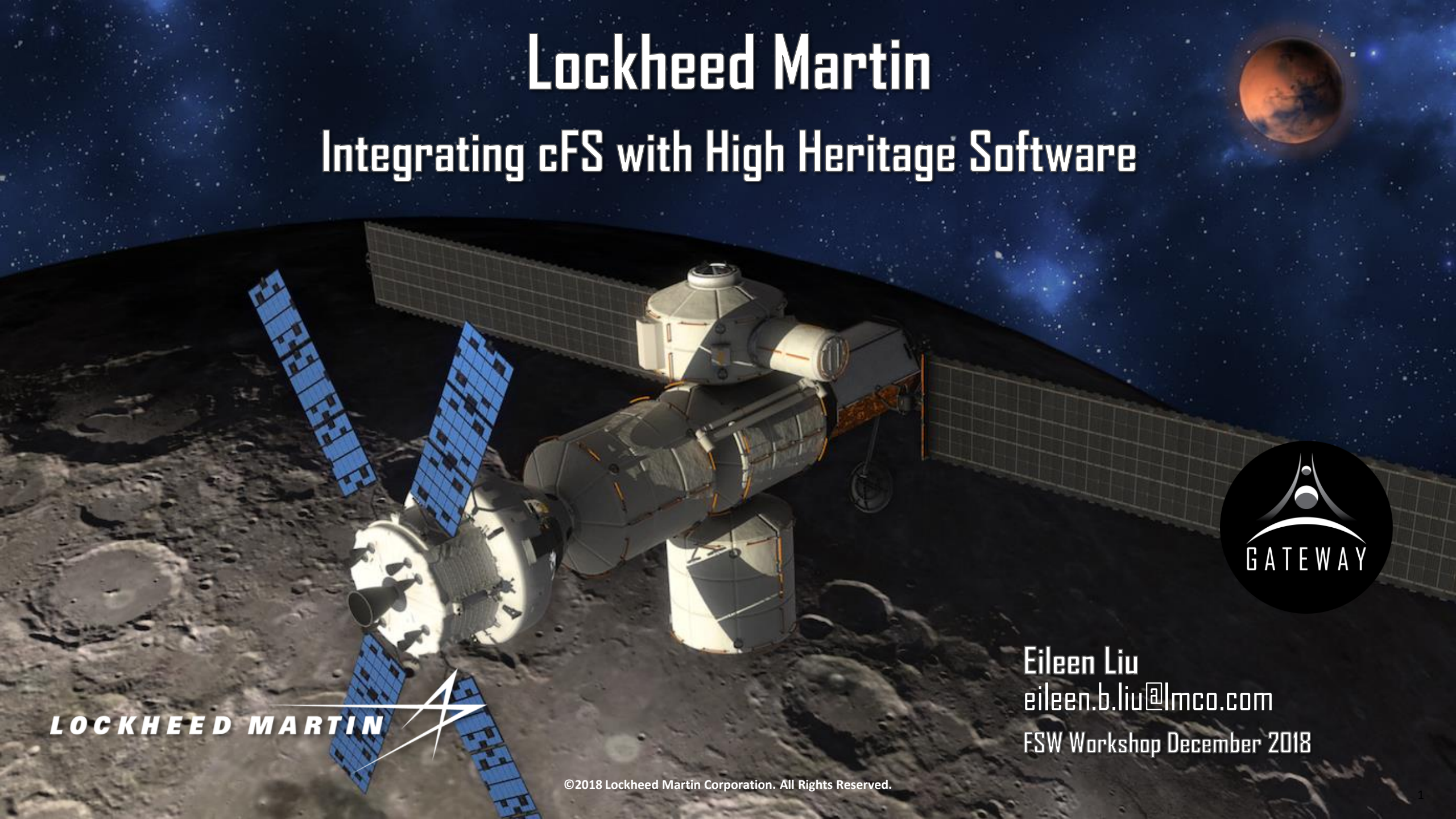
Lockheed Martin

Integrating cFS with High Heritage Software



LOCKHEED MARTIN

Eileen Liu
eileen.b.liu@lmco.com

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