xEMU Lite Development Plan

EVA Technology Workshop 2017

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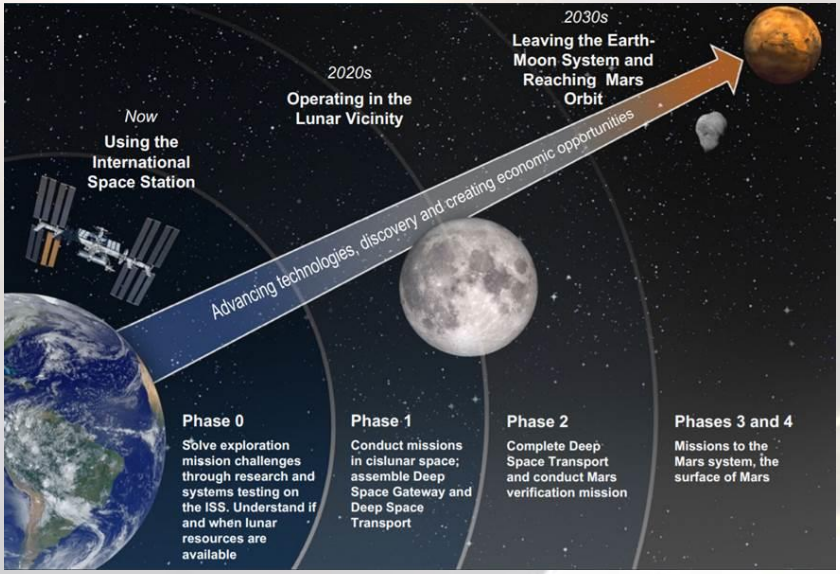
Agenda

- History of EVA Technology Development efforts
- xEMU Lite Flight Demonstration Hardware Development Plan

History of EVA Technology Development Efforts

History of EVA Technology Development

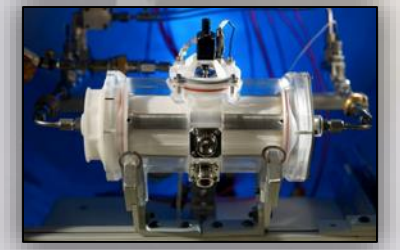
- Since 2007, there has been a continuous effort by NASA to develop EVA technologies to enable future exploration missions
  - Incorporating lessons learned from 30+ years of EMU operations
  - Designing for the different environments of the potential destinations
  - Developing hardware that enables scientific exploration and supports the operational concepts of the potential destinations



- Development has occurred under several NASA programs but the team and overall development plan have remained essentially the same

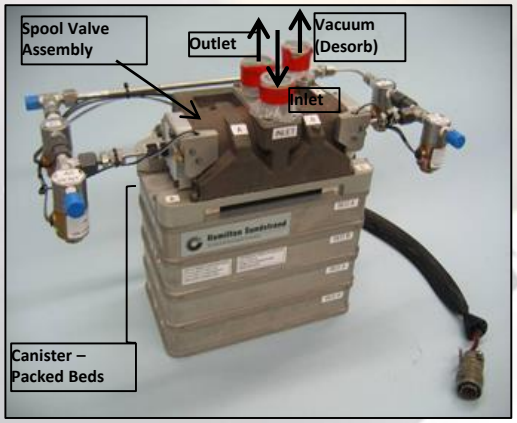
History of EVA Technology Development

- 2007-2010: Exploration Technology Development Program (ETDP) focused on technologies for a lunar mission
  - Performed a PLSS schematic trade study to determine the combination of life support technologies that would best meet exploration mission needs
  - Advanced new system-enabling PLSS component technologies such as the Suit Water Membrane Evaporator (SWME) and Rapid Cycle Amine (RCA)
  - Began work on lunar-focused PGS technologies including bearings, Thermal Micrometeoroid Garment (TMG), and gloves

