

Robotic Systems for OSIRIS-REx, Asteroid Redirect and Mars 2020 Missions Q&A Panel

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TASC

Robotic Systems for near Future Missions

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Panelists



Andre Sylvester



Thomas Evans, PhD



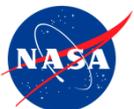
David Turner



Vincent Howard



Charley Price



Panel Purpose and Objectives

■ Discussion

- This panel will discuss the **robotic (mechanical, sensory, and autonomy)** components of three NASA missions currently under early development. The missions are:
 - OSIRIS-REx Mission
 - A robotic mission to **land on an asteroid and returns samples to earth.**
 - Asteroid Redirect Mission
 - A robotic mission to **move an asteroid to lunar orbit**
 - Followed by a **Human mission** to study the asteroid in lunar orbit.
 - Mars 2020 Mission
 - The **next Mars rover mission** will be a rover similar to *Curiosity* but with different mission objectives.
- This discussion will provide an insight into how NASA is preparing for the technological advances required for these missions.

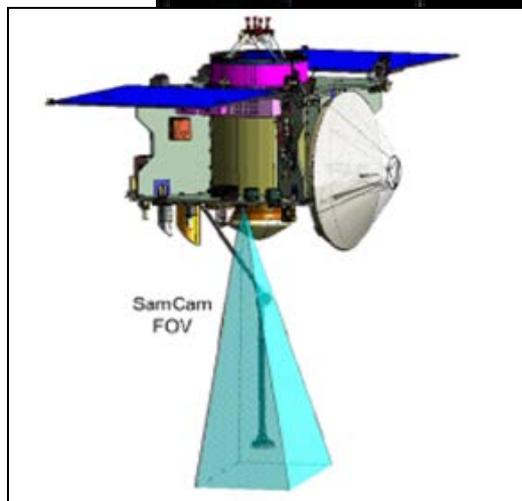
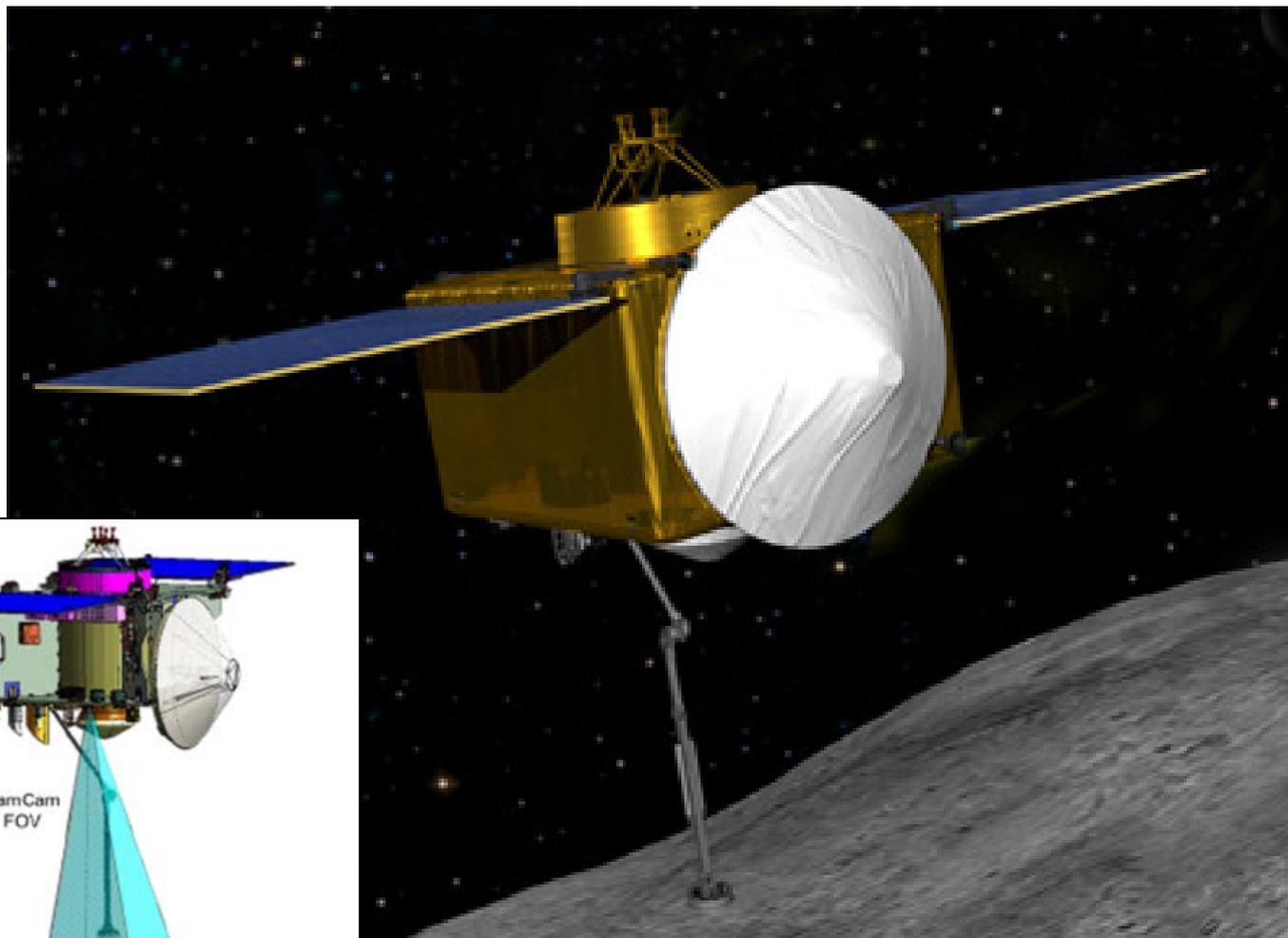


