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ENGINEERS AUSTRALIA

Tailoring a ConOps for NASA LSP Integrated Operations

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About Skip Owens

- B.S. in Aerospace Eng.

- Masters in Space Systems Engineering from Stevens Institute of Technology

- Discipline Expertise: Mission/Flight Design & Orbital Mechanics

- Current Job Title: Senior Systems Engineer in NASA LSP's Integration Engineering Branch

- Job Function: Spacecraft to launch vehicle integration with NASA LSP

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ConOps Tailoring Background

- Fall 2015/Spring 2016: Wanted to undertake a Masters Thesis/Project that would fulfill my requirements to complete my Systems Engineering Master degree and directly benefit NASA LSP
- A Concept of Operations (ConOps) was a product we have needed since the Program began in 1998 but just never had the time/resources to create
- My mentor, Norm Beck (former Air Force Academy instructor and Ascent Engineering Team Lead for STS-1) was retiring from NASA soon and this task was an opportunity capture his knowledge and experience

Full Project Scope vs the INCOSE Paper

- The full Masters project:
  - Paper = 67 pages
  - Separate ConOps Template = 22 pages
- Reducing 89 pages of content down to less than 15 for an INCOSE paper was no easy task
- INCOSE paper had to be narrowed in focus
  - Define a ConOps
  - Explain the tailoring process

Content in Today's Presentation

- Terminology
- Defining a Concept of Operations
- What Does NASA's Launch Services Program Do?
- Scope of the LSP ConOps
- The LSP ConOps Tailoring Process
- The Final ConOps Template

Terminology

- <u>What is a "Concept of Operations?"</u>
  - First recorded use of the term "ConOps" was by R.J. Lano in his paper titled "A Structured Approach for Operational Concept Formulation"…the year was 1980 37 years later there still seems to be a wide variety of uses for the terms "ConOps" and "Concept of Operations"
  - There is no "one size fits all" definition…A Concept of Operations has different meanings depending on its application

ConOps Variability

- NASA's Lifecycle, Process and Systems Engineering course describes a variety of names for an operational concept depending on system level:
- At the Systems Level:
    - Concept of Operations (CONOPS) Document
    - Operational Concept Document
    - Context of Operations Statement
- At the Configuration Level:
    - User's Manual
    - Operator's Manual
- At the Component Level:
    - Design Description

A Tale of Two Terms

- "Concept of Operations" has two terms often associated with it that are sometimes used interchangeably:

  - Concept of Operations (ConOps)
  - Operational Concept (OpsCon)

- In reality the above 2 terms have very different meanings

ConOps

- ANSI, AIAA, ISO, DEC and the Department of Defense all agree on the following definitions for ConOps and OpsCon:

  - ConOps description according to the INCOSE Systems Engineering Handbook Version 4 (as cited in Walden, 2015):

    "The ConOps, at the organization level, addresses the leadership's intended way of operating the organization. It may refer to the use of one or more systems, as black boxes, to forward the organization's goals and objectives. The ConOps document describes the organization's assumptions or intent in regard to an overall operation or series of operations of the business with using the system to be developed, existing systems, and possible future systems. This document is frequently embodied in long-range strategic plans and annual operational plans. The ConOps document serves as a basis for the organization to direct the overall characteristics of the future business and systems, for the project to understand its background, and for the users of ISO/EEC/IEEE 29148 to implement the stakeholder requirements elicitation."

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OpsCon

- ANSI, AIAA, ISO, DEC and the Department of Defense all agree on the following definitions for ConOps and OpsCon:

    - ConOps description according to the INCOSE Systems Engineering Handbook Version 4 (as cited in Walden, 2015):

        "A System Operational Concept (OpsCon) document describes what the system will do (not how it will do it) and why (rationale). An OpsCon is a user-oriented document that describes system characteristics of the to-be-delivered system from the user's viewpoint. The OpsCon document is used to communicate overall quantitative and qualitative system characteristics to the acquirer, user, supplier and other organizational elements."

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  - ConOps ... Handb...

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Definition Conclusions

- Two Main Conclusions:
    - The ConOps is more focused on the operational aspects of the system in question
    - The OpsCon is a higher-level document that is focused on more general system function (what the system will do) in the terms of the user
- Which definition is more applicable to NASA LSP?
    - LSP is focused on operation details, therefore the INCOSE definition of a ConOps is more applicable and will be used for LSP
    - The terms Concept of Operations and ConOps will be used interchangeably from this point forward

What Is a Concept of Operations?