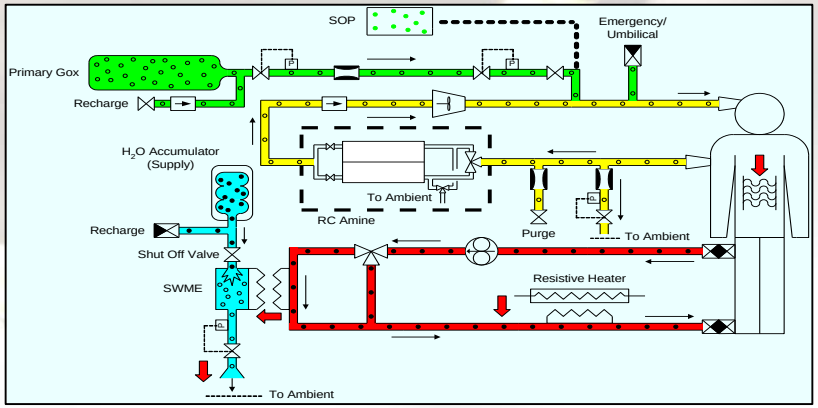


SWME 2.0

Wrist Bearing



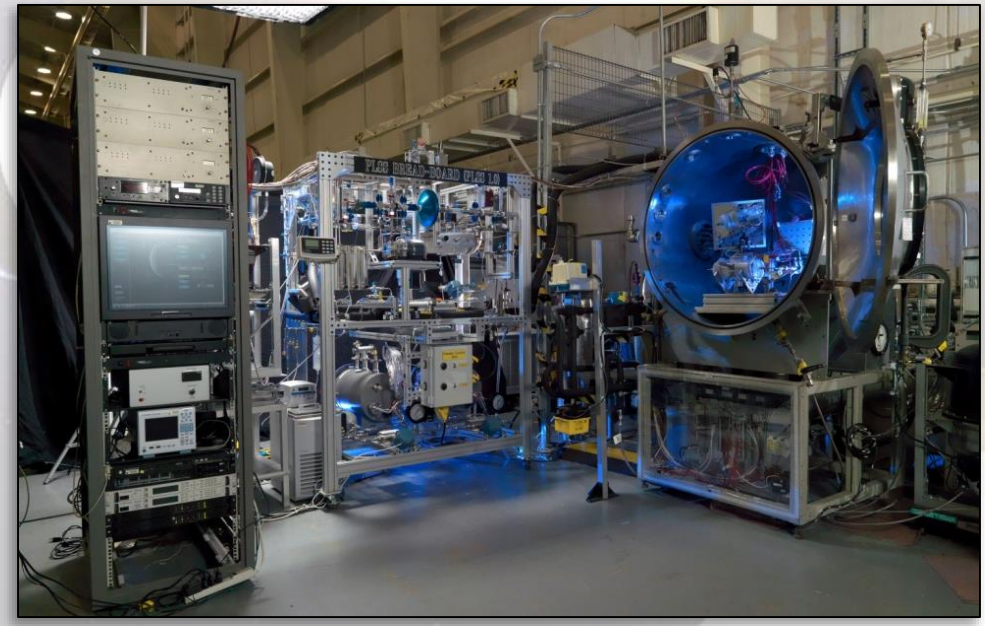
RCA 1.0



Early Exploration PLSS Schematic

History of EVA Technology Development

- 2010-2011: Enabling Technology Development and Demonstration (ETDD) had the goal of developing and demonstrating prototype systems to support exploration goals
  - Continued EVA efforts from ETDP with the addition of SE&I activities
  - Integrated components into systems
  - Culminated in building and testing PLSS 1.0 and Z-1

