Conceptual design of a re-entry analysis platform for investigation of space debris

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5th International Space Debris Re-entry Workshop
December 2, 2020

IDEA-RAP.ID: ESA De-risk Activity

De-risk analysis to pave the way for a possible fully-fledged activity on the design and operation of a re-entry platform for in-flight observation and /or measurements of phenomena of interest for the understanding of space debris re-entry.

Awareness

Review demise-analysis **tools** and ground **testing capabilities**

Review **relevant re-entry experiments**

Perform a **survey to identify scientific requirements** based on needs of relevant players

Design

Identify the new-concept **technical requirements to meet the scientific requirements**

Perform **test** (e.g., plasma testing) of an **identified main critical component**

Obtain a **preliminary conceptual design** of the platform

Planning

Identify **potential stakeholders**

Prepare a **business plan**

Added Values of in Flight Experiments

- Demise phases that cannot be reproduced on ground testing
- Relevant conditions and environment
- Testing of integrated system
- Full interaction of aerothermodynamics phenomena
- Unique opportunity for flight data for validation purposes

Identified Service Product

Recurrent re-entry service to provide an in-flight experimental framework for aerospace industries, agencies and research centers.

How

Customizable/modular carrier (i.e., CubeSat-like maximizing “COTS” components) featuring a survival/recording unit.

What

Standard mission/measurement capability (e.g., material testing similar to Plasmatron, component structural/demise testing).

Why

Recurrent low-cost missions can be appealing for space players seeking for relevant data on the demisability of components/parts/materials that need to be re-designed following the D4D paradigm.
This study convinced VKI that there’s not alternative to a modular platform capable of recurrent “cheap” flights to exploit the commercial benefits of the space-debris emerging market.

Following a Roadmap…

Scientific Mission

De-Risk Study

Demonstration Mission

In-Flight Experiment Service

QARMAN

3U CubeSat

RAP.ID

CubeSat Carrier + Survival Capsule

RAP.IFLEX -Debris
-Materials
-Bio
-…

CubeSat Carrier +Survival Capsule + Payload

Mission Statement & Objectives

[…] ”the RAP.ID system will demonstrate the feasibility and added value of a small-scale, flexible, and cost-effective flight recorder for investigation of debris.” […]

Primary objective:

- Provide **quantitative intrusive measurements** relative to the phenomena and processes occurring during the re-entry of space debris, at **low-cost** and in a **versatile** way.

Secondary objectives:

- Be a **first step** towards a **versatile platform** for missions and researches related to re-entry.
- Leverage the **expertise** acquired with QARMAN project.

