System Requirements Review: OC-Flight-1

Space Flight Design Challenge

Advisory Council

Nov 8, 2012

Entrance Criteria

- Establish System Requirements
  - Present strategy for development
- Acceptance Level Testing plan established
  - Present strategy for ensuring requirements
- System Architecture defined
  - Present scenario-based diagrams
  - Map requirements to spacecraft subsystem architecture
- Acknowledge and assess risk factors

Exit Criteria

- System Requirements established
  - Strategy for development presented
- Acceptance Level Testing plan established
  - Strategy for ensuring requirements presented
- System Architecture defined
  - Scenario-based diagrams presented
  - Requirements mapped to spacecraft subsystem architecture
- Risks acknowledged and assessed
  - Further analysis on-going

OC-Flight-1 Mission

- Overview
  - OC-Flight-1 mission is in Phase A (Concept Development & Technology Studies)
  - Focus is on developing system requirements, system architecture, and acceptance testing strategies
  - To date we have developed:
    - Implementation plan
    - Concept of Operations
    - Mission phases and interactions/activities of the system within phases
    - Established System Requirements
    - Preliminary Hazards Analysis w/ Safety Litmus Test
    - System Architecture
    - Acceptance Testing Plan
  - Current development:
    - Subsystem Architecture

Mission Objectives

- Educate a dedicated team of students in NASA's approach to engineering space-based vehicles.
- Enhance the public's understanding and general knowledge about NASA and the engineering of space-based missions through public seminars and workshops.
- Enhance mentoring, leadership, & domain expertise of IV&V workforce
- Establish an IV&V approach for university-built technology demonstration missions where it is perceived that these types of missions may lack formal engineering artifacts.
- Develop a reusable space system (ground system, space-based vehicle, and payload) using off the shelf components that can be utilized on future increments
  - Measure the magnetic field of the Earth
  - ~~Acquire stereoscopic images of Earth's surface~~
  - ~~Explore artificial intelligence concepts for fault management~~
  - ~~Explore spacecraft-spacecraft communications using off the shelf wireless devices~~

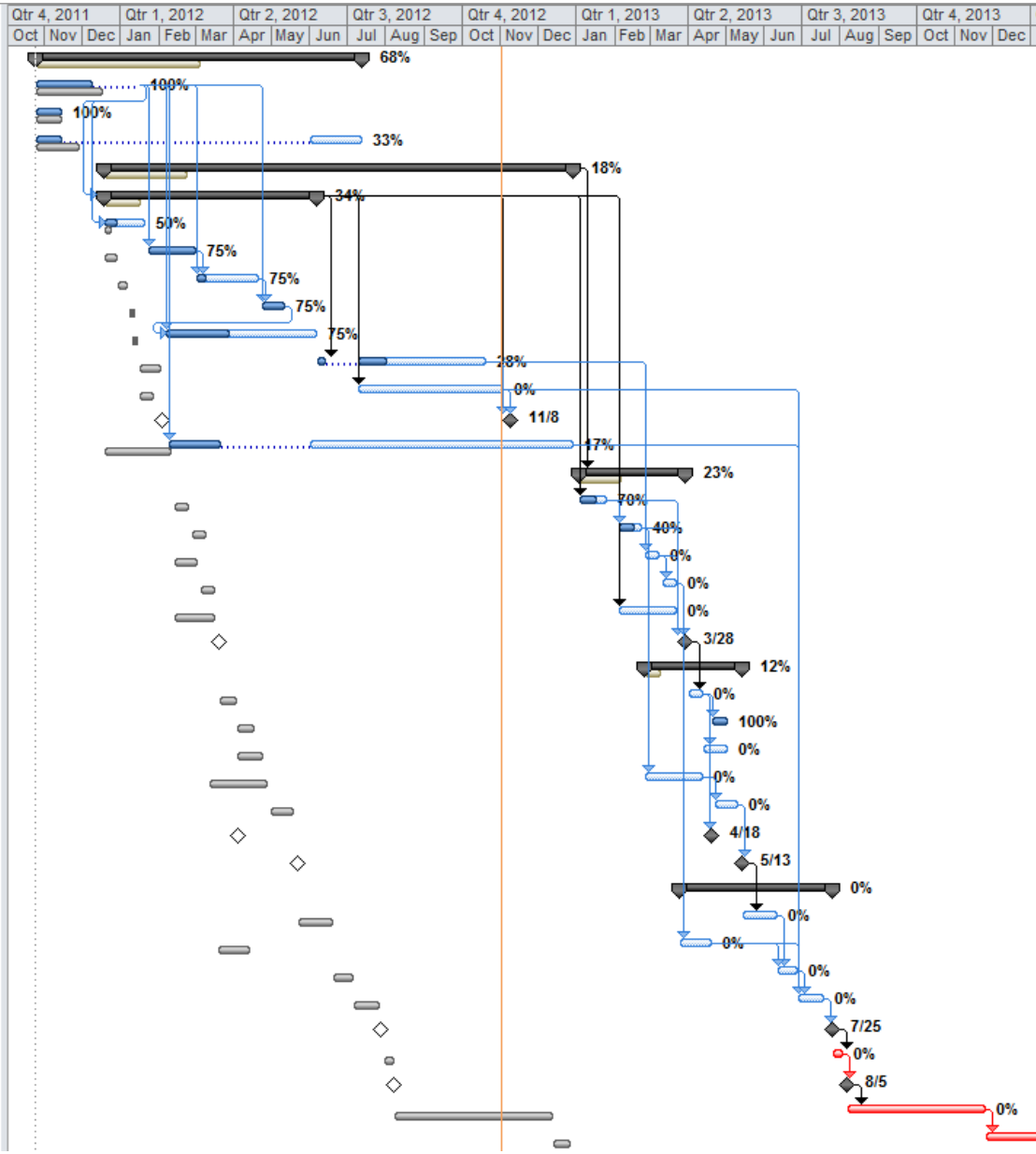
- Minimum Success:
  - Students demonstrate working knowledge of NASA's engineering approaches in building and operating a flight system for space
  - Employees of the NASA IV&V Program demonstrate enhanced mentoring, leadership, and/or domain expertise in space-based missions

Implementation: Where We Are

- Pre-Phase A – Concept Exploration
  - Increment 1 Implementation Plan & Concept of Operations
- Phase A – Concept Development & Technology Studies
  - OC-Flight-1 System Requirements, System Architecture, & Acceptance-level Testing
  - **Milestone = System Requirements Review (SRR)**
- Phase B – Preliminary Design
  - OC-Flight-1 Subsystem Requirements, Designs, Interfaces, & Integration Testing
  - Milestone = Preliminary Design Review (PDR)
- Phase C – Design & Manufacturing
  - OC-Flight-1 Final Designs and Interfaces
  - Milestones – Critical Design Review (CDR) and Systems Integration Review (SIR)
- Phase D – Systems Integration & Test
  - OC-Flight-1 testing results and integrated system
  - Milestone = Safety and Mission Success review (SMSR)
- Phase E – Operations
- Phase F – Decommissioning

Development Schedule

	Task Name	Start	Finish	Predece
1	**Pre-Phase A**	**Tue 10/25/11**	**Thu 7/12/12**	
2	Develop Increment 1 Concept of Operations	Tue 10/25/11	Sun 1/15/12	
3	Develop Increment 1 Implementation Plan	Tue 10/25/11	Mon 11/14/11	
4	Amateur Radio License	Tue 10/25/11	Thu 7/12/12	
5	**Phase A**	**Mon 12/19/11**	**Fri 12/28/12**	
6	**Develop System Requirements**	**Mon 12/19/11**	**Wed 6/6/12**	**2**
7	Seperation & Acquisition	Mon 12/19/11	Fri 1/20/12	2
8	On Orbit Checkout	Mon 1/23/12	Wed 2/29/12	2
9	Operations	Thu 3/1/12	Fri 4/20/12	8,2
10	Decommissioning	Mon 4/23/12	Fri 5/11/12	9,2
11	Performance	Mon 2/6/12	Wed 6/6/12	10,2
12	Develop System Architecture	Thu 6/7/12	Fri 10/19/12	6
13	Develop Acceptance Level Testing	Mon 7/9/12	Fri 11/2/12	6
14	System Requirements Review (SRR)	Thu 11/8/12	Thu 11/8/12	6,12,13
15	Establish Testing Facilities & Equipment	Wed 2/8/12	Fri 12/28/12	2
16	**Phase B Preliminary design**	**Thu 1/3/13**	**Thu 3/28/13**	**5**
17	Develop Subsystem Requirements	Thu 1/3/13	Thu 1/24/13	6
18	Develop Subsystem Designs	Mon 2/4/13	Fri 2/22/13	17
19	Develop Subsystem Interface Control Documents	Mon 2/25/13	Fri 3/8/13	12
20	Develop Integration Testing	Mon 3/11/13	Fri 3/22/13	19
21	Develop Ground System	Mon 2/4/13	Fri 3/22/13	6
22	Preliminary Design Review (PDR)	Thu 3/28/13	Thu 3/28/13	17,18,1
23	**Phase C Design & Manufacturing**	**Mon 2/25/13**	**Mon 5/13/13**	
24	Finalize Designs and Interfaces	Mon 4/1/13	Thu 4/11/13	22
25	Fabricate PCBs	Fri 4/19/13	Thu 5/2/13	24
26	Wiring and Structures	Fri 4/12/13	Thu 5/2/13	24
27	Software Development	Mon 2/25/13	Fri 4/12/13	18
28	Unit Testing	Mon 4/22/13	Fri 5/10/13	27
29	Critical Design Review (CDR)	Thu 4/18/13	Thu 4/18/13	24
30	System Integration Review (SIR)	Mon 5/13/13	Mon 5/13/13	28
31	**Phase D System Integration and Test**	**Mon 3/25/13**	**Thu 7/25/13**	
32	Integrate Subsystems	Tue 5/14/13	Mon 6/10/13	30
33	Finalize Integration Tests and Acceptance Tests	Mon 3/25/13	Fri 4/19/13	20
34	Integration Testing	Tue 6/11/13	Thu 6/27/13	33,32
35	Acceptance Testing	Fri 6/28/13	Thu 7/18/13	13,33,3
36	Safety and Mission Success Review (SMSR)	Thu 7/25/13	Thu 7/25/13	35
37	Ship Spacecraft & Integrate	Fri 7/26/13	Fri 8/2/13	36
38	Launch	Mon 8/5/13	Mon 8/5/13	37
39	Phase E Operations	Tue 8/6/13	Mon 11/25/13	38
40	Phase F Decomissioning	Tue 11/26/13	Mon 7/28/14	39



OC-Flight-1 Process Approach & Products

- Adapting NASA procedures (e.g. 7120.5, 7123, 7150) and guidelines (e.g. GOLD)
  - We are a Class D mission relative to NPR 8705.4 “Risk Classification for NASA Payloads”
- Adapting a MBSE approach (using a modification of SysML)

Pre-Phase A: Concept Exploration

Implementation Plan
Template from 7120

Concept of Operations
Outline from 7120 & 7123

Operational Phases with supporting scenarios describing how the flight system and ground system work together across mission phases for launch, critical activities, science observations, and end of mission to achieve the mission.