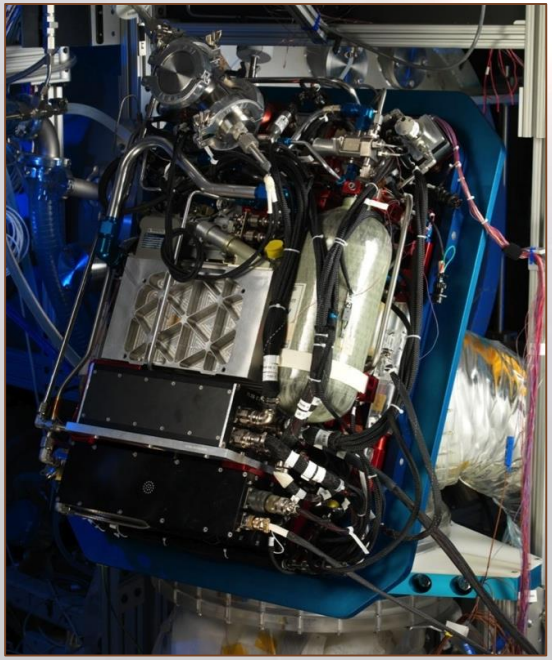


PLSS 1.0 Breadboard

Z-1 Prototype Suit

History of EVA Technology Development

- 2011-2016: Advanced Exploration Systems (AES) and Space Technology Mission Directorate (STMD)
  - Focused on maturing component technologies, integrating them into prototype systems, and demonstrating them in testing
  - Culminated in building and testing PLSS 2.0 and Z-2



PLSS 2.0

PLSS 2.0 Human-in-the-Loop Testing

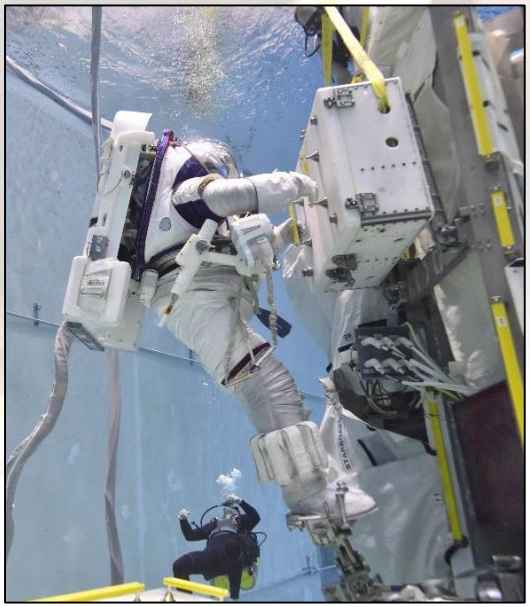
Z-2 Prototype Suit

History of EVA Technology Development

- 2016-2017: ISS Program
  - Continued to advance the TRL of EVA Suit technologies with the goal of developing a NASA reference concept with the capability to support missions at ISS and cis-lunar space
  - Focused near-term development on a “Lite” version of the xEMU, which defers some capabilities
  - Assembled and conducted an electrical live loads test of the xPLSS
  - Performed 19 NBL runs with Z-2