Platform Overview

Platform = CubeSat Carrier + re-entry Capsule

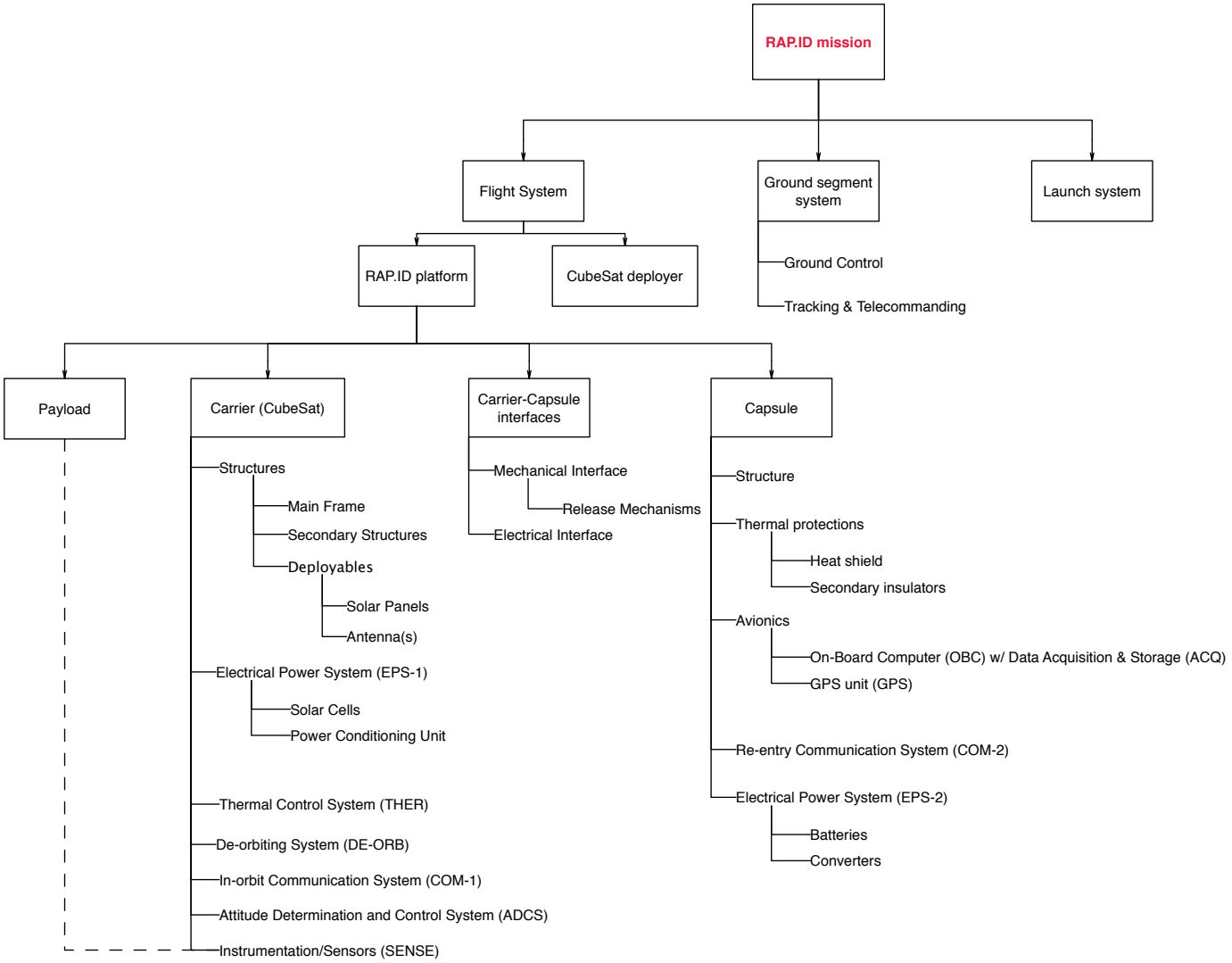
Carrier:

- Functionalities for orbital life
- = debris during re-entry
- COTS & QARMAN heritage