Phase A: Concept Development

SEE Next Slide — Studies using STK, GMAT, SPENVIS, tracking & comm (predict)

Phase B: Preliminary Design

Subsystem Requirements (elaboration of requirements diagram)
Subsystem designs & I/Fs (elaboration of behavior and structure diagrams)
Integration Testing (utilize reqts diagram for tracing, test plans, P/F)

Has been going on in parallel

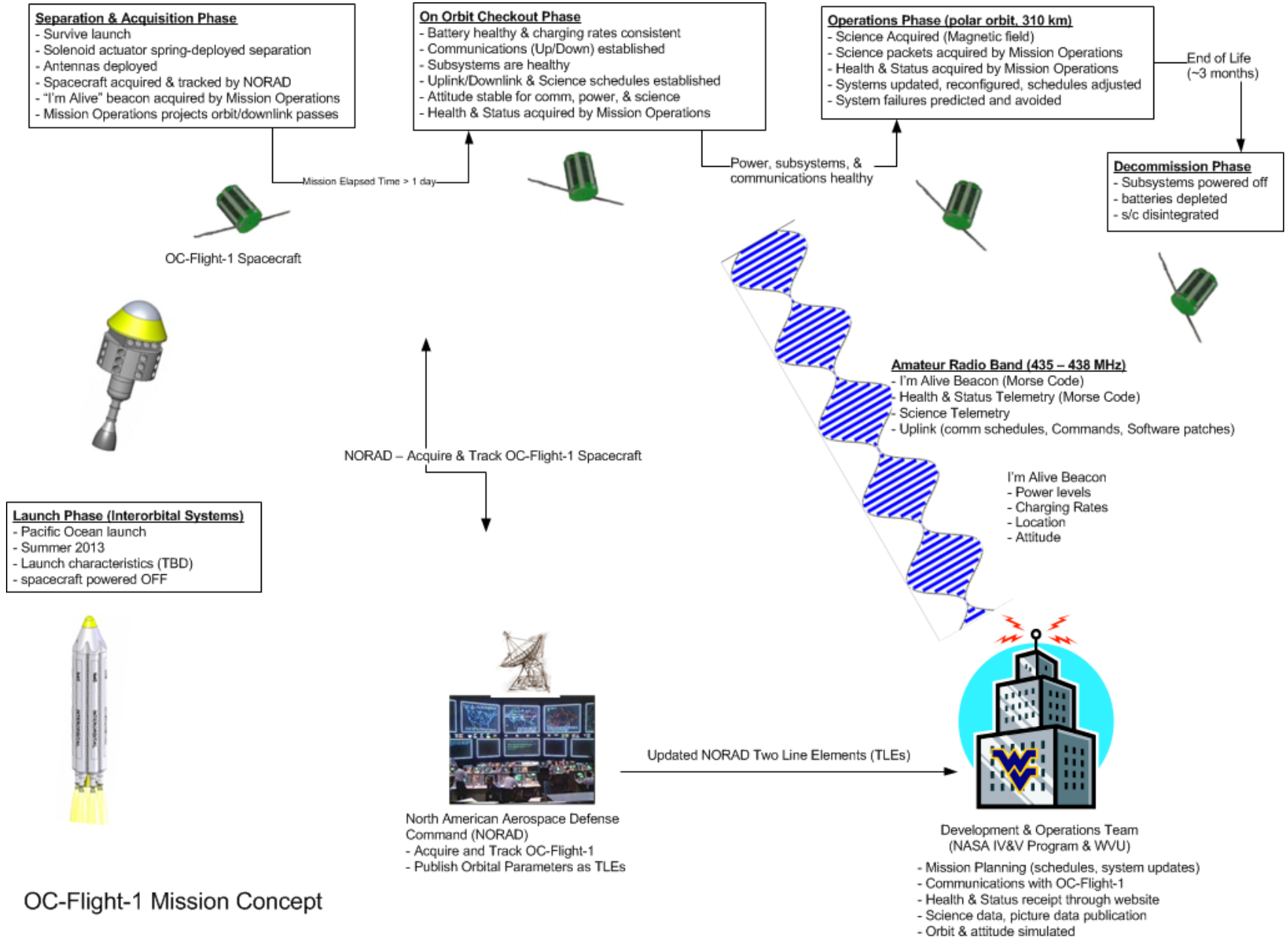
Phase C: Design & Manufacturing

Final Designs (including PCB files) & Fabrication
Software Systems (currently Arduino devp environment on Windows platform)
Ground Systems
Unit testing (within the Arduino devp environment)

Phase D: Systems Integration & Test

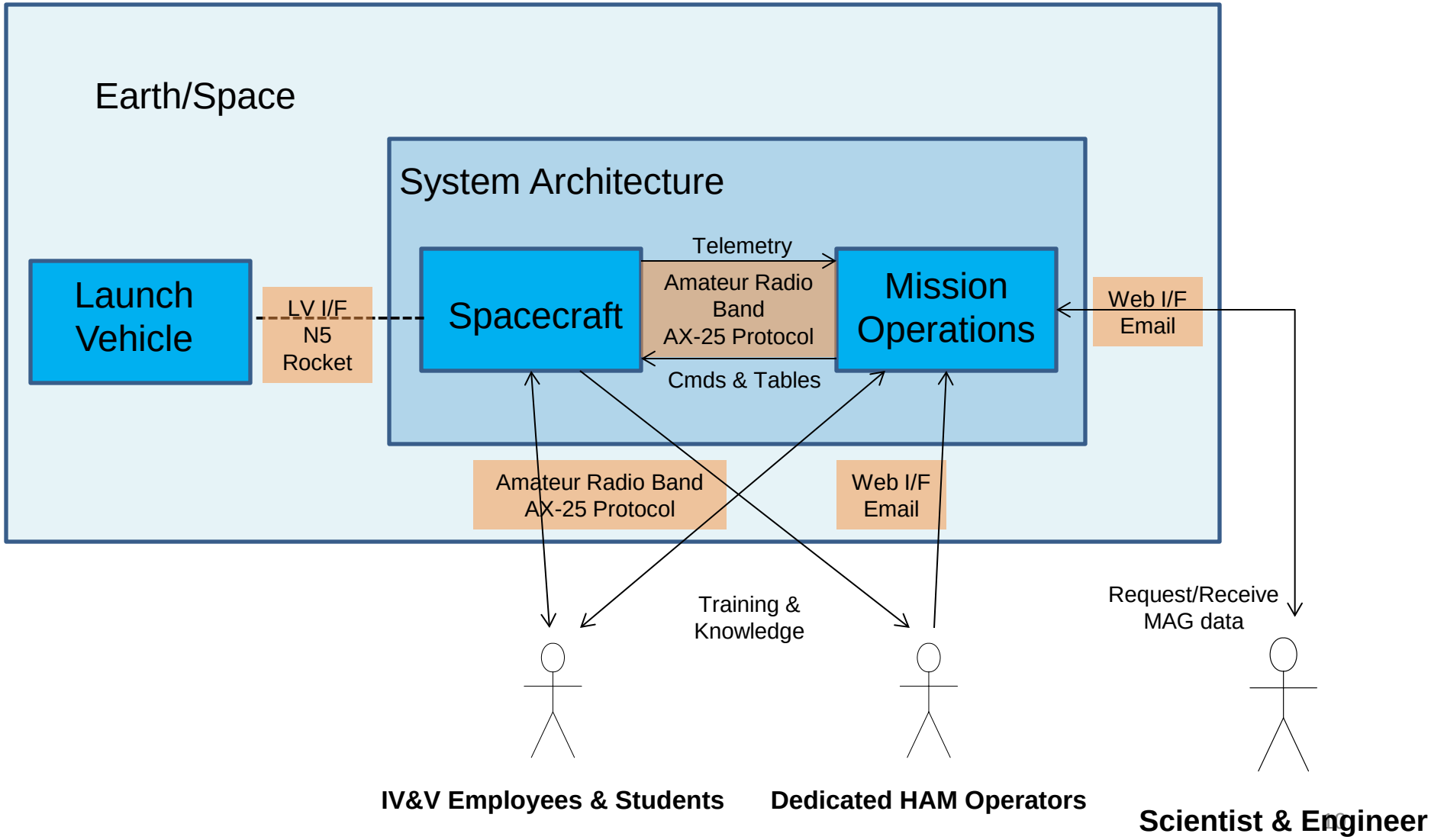
Integrated System
Integration Testing & Acceptance Testing Results

