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Edinburgh, UK
July 18 - 21, 2016

Systems Engineering Process for the OSIRIS-REx Camera Suite (OCAMS)

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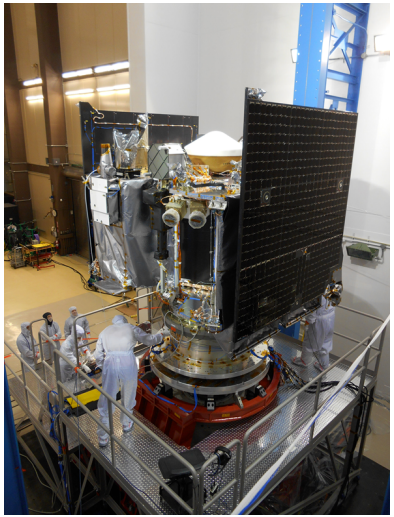
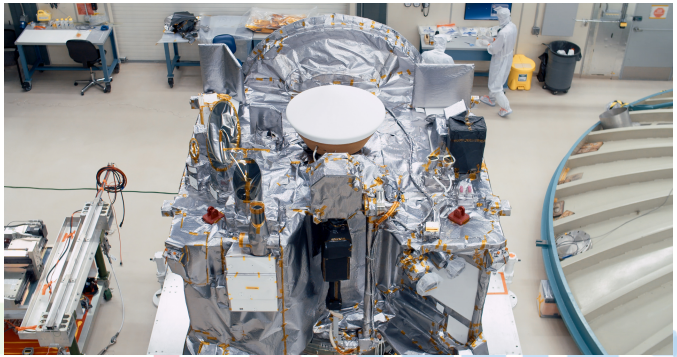
OSIRIS-REx

- **O**rigins
  - Return and analyze a sample of pristine carbonaceous asteroid regolith
- **S**pectral **I**nterpretation
  - Provide ground truth for telescopic data of the entire asteroid population
- **R**esource **I**dentification
  - Map the chemistry and mineralogy of a primitive carbonaceous asteroid
- **S**ecurity
  - Measure the Yarkovsky effect on a potentially hazardous asteroid
- **R**egolith **Ex**plorer
  - Document the regolith at the sampling site at scales down to the sub-cm





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OCAMS OSIRIS-REx Camera Suite

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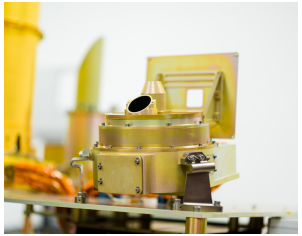
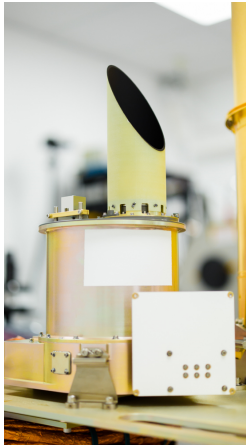
- **O**SIRIS-REx **CAM**era **S**uite
- One of 2 mission critical instruments on the spacecraft.
- OCAMS is comprised of three cameras and a dual sided electronics system.
- OCAMS was designed specifically for OSIRIS-REx and its imaging requirements.





