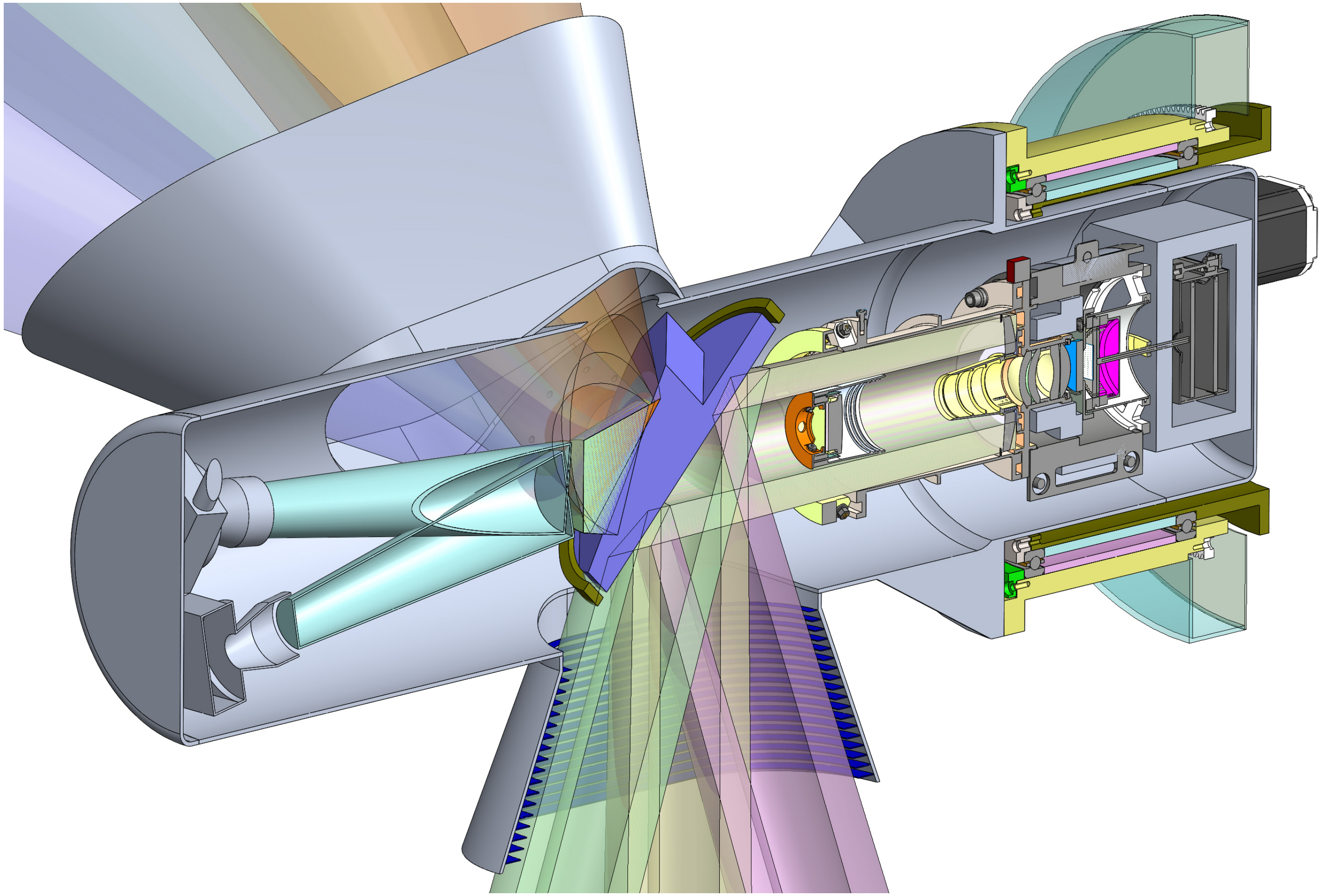

Advanced Pointing Imaging Camera (APIC)

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Alfred McEwen, Ed Riedel, Marc Walch, and Michael Watkins