Discussion Assumptions

- The **asteroids** were/will be selected after years of study using a variety of earth and space based telescopes to determine its orbital parameters (energy, perihelion, aphelion) as well as its spin, mass, inertia, and albedo. A **geometric/physics model** of each asteroid is developed based on these observed data.
- The **landing and exploration area** for the next Mars Mission will be selected based on years of observation by terrestrial and space telescopes and by Mars-orbiting spacecraft.
- A **topographical map** of this surface area on Mars might be accessible by the onboard vision system.
- **Uncertainties in all of these parameters**, however, require that spacecraft/rover sensors be used to refine the knowledge of state information of the targets relative to the active spacecraft control systems.



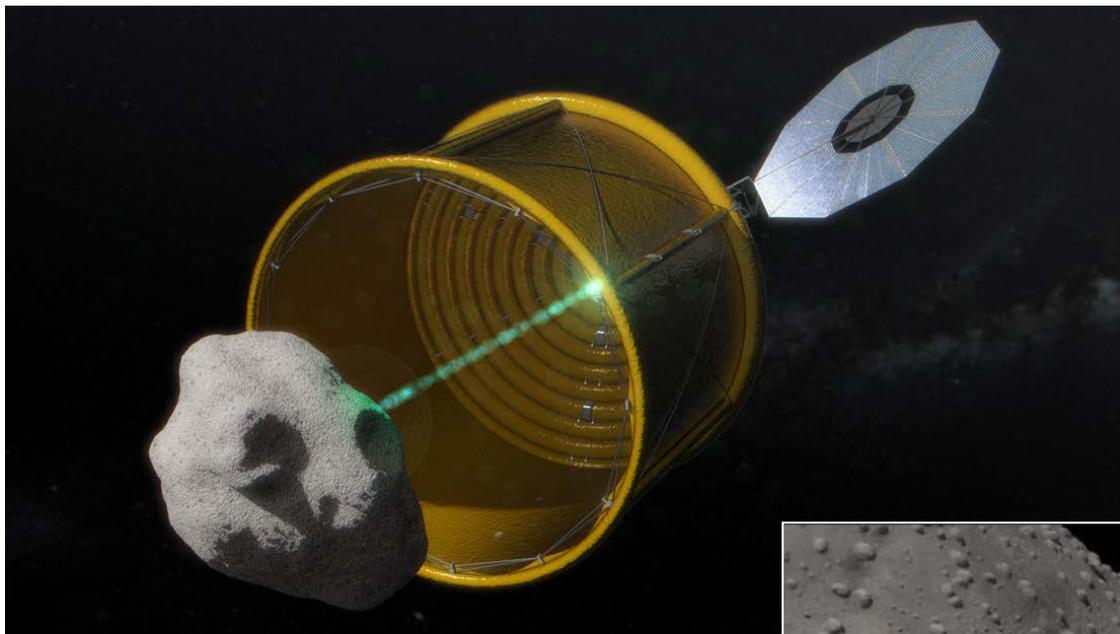
OSIRIS-REx Mission to Asteroid Bennu



- **David**, please describe the robotic manipulator for this mission, and its operation.
- Does the spacecraft establish a rigid interface with the asteroid?
- Are there other mechanisms on this spacecraft?
- What kind of sensors do you expect to be used to drive these mechanisms?
- Given that these operations are likely to occur beyond the orbit of Mars, can these complex operations be successful using telerobotic controls, i.e. 'command and wait'?
- What amount of autonomy can be expected in these operations?



NASA Robotic Asteroid Capture and Redirect Mission



Design Option A:

*Capture an asteroid,
...and move it to lunar orbit.*

Design Option B:

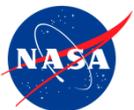
*Pluck a boulder
from the surface of
an asteroid,*

...and move it to lunar orbit.



Asteroid Redirect Questions

- **Andre**, please contrast the mechanisms that would be employed for Option A and Option B.
- What are the capture/anchoring mechanisms, respectively, for the ARD spacecraft to establish a rigid interface with the asteroid?
- After achieving the rigidized interface; for scientific and engineering investigation of the asteroid, what other articulated mechanisms are required?
- What kind of sensors do you expect to be used to drive these mechanisms?
- Given that these operations are likely to occur beyond the orbit of Mars, can these complex operations be successful using telerobotic controls, i.e. 'command and wait'?
- What amount of autonomy can be expected in these operations?



NASA Mars 2020 Mission: Robotic Landing and Surface Ops



*Similar to Curiosity
Leaned down ~40% to accommodate
caching samples for return to Earth.*

