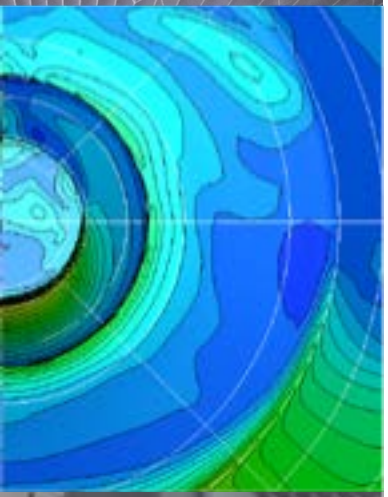
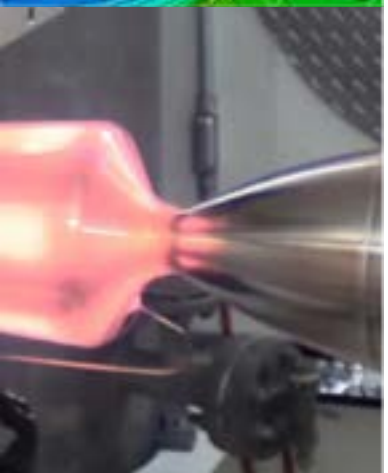




Jet Propulsion Laboratory
California Institute of Technology

Mars 2020 Project

Mars 2020
Entry, Descent, and Landing Verification and Validation

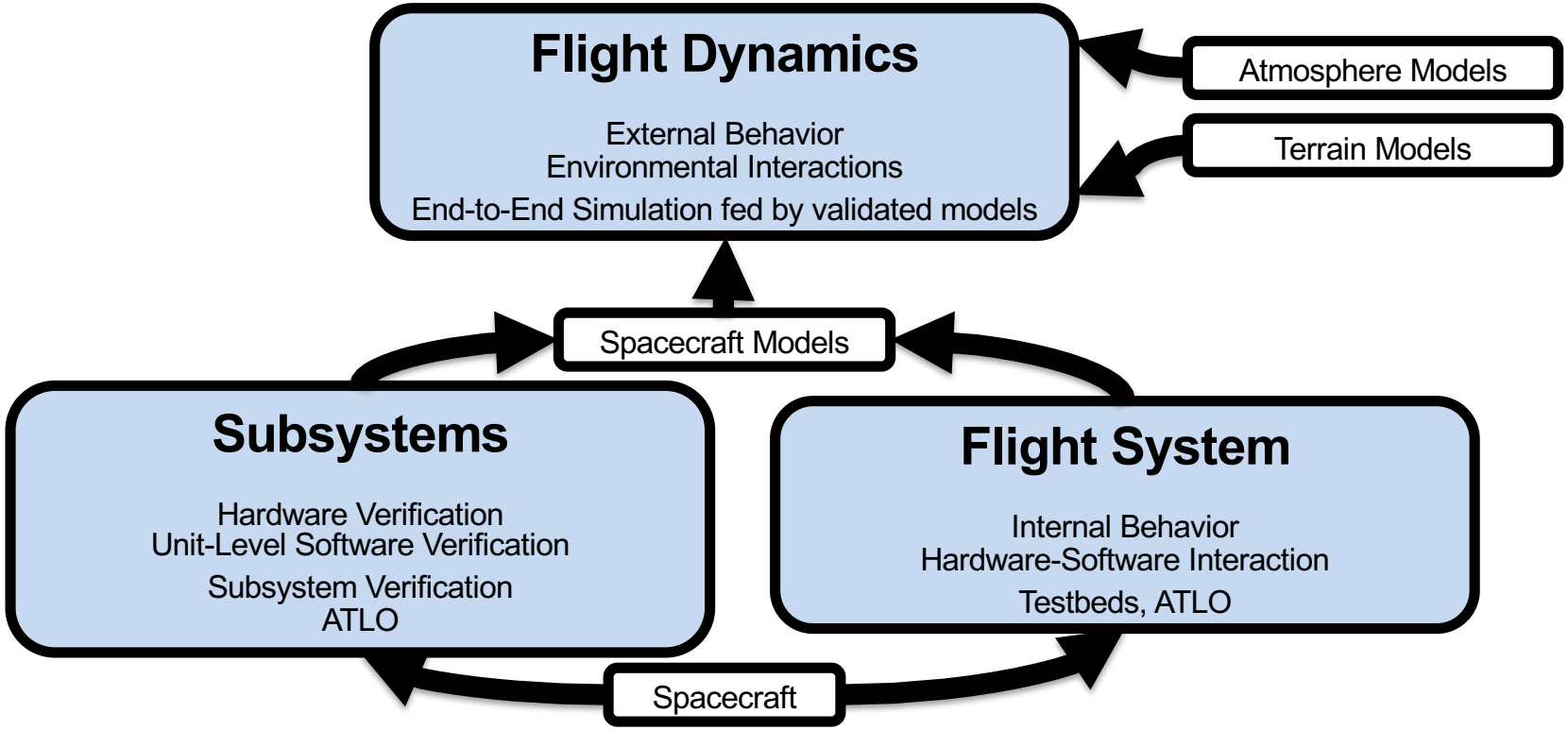
Gregory Villar, Cj Giovingo, Aaron Stehura, Allen Chen

