Plateau d'Architecture des Systèmes Orbitaux

Masts for long focal lengths

DEFI study and MA2C R&T

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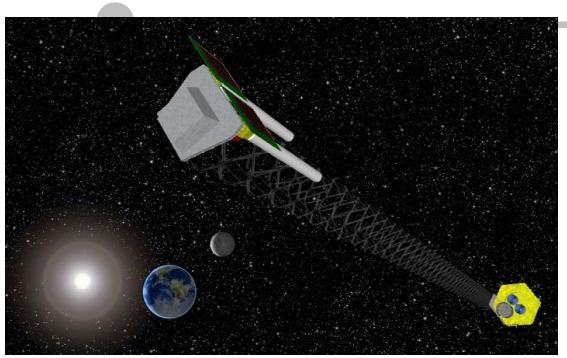
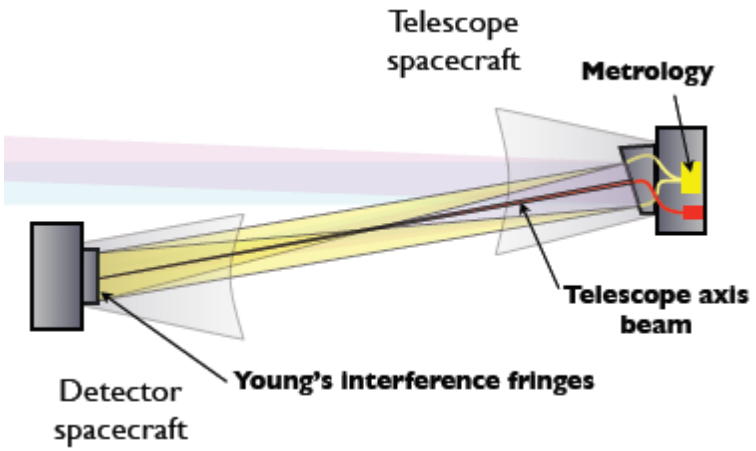
Masts for long focal lengths

Introduction

- Space agencies still hesitate to select astrophysics missions using deployable masts or formation flying
- A previous trade off shown that, up to 50m, a deployable mast could be much cheaper to implement than formation flying for such a type of missions
- The US Adam mast has already flown several times with lengths between 10m and 60m for civil applications
  - NuSTAR mast behavior is very convincing
- CNES is currently developing a deployable carbon structural mast that is expected equivalent performances to Adam mast in a passive mode and upper ones in driving mode

Masts for long focal lengths





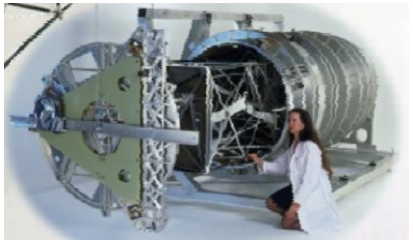
Which needs

- High energy astrophysics
  - ✦ focalizing photons imposes long focal length
    - » Each photon is tagged ➔ image can be re-built a posteriori with the telescope alignment knowledge
  - ✦ allowed misalignment is given by the detection plan oversizing w.r.t the field of view ➔ generally few mm
  - ✦ the frequency bandwidth of troublemakers impacts on front end electronics performances
  - ✦ examples: PheniX, COSPIX (ex SIMBOL-X), Dual (γ), …
- Ultra fine astrometry (NEAT)
  - ✦ not foldable focal length avoiding optical defects due to added optical elements
  - ✦ observation in visible wavelength with multi short exposure time and averaging ➔ mixt between pointing absolute performance need and averaging using very high performance laser metrology at final stage.
  - ✦ ➔ request additional internal control loops