New Frontiers Technology Workshop
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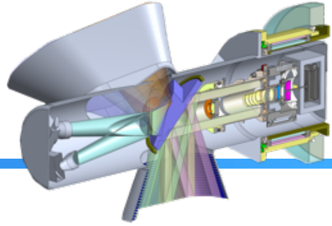
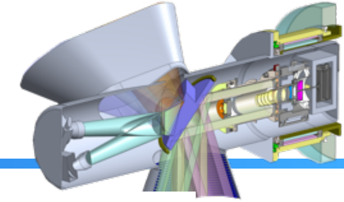
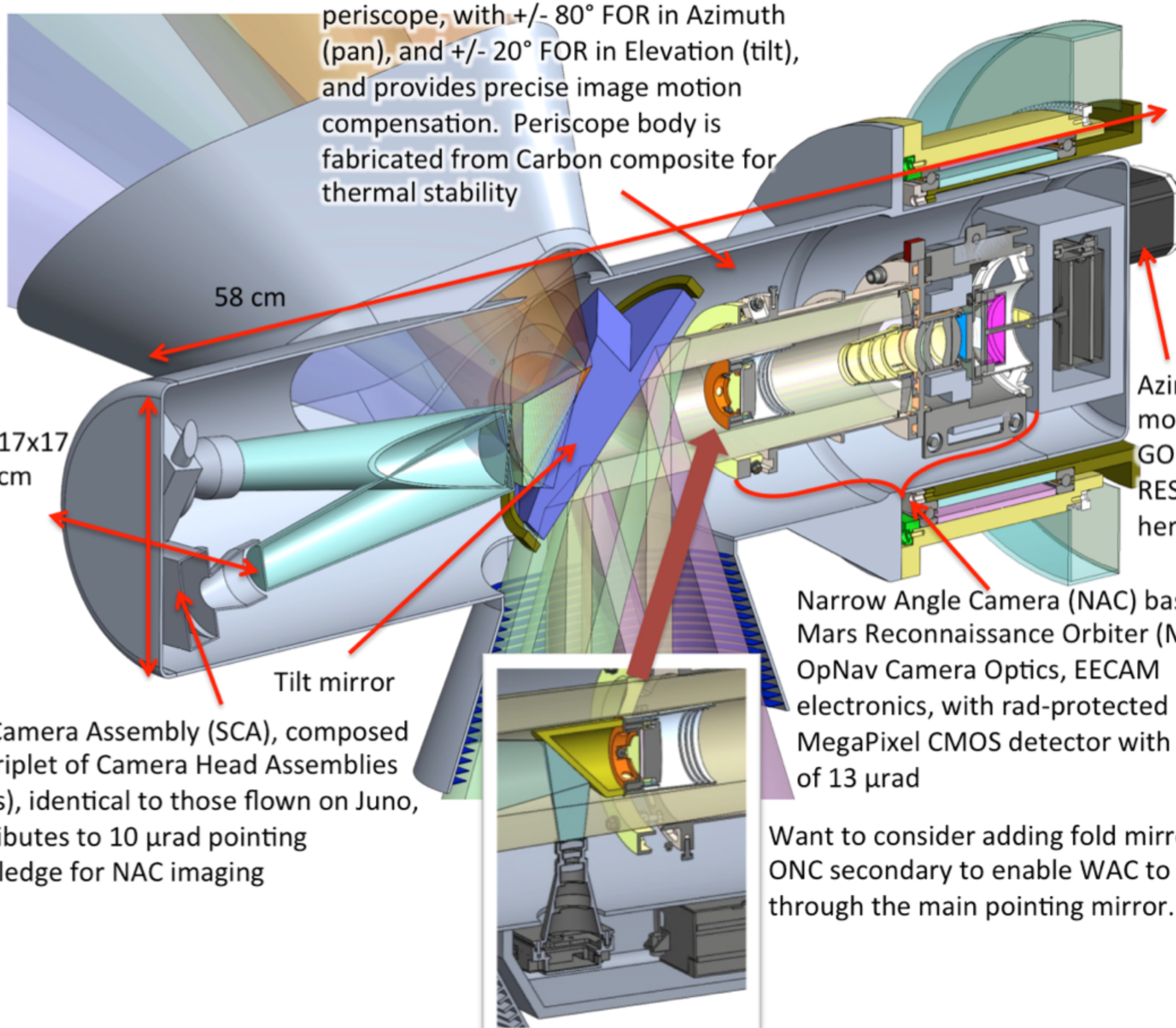
Overview



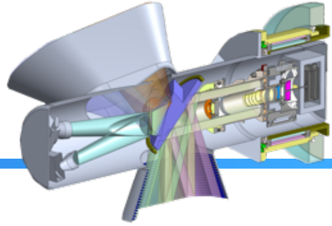
- The Advanced Pointing Imaging Camera (APIC) is an integrated system, with optical bench and flight-proven components, designed for deep-space planetary missions.
- APIC's unique capabilities include:
  - 2 degree-of-freedom (DOF) control capability, allowing rapid and flexible image acquisition, and image motion compensation.
  - Innovative periscope design capable of simultaneously acquiring images of target and star field for precise image pointing knowledge.