15th International Planetary Probe Workshop
Boulder, CO
June 2018

EDL V&V is Challenging

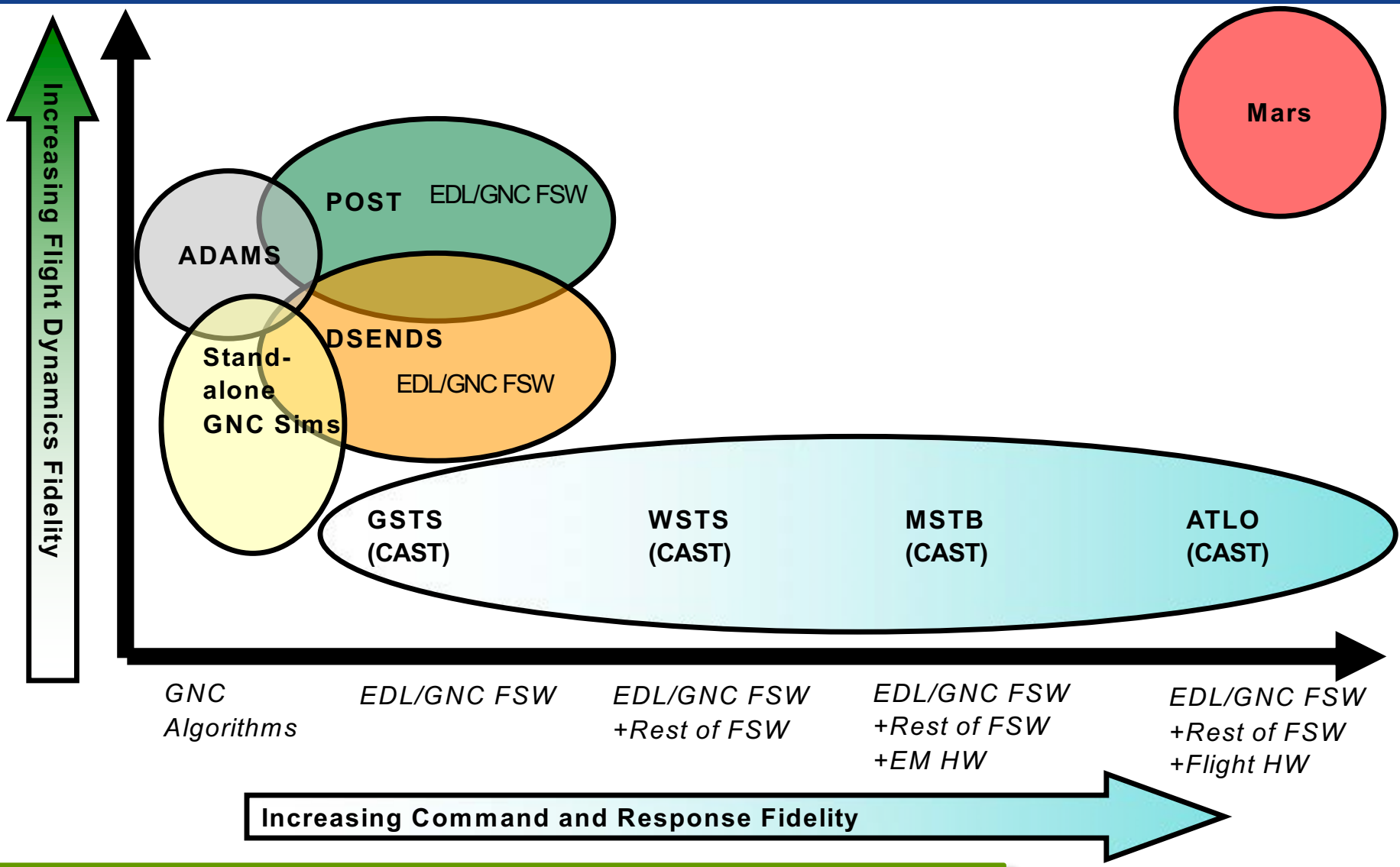
- **EDL is very complex**
- **Cannot completely ”test as you fly, fly as you test”**
- **Strive to design EDL System and EDL V&V Program together**

