Scoping & Concept of Operations (ConOps) Module

Exploration Systems Engineering, version 1.0
Module Purpose: Scoping & ConOps

♦ To understand the importance of defining a mission or project’s scope.

♦ To explain the contents of scope, including needs, goals, objectives, assumptions, authority and responsibility, constraints, and concept of operations.

♦ To understand the importance of developing a mission concept of operations (ConOps).

♦ To describe the information contained in a ConOps and show examples.
Defining Scope

♦ The first step in building a strong foundation for writing good requirements is defining the scope.

♦ What’s involved in defining the scope:
  - Defining the needs, goals, and objectives
  - Identifying stakeholders
  - Developing operational concepts
  - Understanding constraints

♦ Become familiar with parent system-of-interest documents. Examples:
  - Presidential Directive (for highest level systems)
  - Announcement of Opportunities contain need statements
  - Proposals contain goals and objectives

♦ “The beginning is the most important part of the work.”
  Plato, 4th Century BC
Scope Dimensions

**Scope is a definition of what is germane to your project.**

**Goal**
- Broad, fundamental aim you expect to accomplish to fulfill need.

**Objectives**
- Initiatives that implement the goal.
- What is the minimum that the stakeholders expect from the system for it to be successful?

**Need**
- Explains why the project is developing this system from the stakeholders’ point of view.

**Assumptions**
- Examples:
  - Level of technology
  - Partnerships
  - Extensibility to other missions

**Authority and Responsibility**
- Who has authority for aspects of the system development?

**Mission**
- Defining and restricting the missions will aid in identifying requirements.

**Constraints**
- External items that cannot be controlled and that must be met, which are identified while defining the scope.

**Operational Concepts**
- Imagine the operation of the future system and document the steps of how the end-to-end system will be used.

**Budgets**

**Schedules**
Apollo Program Scope Example

♦ **Need:** Counter Soviet military threat.

♦ **Goal:** Demonstrate American technological superiority.

♦ **Objective:** Make a decisive move in the conquest of space.

♦ **Mission or business case:** Transport a man to the Moon, and return him safely.

♦ **Operational Concept:** Launch crew, lunar lander, and return vehicle on multistage rocket into trajectory for moon. Crew will leave return vehicle in lunar orbit while they take lunar lander to the Moon surface. Crew will return to lunar orbit and rendezvous with return vehicle. Crew in return vehicle will land in ocean.

♦ **Assumptions:** All technology needs are achievable.

♦ **Constraints:** Do it within this decade. Use American-made components.

♦ **Authority and Responsibility:** NASA has the responsibility to carry out the mission.
Crew Exploration Vehicle Scope Example

♦ Need: Provide crewed access to space once the Shuttle is retired.

♦ Goal: Make access to space safer and cheaper than current system.

♦ Objective: Provide access to space and Earth re-entry for missions to ISS, Moon and Mars. [Too broad – no specifications]

♦ Mission or business case: Support for all human space flight missions post Shuttle.

♦ Operational Concept:
Launch...Rendezvous...Docking...Transfer...Re-entry...

♦ Assumptions: Separation of crew and cargo for launch phase.

♦ Constraints: Deliver an operational vehicle no later than 2014; Minimize the gap with Shuttle retirement in 2010.

♦ Authority and Responsibility: CEV is to be managed by NASA with no international involvement.

♦ Drivers: Presidential vision for space exploration in 2004; safety concerns with Shuttle post Columbia accident.
What is a ConOps?: a description of how the system will be operated during the mission phases in order to meet stakeholder requirements.

Importance of a ConOps:
- Provides an operational perspective
- Stimulates requirements development related to the user
- Reveals requirements and design functions as different “use cases” are considered (e.g., Shuttle)
- Serves as the basis for key operations documents later

Mars Phoenix mission example:
- ConOps leads to addition of the requirement to “view” the descent, and landing phase during the mission. This requires a camera in a specific location that can withstand the entry profile. Under nominal operations, the camera may not be required.
- “Beginning just after the aeroshell is jettisoned at an altitude of about 5 miles, the Mars Descent Imager (MARDI) will acquire a series of wide-angle, color images of the landing site all the way down to the surface.”
Typical Information Contained in ConOps

- Description of the major phases
- Operational scenarios and/or design reference missions (DRMs)
  - For human exploration missions, multiple DRMs make up a ConOps
- Operation timelines
- End-to-end communications strategy
- Command and data architecture
- Operational facilities (e.g., mission control, science data center)
- Integrated logistics support (resupply, maintenance, and assembly)
- Critical events