xPLSS Electrical Live Loads Configuration

Z-2 Ingressing the Airlock in the NBL



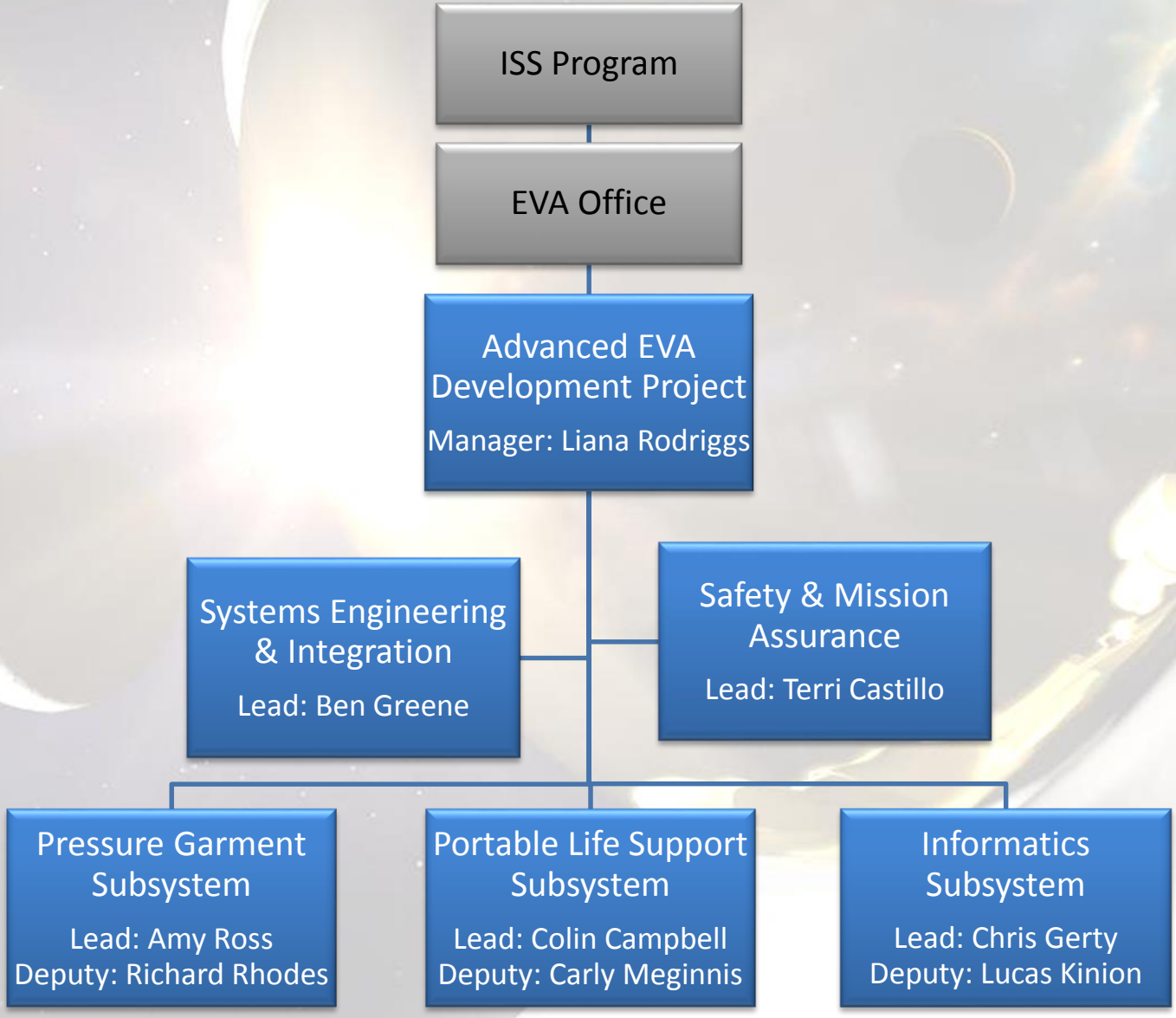
Z-2 Foot Restraint Evaluation in the NBL

xEMU Lite
Flight Demonstration Hardware Development Plan

Transition to Flight Hardware Development

- The technologies developed over the last 10 years are now being pulled into a flight hardware development effort
- Starting in FY18, the project objective is the development of the xEMU Lite for a flight demonstration on ISS
  - Demonstrate core suit capabilities needed for the full xEMU for exploration missions
- The in-house NASA Advanced EVA Development team that has been performing EVA technology development will design the xEMU Lite and build a single flight demonstration unit
  - NASA will be procuring components and will perform the role of system integrator