EDL V&V Domains



EDL V&V is very complex and having domains allow us to decompose the problem

EDL V&V Venues



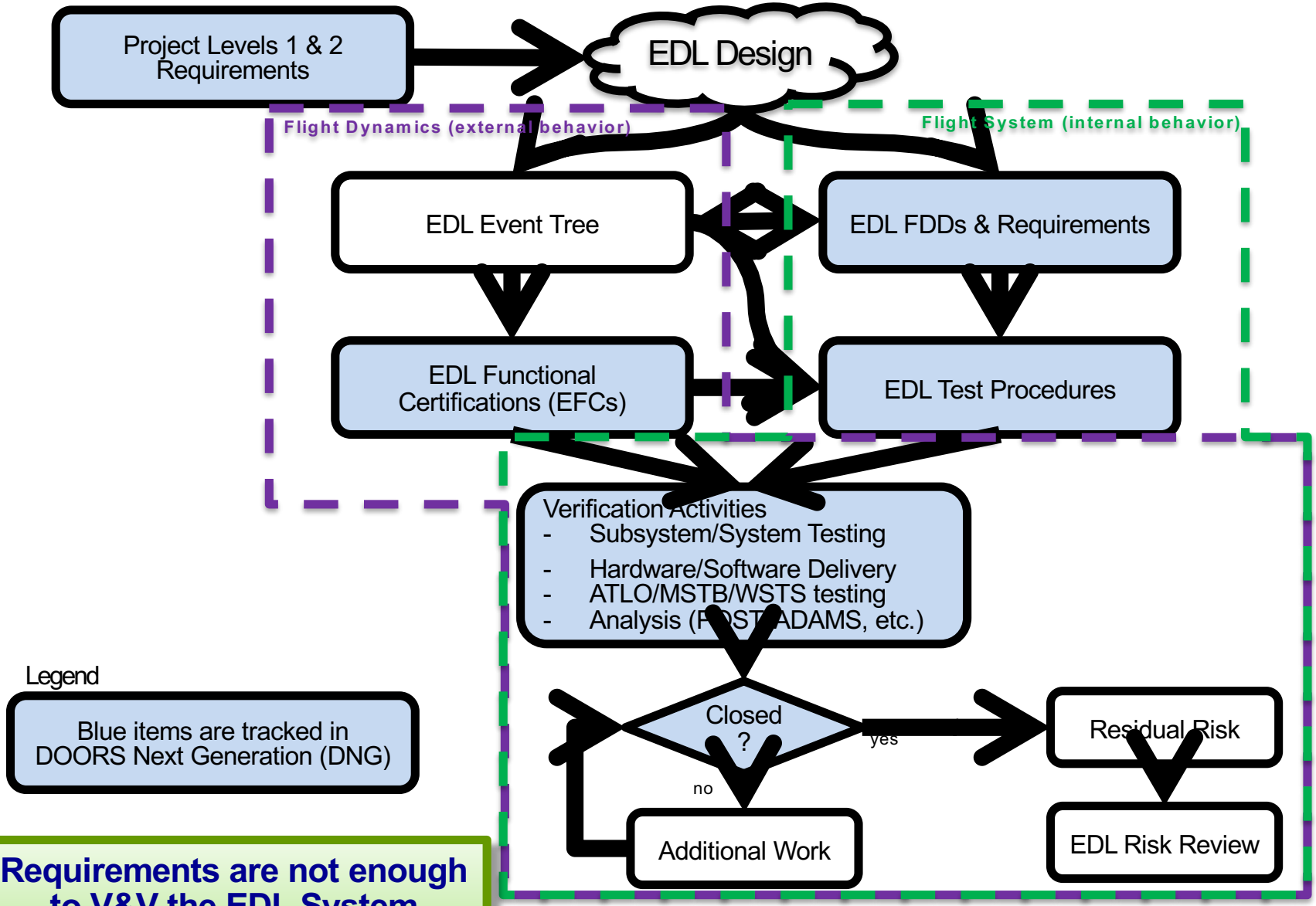
Mars 2020 EDL architecture allows for axes to be decoupled