- A Very Detailed Description of a ConOps is Needed
- ConOps can have many uses and therefore there are many different variants
- The first example to consider is the definition by the Department of Defense from the Dictionary of Military and Associated Terms ("DOD Dictionary of Military and Associated Terms", 2002):

"A verbal or graphic statement that clearly and concisely expresses what the joint force commander intends to accomplish and how it will be done using available resources. The concept is designed to give an overall picture of the operation. Also called commander's concept or CONOPS."

What Is a Concept of Operations?

- The "Applied Space Systems Engineering" book (Larson, 2009) is another good source for a concise definition of a Concept of Operations:

"A good concept of operations verbally and graphically reflects stakeholders' expectations, so it becomes a platform for validating the system's architecture and technical requirements."

What Is a Concept of Operations?

- Both of the previous definitions use the terms "verbal" and "graphic"…meaning that a ConOps should use both words and pictures to convey the content to the audience.
- Other attributes of a ConOps established by these definitions
  - Overall picture of the operations
  - A platform for validating the system's architecture and technical requirements
  - A concise expression of what must be accomplished by the system

What Is a Concept of Operations?

- The Applied Space Systems Engineering book also cites the following as the purpose behind establishing a ConOps (as cited in Larson, 2009):
  - Describe the system's operational characteristics
  - Help users, customers, implementers, architects, testers, and managers understand system goals
  - Form a basis for long-range operations planning
  - Guide how system definition documents, such as system and interface specifications, develop
  - Describe how the user's organization and mission relate to the system

What Is a Concept of Operations?

- The NASA Systems Engineering Handbook provides some additional characteristics that are worth consideration (NASA Systems Engineering Handbook, 2007):
  - Must be established early in the system design process
  - Should consider all aspects of operations including integration, test and launch through disposal
  - Must include operational scenarios that are dynamic in nature, covering various modes and mode transitions with the key component being the inclusion of interactions with external interface

A Summary of NASA LSP

"The Launch Services Program is responsible for NASA oversight of the launch service including launch vehicle engineering and manufacturing, launch operations and countdown management, and providing added quality and mission assurance in lieu of the requirement for the launch service provider to obtain a commercial launch license."
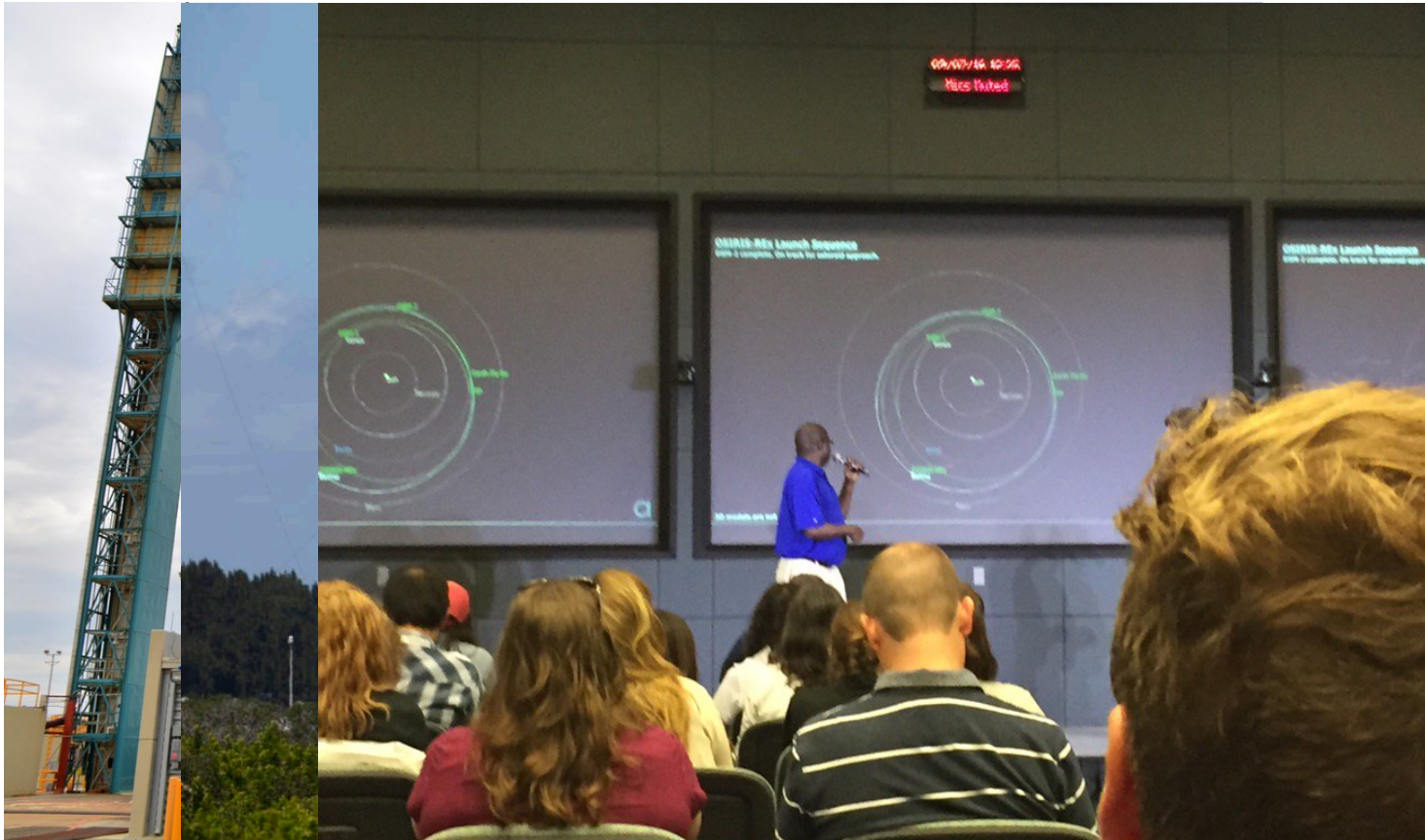
A Summary of NASA LSP