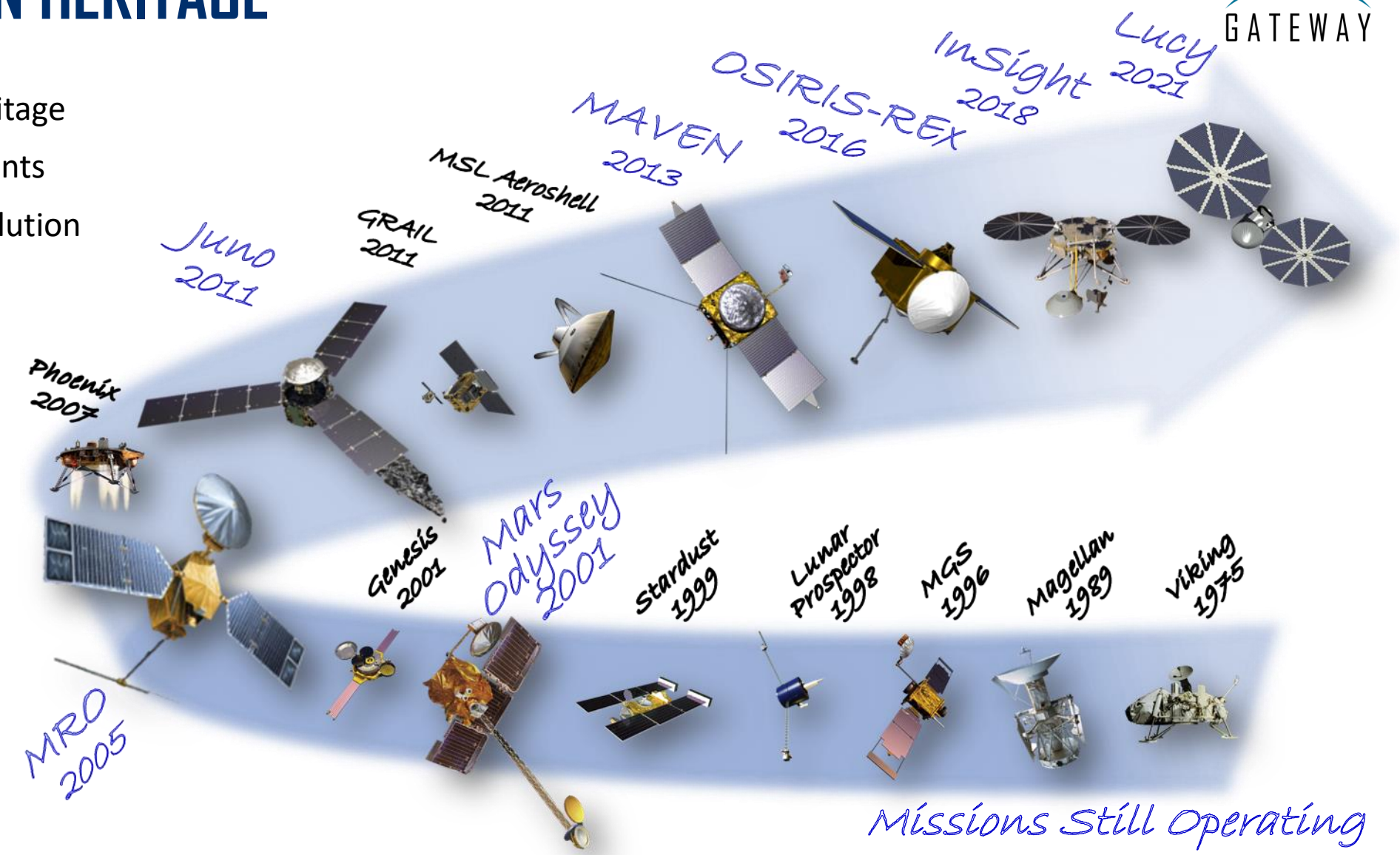
LOCKHEED MARTIN HERITAGE

- 40+ years of planetary heritage
- Diverse mission requirements
- Incremental hardware evolution
- Strong operations focus
- Multiple NASA interfaces