EDL Event Tree

- Hierarchical method of enumerating all conditions and events that must be successfully executed to ensure EDL success
- Activities required to satisfy the nodes of the success tree are a superset of those that appear in a requirements-based V&V matrix
- All EDL requirements are mapped to Event Tree elements; not all elements can be associated with requirements

Element	Element Description	Study Numb	Study Title	Study Owner	Relevant Requirement(s)
1000	•Final Approach Segment Successful	66	Final Approach Successful	Burkhart/Chen	
1001	•Segment Framework	66	Final Approach Successful	Burkhart/Chen	
1002	•Initial Conditions within System Capability	66	Final Approach Successful	Burkhart/Chen	
1003	•Initial Position and Velocity within Bounds	26	MDNAV Peer Review	Burkhart	FS-548
1004	•Spacecraft Attitude and Attitude Rates within Bounds	46	Cruise attitude	Collins	GNC-114
1005	•Flight System Healthy and in Correct Configuration	80	Flight System Healthy	Greco/Rozek	
1006	•Pre-EDL Nav Performs	30	Nav Filter Study	San Martin/Serrichio/Sell	
1007	•DIMU Calibration Successful	17	GNC alignment error budgets	San Martin/Essmiller	
1008	•Spacecraft Clock as Expected	57	Spacecraft clock verification	Krasner	I&T-288
1009	•Attitude Estimation is Correct	67	Entry Controller and Entry Guidance St	San Martin	
1010	•Nav Filter Processes Data Correctly	29	Nav Filter Study	San Martin/Serrichio/Sell	
1011	•DIMU Performs	12	DIMU Cert	San Martin	FS-910, GNC-20
1012	•DIMU Phasing is Correct	13	EDL FS VAG	Kornfeld	
1013	•DIMU-to-DSH Alignment & Stability is within Bounds	17	GNC alignment error budgets	San Martin/Essmill	FS-720
1014	•Sensor Alignments Knowledge within Bounds at Launch	17	GNC alignment error budgets	San Martin/Essmill	FS-285, 1146, 1147, 1153, 1151
1015	•DIMU-to-DSH Static deflection as Expected	17	GNC alignment error budgets	San Martin/Essmill	MECH-110, 116
1018	•Attitude Propagator Performs	29	Nav Filter Study	San Martin/Serrichio/Sell	
1019	•Cruise Functionality Performs	93	Cruise Functionality	Portock	