Classic Systems Engineering

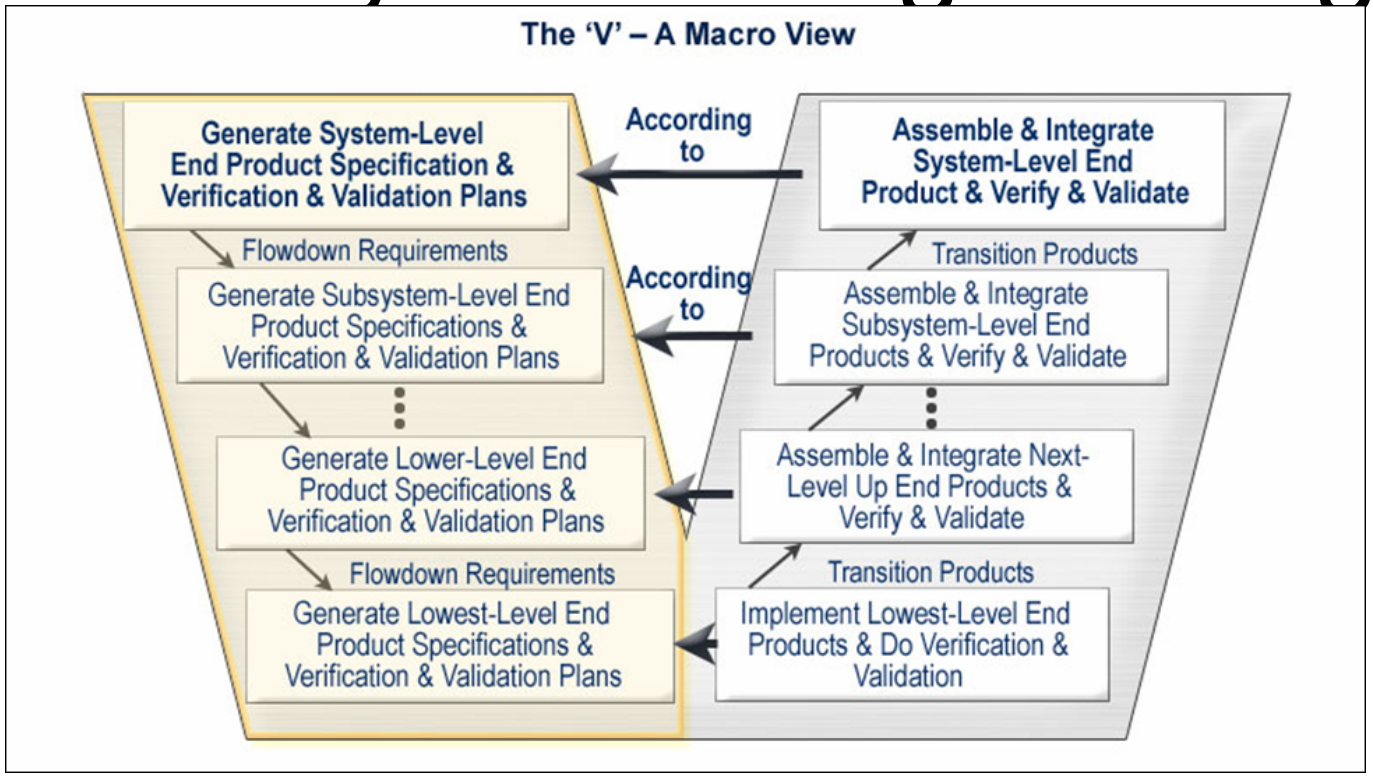