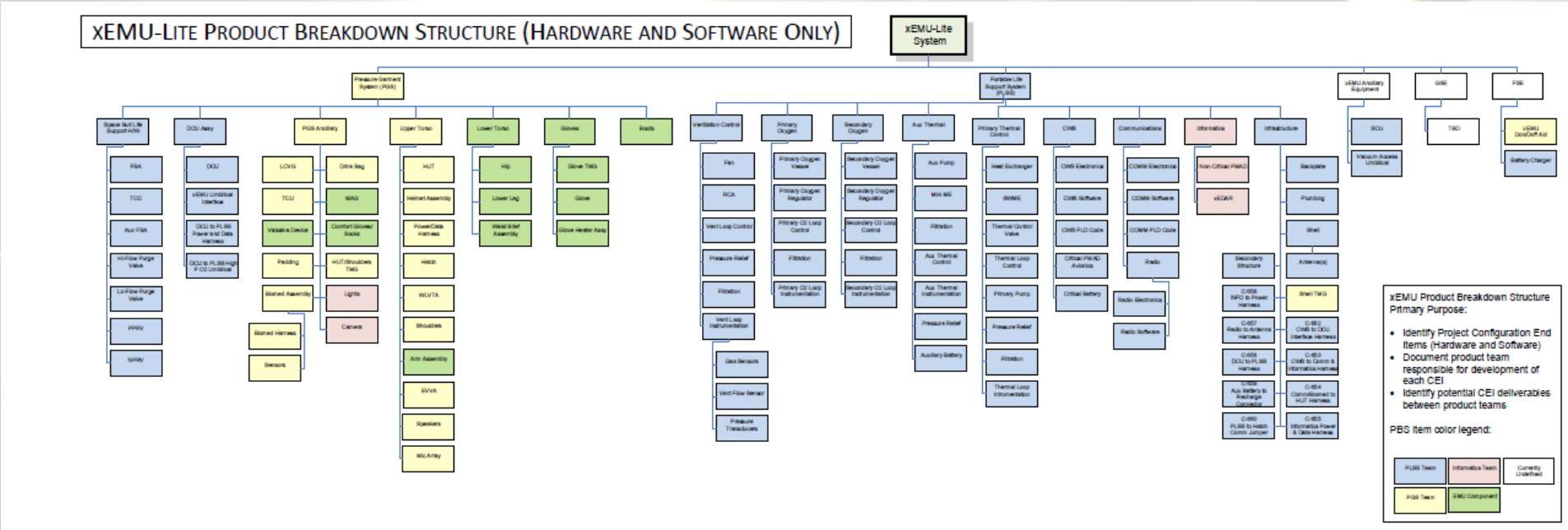
Project Organization



xEMU Lite Architecture

- The xEMU Lite is a subset of the fully outfitted xEMU, with non-critical capabilities deferred
- Details of the architecture are captured in the Architecture Description Document
- The Product Breakdown Structure identifies and organizes the hardware and software deliverables for the project

System	Lite-Configuration
PLSS	xPLSS Lite
PGS	xPGS Lite, EMU Softgoods
INFO	xINFO Lite
FSE	New ISS FSE
T&E	ISS Standard Tools