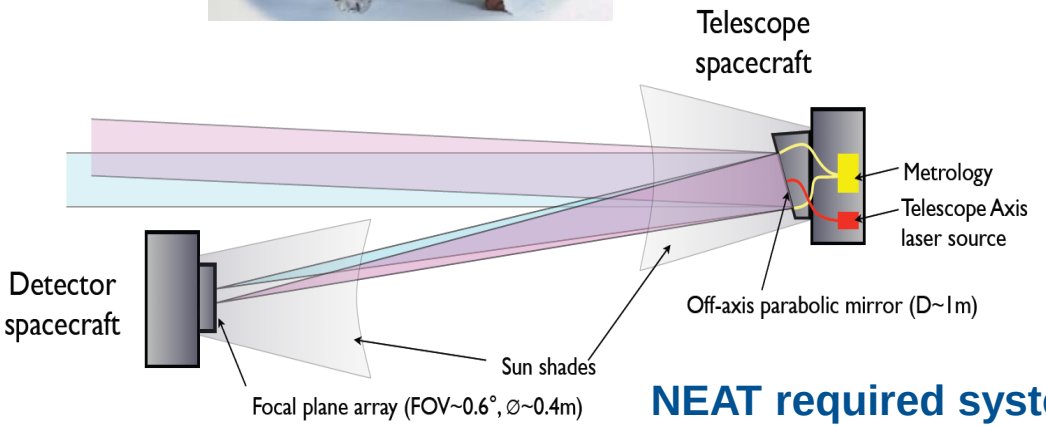
Masts for long focal lengths

Requirements

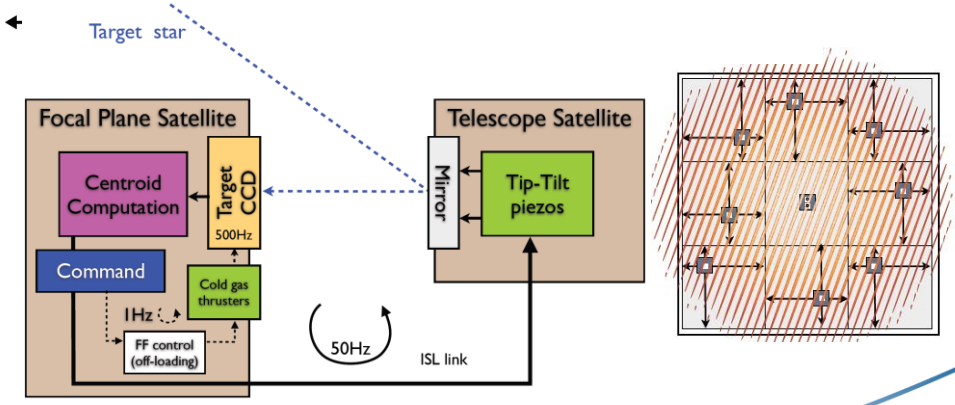
- Operational performances
  - absolute pointing accuracy
  - stability
  - duration
  - restitution
- Features
  - folded and unfolded bulk
  - harness facilities
  - stray light
- GNC
  - satellite – hanged up payload part
  - payload part - another payload part
  - internal control loops – external loops
- Relative positioning
  - box of 3mm span seems OK for all applications



ADAM folded bulk



NEAT required system



Masts for long focal lengths

Past and present examples

- SRTM (Shuttle Radar Topography Mission)
  - 60m ADAM mast
  - very noisy environment
  - very complex metrology
  - a posteriori images building