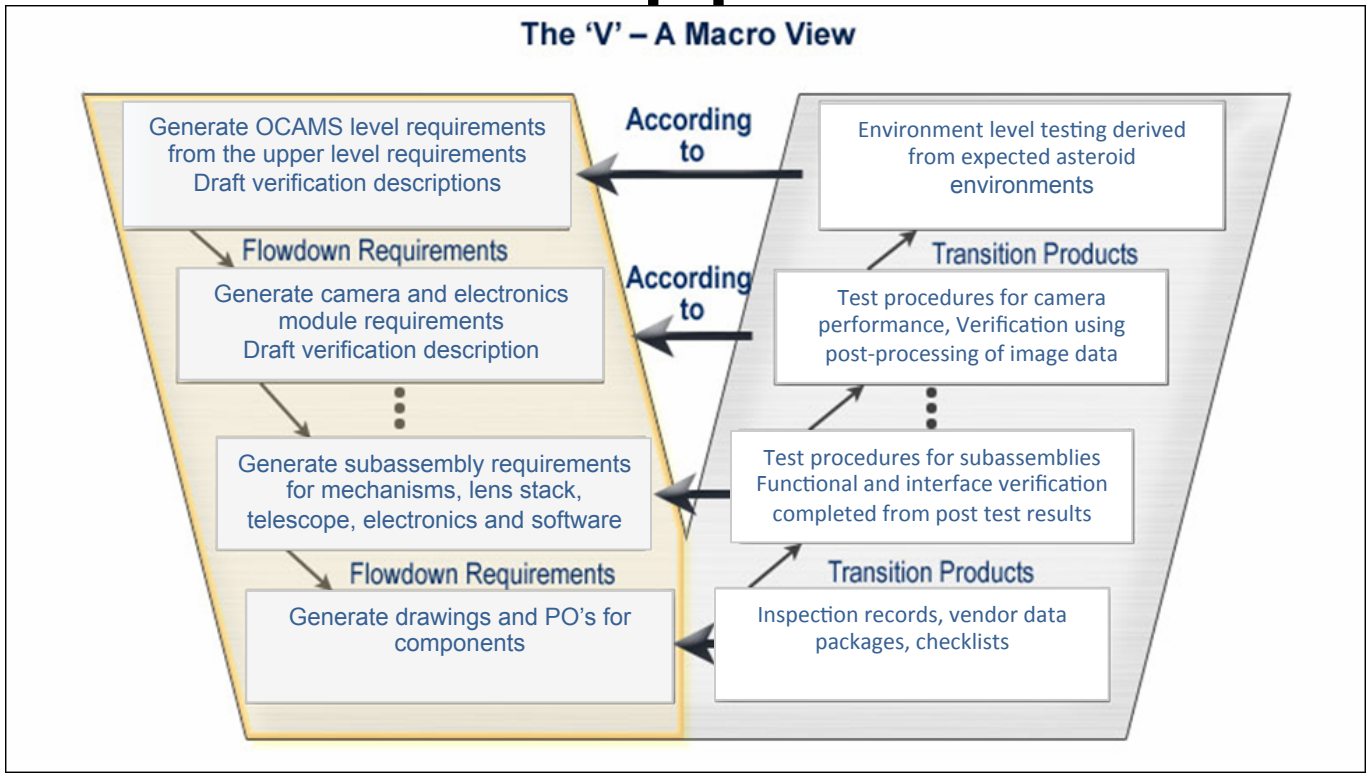