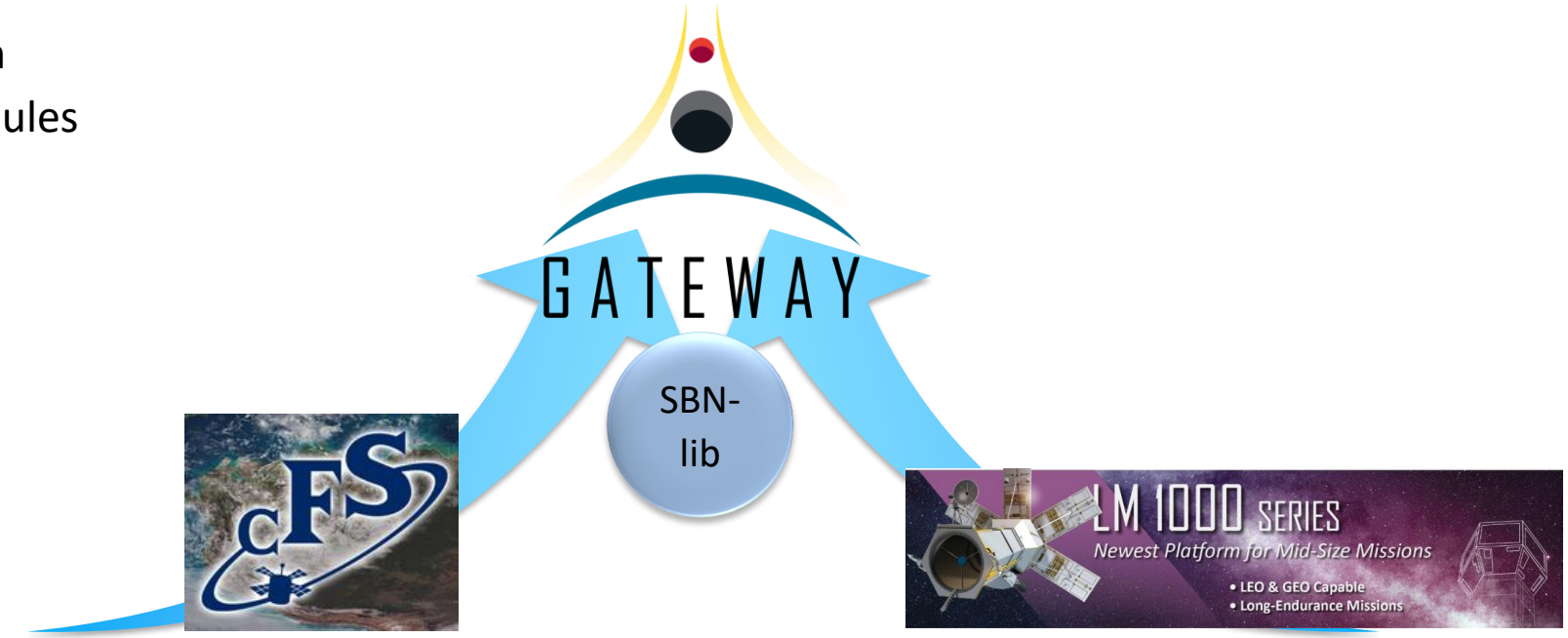
LOCKHEED MARTIN SPACE SOFTWARE

GATEWAY

- Product line focused organization (LM1000)
  - Deep space heritage avionics/software leveraged for LM1000 product line solution
- Combined commercial and civil space organizations
  - Driving commonality between commercial and government solutions
- Lockheed Martin (LM) NASA core Flight System (cFS) expertise throughout the organization
  - Orion backup flight software and camera control
  - Qualification via LM research and development
  - Development of LM specific cFS apps
  - Flight Software (FSW) common core (small sat and beyond)

LM PLANETARY FLIGHT SOFTWARE PRODUCT LINE AND CFS

- LM integrates multi-mission Planetary FSW and cFS components
  - Architecture agnostic interface to cFS allows interoperability with LM Planetary FSW Product Line (LM 1000)
  - Leverage NASA investment into refining/integrating cFS Software Bus Network (SBN) and SBN-lib technology
  - Flexibility to expand LM 1000 functionality and pivot based on unique mission needs
    - TT Ethernet
    - Voting Architecture
    - Add Compute Strings post launch
    - Future Payloads or Gateway modules
    - Flexibility for future partners