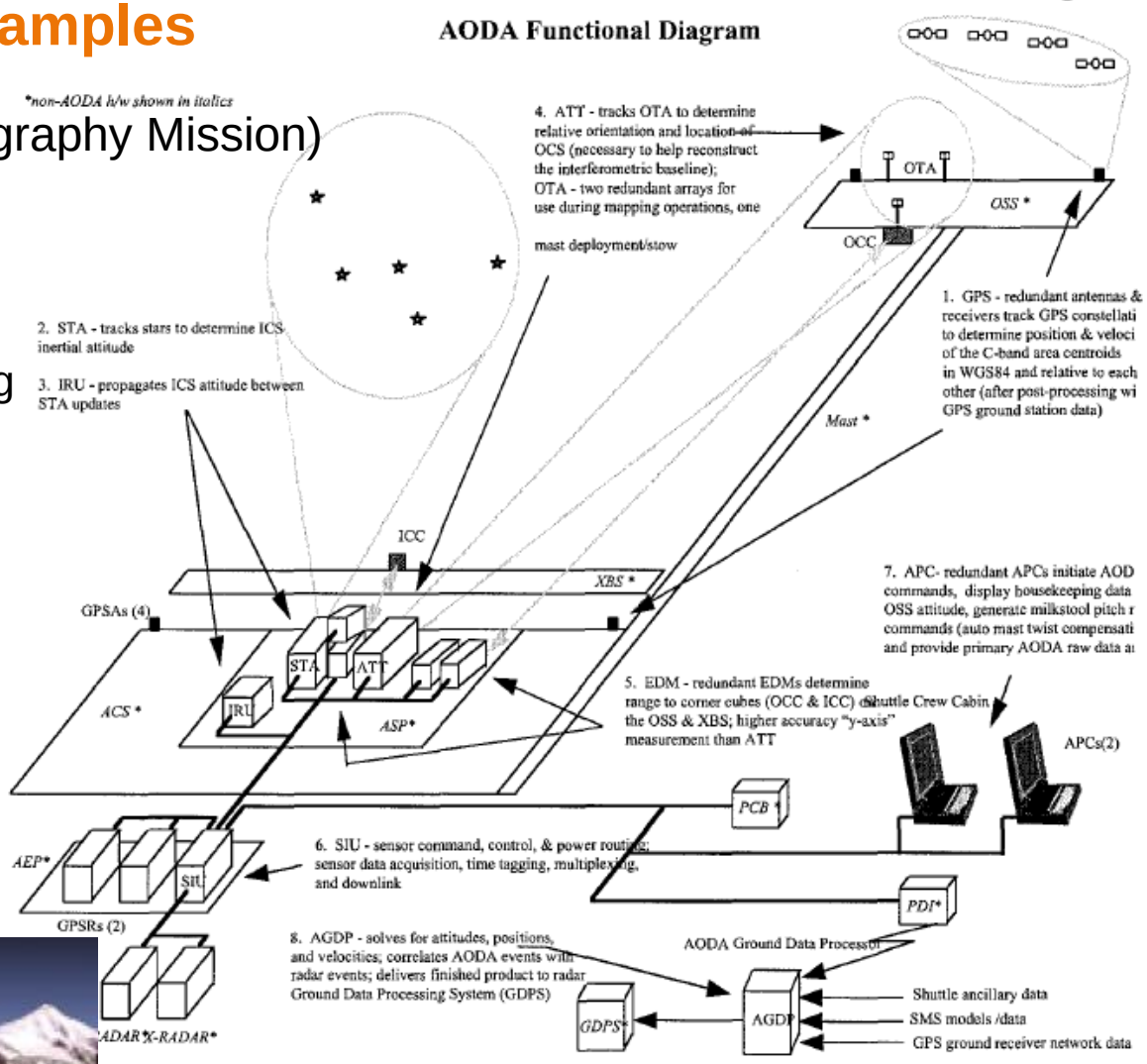
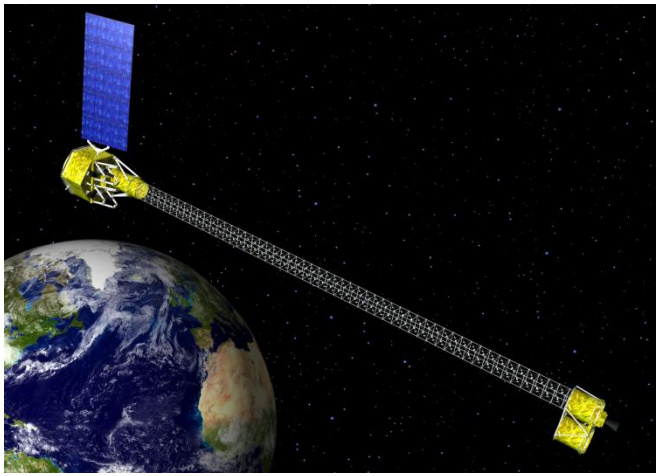


