Caging Mechanism for LISA Pathfinder

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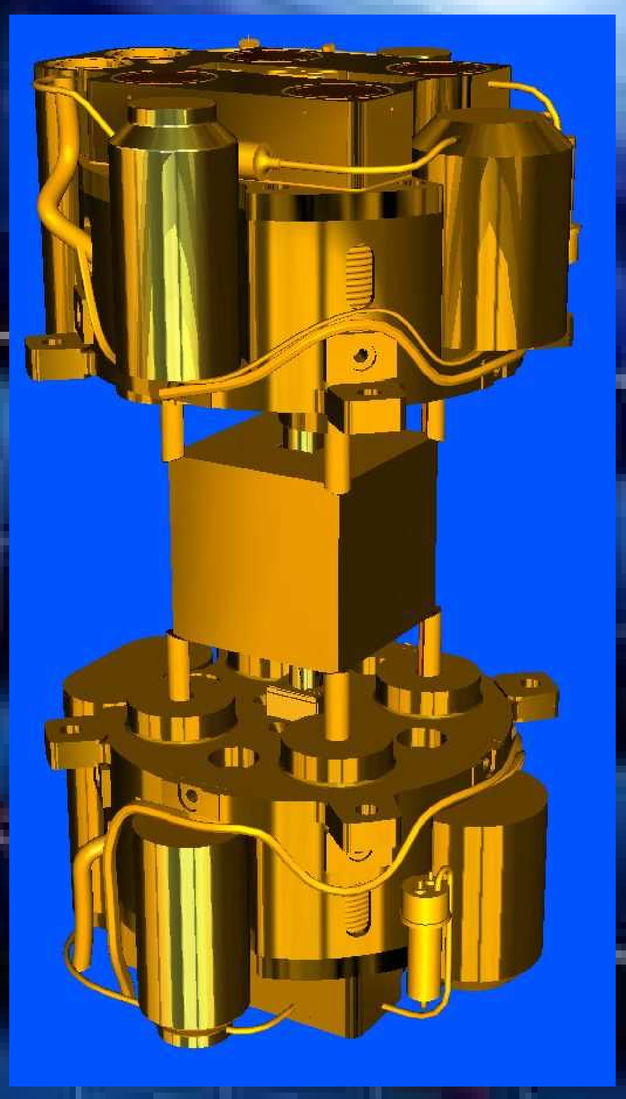
ABSTRACT

LISA Pathfinder is a technological precursor of LISA mission.
To achieve the "free fall" condition of the 2 kg test mass is a major issue of this precursor. A Caging Mechanism Assembly (CMA) is being developing by Alcatel Alenia Space Italia (AASI), as a contract of EADS/ESA, devoted to keep the test mass caged, during the launch and the in-orbit commissioning phase, releasing it with a residual translational velocity lower than few micro-meters/sec and an angular velocity lower than about 100 micro-radians/sec.
The Caging Mechanism has to provide two main functions: on one side it should guarantee the grabbing, the positioning and the releasing of the test mass for which an applied very low load is needed, on the other hand the mechanism has to be able to cage the test mass with high loads during the launch (3000 N) without any degradation of the test mass coating and avoiding any surface deformations.
These two such different functions will be provided by two subsystems inside the CMA:
The Caging Mechanism S/S (CMSS)
The Grabbing, Positioning and Release Mechanism S/S (GPRM)
In the related Poster the architecture of the Caging Mechanism Assembly and the characteristics, in terms of expected performances, of the two Subsystems (CMSS & GPRM) are given.

CAGING MECHANISM

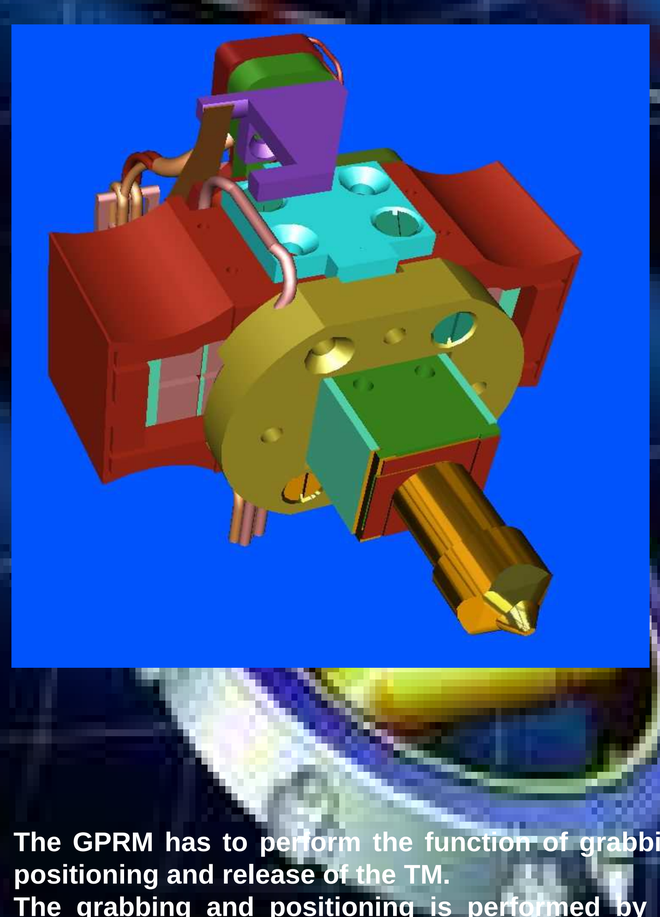
CMA must provide two main functions, each of them satisfying very different requirements.
On one side we have grabbing, positioning and release operations for which very low load applied to the TM and high accuracy in positioning and releasing is needed, on the other side the TM must be caged with high loads for launch (3000 N) and storage (300 N).
To conceive a unique mechanism able to perform both the functions appears to be a problem without useful solutions.
The requirements can be much easier fulfilled if we separate the CM in two mechanisms with different characteristics and actuation features:
Caging Mechanism S/S (CMSS)
Grabbing Positioning & Release Mechanism (GPRM)