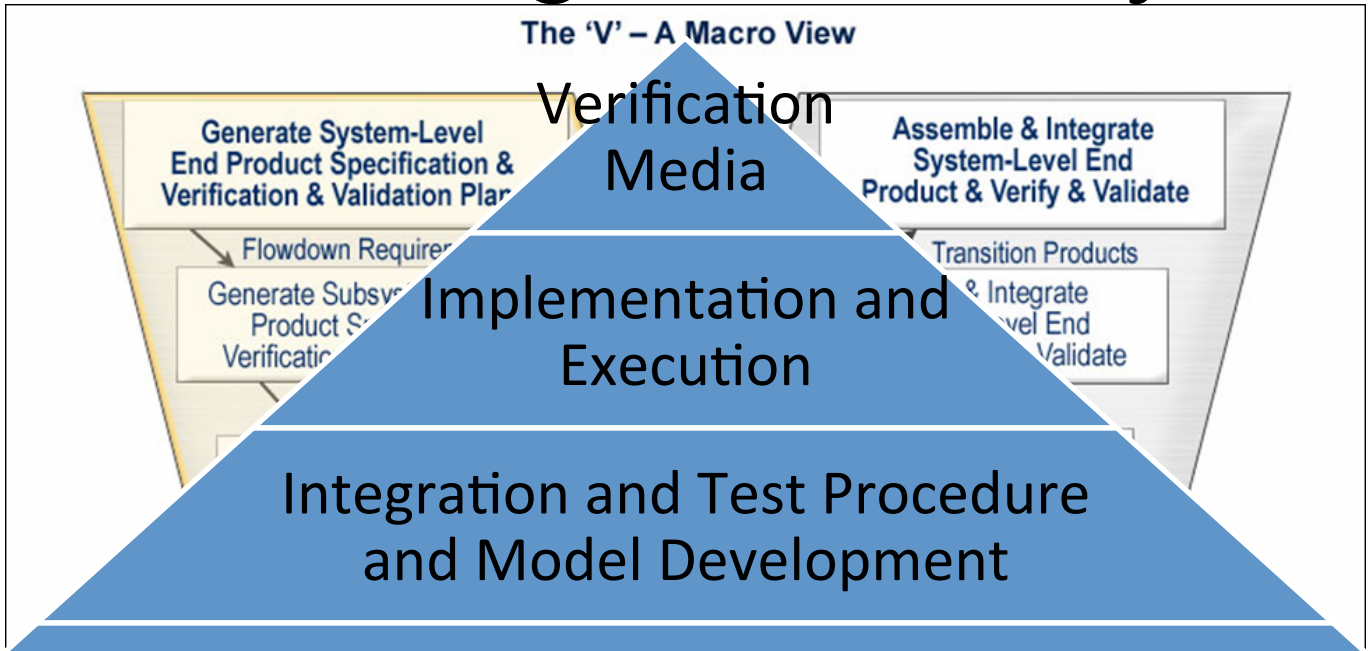