Concept of Operations

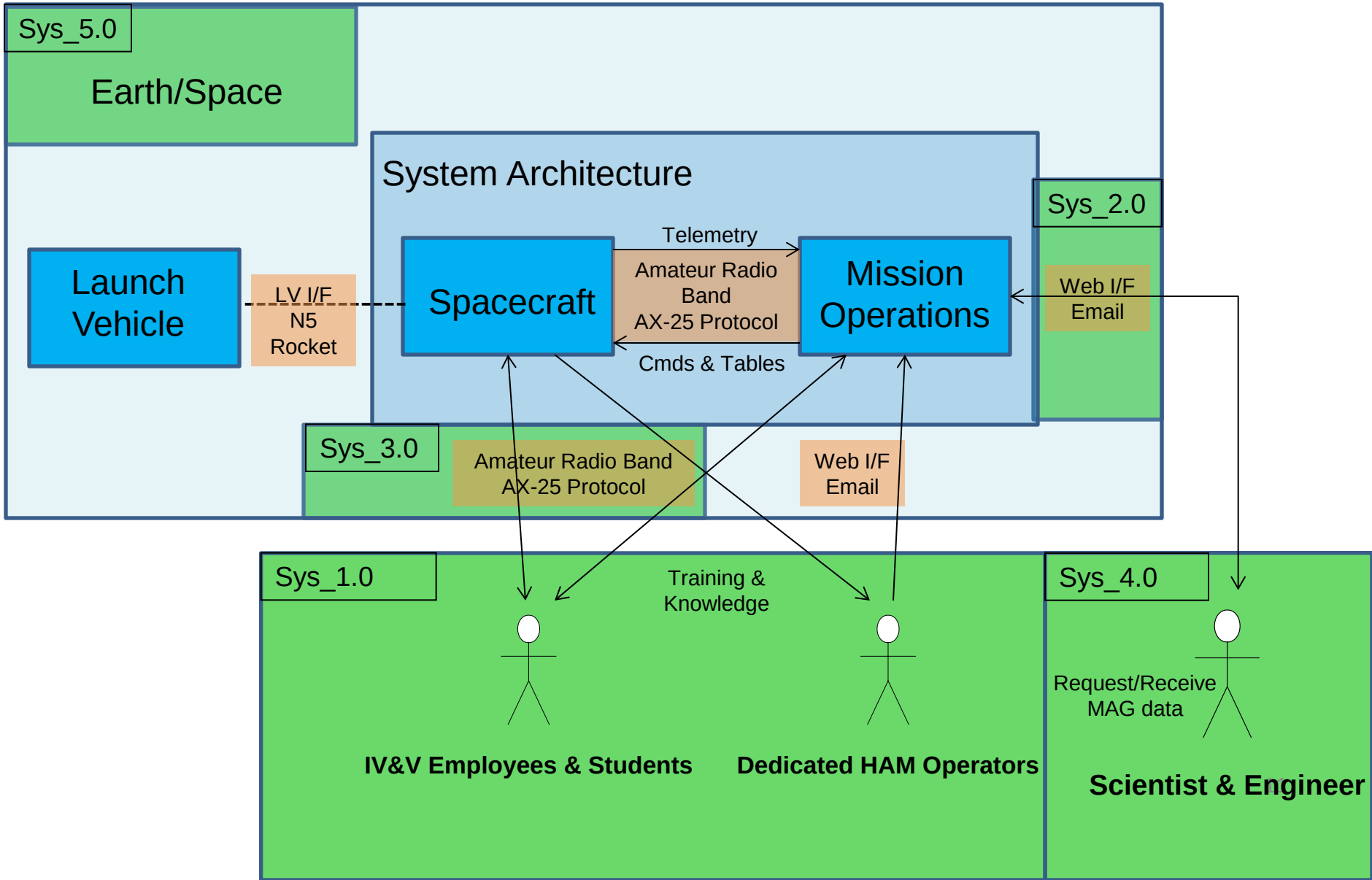


OC-Flight-1 Mission Concept

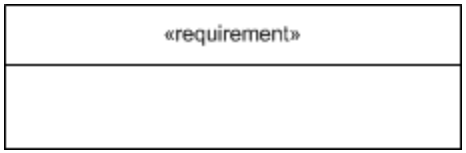
System Interactions



System Interactions



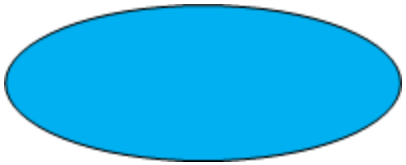
System Requirements Breakdown



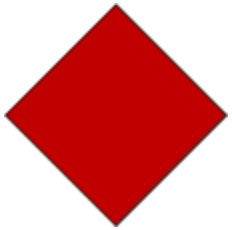
– System Requirement

– Notional Solution

– Hardware Solution

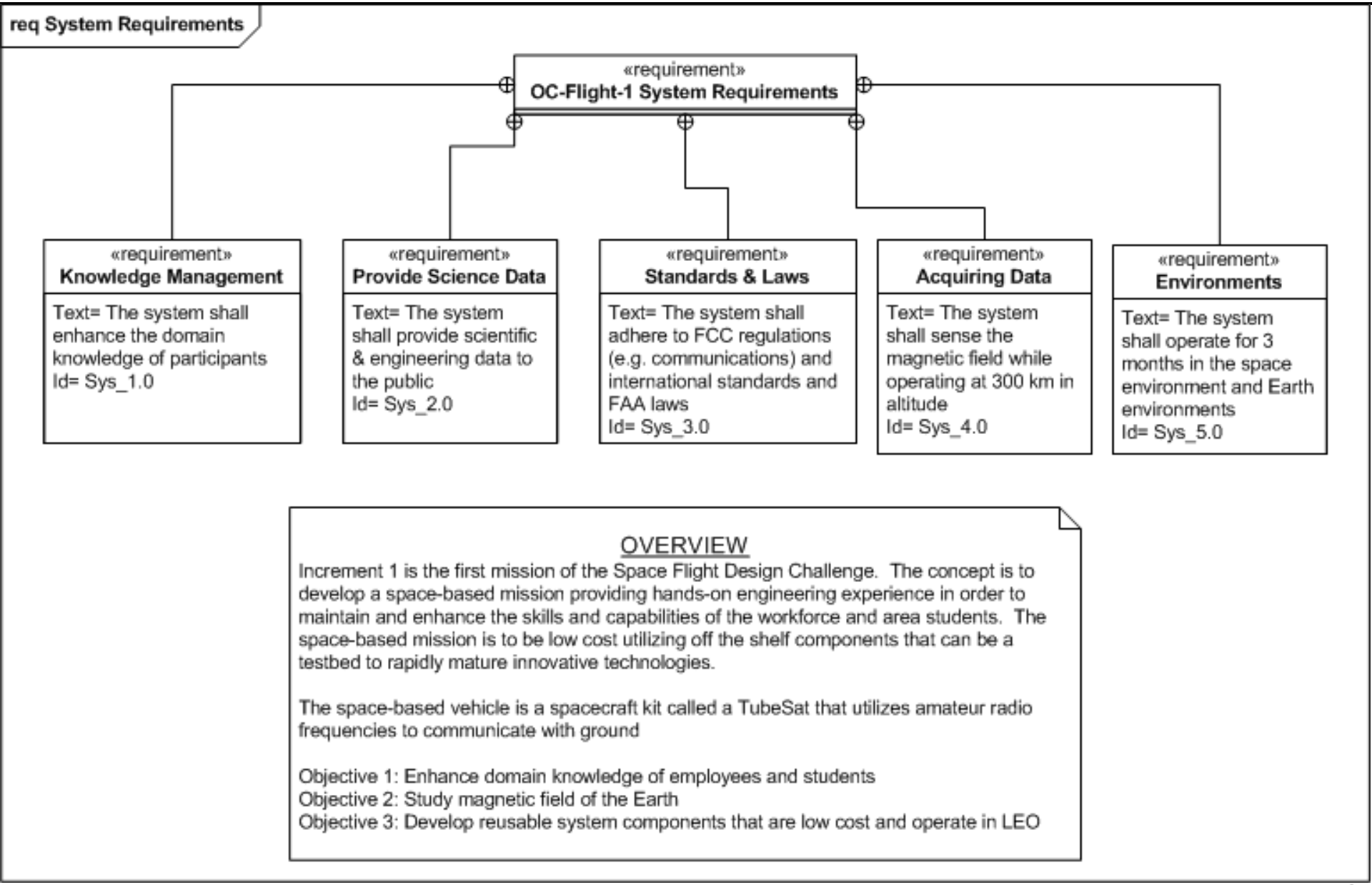


