inputs

- Science from Daedalus ESA CDF final report
- BPL optical design
- IS characteristics
- Input from the Science Team about data visualization and expected products

Activities

- Definition of the SW top level requirements.
- Production of the SW design document and report.
- Drawing of the Class Diagram architecture (in SysML+UML) and overall SW organization in terms of
  - packages,
  - classes
  - interfaces.
- SW developing management activities (monitoring of the progress, definition of milestones and versions).
- Managing of the testing and debugging phases with possible continuous integration approach.
- Managing of the "Continuous Feedback" from IS and the Science Team and relative modifications in the documents.

Outputs

- Software design document.
- Class architecture report (SysML+UML).
- Software management plan document.
- Software acceptance and test document.
- Integration and commissioning test report.
- user analysis s/w package, source code and documentation
  User manuals.

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**GS s/w: Dewarping Package**	**WP ID.: 3B1-LX**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+36	
WP manager:	Lorenzo Paoletti	Sheet 1 of 1	

Inputs

- BPL optical design (WP2B1-A)
- Daedalus ESA CDF final report
- Environment specs

Activities

- s/w analysis for geometrical image distortion correction
- s/w development for geometrical image distortion correction

Outputs

- s/w code for geometrical image distortion correction

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**GS s/w: Stereoscopy Package**	**WP ID.: 3B1-LY**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+36	
WP manager:	Cristina Re	Sheet 1 of 1	

Inputs

- BPL optical design (WP2B1-A)
- Manufactured BPL

Activities

- Stereoscopic image acquisition
- Intrinsic heads projective model calibration
- Extrinsic stereo calibration pipeline
- Dewarping oriented to photogrammetric homologous matching.
- Triangulation tool

Outputs

- s/w code to retrieve depth map

Work Package Description			
Project:	DAEDALUS-CAM	Issue date: 30-07-2019	issue: 1
WP title	**GS s/w: Multi-frame Super-Resolution Package**	**WP ID.: 3B1-LZ**	
Supplier:	**INAF**	Country: Italy	
Start event:	KO	Start date: To	
End event:		End date: To+36	
WP manager:	TBC	Sheet 1 of 1	

Inputs

- Multiple images in the (frontal) high resolution channel
- Multiple images from the panoramic channel

Activities

- Development of deep learning algorithm using the frontal (high resolution) channel
- Algorithm analysis for reconstruction from multiple low-res (panoramic) images.

Outputs

- Report on the MF-SR analysis for multiple BPLs images