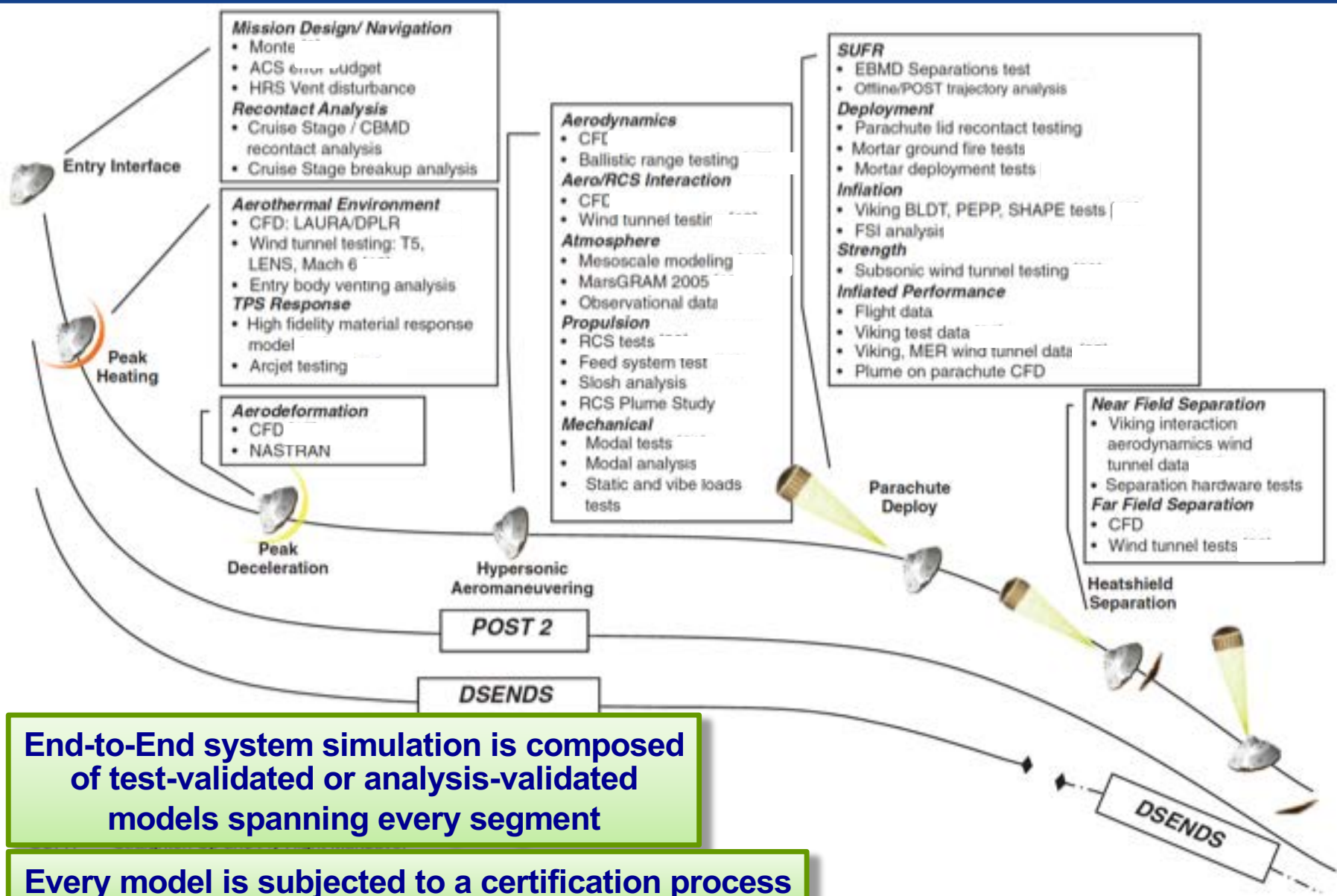
EDL V&V Structure



Requirements are not enough to V&V the EDL System

Flight Dynamics

(1 of 2)