– Software Solution

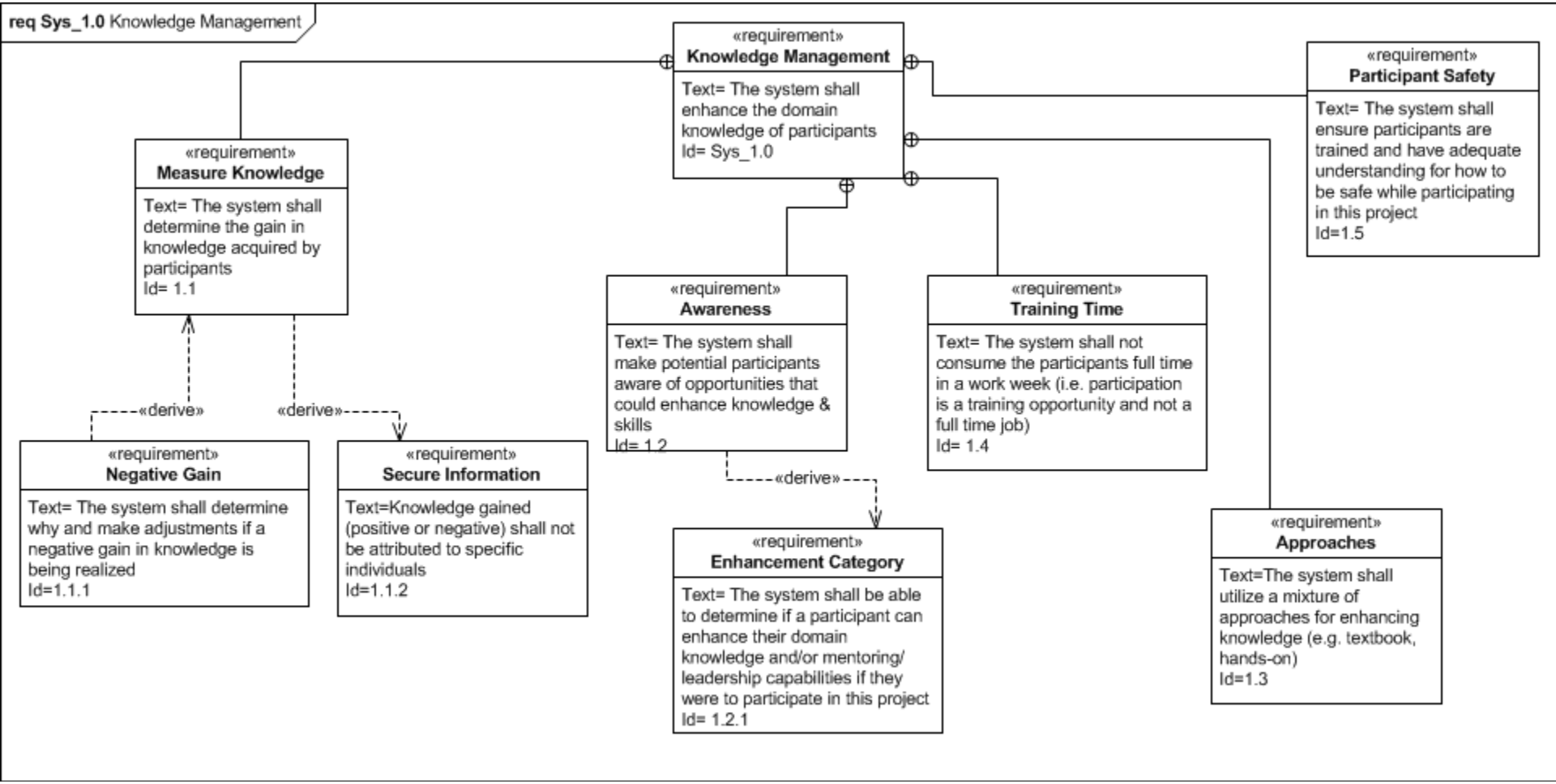


– Acceptance Level Test

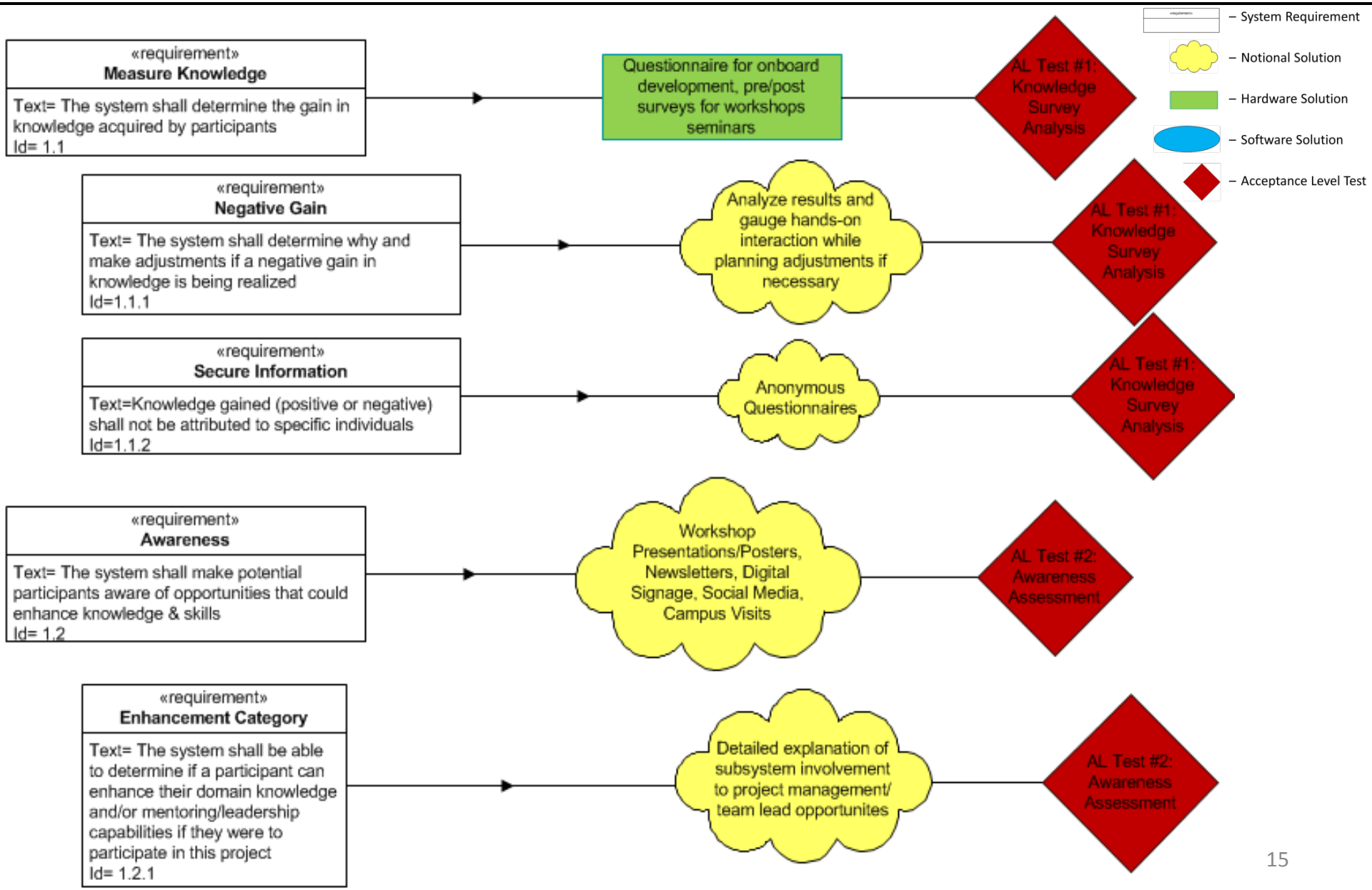
System Requirements for OC-Flight-1



Sys_1.0 Knowledge Management Requirements



Sys_1.0: Knowledge Management



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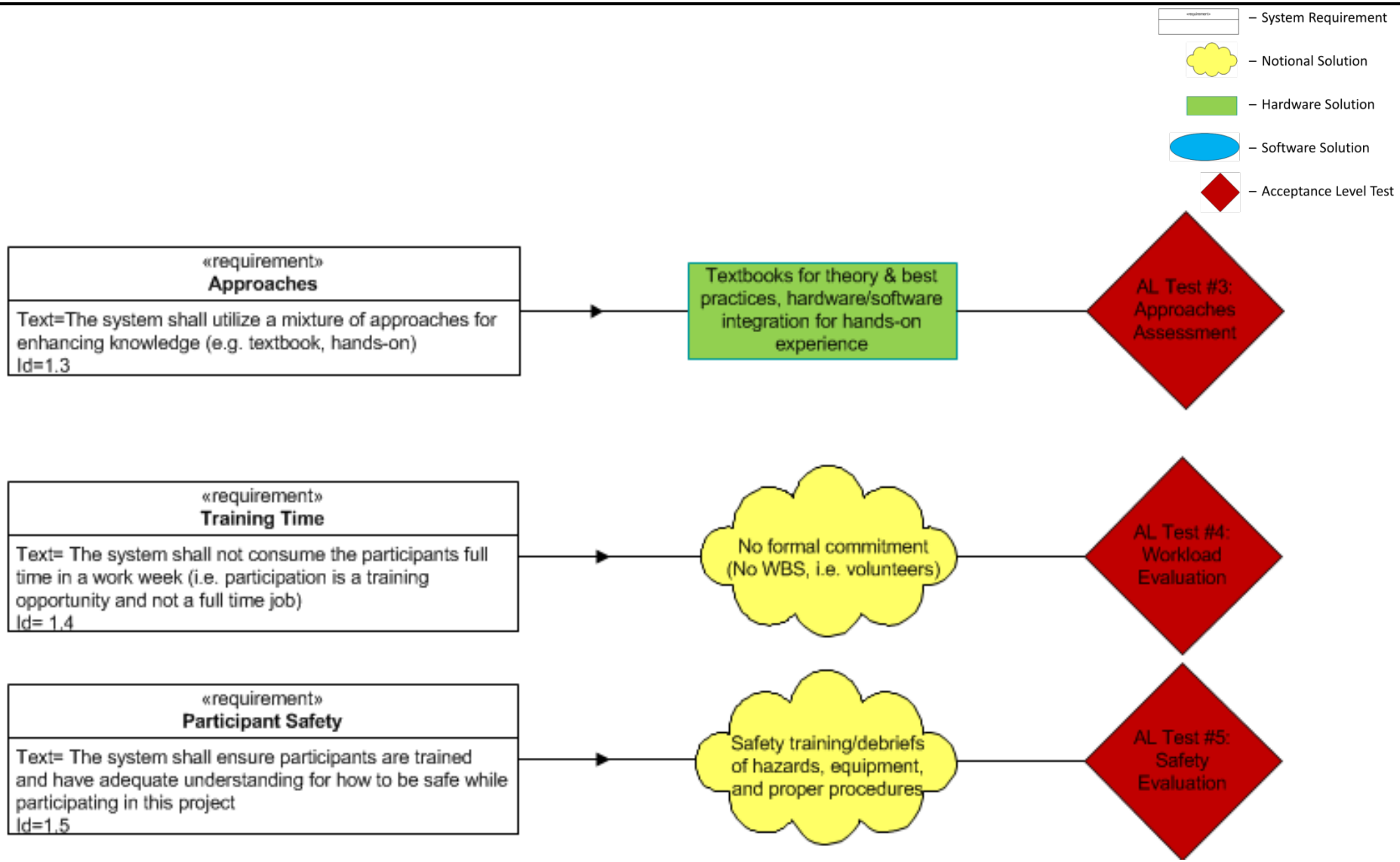
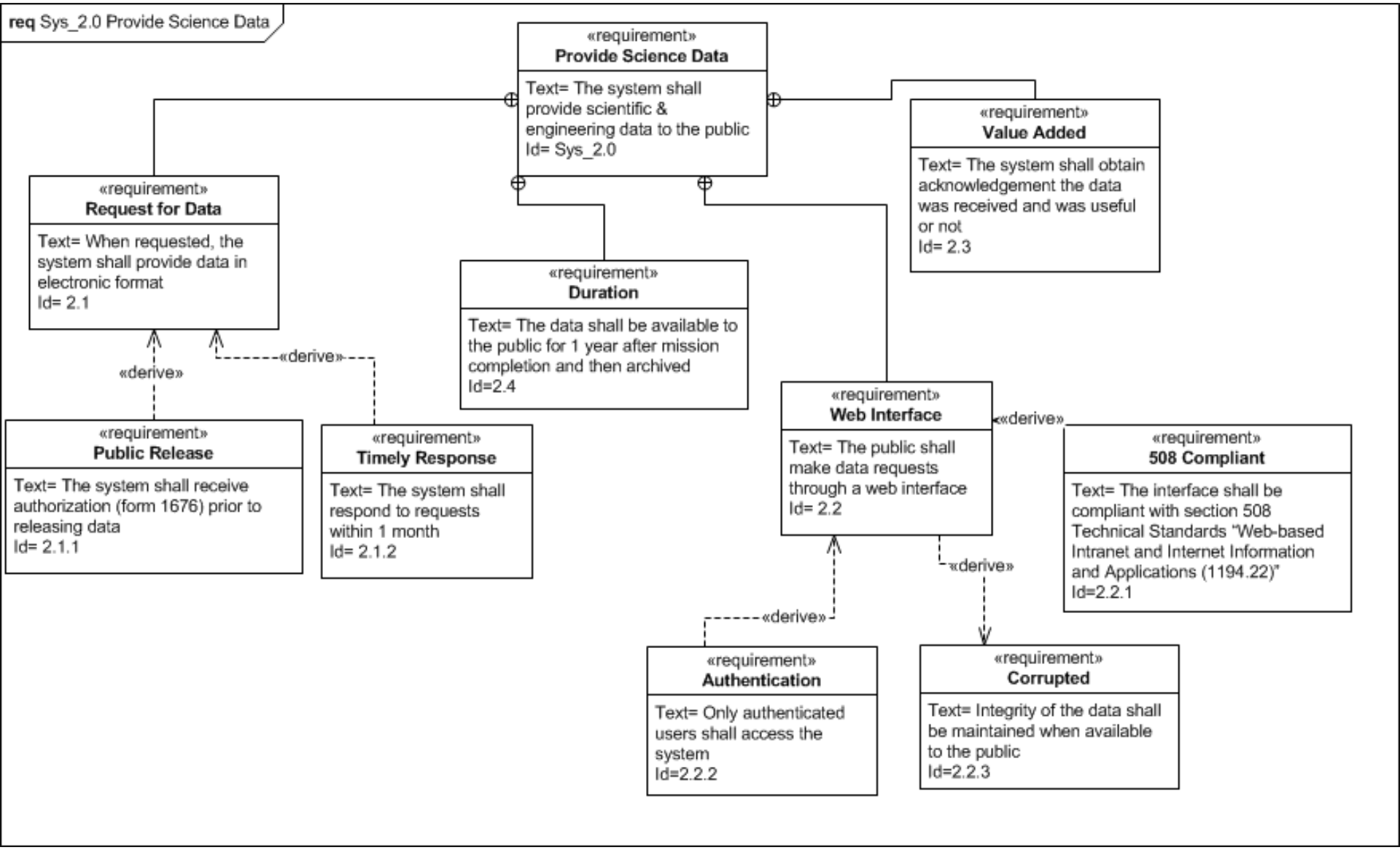