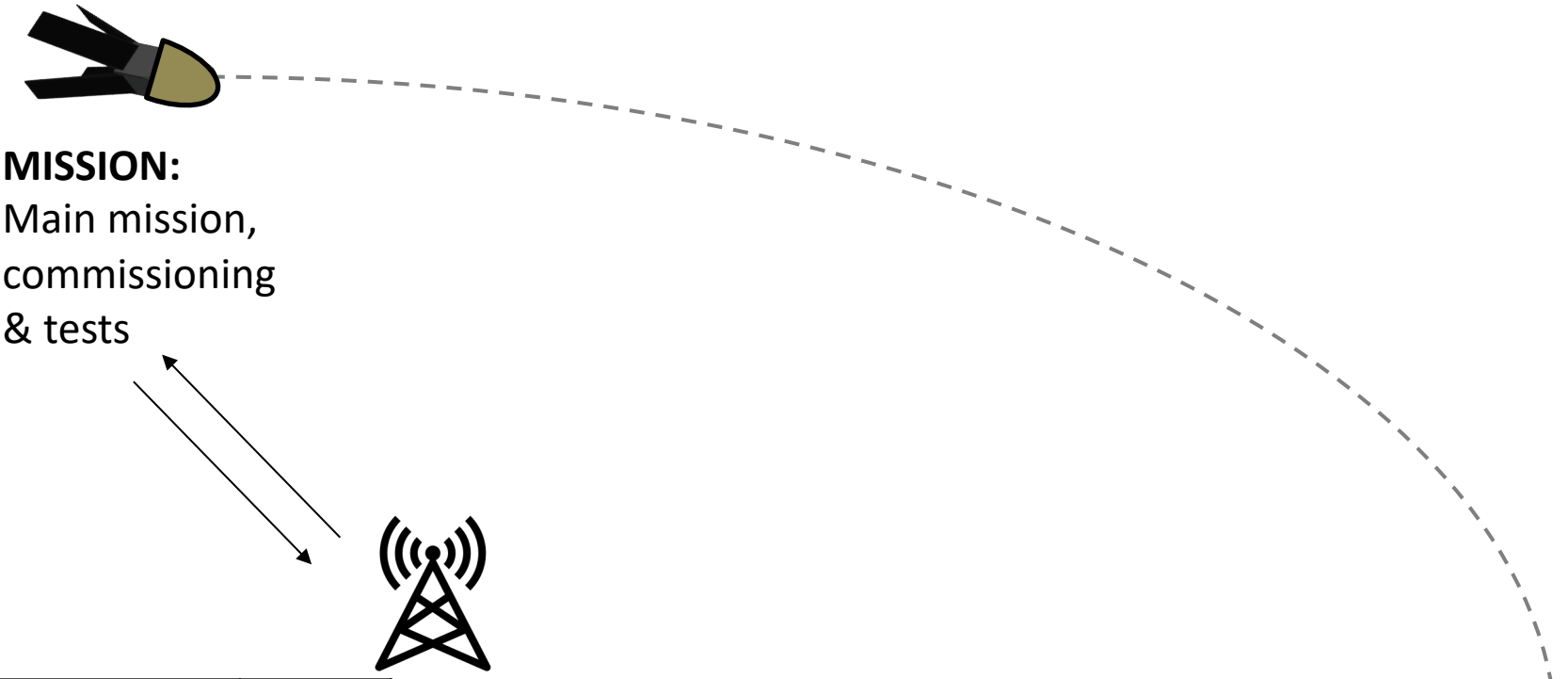
Capsule:

- Survival unit: record + send measurements taken on demising carrier
- Re-entry functionalities inherited from QARMAN
  ↳ De-risked in experimental activity