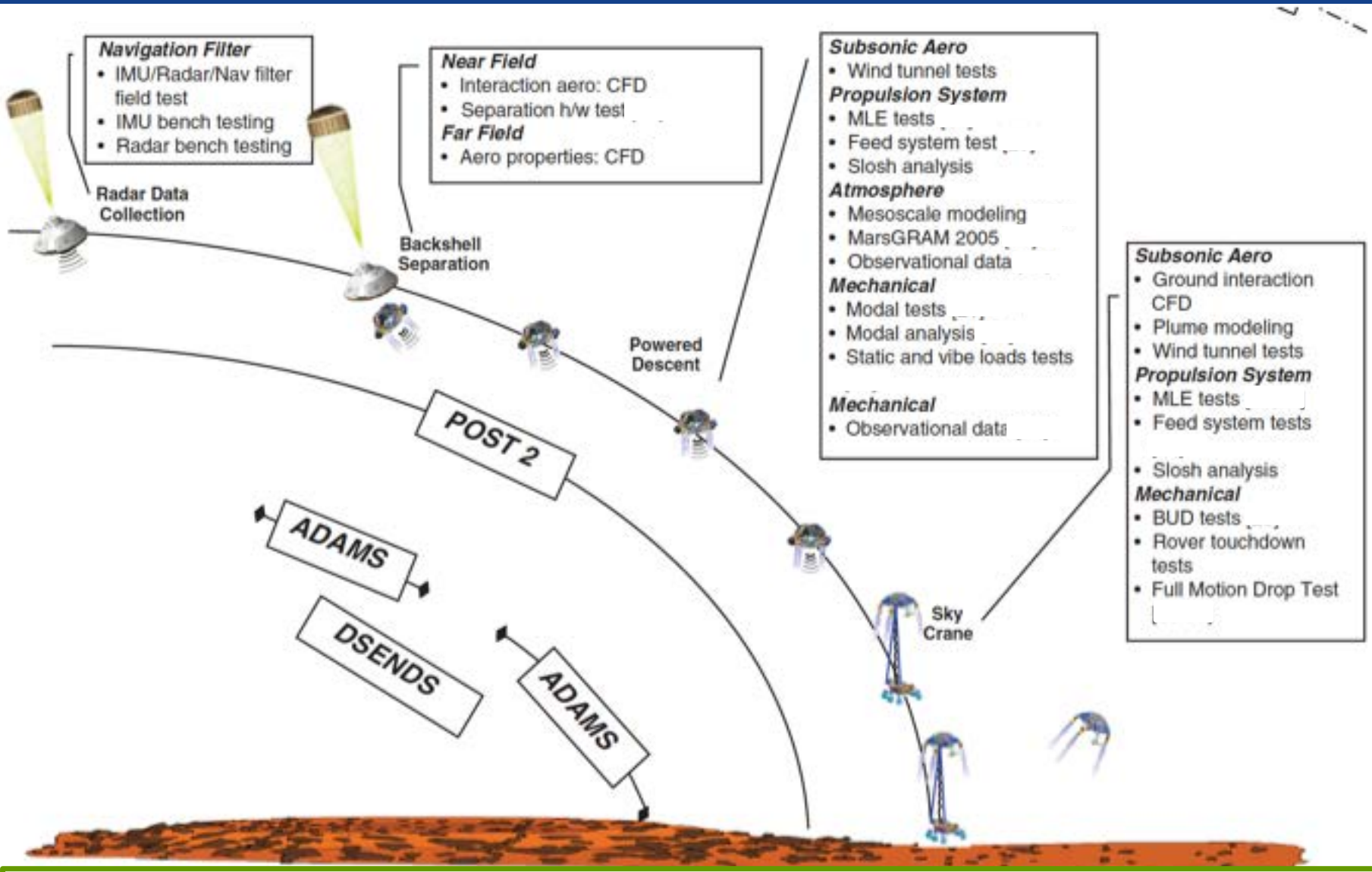


End-to-End system simulation is composed of test-validated or analysis-validated models spanning every segment