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A Summary of LSP Integration Engineering

- **More Specifically, the LSP Integration Engineer (IE), is the systems engineer responsible for defining, managing, integrating and verifying the spacecraft-to-launch vehicle interface**

LSP Integration Engineering
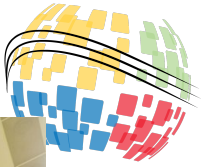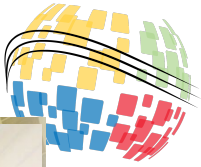
LSP Integration Engineering

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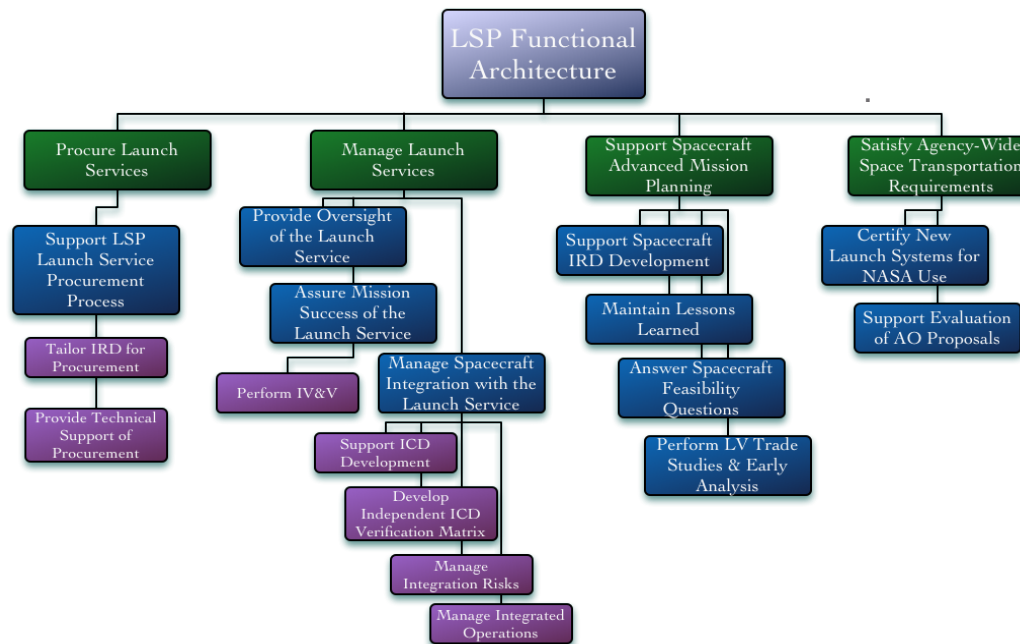
LSP Integration Engineering