Sys_2.0 Provide Science Data Requirements



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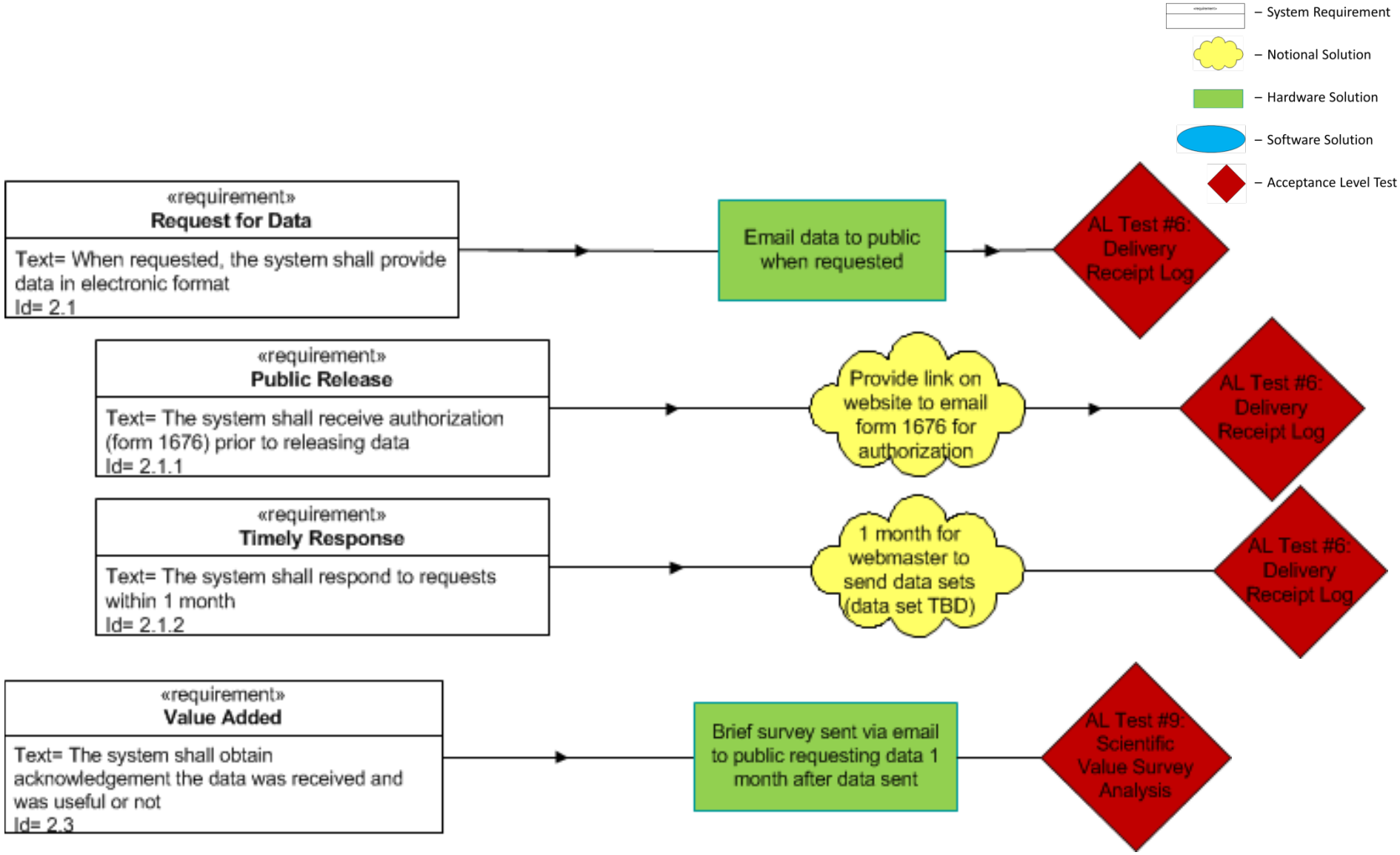

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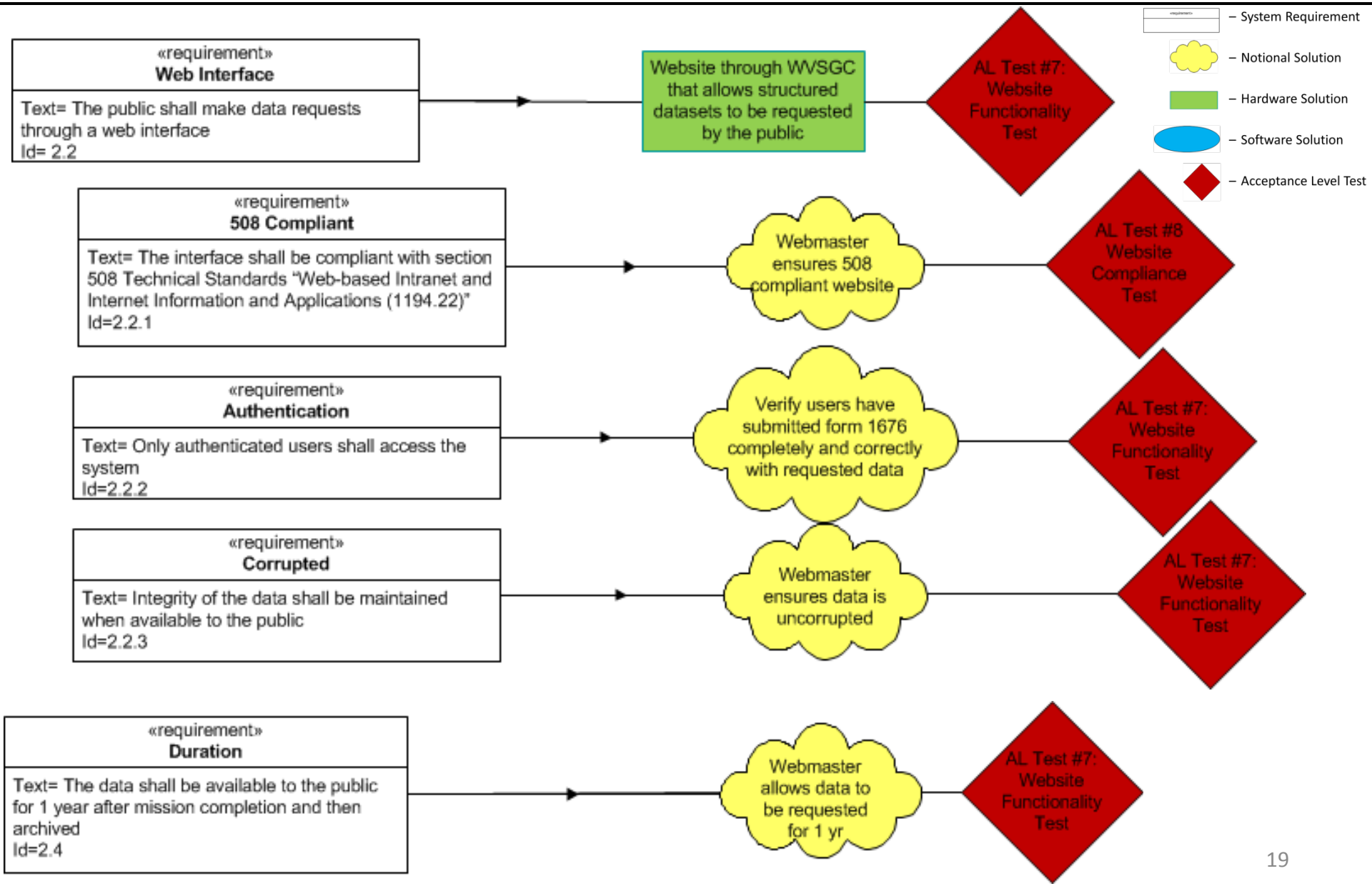
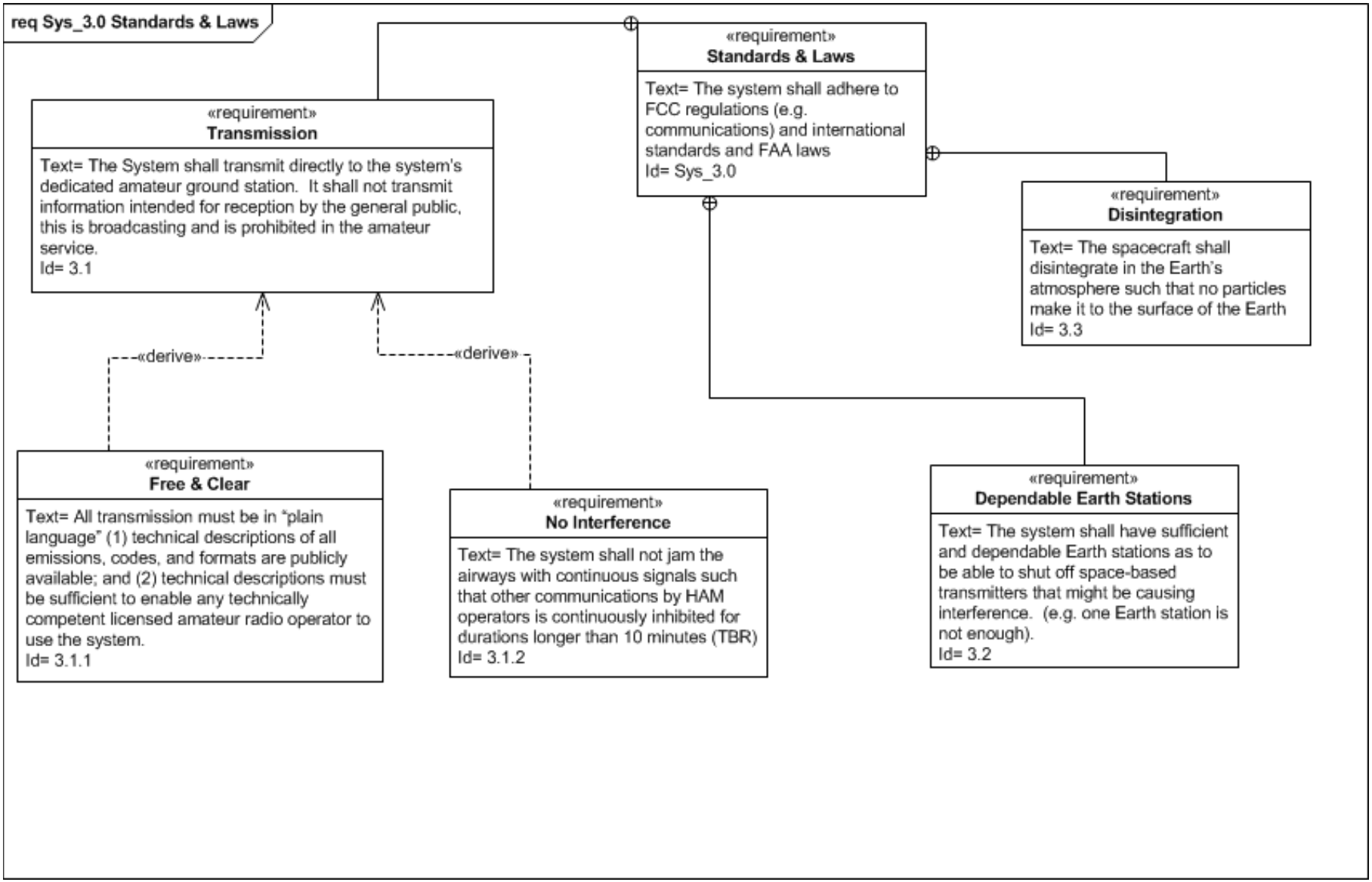