Fig 2.1 SRTM Attitude Determination Configuration

Masts for long focal lengths

Past and present examples

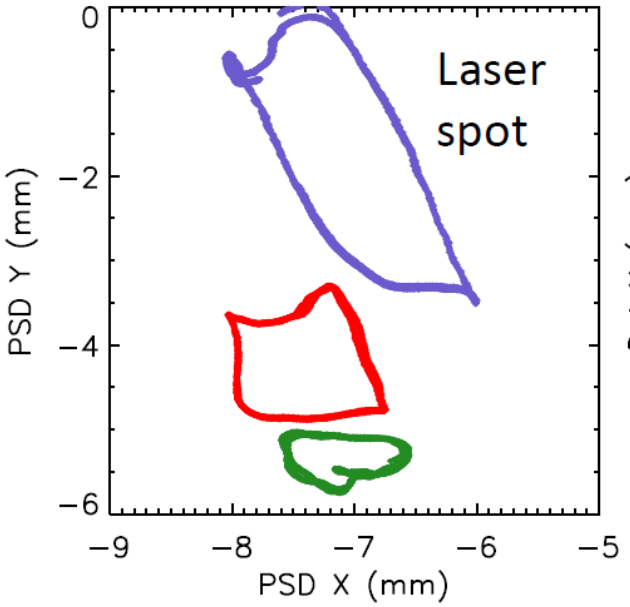
- NuSTAR (Nuclear Spectroscopic Telescope Array)
  - Adam mast (ATK): 10m + high inertia on both parts
  - low earth equatorial orbit ➔ several troublemakers
  - only thermoelastic effects are measurable



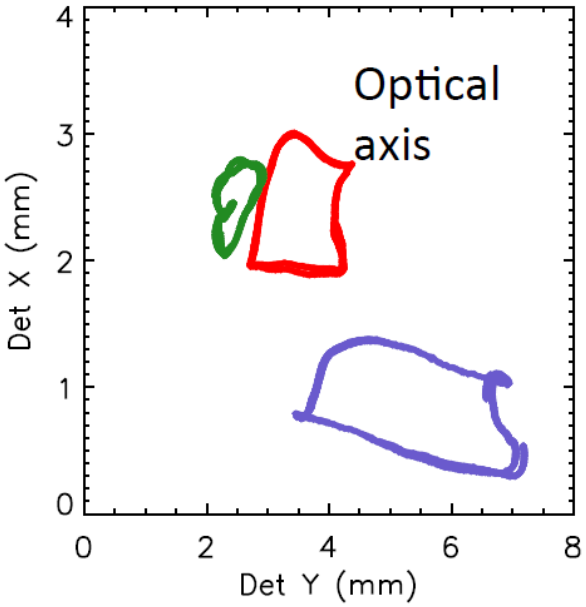
2 optical modules at the mast tip

Head mast motion compared to detection plan

PSD, module A



Optical axis, module A



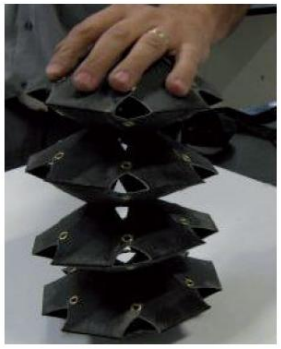
3 colours for 3 targets:
- different sun orientation