Figure. The Vee Activity Diagram (Source: Prosnik, 2010 /Released)

OCAMS Approach



Establishing Verifiability



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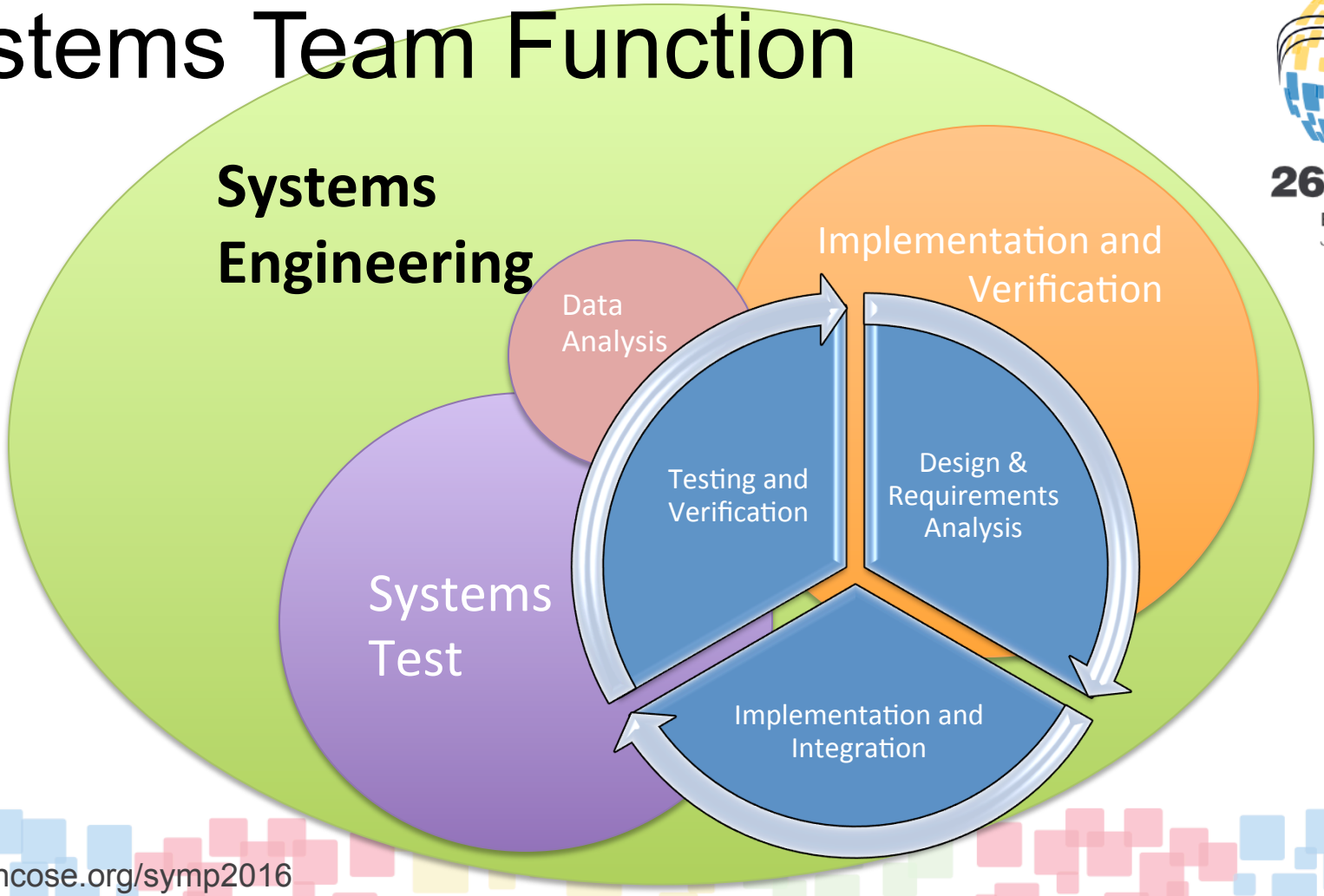
Systems Team Function