LSP Integration Engineering

LSP Functional Architecture

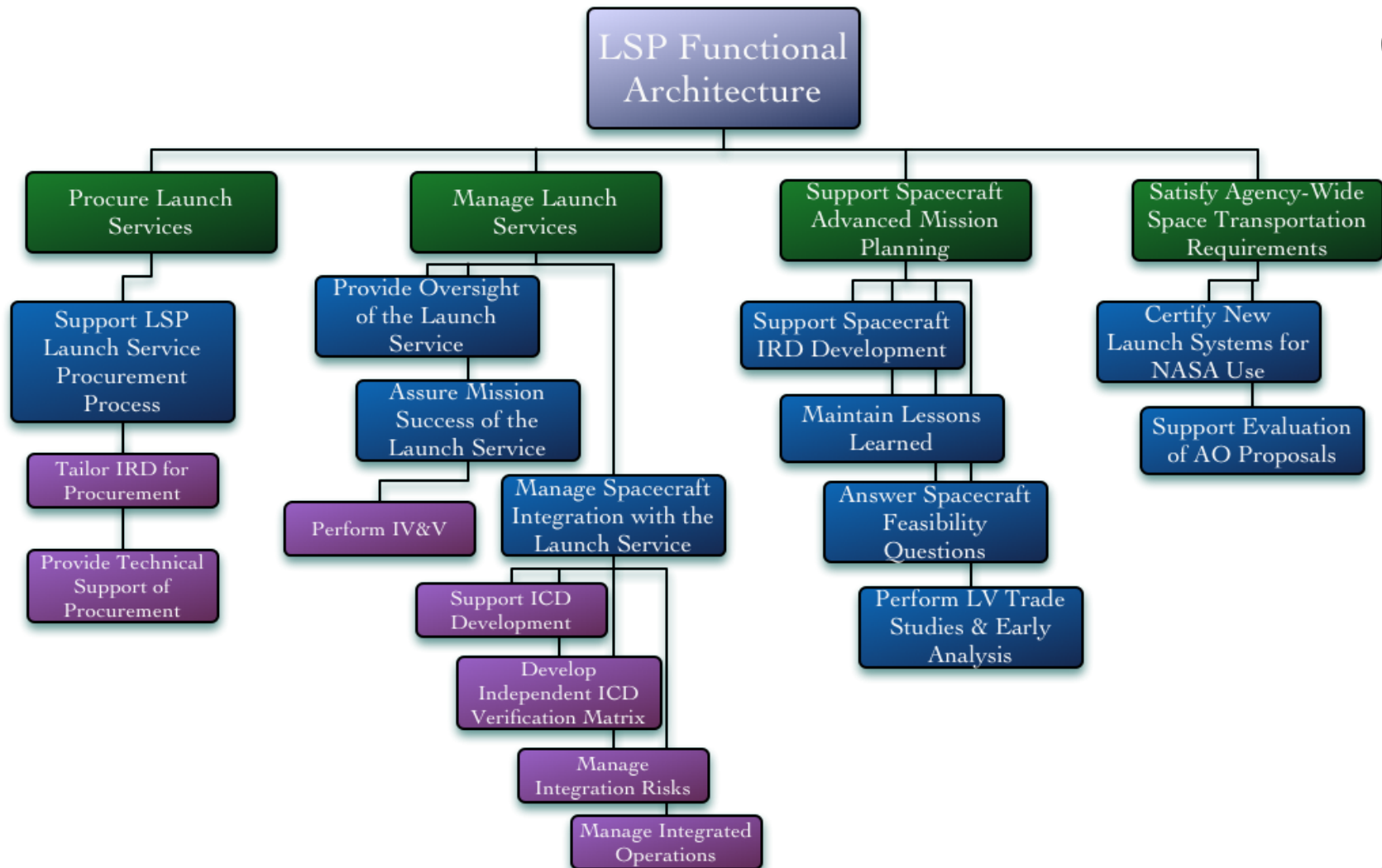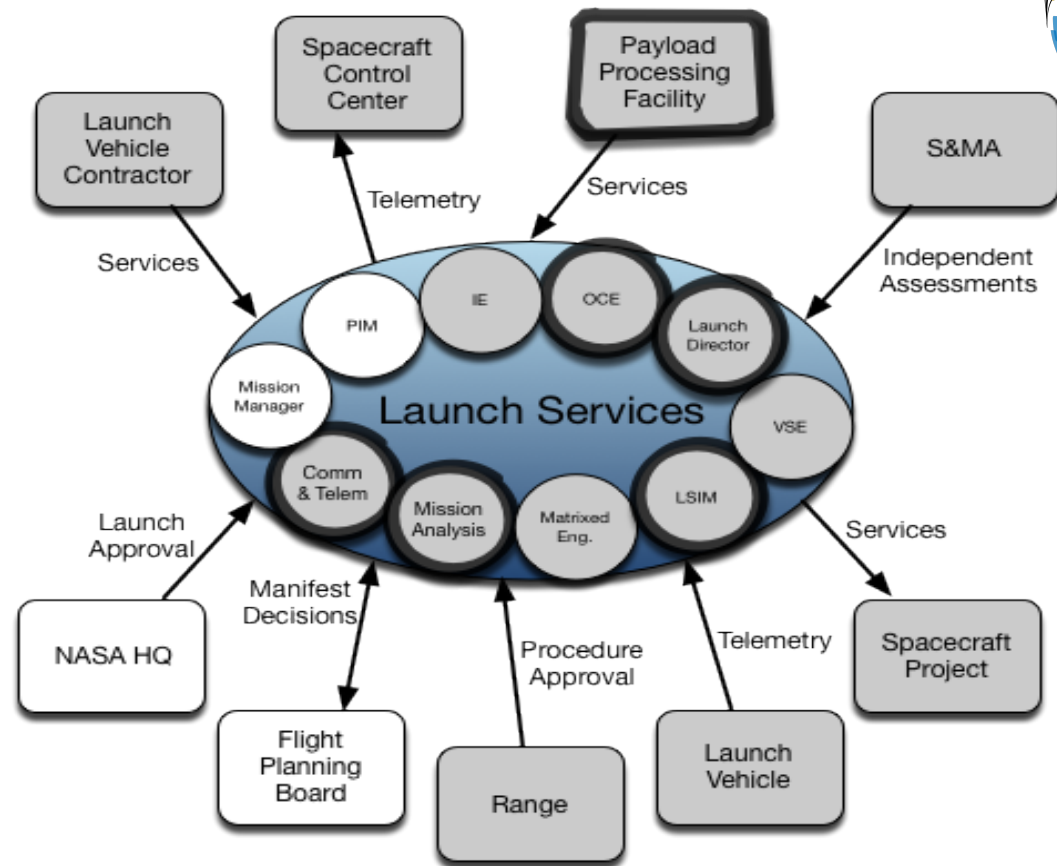- Functions performed by the LSP Integration Engineer (IE)