The RAP.ID demonstration mission product tree



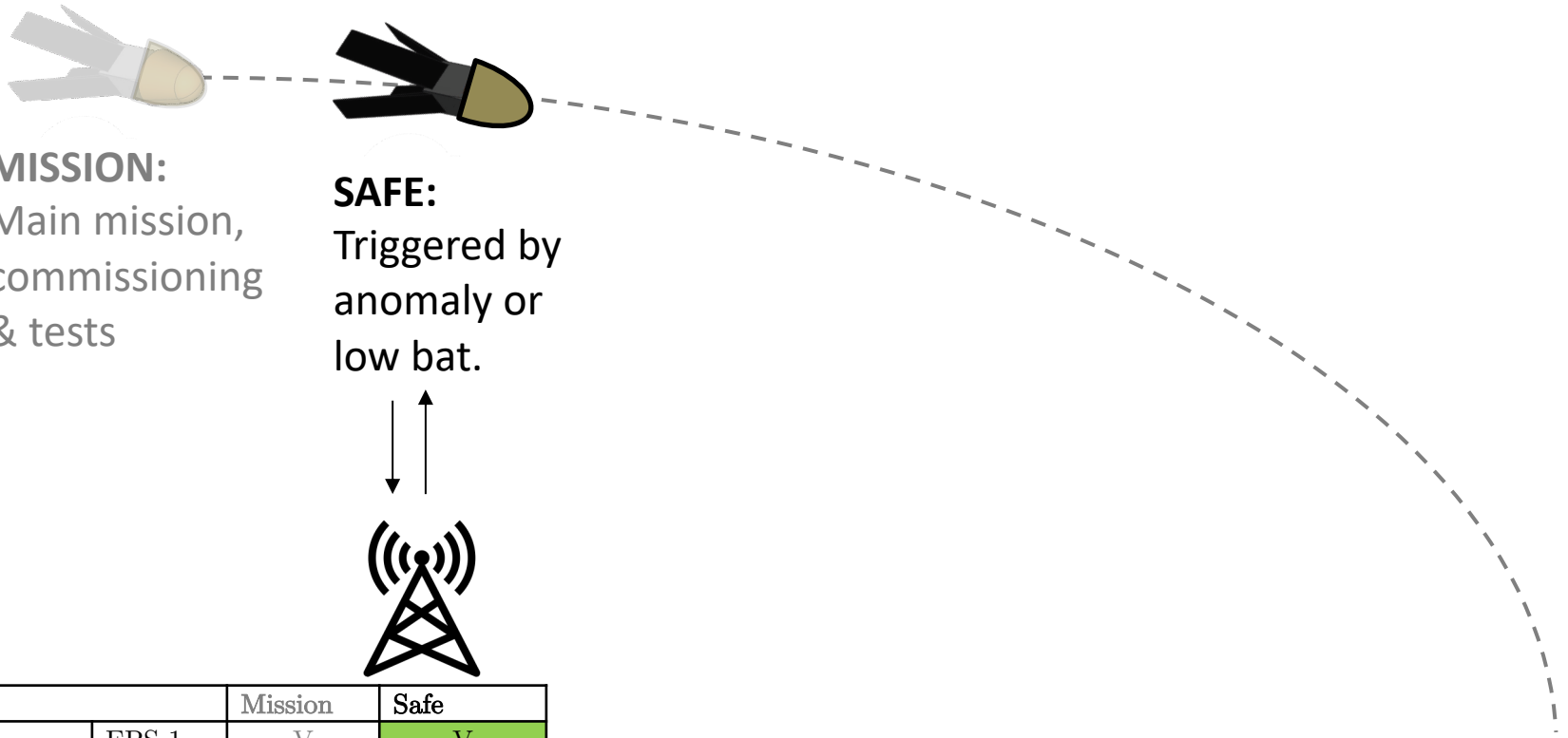
Functional architecture & mission modes



MISSION:
Main mission, commissioning & tests

		Mission
Carrier	EPS-1	V
	COM-1	V
	ADCS	V
	SENSE	*
	DE-ORB	X
Capsule	OBC	V
	ACQ	*
	EPS-2	V
	GPS	*
	COM2	X