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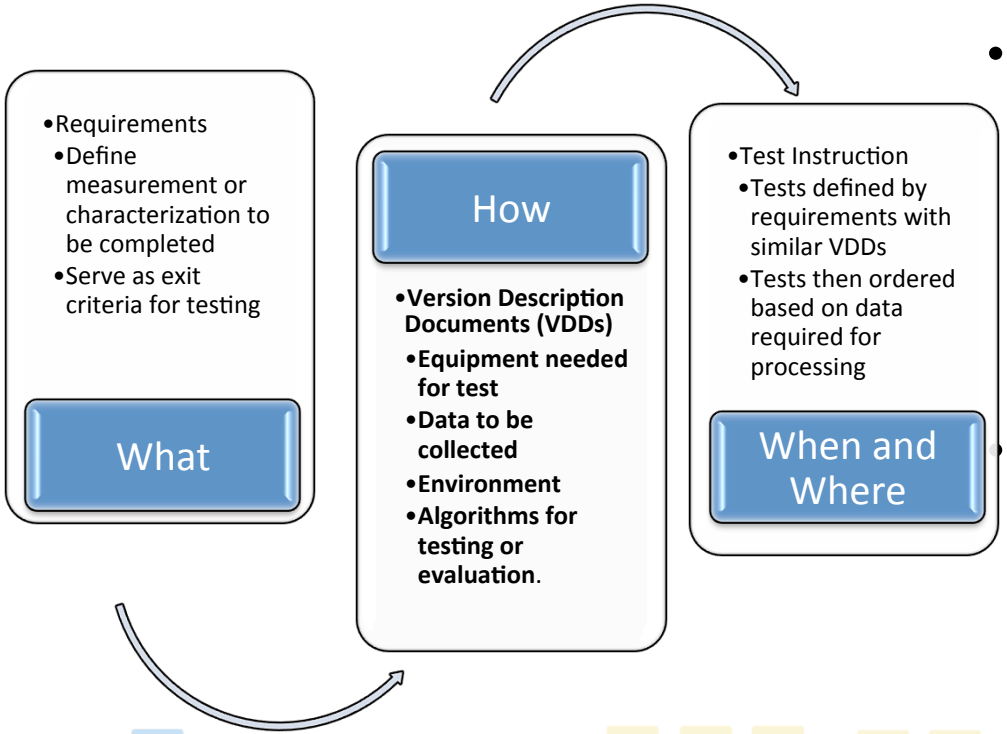
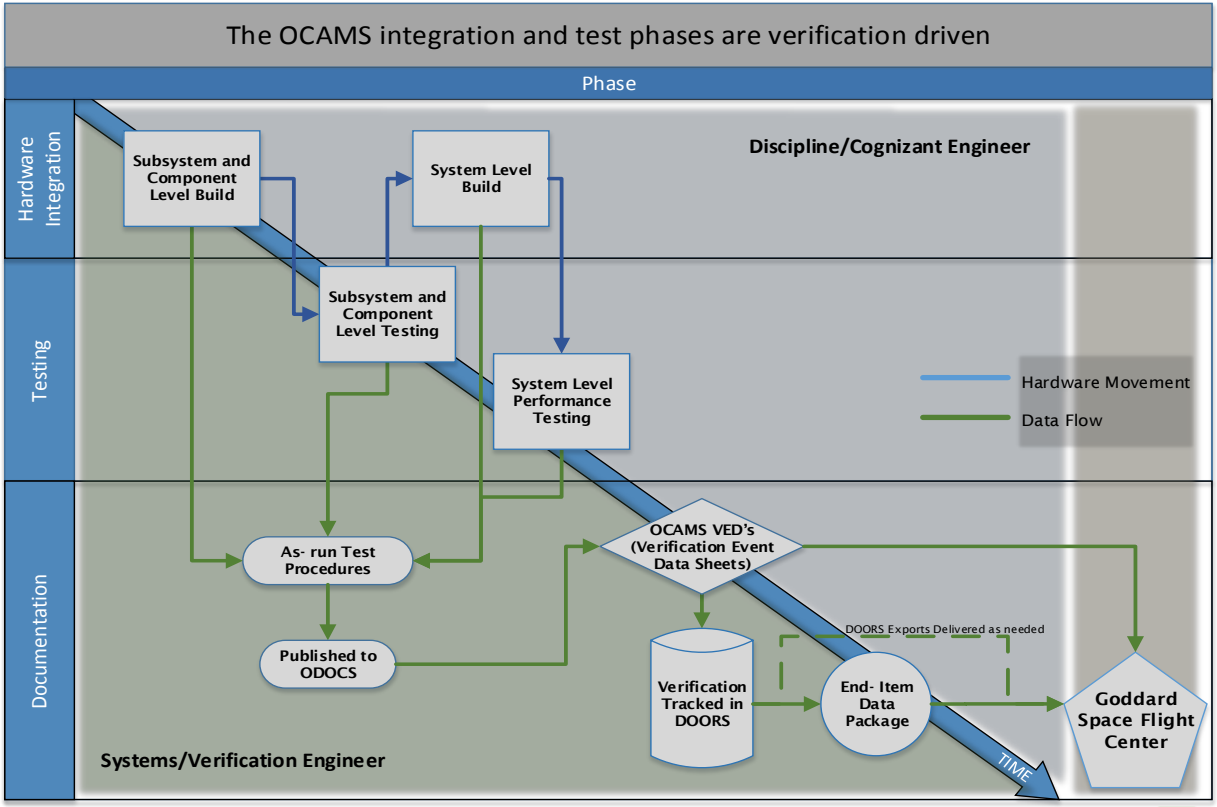
Verification Description