Sys_3.0 Standards & Laws Requirements



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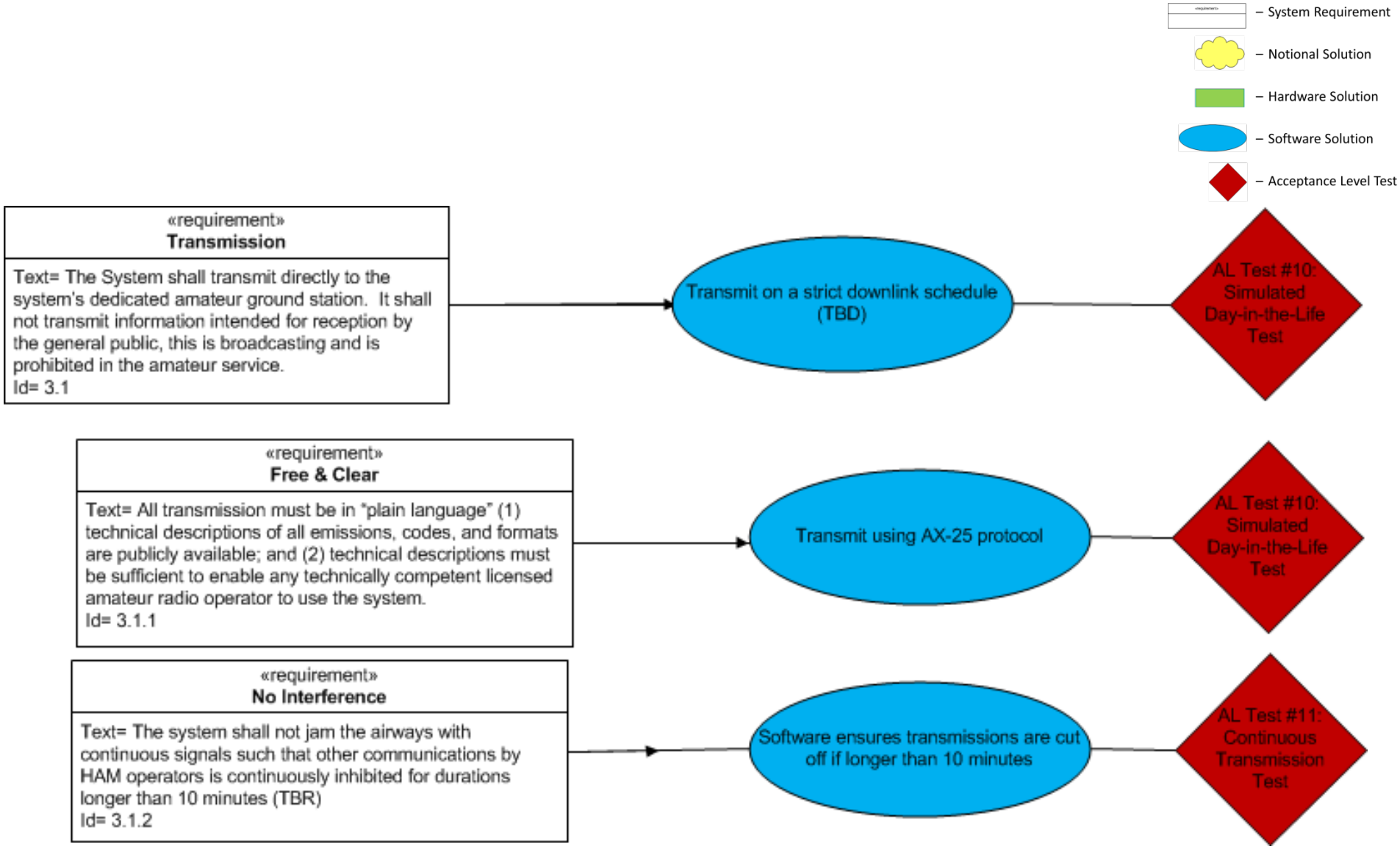