Functional architecture & mission modes

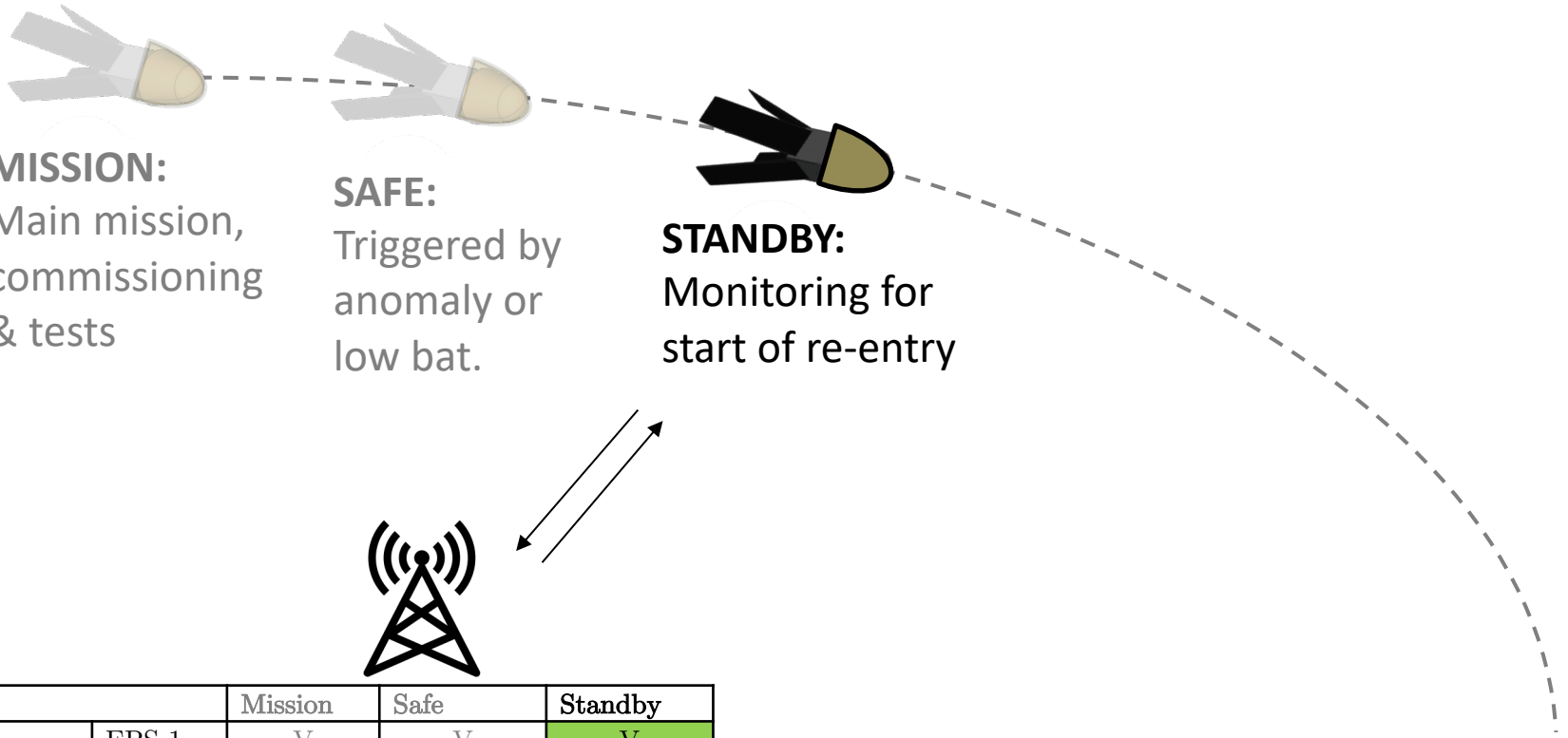


MISSION:
Main mission, commissioning & tests

SAFE:
Triggered by anomaly or low bat.

		Mission	Safe
Carrier	EPS-1	V	V
	COM-1	V	V (low)
	ADCS	V	X
	SENSE	*	X
	DE-ORB	X	X
Capsule	OBC	V	V
	ACQ	*	X
	EPS-2	V	V
	GPS	*	X
	COM2	X	X