**Design Reference Mission:** a use-case scenario which stress all of the system's capabilities to a significant extent and which all design alternatives will have to be able to accomplish. The purpose of such missions is to keep the design space open.
ConOps - Start with Pictures
Operational Scenario and Timeline

Source: Texas 2-Step Mission, Project Plan, 2007
FireSat Operational Concept

TDRSS

FireSat I

FireSat II

Pegasus Launch

Forest Service Fire Monitoring Office

TDRSS White Sands Ground Terminal

Field Operators and Customers

FireSat Ground Station

Exploration Systems Engineering: Scoping & ConOps Module
**ConOps - Example Timeline**

*more detailed, later in mission design*


<table>
<thead>
<tr>
<th>Coverage</th>
<th>Launch</th>
<th>Note: nominally acquire TDRS pre-launch and stay on until acquisition at Dongara</th>
</tr>
</thead>
<tbody>
<tr>
<td>USN Sites</td>
<td></td>
<td>Dongara, Australia - 9.4 hrs (11:45:38z - 21:00:23z)</td>
</tr>
<tr>
<td>TDRS</td>
<td></td>
<td>TDRS Prime at Sep then Backup/Contingency Only</td>
</tr>
<tr>
<td>Atlas EELV</td>
<td></td>
<td>Firing, MECO, SECO-1, LV to Sep, Attitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overburg, So Africa - 25 mins (11:30:48z - 11:56:04z)</td>
</tr>
</tbody>
</table>

**GN&C**
- IRU's ON
- ACE-A ON
- RWAs OFF
- ST's OFF
- DIS' OFF
- ACS Thr_iso Valves Open

**Control Mode**
- Sun ACQ Mode

**Propulsion**
- (If High (Moff rates, Delta-H if needed by gnd cmd only)

**C&DH / RF**
- Recorder: Record 16kX
- S-Downlink: 64kps hardship, 56kps hardline
- S-XMTR: Start XMTR On Sequence (RTS)

**Power/Elect.**
- 100% SOC
- \( \geq 95\% \) SOC
- L-5 mins: SAS OFF
- Go to Internal Power

**S/C Load**
- 258 W
- 293 W
- 551 W
- 616 W
- 556 W

**Deployables**
- SADIS & HGADIS Damper Hrs On
- Solar Array Deployment

**Thermal**
- Survival Heaters Enabled
- Prop lines & HGA Survival Heaters Come On
- Decontamination Heaters On

**Instruments**
- BME ED & OP OFF
- AIA ED & OP OFF
- EVE ED & OP OFF

**Ground**
- 1 Hour launch window
- >95% Battery SOC launch criteria
- FDF receives MECO State
- Vector from EELV
- Update on-board EPV

---

*Exploration Systems Engineering: Scoping & ConOps Module*
ConOps - Example Design Reference Mission

Launch to TLI
Post-TLI Separation
Gateway Operations
Departure
Surface Operations
Ascent
Disposal
Earth Return

Three-element HLS architecture is non-prescriptive, shown for reference only.

Fast or slow transit to NRHO
CLV

L2 3:2 NRHO

Orion and CSM

Fast transit to NRHO

SLS

LM

Gateway

Exploration Systems Engineering: Scoping & ConOps Module
ConOps - End-to-End Communications Strategy

Scoping Exercise Leads to Organized Requirements

Mission Statement
- Clear, specific statement describing goals & objectives
- Does not necessarily require justification
- Should not, in general, specify requirements

Mission Goals & Requirements
- Clear, specific statements describing mission products & methods
- Define minimum success and preferred goals
- In general, should drive (but not specify) system requirements

System / Operational Requirements
- Subsystem specifications
- CONOPs plan
The first step in understanding the mission at hand is defining the scope, where scope is a definition of what is germane to your project.

The scope content involves:
- Defining the needs, goals, and objectives
- Identifying stakeholders
- Developing operational concepts
- Understanding the constraints

A thorough scoping effort leads to organized and informed mission and system requirements.

A concept of operations (conops) is a description of how the system will be operated during the mission phases in order to meet stakeholder requirements.