Cut-away view of APIC Concept Design



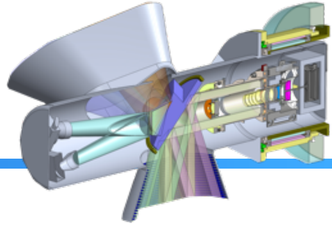


APIC Characteristics



Parameters	Values
Dimension	60x19x19cm
Mass	14 kg
Radiation Shielding	4 kg
Power	12 W
Image Resolution	13 µrad (~3 arcsec)
Pointing Knowledge	<2 arc-second
Azimuth Range	±80°
Elevation Range	±30°
Azimuth max IMC rate	30°/s
Elevation max IMC rate	30°/s

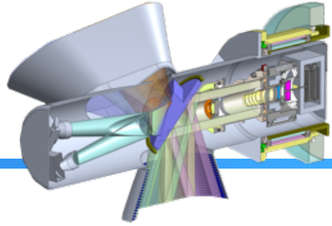
Functions of APIC



- APIC's 2-DOF actuation would allow significantly more effective and efficient science/mission operations by providing rapid and flexible imaging capability (e.g., significant reduction in mission duration and much less constraints on spacecraft operational geometry).

- APIC's internal image-motion compensation using the internal gimbal and attitude knowledge dramatically reduces the operational cost of image motion compensation for any mission, and increase fast flyby mission imaging resolution.

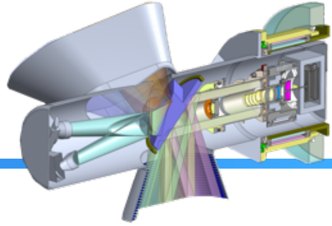
Functions of APIC



- APIC's unique periscope design with high-resolution narrow-angle-camera (NAC), and an optional wide-angle-camera (WAC), would provide important unique science return via the ability to simultaneously take the images of target body and star field, allowing high-resolution surface imaging with extremely precise pointing knowledge.

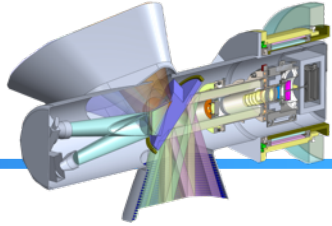
- APIC images with precise pointing information can accurately measure the tidal deformation and/or libration/precession of the target body, and thereby reveal target body's interior structure.

Functions of APIC

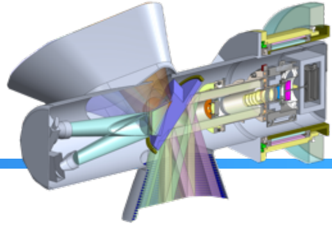


- APIC can provide stereo reconstruction of target topography and control network that would provide very accurate determination of the target-relative position of the spacecraft.
- APIC's combined functionalities would offer a powerful optical navigation capability, that would significantly enhance spacecraft orbit reconstruction and prediction accuracy, and thus, reducing operational cost.
- APIC can serve as an ideal platform for autonomous navigation.
- APIC's internal star-finding/tracking can provide backup attitude information for the host spacecraft.

APIC Current Status



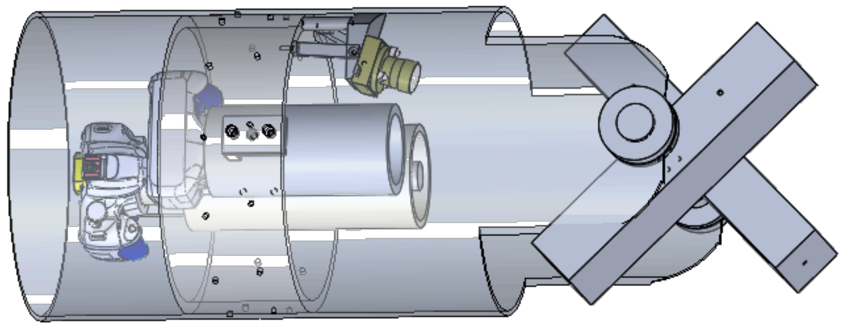
- APIC is a part of NASA's New Frontier's Homesteader Program. By the end of 2016, all of APIC's components will achieve TRL 5-6, making APIC, as a whole, to be TRL 5. More specifically, these tasks would retire:
  - Almost all radiation-related issues (including the Jovian system environment). TRL-5.
  - Field-test proven 2-DOF actuation/control. TRL-6.
  - Thermally stable optical-bench structure (Carbon-fiber-composite) with arc-second stability in rad-hard environment. TRL-6.