A Story of Two ConOps

- LSP's Integration Engineers job required the development of 2 separate ConOps:
  - One early in the mission integration life cycle (the "Preliminary ConOps")
  - And another later in the life cycle… closer to the start of integrated operations

The focus of this presentation is on the earlier "Preliminary ConOps"

ConOps Scope

Launch Vehicle Contractor — Services

Spacecraft Control Center — Telemetry

Payload Processing Facility — Services

S&MA — Independent Assessments

Launch Services
- Mission Manager
- PIM
- IE
- OCE
- Launch Director
- VSE
- Comm & Telem
- Mission Analysis
- Matrixed Eng.
- LSIM

NASA HQ — Launch Approval

Flight Planning Board — Manifest Decisions

Range — Procedure Approval

Launch Vehicle — Telemetry

Spacecraft Project — Services

Solid Fill- In-Scope for this project

Outlined = Applicable but out of scope for this project

No-Fill = Not Applicable to an Integrated Operations ConOps

7-Step Tailoring Process

1. **Identify Key Characteristics**
2. **Identify Key Functions**
3. **Identify Design Artifacts**
4. **Tailor Industry Standard ConOps Content**
5. **Identify Requirement Content**
6. **Identify Applicable Best Practices**
7. **Perform Full Content Mapping**

1. Identify Key Characteristics

1. Will describe how the spacecraft and the LSP managed Launch Service will be operated during all integrated operations

   Rationale: Each operation that includes some combination of spacecraft assets (hardware or personnel) and launch vehicle contractor assets (hardware or personnel) is considered an integrated operation. Operations can drive additional mission unique requirements that are not always apparent while developing an interface requirements document like an IRD or an ICD.