Functional architecture & mission modes



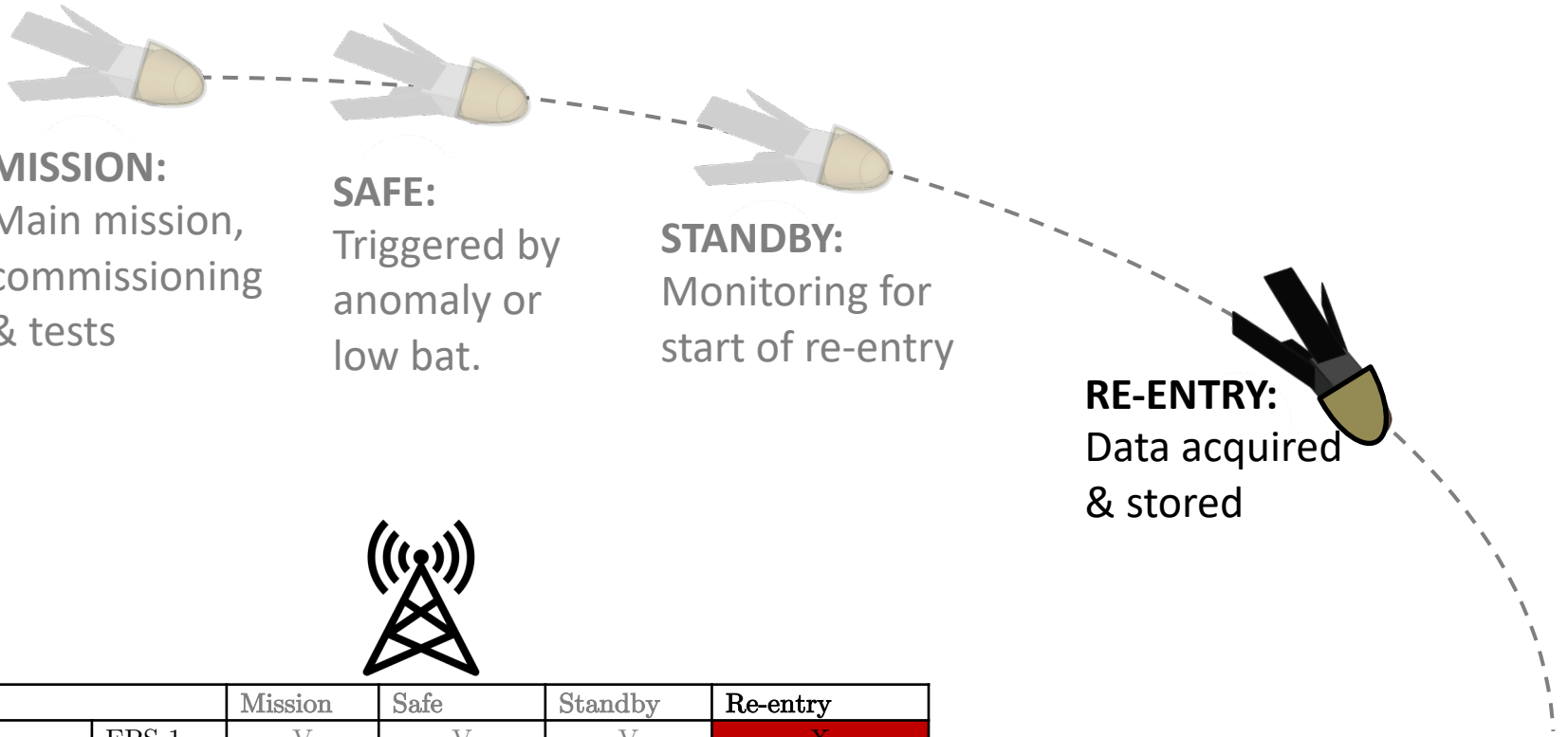
MISSION:
Main mission, commissioning & tests

SAFE:
Triggered by anomaly or low bat.

STANDBY:
Monitoring for start of re-entry

		Mission	Safe	Standby
Carrier	EPS-1	V	V	V
	COM-1	V	V (low)	V
	ADCS	V	X	V
	SENSE	*	X	V
	DE-ORB	X	X	+
Capsule	OBC	V	V	V
	ACQ	*	X	V
	EPS-2	V	V	V
	GPS	*	X	V
	COM2	X	X	X