CFS AND LOCKHEED MARTIN FSW PRODUCT LINE COMMONALITY

GATEWAY

- Common design principles
  - Modular/layered architecture
  - Maximize leverage from heritage spacecraft
  - Minimize clone-and-own
- Commonalities provide unique opportunity to leverage the best of both

cFS	LM 1000
Strict hardware abstraction	>1M flight hours
Low barrier to entry	Proven time to orbit (<36 months)
Abundant interface support	Unattended deep space operations
Re-loadable app structure	Large suite of ancillary tooling
Large support community	Efficient operation heritage (shared ops)
Reusability and flexibility	Inherited common mission sequences

NEXTSTEP PHASE II

GATEWAY

Study Objectives

- Assess multiple architectures to optimize safety, affordability, and performance for the Gateway
- Demonstrate crew interface commonality between Gateway assets and NASA's Orion

Study Action

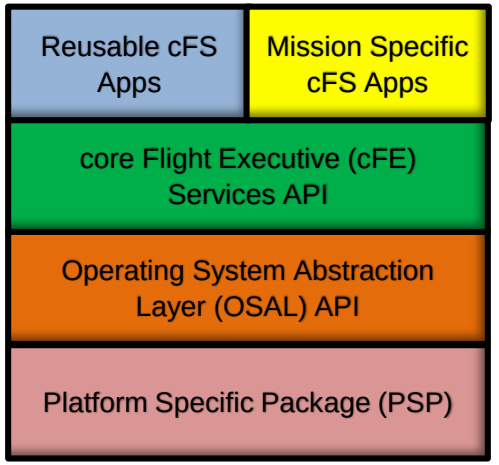
- Gain experience with integrating sample payloads to inform architecture design decisions

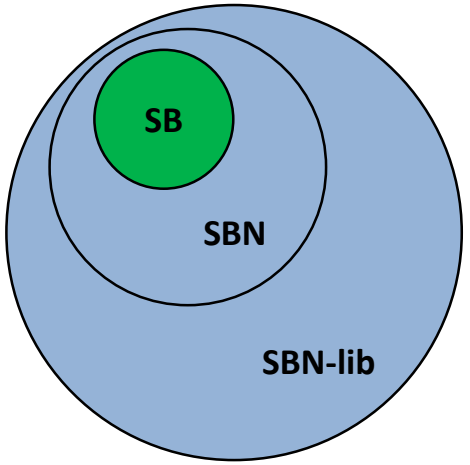
SOFTWARE BUS APPLICATIONS

GATEWAY

- **Software Bus (SB)**
  - cFE application
  - Inter-application messaging service within a cFS implementation
  - Publish-subscribe messaging pattern with unique message IDs
- **Software Bus Network (SBN)**
  - cFS application
  - Extends the SB messaging service across partitions, processes, and networks
  - Allows applications within different cFS peers to send messages to each other
- **Software Bus Network Library (SBN-lib)**
  - Standalone interface library built from a cFS application
  - Allows non-cFS-compliant peers to communicate with cFS-compliant peers

- **SBN can communicate with other SBN's or SBN-lib's**
- **SB can only communicate with SBN**