- Verification Description Documents were devised to make the systems team, the Cog-E and the test team all define how each requirement would be answered.

This resulted in changing and re-wording of requirements to clarify and pinpoint programmatic needs.

Verification & Validation



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HARs and BARs

- Milestone status reviews with key stakeholders
  - What, how, when, where, why

VEDs

- Integrated approach to providing robust verification media

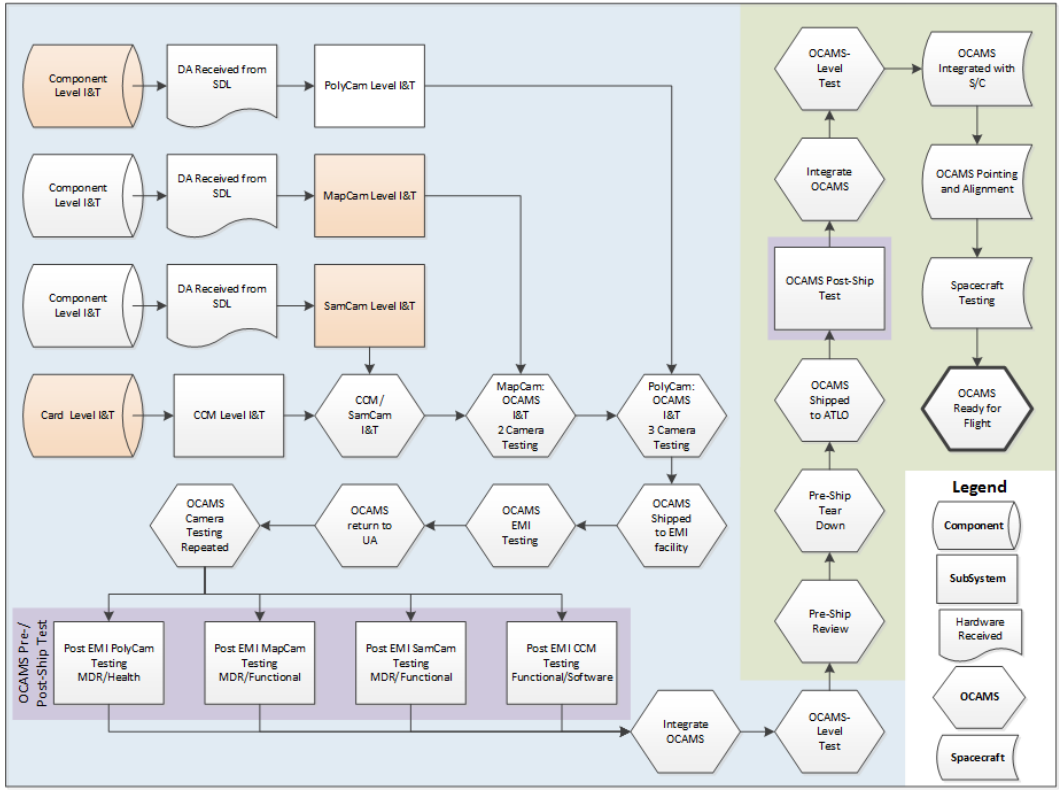
Test Program Summary

EQM Hardware	Copper Path Check	Software ATP	Interface Verification	CCM Functional ATP	Resolution (MTF/ PSF)	Sensitivity (MDR/MDM)	Ghosting	Illumination	Field of View	Spectral Characterization	Torque Margin	Solar Scattered Light Intensity	Stray Light	Boresight	3 Axis Vibration	Shock	Structural Load	Life Testing	STL	Thermal Vacuum Cycle	Thermal Balance	CE, CS, RE, RS	Grounding
	Functional, Performance, and Calibration Testing													Dynamic Test		Other			Thermal Testing			EMI/EMC	
SamCam 101	---	---	---	---	F	F	F	F	F	F	F	F	F	F Q	**	---	F	---	F Q†	F		F	F
MapCam 100	---	---	---	---	F	F	F	F	F	F	F	F	F	F Q	**	---	F	---	F Q†	F		---	---
PolyCam 102	---	---	---	---	F	F	F	F	F	F	C	C	C	F Q	**	---	F	---	F Q†	F		---	---
CCM 001	X	---	X	X	---	---	---	---	---	---	---	---	---	F P	**	---	---	---	F Q†	---		F	F
Flight Hardware																							
SamCam 1001	---	---	F	---	F	F	F	F	F	F	F	F	F	F	**	---	---	---	9	---		F	F
MapCam 1000	---	---	F	---	F	F	F	F	F	F	F	F	F	F	**	--	---	---	14	---		F	F
PolyCam 1002	---	---	F	---	F	F	F	F	F	F	F	F	F	F	**	X	---	---	8	---		F	F
CCM 002	F	F	F	F	---	---	---	---	---	---	---	---	---	F	**	---	---	---	12	---		F	F
Other																							
EM CCM (6)	X	X	X	X	X	X	X	X	X	X	X	X	X	---		---	X	X	---	---		---	---
EGSE (6)	X	X	X	X	X	X	X	X	X	X	X	X	X	---		---	X	X	---	---		---	---
Focus Mechanism Sim	X	X	X	X	---	---	---	---	---	---	---	---	---	---		---	---	---	---	---		---	---
Filter Wheel Sim	X	X	X	X	---	---	---	---	---	---	---	---	---	---		---	---	---	---	---		---	---

--- = not applicable	P = Protoflight levels	† Two cycles	* Denotes test to be performed before Flight unit build begins
C = Compressible	Q = Qualification levels	†† Eight cycles	
1 = One Side	## = Number of total TVAC cycles		** Shock assessment to be completed. Shock testing required
F = Finished	X = applicable		depending on analysis results