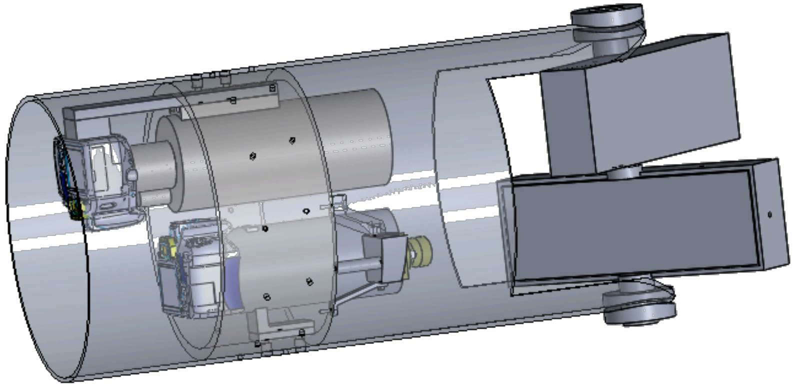


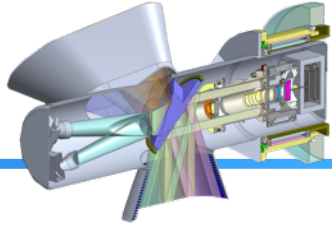
Task Progress and Status

- When the EM periscope is complete, it will be taken to JPL's Table Mountain Observatory for testing.
- The instrument will be oriented vertically, with a view of the sky, and the cameras will be directed onto a mirror, to have a net orientation roughly toward zenith
- The instrument will be directed to slew at specific rates; and all the cameras will image the smeared stars. The ability to track at very precise rates will be tested by measuring the length and direction of the smeared star signatures.

EM Design, reflecting considerable refinement and simplification of the APIC concept

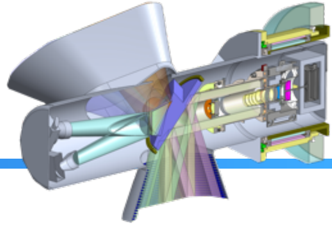






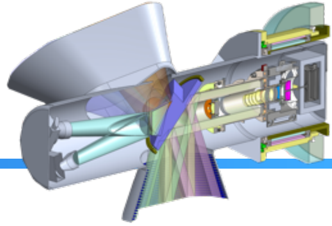
Back up

TRL Table

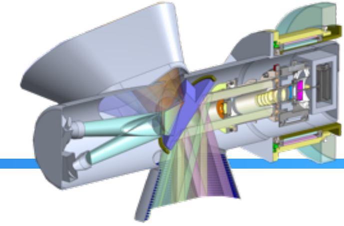


Subsystem or componet	Expected TRL at the end of Homesteader effort	Things to do from now to achieve the TRL
Camera back-end, M2020EECAM	Radiation Resilience: TRL-6	Starting with the TID tests already complete, we will complete the high energy e- testing (at Brookhaven) and the proton testing (at Davis). All active radiation tests pertain to the camera detector, which is the only sensitive component to live radiation (causing noise in the images.).
CFC Tube Optical Bench	Thermal stability: TRL-5	CFC mock up elements will be laboratory tested for thermal stability, reliably maintaining required alignment in simulated environmental conditions.
Pointing Control	Tracking ability: TRL-6	Test the Honeybee-supplied control mechanism to the APIC EM telescope, and test in the lab and field with the ability to track at the required image-motion-compensating rate.

APIC Error Budget

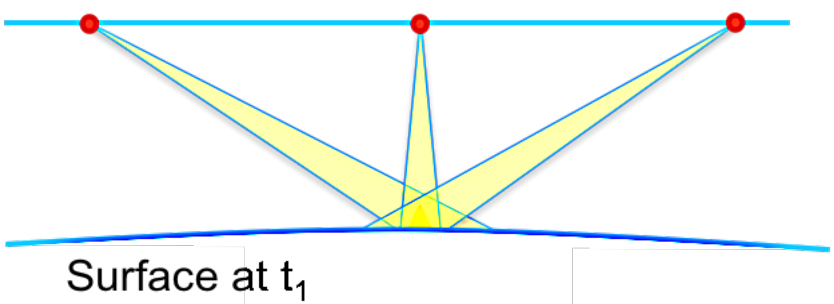


Quantity	μradian	μradian
Net Tracker pointing accuracy	5.5	
Single CHU observation		2.0
Triplet CHU observations		1.2
1 sec 10 Hz data filtering		3.6
Net with 40 deg offset from NAC boresight		3.8
Pointing rate AND control error over one exposure (40 msec)	5.6	
Rate matching ability		4.0
Sef-induced jitter		3.0
Net control		5.6
Feature location accuracy	3.7	
Image processing accuracy (0.25 pixels)		3.2
Image processing degradation relative to ONC (decreased energy in central PSF pixel)		1.8
Net feature location accuracy		3.7
NAC Optics and detector field distortion	2.0	
Thermal stability of structure between calibrations	5.0	
Mirror distortion	2.0	
Net individual Feature Location Positional Obervational Accuracy (μrad)	10.1	



APIC Time-varying Observation

Reconnaissance Imaging



Tidal Deformation Imaging