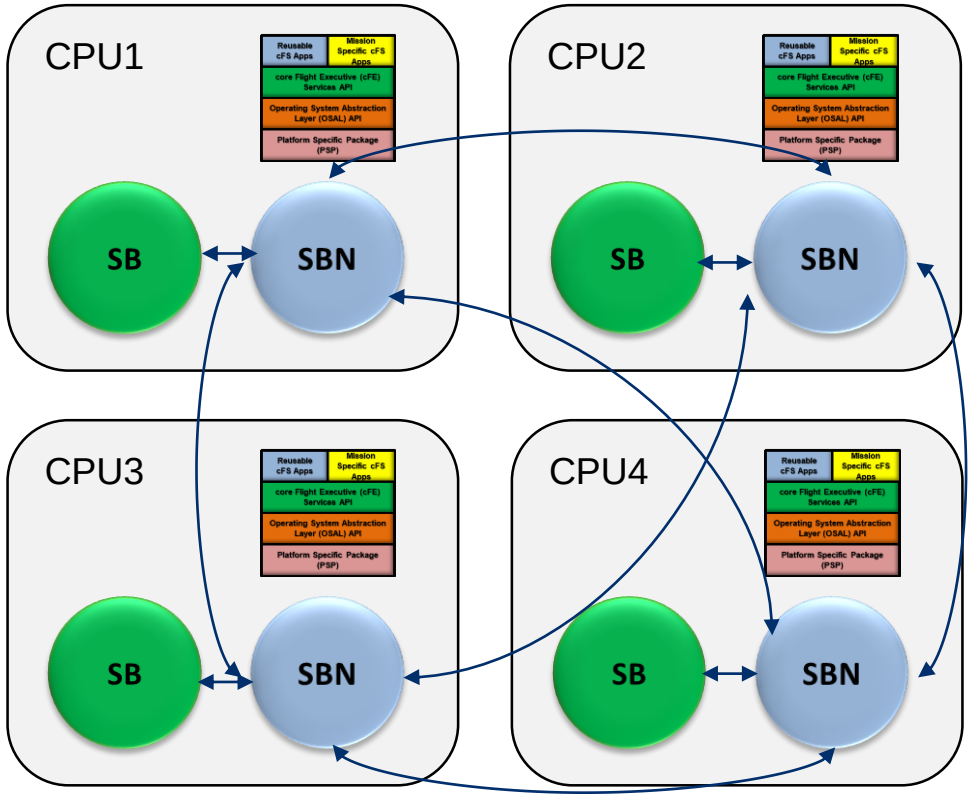




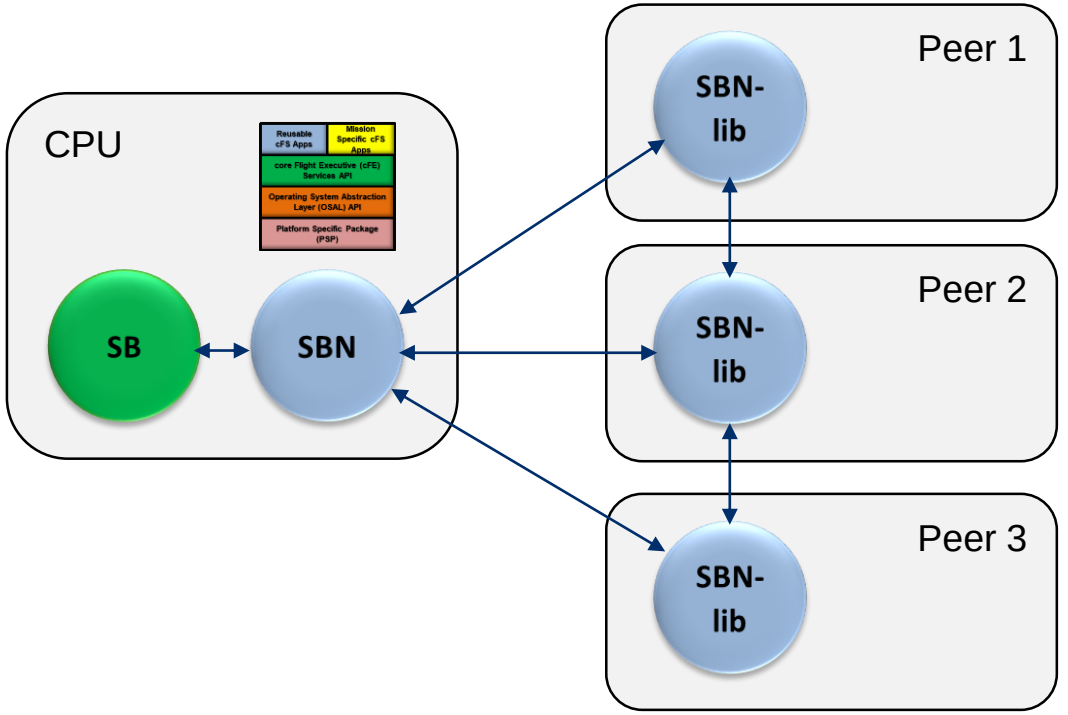
SOFTWARE BUS CONFIGURATION OPTIONS

GATEWAY

- **Option 1**: enforce full cFS implementation for all peers
  - Added complexity for payload design
  - Cohesive platform