A concept of operations can include many aspects of operations, such as a timeline, a communications strategy, varying operational scenarios, etc.
Backup Slides
for Scoping and ConOps Module
**Initial Mission Flow Diagram**

**Low Mars Orbit**
- DESC/ASC_MOI
- HAB_MOI
- HAB_MD
- HAB_ML

**Low Earth Orbit**
- DESC/ASC_MT
- HAB_MT
- HAB_TMI
- DESC/ASC_TMI

**Ground Processing**
- EDS_LAUNCH
- CARGO_LAUNCH

**EDS.LAUNCH**
- EDL
- Direct Entry Land Landing

**EDS, HAB, LANDER**
- CLV.LAUNCH
- CLV_WINDOW
- CEV_LEO_OPS
- LMO_Dock

**3X CLV_LAUNCH**
- MTV_MT
- LMO_Dock
- MTV_MOI
- MTV_TMI
- MTV_TMI

**DESC/ASC_VEH**
- MTV_LO
- LMO_Dock
- MA
- MTV_ML

**HAB_MD**
- MA

**HAB_MT**
- MA

**HAB_TMI**
- MA

**TMI : Multi-burn injection used at perigee to inject vehicles toward Mars.**

**Total mission duration:** 892-945 days

**Time on Mars surface:** 500-600 days
Scope Elements - Definitions

Need
- Drives everything else
- Related to your strategic plan or business plan
- NOT a definition of the system or solution
- Explains why the project is developing this system from the stakeholders’ point of view
- Does not change much during the life of the project

Goals
- A goal is a broad, fundamental aim that your organization expects to accomplish to fulfill its need.

Objectives
- Expand on how you will meet the goals.
- Initiatives that implement the goals
- Also specify the success criteria - what is the minimum that the stakeholders expect from the system for it to be successful?

Mission
- The business case for why product is needed.
- Defining and restricting the missions will aid in identifying requirements.
Scope Elements - Definitions

Constraints

• External items that cannot be controlled and that must be met, which are identified while defining the scope.
• Often defined in terms of schedule and budgets.

Authority and Responsibility

• Who has authority for aspects of the system development? (e.g. government center, contractor, customer)

Assumptions

• As identified by stakeholders, as part of the scope elements listed above

Operational Concepts

• A step-by-step description of how the proposed system should operate and interact with its users and its external interfaces (e.g., other systems).
• Don’t forget to include the stakeholders’ perspectives, such as astronauts
• Imagine the operation of the future system and document the steps of how the end-to-end system will be used.
• Describes, at a high level, the nominal and off-nominal scenarios
Additional Information for Defining Stakeholder Expectations

Driven by science strategic plans or from a Presidential Directive?

How the mission must be operated in order to achieve mission objectives.

Dependent upon ConOps - operational environment, orbit, mission duration, etc.

Typical Operational Phases for a NASA Mission

♦ Integration & Test (I&T) Operations

  • Project I&T — During the latter period of project I&T, the system is tested by performing operational simulations during functional and environmental testing. The simulations typically exercise the end-to-end command and data system to provide a complete verifications of system functionality and performance against simulated project operational scenarios.

  • Launch Integration — The launch integration phase repeats I&T operational and functional verification in the launch integrated configuration.

♦ Launch Operations

  • Launch — Launch operation occur during the launch countdown, launch ascent, and orbit injection. Critical event telemetry is an important driver during this phase.

  • Deployment — Following orbit injection, spacecraft deployment operations reconfigure the spacecraft to its orbital configuration. Typically, critical events covering solar array, antenna and other deployments, and orbit trim maneuvers occur during this phase.

  • In-orbit checkout — In-orbit checkout performs is used to perform a verification that all systems are healthy. This is followed by on-orbit alignment, calibration, and parameterization of the flight systems to prepare for science operations.
Typical Operational Phases for a NASA Mission

- **Science Operations**
  - The majority of the operational lifetime is used to perform science operations.

- **Safe Hold Operations**
  - As a result of on-board fault detection, or by ground command, the spacecraft may transition to a safe hold mode. This mode is designed to maintain the spacecraft in a power positive, thermally stable state until the fault is resolved and science operations can resume.

- **Anomaly Resolution and Maintenance Operations**
  - Anomaly resolution and maintenance operations often requires the support of personnel beyond those used for science operations.

- **Disposal Operations**
  - Disposal operations occur at the end of project life. These operations are used to either provide a controlled reentry of the spacecraft, or a repositioning of the spacecraft to a disposal orbit. In the latter case, the dissipation of stored fuel and electrical energy is required.
**Pause and Learn Opportunity**

View the James Webb Space Telescope (JWST) Mission Operations Concept Document (.pdf)

It is 256 pages; viewing the table of contents alone demonstrates the key elements, such as the science goals, the astronomer’s (i.e., customer’s) view, the basic system architecture, operations strategies, and more.