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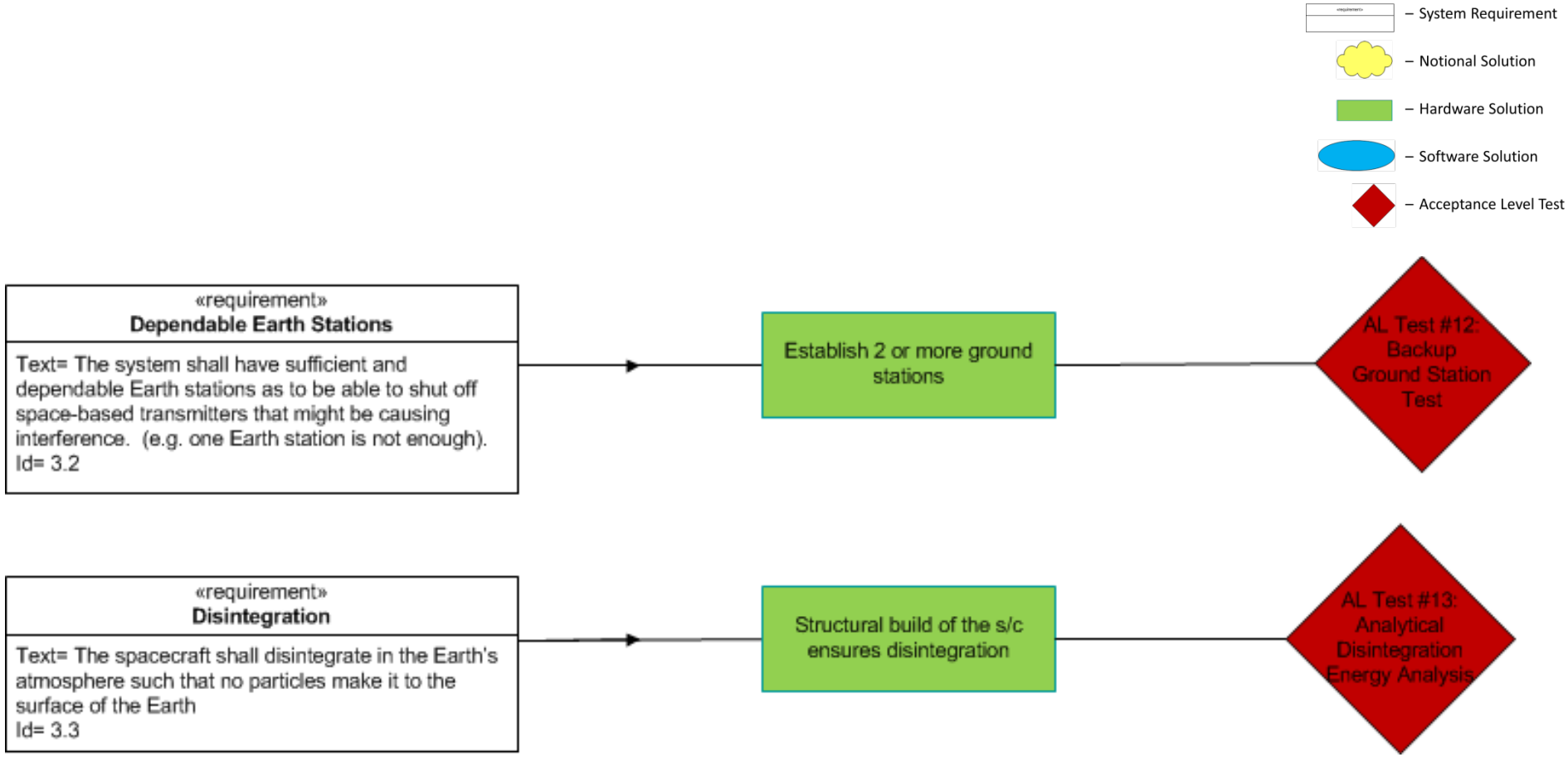
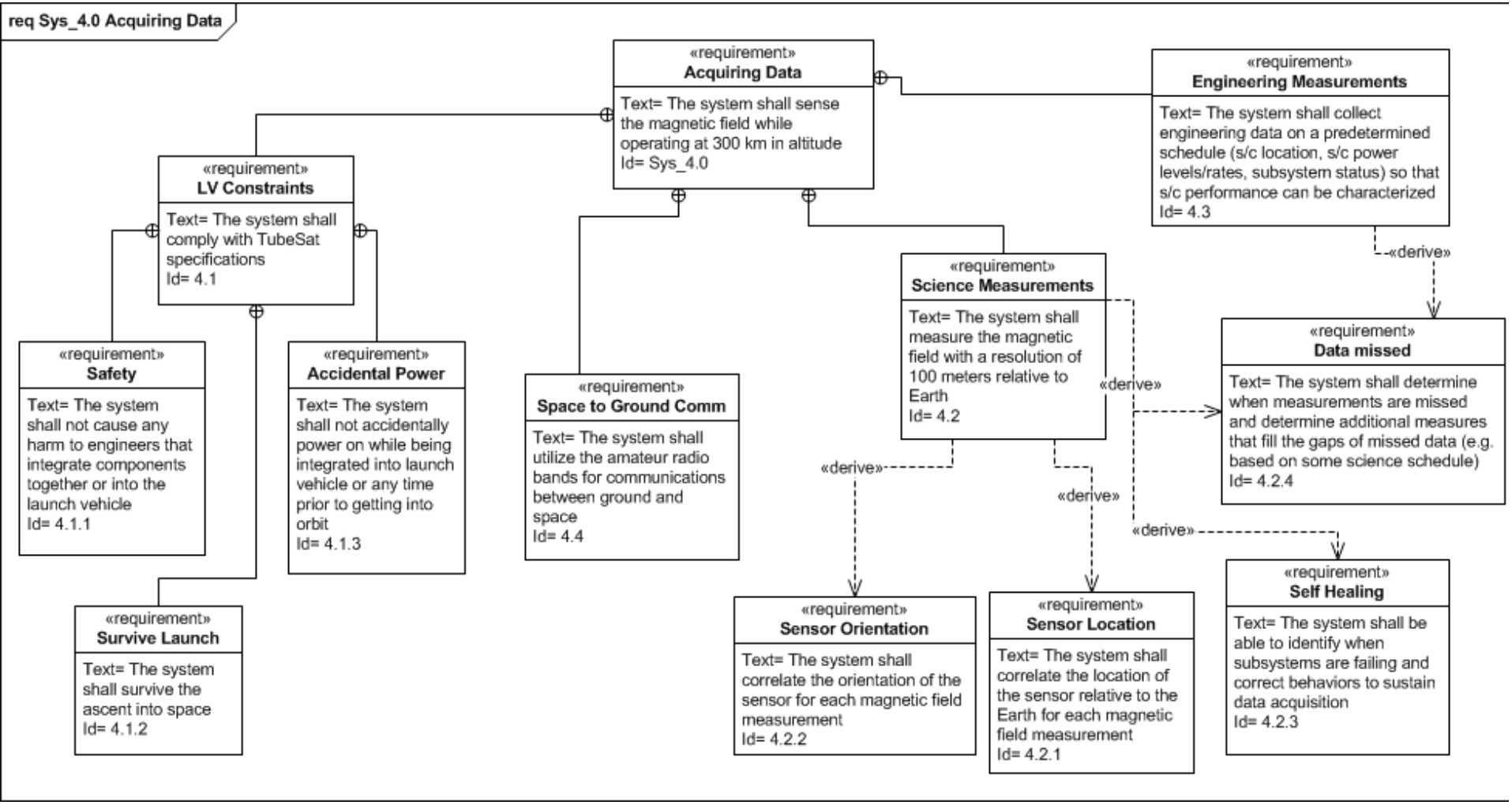
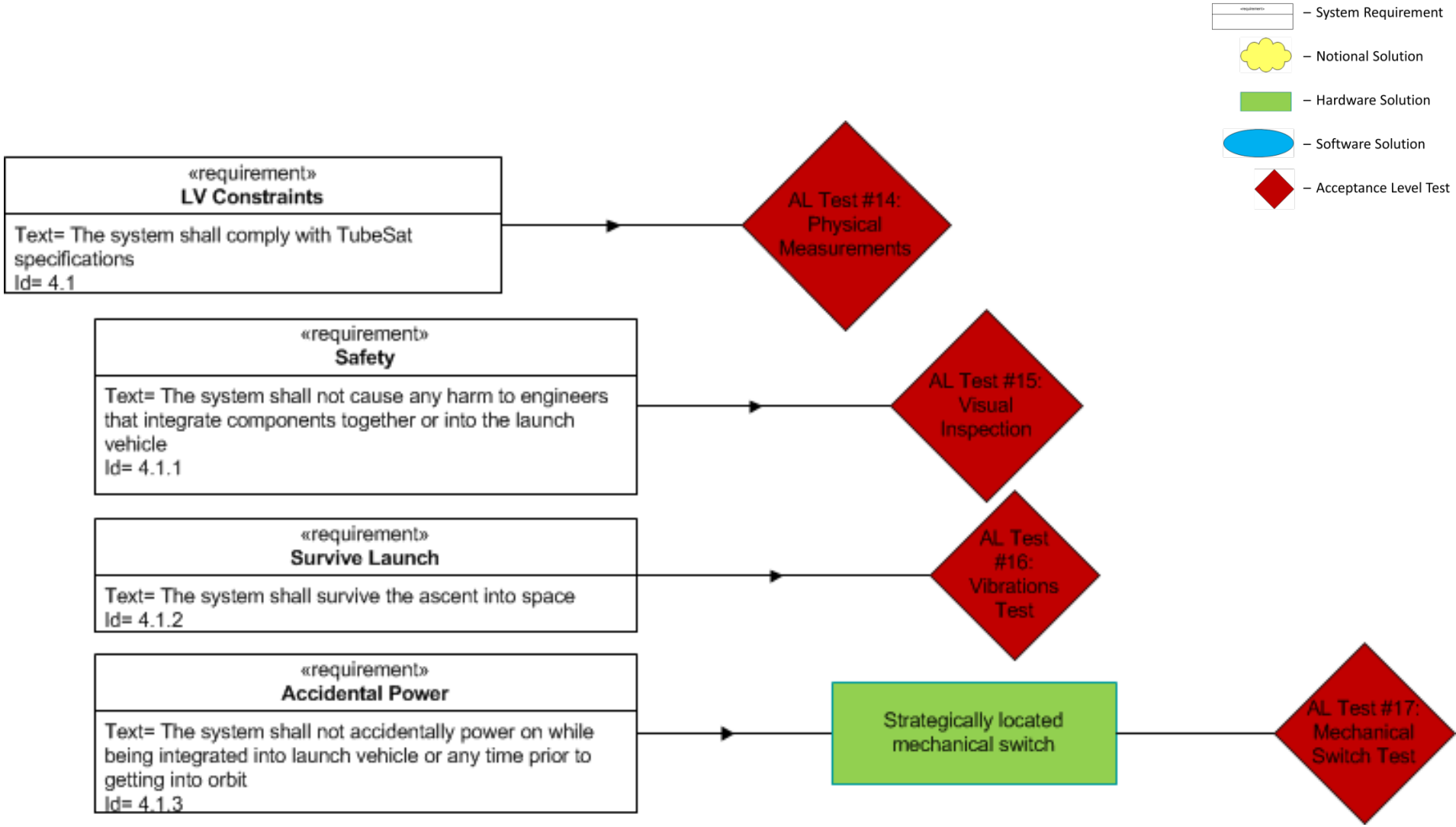


Sys_4.0 Acquiring Data Requirements



Sys_4.0: Acquiring Data



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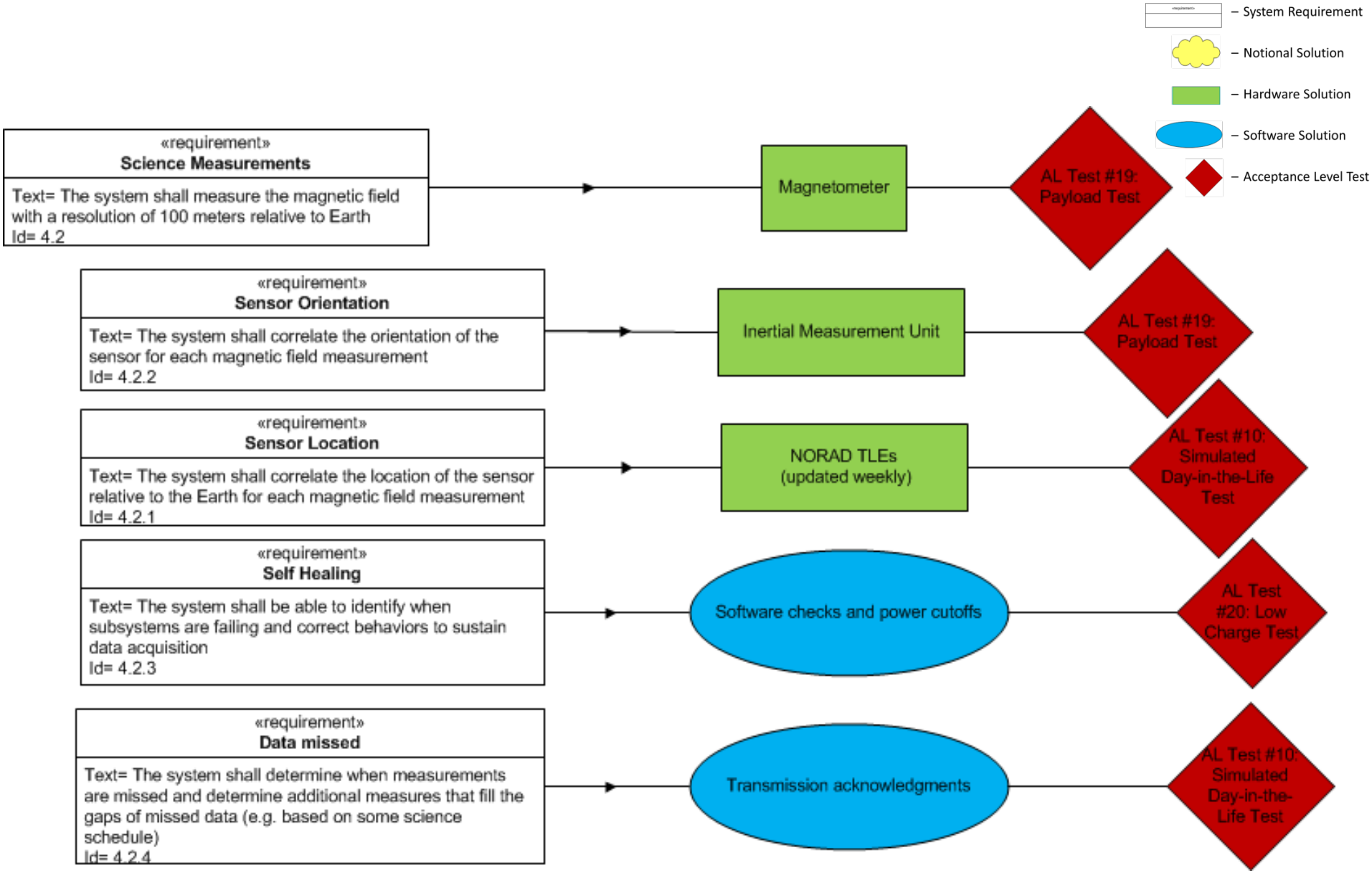