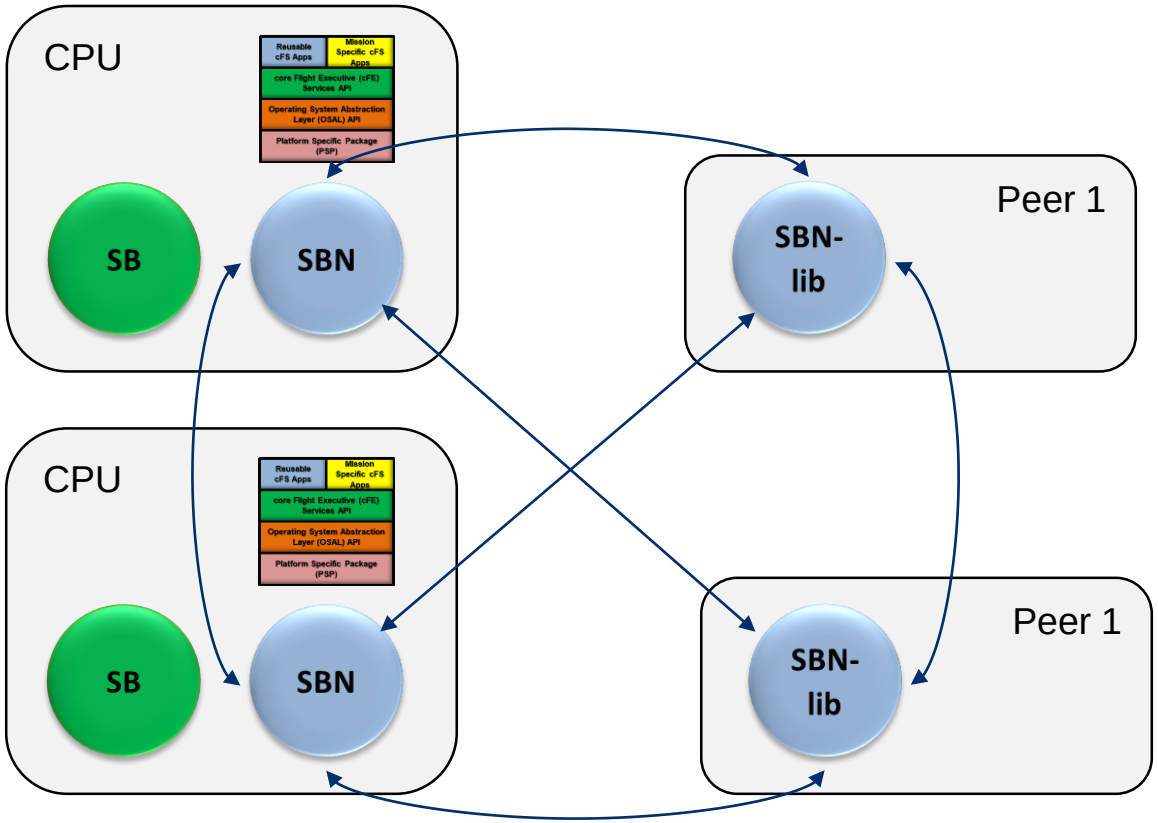
- **Option 2**: control node, all other peers use SBN-lib
  - Easier to integrate after payload has been fully designed
  - Allows for flexibility with configurations
  - Disjointed platform