Caging Mechanism Sub-System

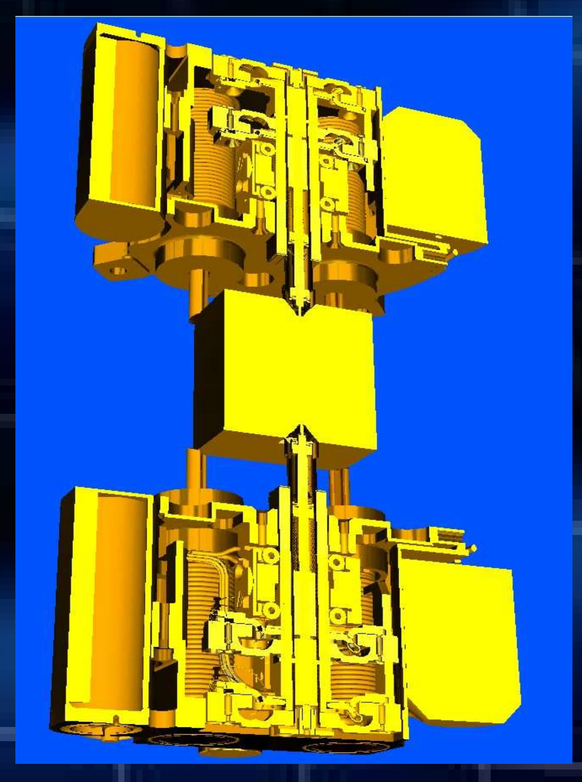
The functions of CMSS are either to apply the high preload to the Test Mass during the launch, to change the load from high to low level and finally to unload the TM for the foreseen experiment activities.
Among these functions the first one is the most critical for the design of the system.
In fact during the launch, to face the vibration conditions CMSS has to cage the TM with a force of 3000 N minimum; since the design requires a force actuator able to generate such a value.
For the implementation of the design an hydraulic actuator has been chosen, composed by a piezo driven pump sucking the liquid from a reservoir and transferring the correspondent amount, via an unidirectional valve, to four metallic bellows each of these directly connected to a mechanical finger which cages the Test Mass.
A bellow reservoir will compensate the liquid volume variation during the load and unload condition.
Once the necessary amount of liquid is pumped and the correspondent level of force (pressure) is achieved, the unloading procedure is attained via an auxiliary piezo valve which opens to allow the liquid inside the swollen bellows to circulate again into the reservoir. The piezo valve will used also for pressure regulation during on flight release sequence.

Grabbing Positioning Release Mechanism



The GPRM has to perform the function of grabbing, positioning and release of the TM.
The grabbing and positioning is performed by the "grabbing finger" which can be extended and retracted for a travel range of 19mm. The movement of the grabbing finger to grab and position the TM very accurately is assured by the Nexline™ piezo actuator.
The release function is performed by the release tip, which is drawn back inside the grabbing finger and it is moved by piezo stack actuators within some milliseconds.
The force applied to the TM during release and grabbing and the position of the TM is measured by a position sensor and a force sensor.

SYSTEM CAGING MECHAINISM INTERNAL CUTTING VIEW



Main characteristics of the caging Mechanism

Position Accuracies for optical Metrology Measurement:
- in translation: ±60μm in all axis
- in rotation: ±60 μrad around all axis

TM Release velocity:
- linear: ±5μm/sec along all directions
- angular: ±100 μrad/sec about all axis

Force to be applied to the TM for caging during lauch: minimum 3000N
First eigenfrequency (with the TM)>400Hz
Mass < 2900g
Energy dissipated < 300J
No ferromagnetic materials used
Outgassing rate < 10-7 Pa L/s

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