xEMU Lite vs xEMU

xEMU Lite
ISS Demonstration

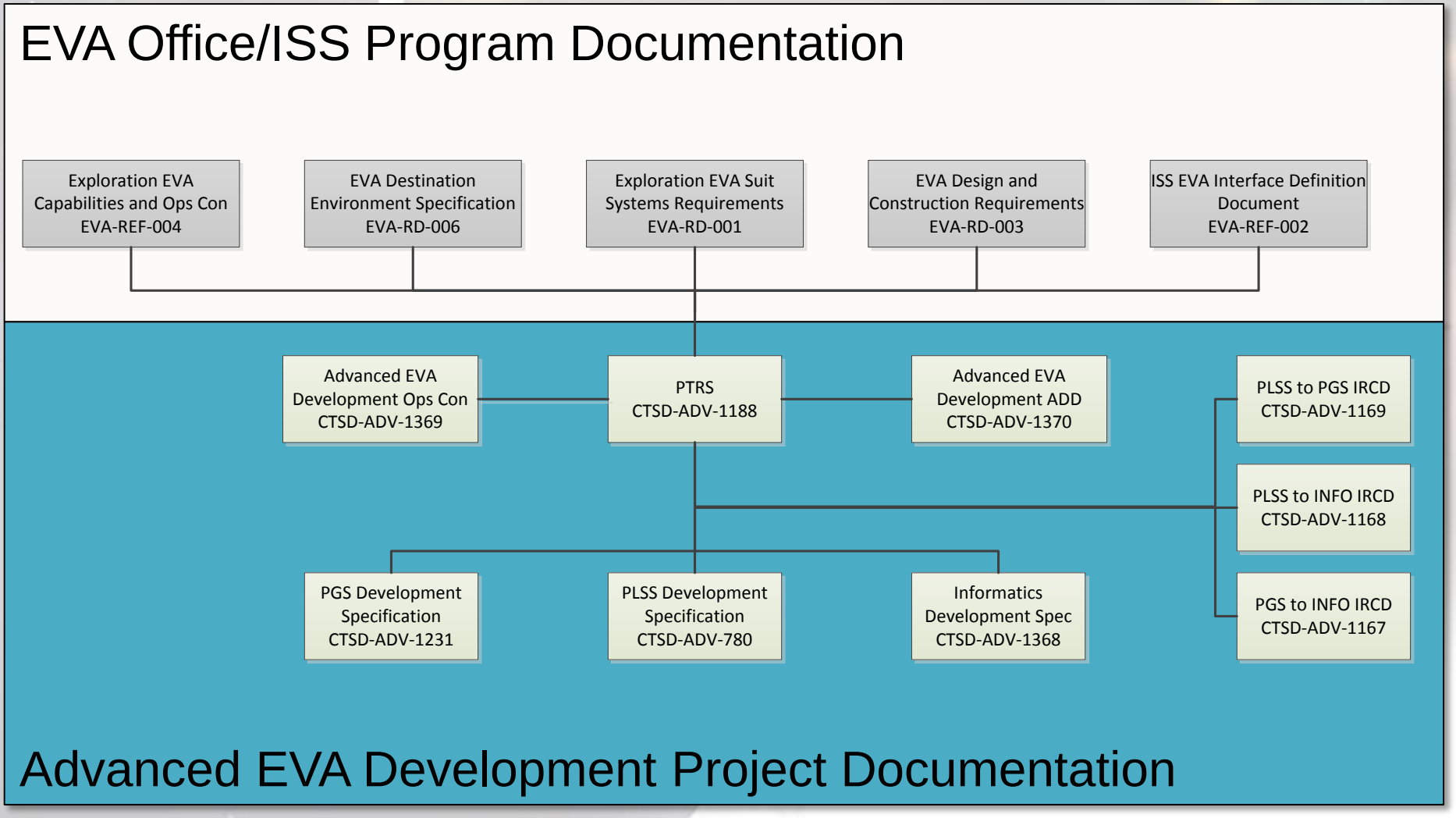
xEMU Lite	Feature	xEMU
4.3 psi	**Operating Pressure**	8.2 psi
LEO Microgravity	**Design Environment**	Deep Space Microgravity Surface
Upper Torso + Min. Lower Torso	**Mobility**	Upper Torso + Full Lower Torso
Scarred for future upgrade	**Crew Autonomy**	Graphical Display

xEMU
Deep Space EVA
For
Gateway and Mars Transit

xEMU Lite Development Assumptions

- 3 complete hardware iterations will be built
  - Design Verification Test (DVT) prototype – pre-qualification testing
  - Qualification unit
  - Flight unit
- The flight demo will be performed with a single xEMU Lite suit
- Flight demonstration objectives and a concept of operations will be developed prior to SRR
  - Dual suit operations with EMU
  - Multiple EVA's over a period of time
- Goal is to design the xEMU Lite to meet as many of the xEMU requirements as feasible within cost and schedule constraints, but it will be certified for a demo, not for full EMU replacement or xEMU (ex. Life requirements)
  - Details are being worked out in preparation for the project Systems Requirement Review (SRR)
- Work is underway to determine best approach to interface xEMU Lite with the ISS airlock
  - Permanent vs. temporary approaches are being considered