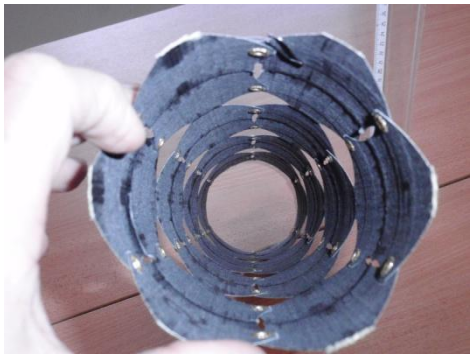
5 to 6 orbital periods (90mn) each
- not expected at L2

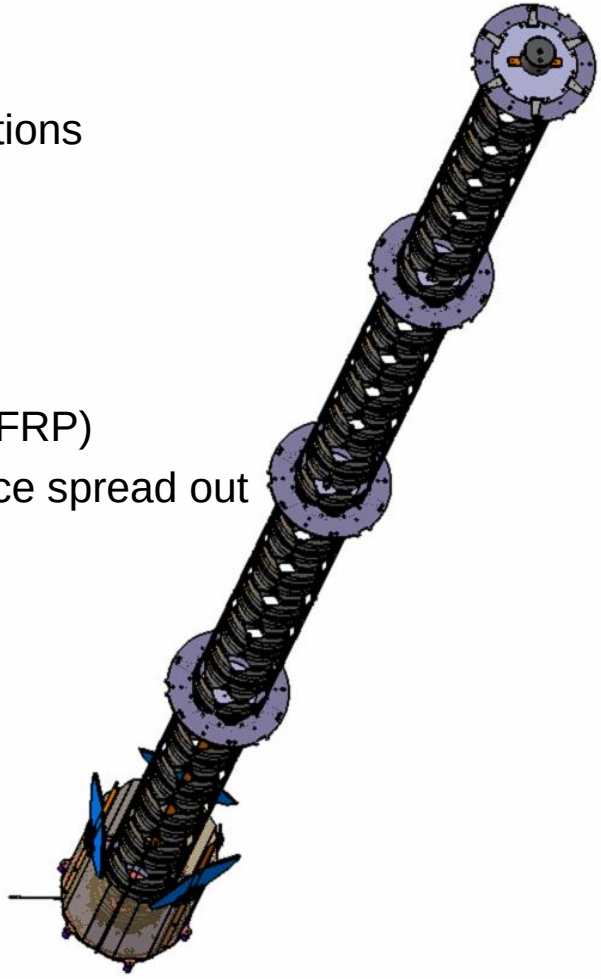
Masts for long focal lengths

MA2C: Mat Auto-deployable Auto-verrouillable en Carbone (self spread out and self locked carbon mast)

- Concept (CNES property)
  - ultra light cylindrical mast made of independent sections lined up and end to end assembled
  - section
    - » all identical
    - » made of a set of plates
      - ➢ thin carbon fibre reinforced polymers (CFRP)
      - ➢ pivot links and flexible hinges locked once spread out



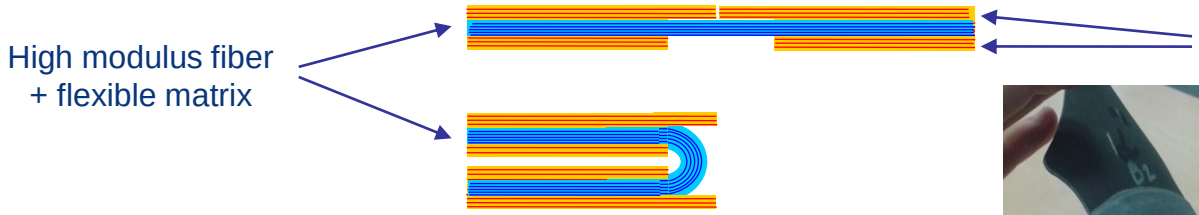




Masts for long focal lengths

MA2C: Mat Auto-deployable Auto-verrouillable en Carbone (self spread out and self locked carbon mast)

- Technology (CNES property)
  - flexible hinge, locked once spread out
    - » thin carbon fibre reinforced polymers (CFRP)