Functional architecture & mission modes



MISSION:
Main mission, commissioning & tests

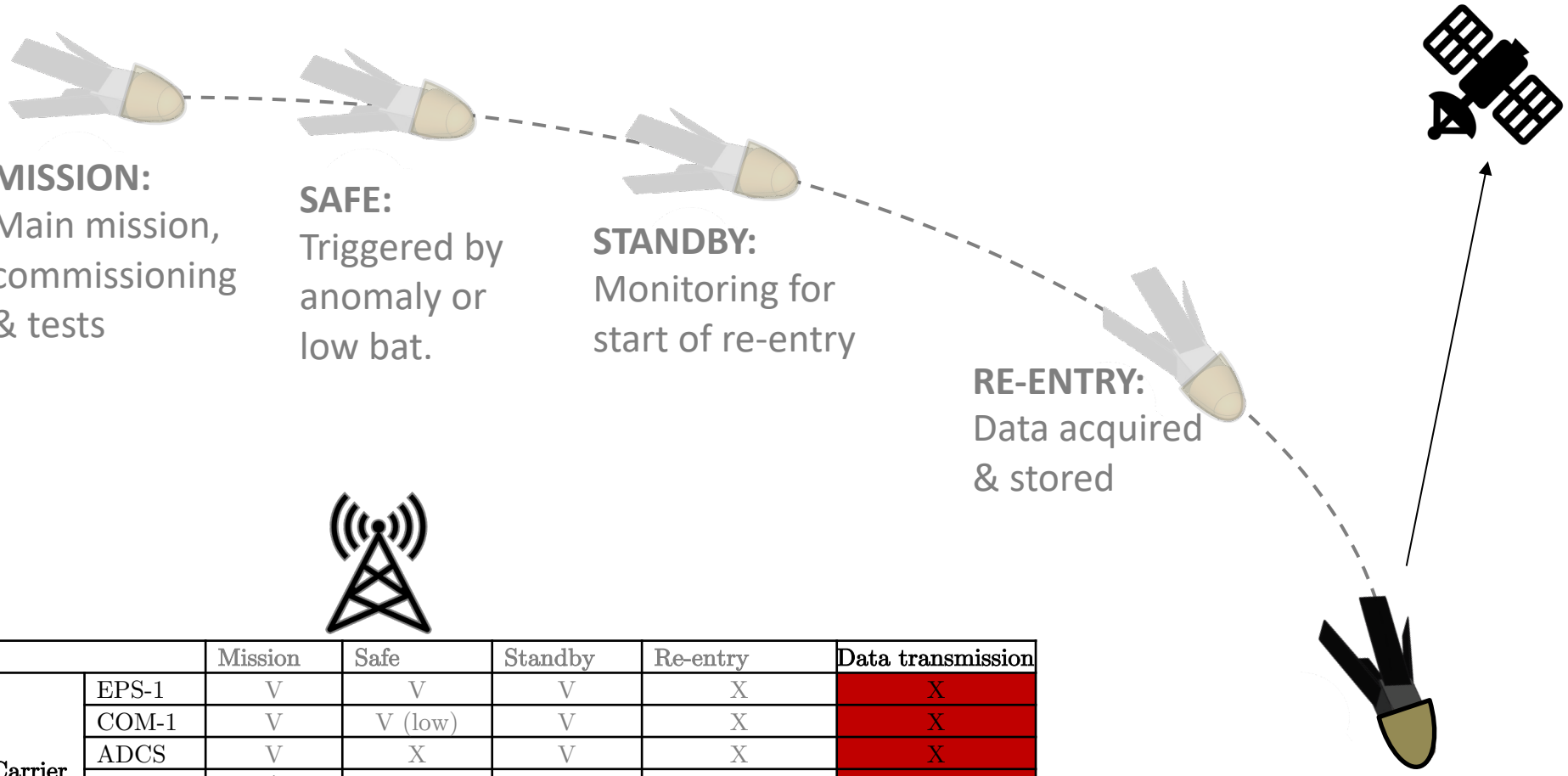
SAFE:
Triggered by anomaly or low bat.

STANDBY:
Monitoring for start of re-entry

RE-ENTRY:
Data acquired & stored

		Mission	Safe	Standby	Re-entry
Carrier	EPS-1	V	V	V	X
	COM-1	V	V (low)	V	X
	ADCS	V	X	V	X
	SENSE	*	X	V	V
	DE-ORB	X	X	+	X
Capsule	OBC	V	V	V	V
	ACQ	*	X	V	V
	EPS-2	V	V	V	V
	GPS	*	X	V	V
	COM2	X	X	X	X

Functional architecture & mission modes



MISSION:
Main mission, commissioning & tests

SAFE:
Triggered by anomaly or low bat.

STANDBY:
Monitoring for start of re-entry

RE-ENTRY:
Data acquired & stored

DATA TRANSMISSION:
After black-out, data transmitted to MCC

		Mission	Safe	Standby	Re-entry	Data transmission
Carrier	EPS-1	V	V	V	X	X
	COM-1	V	V (low)	V	X	X
	ADCS	V	X	V	X	X
	SENSE	*	X	V	V	X
	DE-ORB	X	X	+	X	X
Capsule	OBC	V	V	V	V	V
	ACQ	*	X	V	V	X
	EPS-2	V	V	V	V	V
	GPS	*	X	V	V	V
	COM2	X	X	X	X	V

Acknowledgment

This activity was funded through ESA contract no. 4000127100/19/NL/BJ/va “Assessment to Prepare and De-Risk Technology Developments— Black Box Re-Entry Capsule for Satellites”

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