Every model is subjected to a certification process

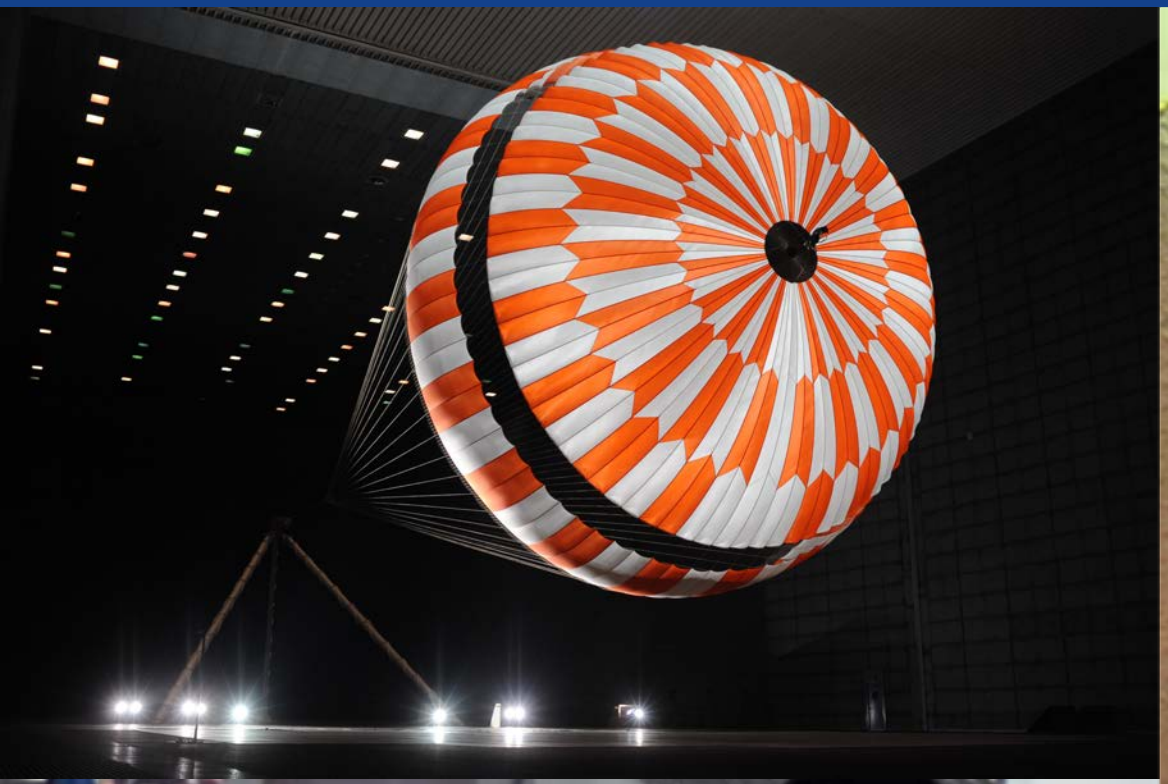
Flight Dynamics

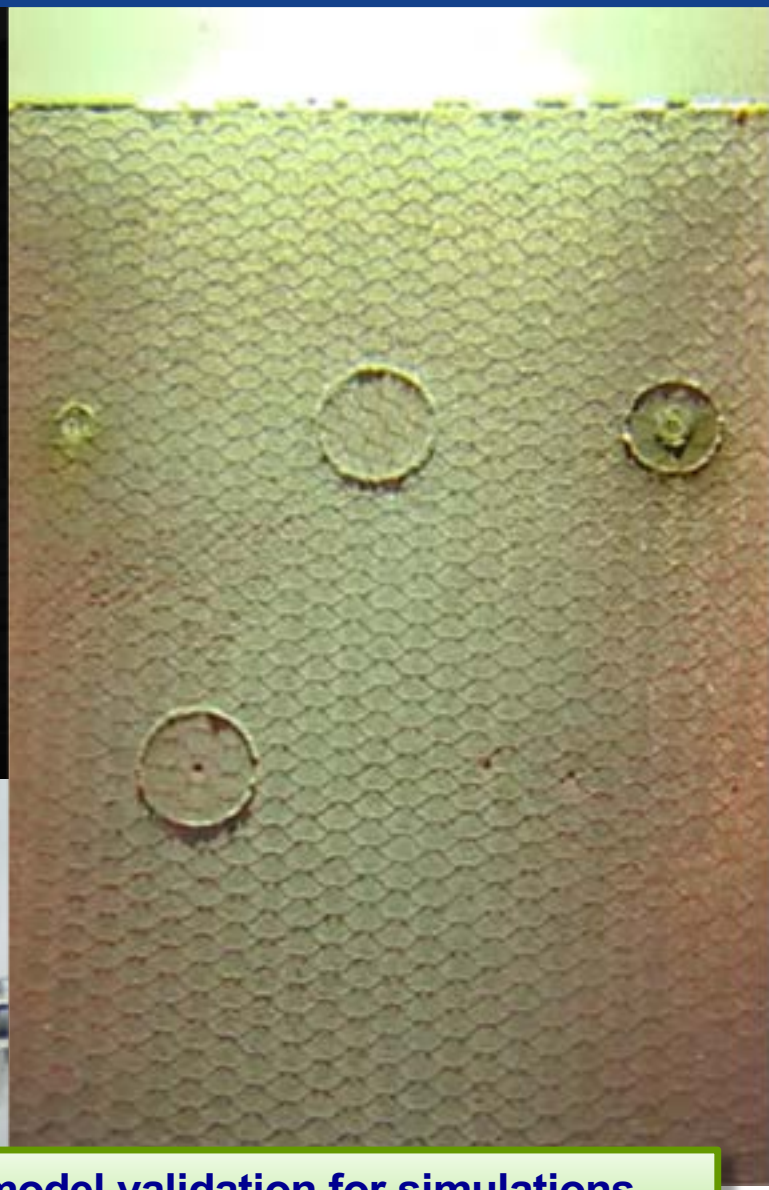
(2 of 2)