*Has new zoom camera on mast
for longer range vision operations.*

*...rove, conduct science, collect rocks
and other samples..*



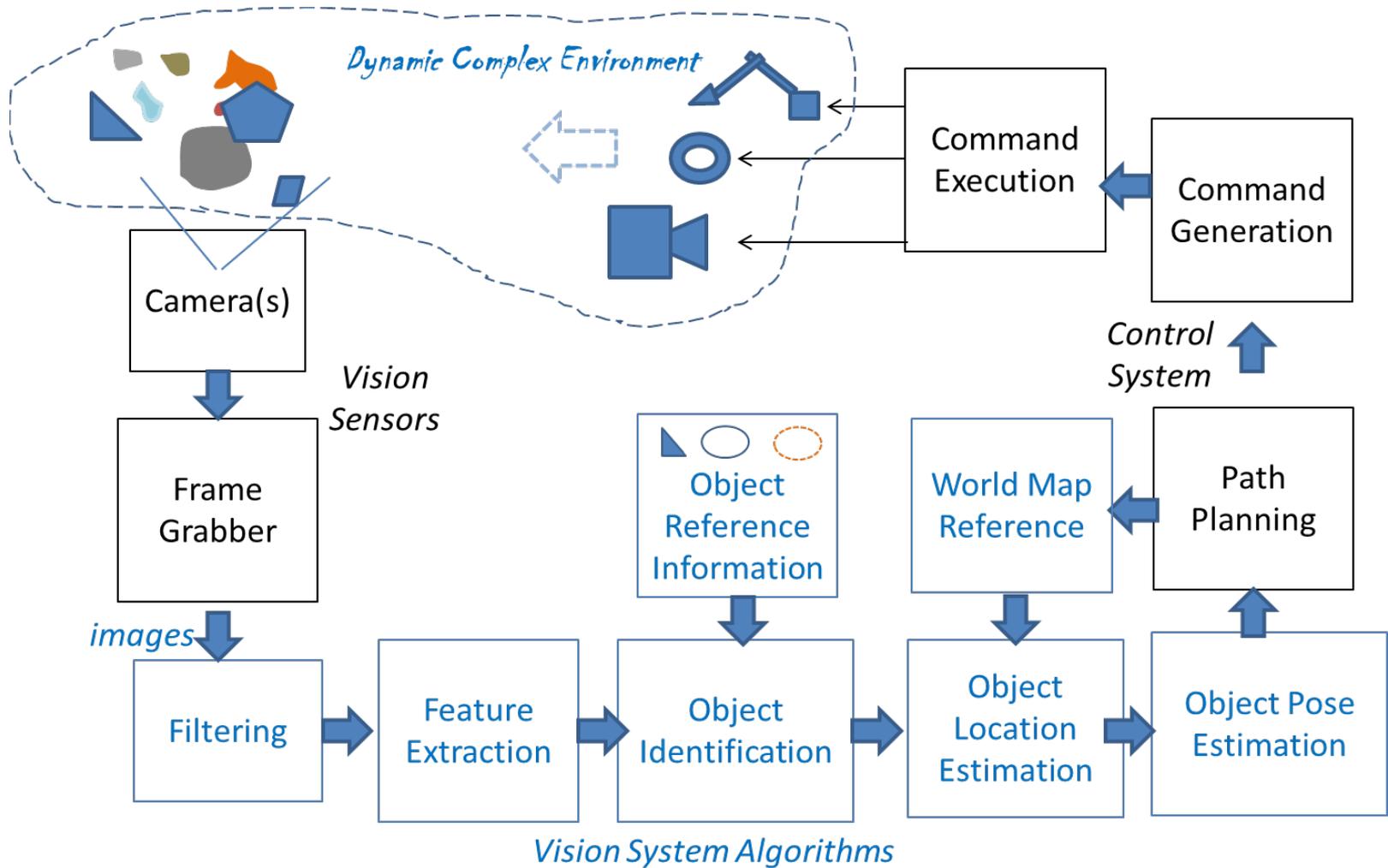
- **Charley, what are the mechanisms for the Curiosity-class rover?**
 - Six wheels for stability over rough terrain, all drive, four steer.
 - A five degree of freedom manipulator arm that can reach 2 meters.
 - And rotates a turret to position and preload tools and instruments.
 - For Mars 2020, different science instruments & probably a lid on the container for caching the rock samples.

- **What kind of sensors do you expect to be used to drive these mechanisms?**
 - Redundant stereo pairs of cameras on the mast. (zoom added for Mars 2020)
 - Two pairs of hazard cameras on the carriage front, one pair on rear.

- **What amount of autonomy can be expected in these operations?**
 - Significant autonomy to maximize science yield during daylight hours.



Robotics operations using vision systems



Asteroid Redirect Questions

- **Thomas**, please describe how a vision system can be used to drive the robot actuators on these missions.
 - Please describe the robots and vision systems you have in your laboratory.
 - Other thoughts that this discussion brings to mind.
-
- **Vincent**, what risks would likely be identified during the IV&V of a mission having a vision and autonomous system?
 - How can vision systems be proven to work adequately (or not)?



Anything-robotic Q & A

- NASA missions ?
- Robot cars?
- Health care robots?
- Terminator?
- Robot competitions?



Wrap Up and Take Aways

We have discussed the **robotic components** of three NASA missions currently under development.

- The Asteroid Sample and Return OSIRIS-REx mission.
- The robotic Asteroid Redirect Mission:
- The Mars 2020 rover

- All missions will use **robotic mechanisms** to accomplish their missions, and will likely use **vision systems and laser ranging** as inputs to the **robotic control systems**.

Thank you for your participation!