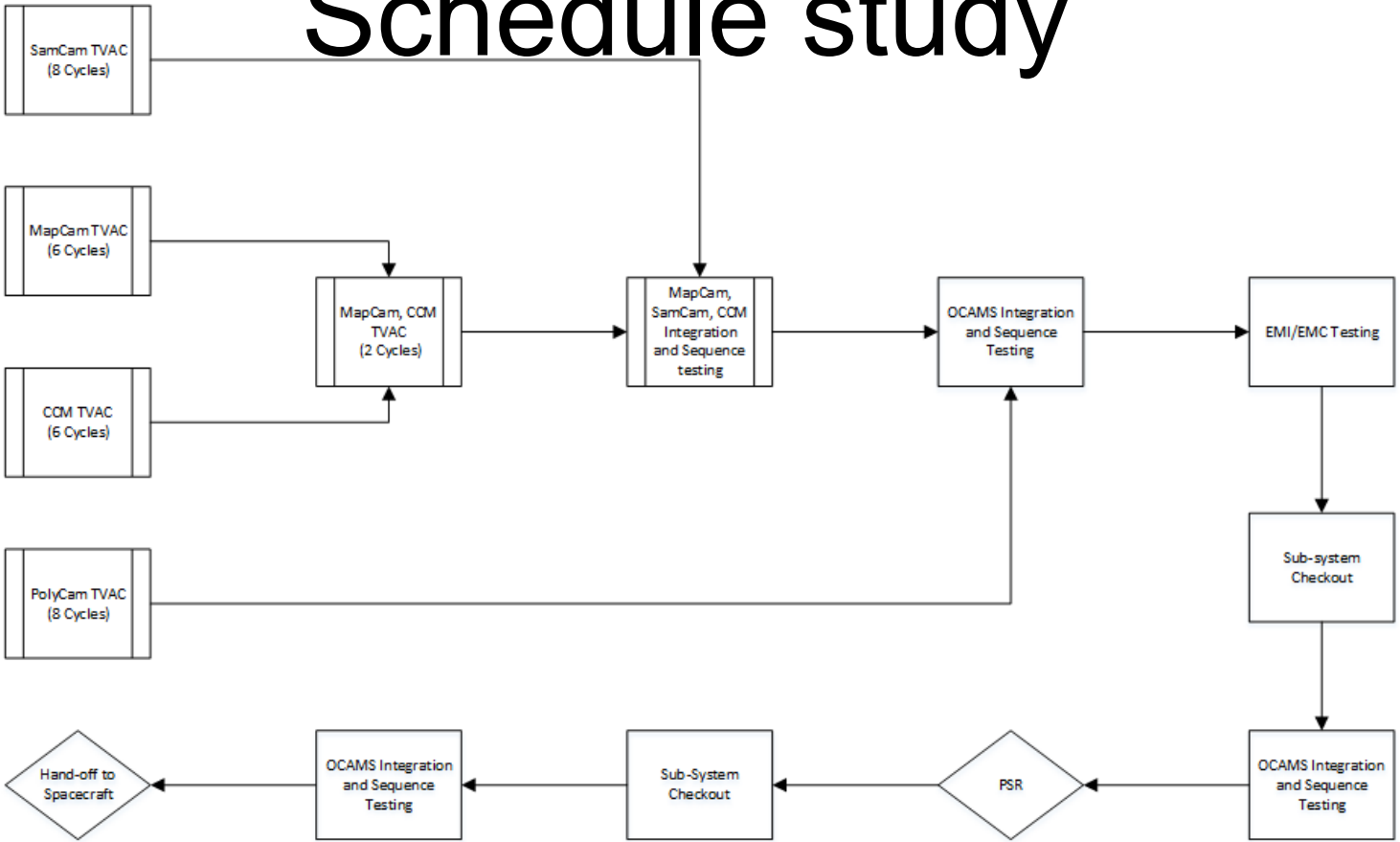
- **Test program evaluated performance of each camera before and during environments.**
- **Test program allowed team to develop and proof tests.**
- **Test program expanded as required to fit the concerns/risks of the program.**

Test Program at a Glance



- **Mimics requirement levels to "fail fast"**
- **Cameras can be tested separately, as all requirements were independent.**
- **Allows for system build and integration with high confidence in the hardware.**
- **Allows OCAMS to isolate issues to minimize lost time.**

Schedule study



Moving Forward

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- OSIRIS-REx is completing the last of the system level testing at Kennedy Space Center in Florida before fairing encapsulation and integration with the Atlas V launch vehicle

- We launch on September 8, 2016

Thank You

- Information about the mission: www.asteroidmission.org