Independent validation is achieved using another simulation or analysis, where applicable

Subsystem



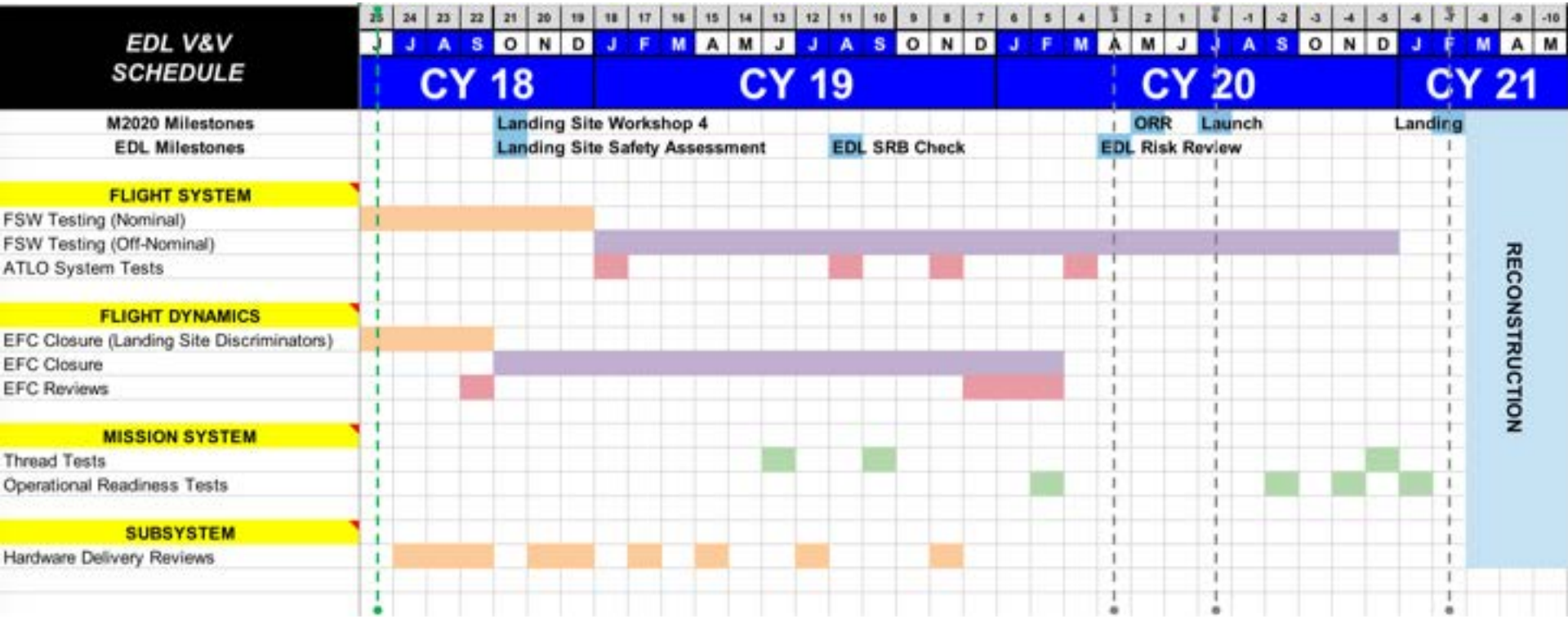


Serves as lower-level V&V for EDL functions and model validation for simulations

Mission System

Flight activities leading up to EDL are executed in a short timeline, so the associated personnel, processes, and tools need to be exercised

EDL V&V Schedule



There is more time to execute the Mars 2020 EDL V&V Program (compared to MSL)

All essential components of Mars 2020 EDL V&V will be completed before launch in 2020, with additional flight software and operations testing extending until landing in 2021.