Requirements Structure/Doc Tree



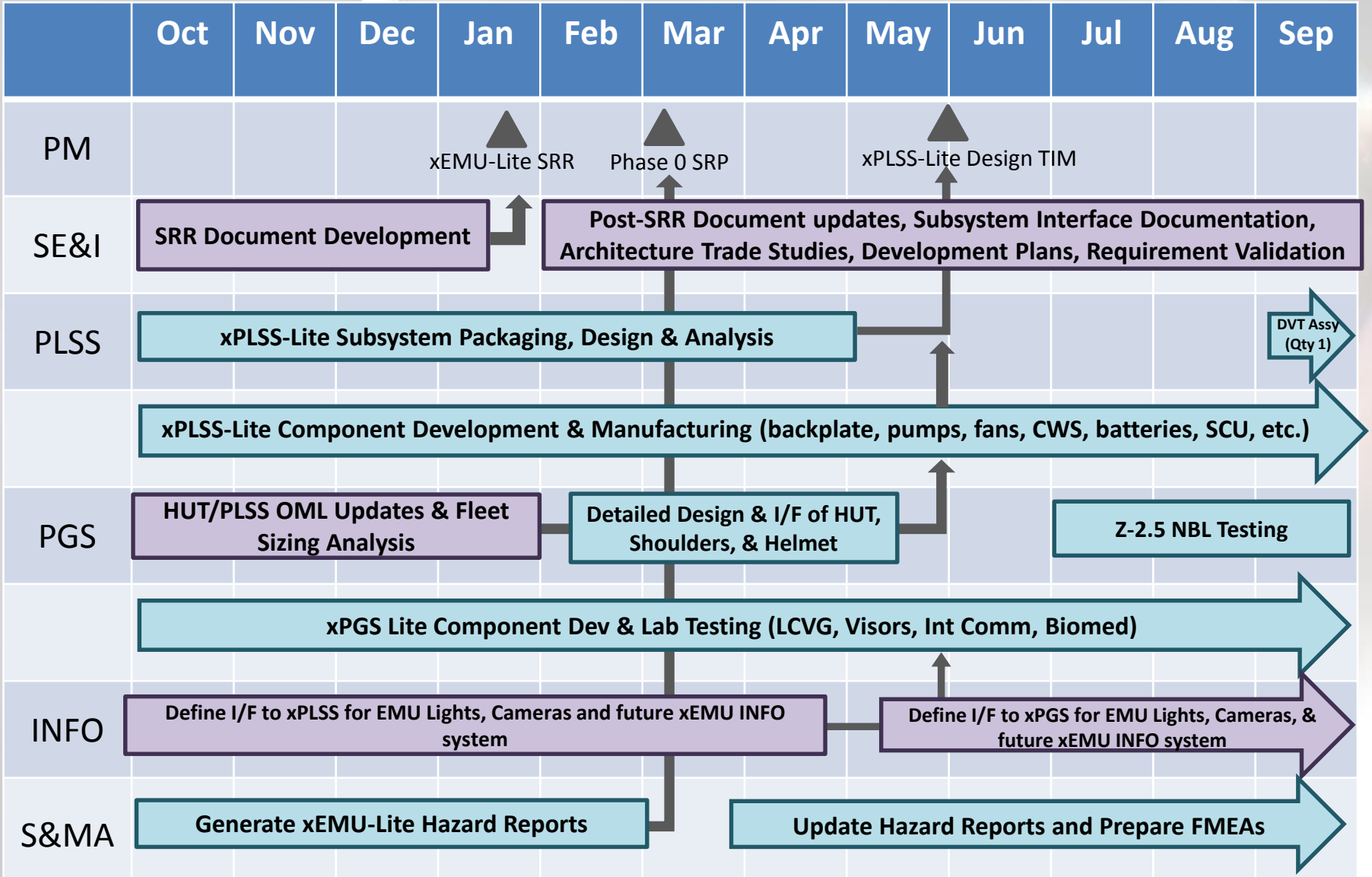
Tentative Schedule

	FY18	FY19	FY20	FY21
xEMU Lite Milestones	SRR	PDR	DVT Build/Test	CDR

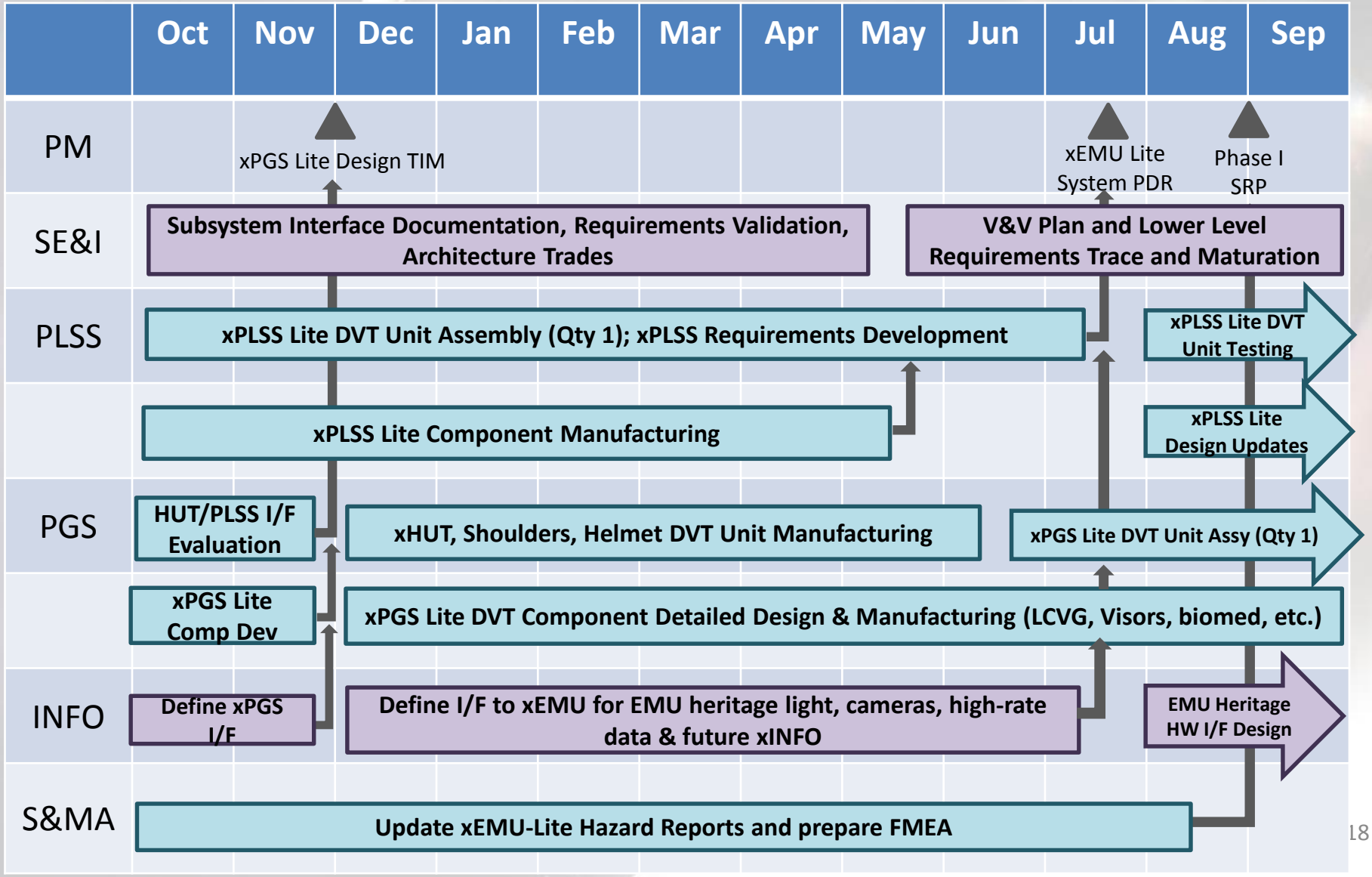
Terms and Definitions: SRR – System Requirements Review, PDR – Preliminary Design Review, CDR – Critical Design Review, DVT – Design Verification Testing

- Project-level System Requirements Review (SRR) in January 2018
- PLSS Subsystem design TIM in late spring 2018
  - Informal peer review
- PGS Subsystem design TIM in fall of 2018
  - Informal peer review
- Project-level Preliminary Design Review (PDR) in mid-2019
  - Initial assumption is that we will have a series of component PDR's leading to the system review
- Project CDR in FY21
- Flight demonstration by mid-2020's

FY18 Plan Overview



FY19 Plan Overview




Questions?