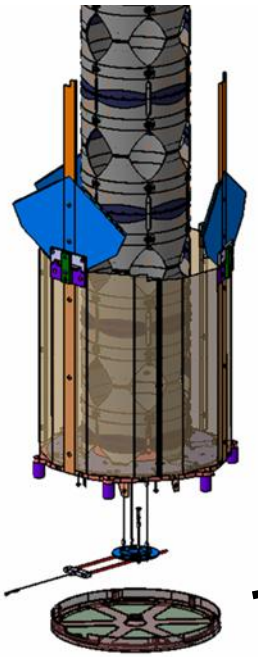
Patent : CNES B0832. Brevet FR2936551.

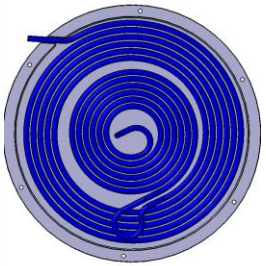
- design features
  - low mass and high rigidity
  - compact when folded
  - intrinsic high mechanical and thermal stability
  - wild range of operating and non operating temperatures
  - potential high lengths (the section grows with the length)
  - high mechanical and thermal stability
  - potential static and dynamic behaviour control capability

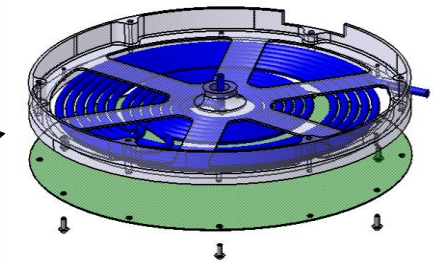
Masts for long focal lengths

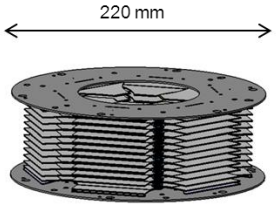
MA2C: Mat Auto-deployable Auto-verrouillable en Carbone (self spread out and self locked carbon mast)

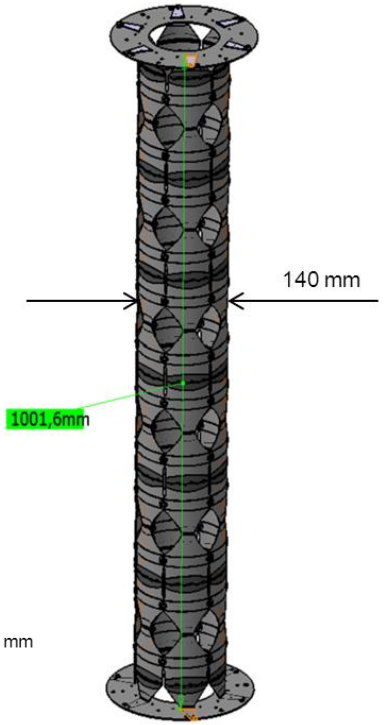
- CNES R&T with SMEs in Toulouse (Latécoère services, CLIX and CRITT)
- Accommodation (CNES property)
  - internal harness
  - customizable for specific missions
    - » folded and spread out dimensions
    - » static and dynamic behaviour











Masts for long focal lengths

MA2C: CNES R&T present development

- 2m long mast manufacturing then 4m long one end 2014
  - behaviour characterization
    - » deployment test in a large range of temperature [-40°C, + 80°C] in vacuum chamber
    - » 0g deployment during parabola flight
    - » static and dynamic behaviour measurement
    - » deployment monitoring system development
    - » end position deployment damping system development
    - » local behaviour understanding
  - linear and non linear finites elements models updating
    - » NASTRAN, FEMAP and SAMCEF
  - same process for 2m mast this year and 4m mast next year
- Objectives
  - having credible mathematical models for project development up to PDR
    - » scaling capacities up to 40m
    - » precise static and dynamic behaviour under different space environments for instrumental and GNC sizing