2. Identify Key Functions
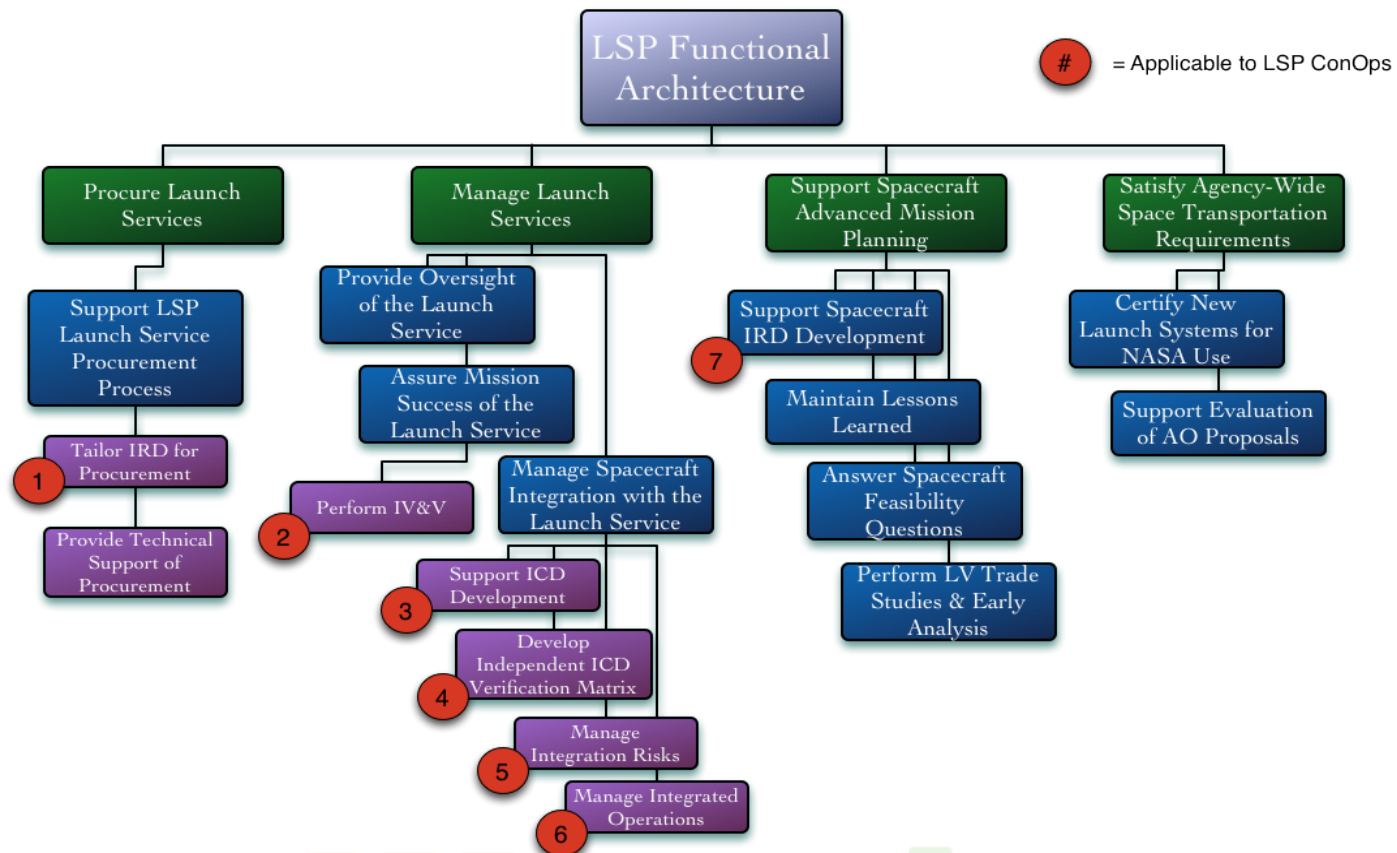
3. Identify Design Artifacts

Design Artifacts	MCR (NPR 7123.1A)	SRR (NPR 7123.1A)	PDR (NPR 7123.1A)	Ref # of Identified Applicable Content
Preliminary Mission De-scope Options	✔			
Preliminary Technical Plans to Achieve Next Phase	✔			
Defined Measures of Effectiveness (MOE) and Measures of Performance (MOP)	✔			1
Mission Goals and Objectives	✔			2
System Software Functionality Description		✔	✔	