SOFTWARE BUS CONFIGURATION OPTIONS

GATEWAY

- **Option 3**: hybrid approach
  - Allows for greater modularity



KEY GATEWAY TAKEAWAYS

GATEWAY

- **SBN-lib allows for quick prototyping**

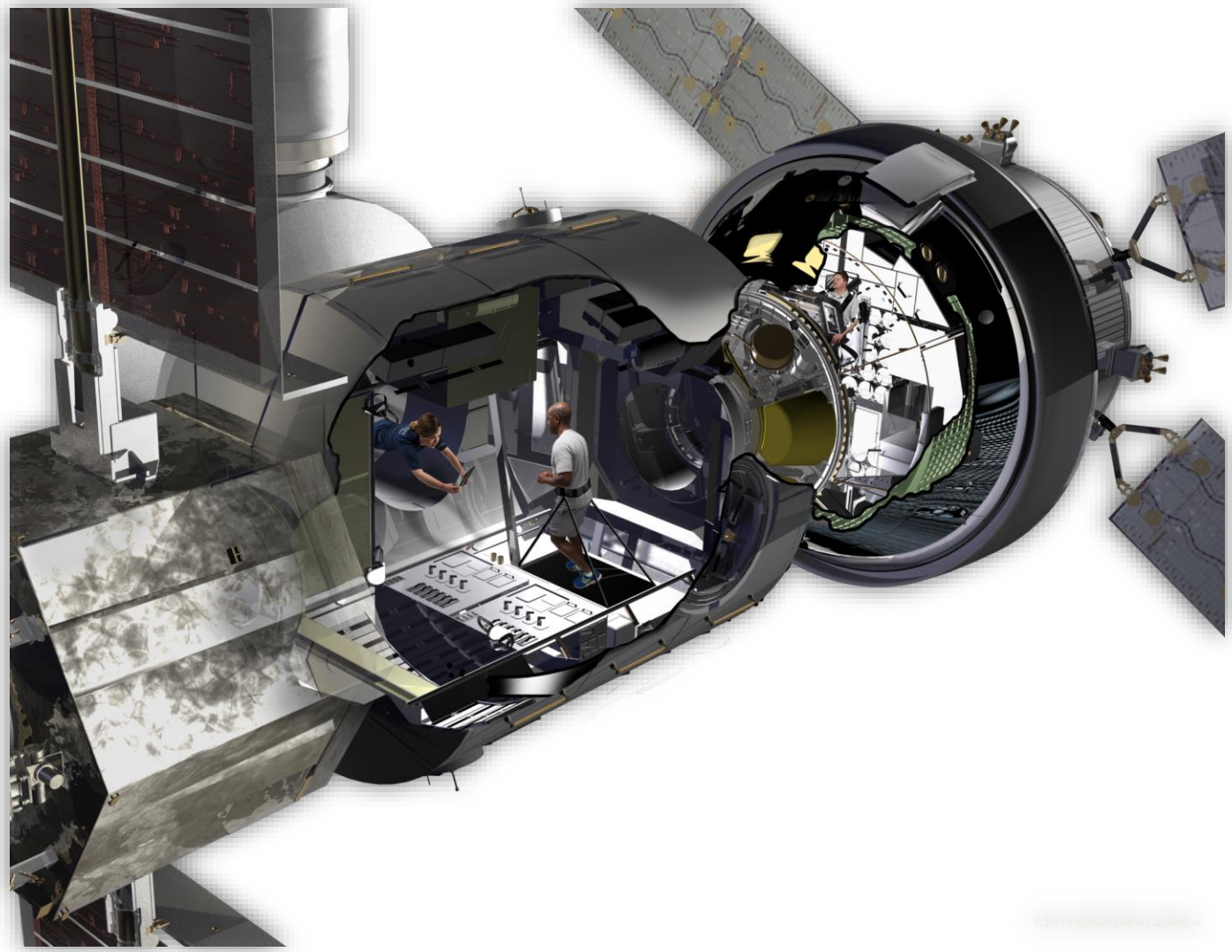
- **SBN-lib needs a SB running on some peer**
  - Even if we rely mainly on SBN-lib, we will need a control node
    - A control node makes it easier to update tables, schedules, and configurations
    - Would be a critical component

- **SBN connections are defined at start time**

- **SB limits the total number of MIDs to 256**
  - Limits the total number of peers

THE COMMAND DECK OF THE FUTURE

GATEWAY

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