4. Tailor Industry Standard ConOps Content

Several industry ConOps examples were chosen specifically because their structure was uniquely suited for the LSP ConOps need:

1.) IEEE Guide for Information Technology-System Definition-Concept of Operations (ConOps) Document (IEEE, 2007)

2.) ANSI/AIAA G-043A-2012 Guide to the Preparation of Operational Concept Documents (ANSI, 2012)

3.) Operational Concept Description (OCD)-Space and Naval Warfare Systems Command (DI-IPSC-81430A, 2000)

4.) Federal Highway Administration - California Division: Concept of Operations Template (Federal, 2016)

ANSI	Space and Naval Warfare Systems Command (DID: DI-IPSC-81430)	IEEE	California Division-FHA ConOps Template	LSP ConOps Content	Applicable LSP ConOps Char.
Scope: Identification			Purpose of the Document	**Purpose**	1,2,4,5,6,7
	Scope	Scope	Scope	**Scope**	1,2,4,5,6,7,8
Reference Documents	Reference Documents	Reference Documents	Referenced Documents	**Reference Documents**	2,3,7
Background information	Current system or situation	Current system or situation	Background	**Mission Goals & Objectives**	1,3,4,6
Existing systems and operations	Justification or nature of changes	Justification or nature of changes		**Operational Overview**	1,2,3,4,6,7
System Overview	Concept for a new or modified system	Concept for the proposed system	System Overview Concept of the Proposed System	**System Overview**	1,2,3,4,6,7
Other operational needs	Operational Scenarios	Operational Scenarios	Operational Environment	**Operational Environment**	1,2,3,7,8

5. Identify Requirement Content

1. Instrument Purge Interface & Ops	2. Spacecraft Fairing Access Points/Ops	3. Electrical Interfaces, timing of connection and data types	4. Separation Indication	5. Launch Vehicle Telemetry Ops
6. Pre-Launch Env. Control System Limits and Ops	7. Mission Unique Cooling Ops	8. Contamination Control Ops	9. Planetary Protection Ops	10. Trajectory/Flight Ops
11. Ground Ops	12. Env. Test Support	13. Propellant Offload Ops	14. Transport Ops	15. Payload Processing Facility Ops
16. Mechanical Interfaces Ops	17. Post-Separation Ops			

6. Identify Applicable Best Practices

1. Description of the major phases (includes the following: Integration and test operations, Launch Operations, Science Operations, Safe-Hold Operations, Anomaly Resolution and Maintenance Operations, Disposal Operations)			
2. Operational Timelines	3. Operational Scenarios and/or DRM	4. End-To-End Communications Strategy	5. Integrated Logistics Support (re-supply, maintenance and assembly)
6. Critical Events	7. Command and Data Architecture	8. Operational Facilities	

7. Perform Full Content Mapping

Three main sources used for determining the final table of contents for the Preliminary LSP ConOps were:

• James Webb Space Telescope Operations Concept Document (JWST, 2014)

• Space Vehicle Operators Concept of Operations (Space, 2004)

• NASA Space Systems Engineering ConOps Training Module (Scoping, 2016)

LSP ConOps Content	LSP Functions	Spacecraft Design Artifacts	LV Procurement Requirements	NASA SE Handbook	Tailored LSP ConOps Characteristics
Purpose					1,2,4,5,6,7
Scope		1-9			1,2,4,5,6,7,8
Reference Documents	7	1-9			2,3,7
Mission Goals & Objectives	7	2,3,4		3,6,7	1,3,4,6
Operational Overview	3,7	2,3,8	1-17	1-8	1,2,3,4,6,7
System Overview	3,7	1,2,3,4,5,7,8,9	1-17		1,2,3,4,6,7
Operational Environment	1,2,3,6,7	3,4,7,8	1-17	1,3,5,8	1,2,3,7,8
Operational Scenarios	1-7	1, 3, 7, 8	1-17	1,3,4,5,8	1-8
Appendices					
Acronyms, Abbreviations and Glossary					

LSP ConOps Content	LSP Functions	Spacecraft Design Artifacts	LV Procurement Requirements	NASA SE Handbook	Tailored LSP ConOps Characteristics
Purpose					1,2,4,5,6,7
Scope		1-9			1,2,4,5,6,7,8
Reference Documents	7	1-9			2,3,7
Mission Goals & Objectives	7	2,3,4		3,6,7	1,3,4,6
Operational Overview	3,7	2,3,8	1-17	1-8	1,2,3,4,6,7
System Overview	3,7	1,2,3,4,5,7,8,9	1-17		1,2,3,4,6,7
Operational Environment	1,2,3,6,7	3,4,7,8	1-17	1,3,5,8	1,2,3,7,8
Operational Scenarios	1-7	1, 3, 7, 8	1-17	1,3,4,5,8	1-8
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Example Content: FireSat Objectives Diagram
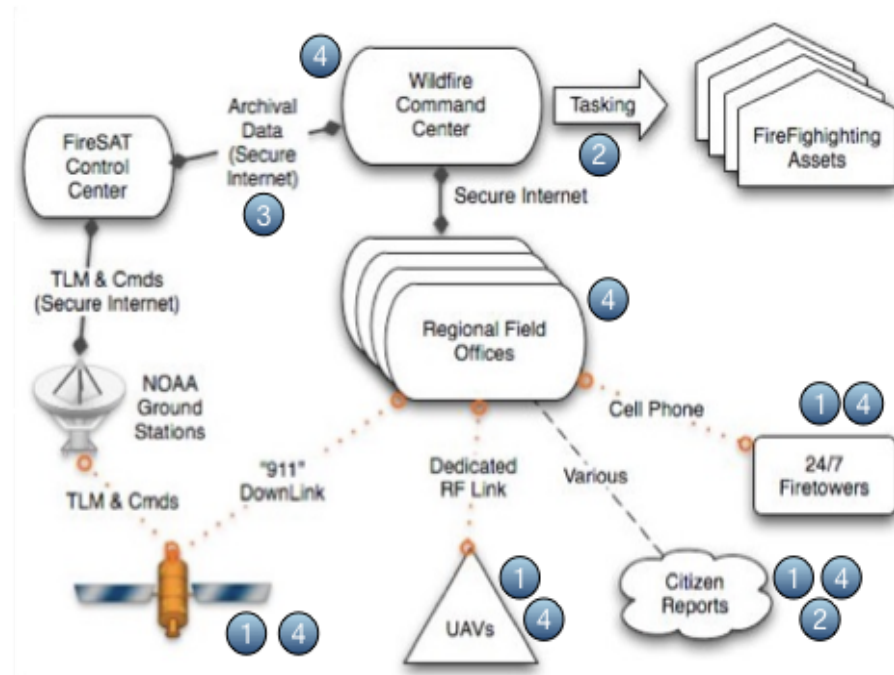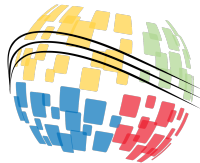
Original figure is from the Stevens Institute of Technology and has been used and annotated with permission

1	Data collecting assets detect, identify and monitor forest fires
2	Demonstrate positive action to the public by utilizing citizen reports and tasking firefighting assets
3	Perform statistical calculations on archived data to better understand outbreak and growth of fires
4	Collect other data from assets and field offices

Example Content: Integrated Operations Summary Figure

Operation Name	
Start Date (L-#)	
Duration	
Facility Name & Location	
Lead Spacecraft Personnel	Role/Title: Name:
Lead Spacecraft Personnel	Role/Title: Name:
Lead LV Personnel	Role/Title: Name:
Major Spacecraft Components	
Major Launch Vehicle Components	
GFE	
Inputs and Preceding Operations	
Operational Objectives	
Operational Environment/Restrictions	
Timeline/Sequence	
Spacecraft Procedure Name(s)	
Launch Vehicle Procedure Name(s)	

Questions???