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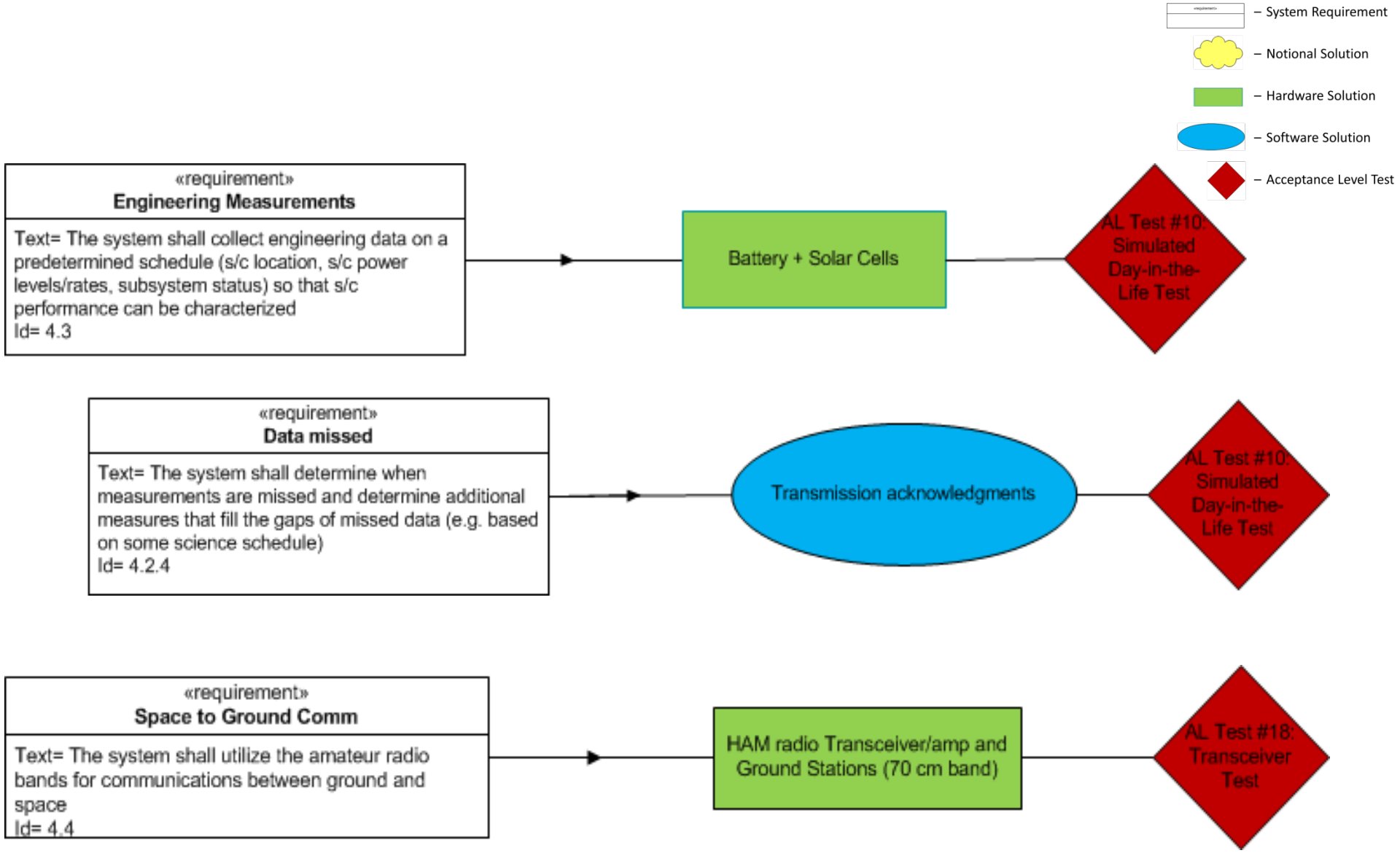
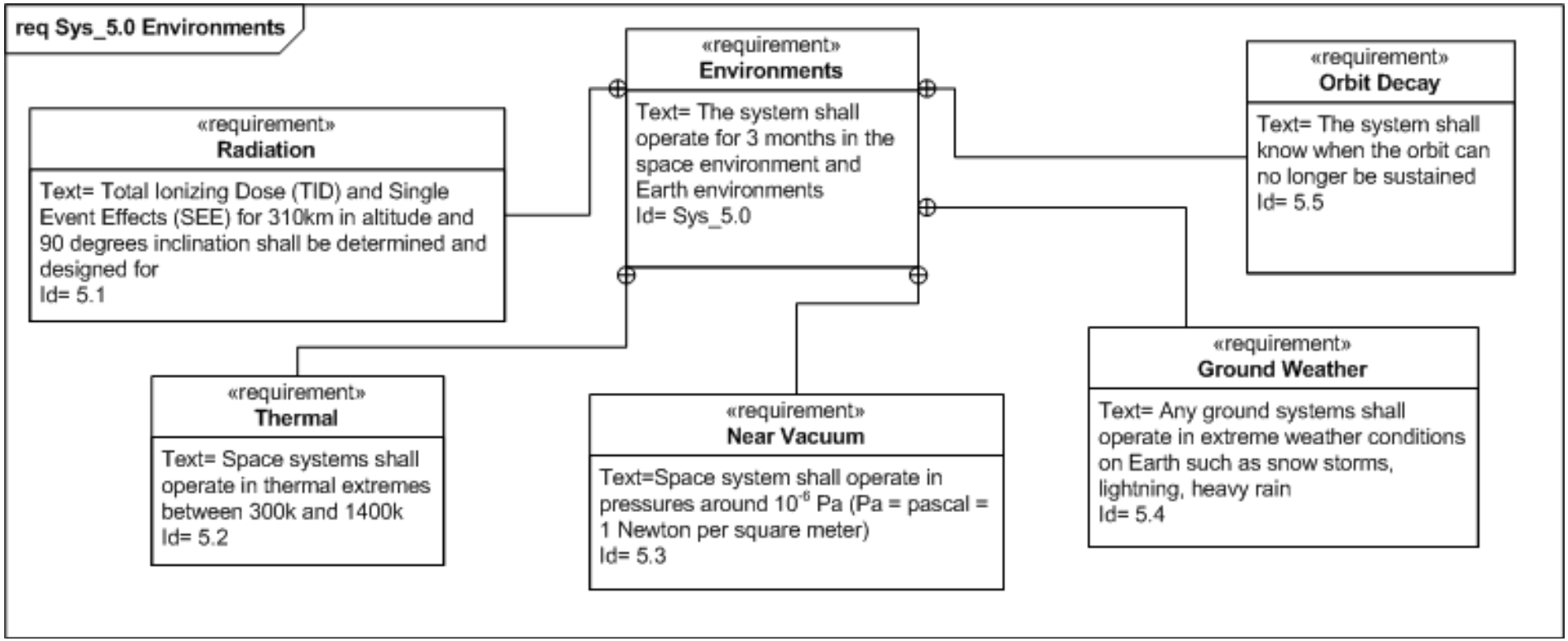
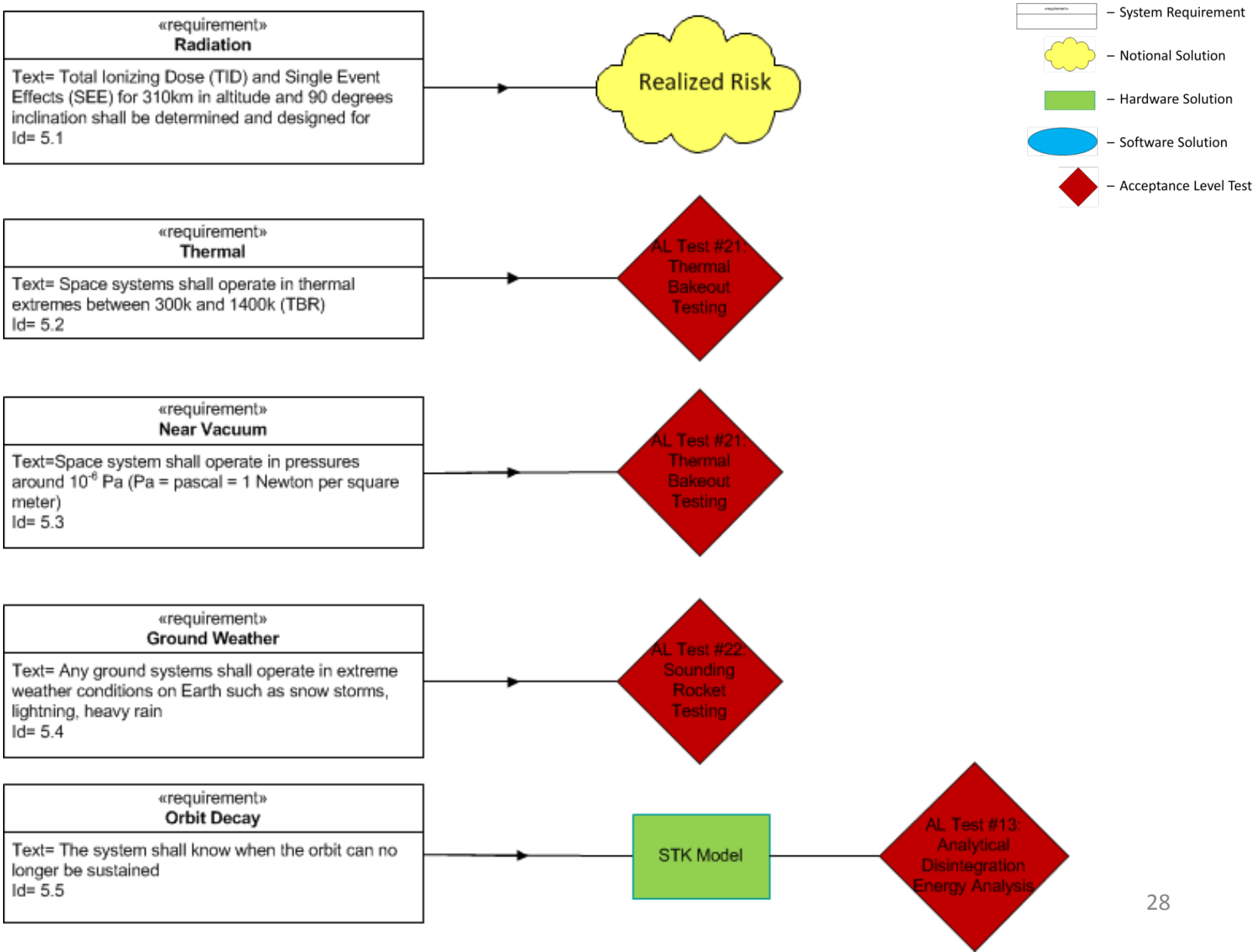


Sys_5.0 Environments Requirements



Sys_5.0: Environments



Acceptance Level Testing

- AL Test #1: **Knowledge Survey Analysis**
  - Analyze responses to development team questionnaires,
  - Tally results of pre/post workshop surveys
- AL Test #2: **Awareness Assessment**
  - Spot checks for digital signage
  - Gauge interest level in workshops and school visits
- AL Test #3: **Approaches Assessment**
  - Ensure textbooks/documentation are made readily available for architecture devp, programming techniques, and hardware components

Acceptance Level Testing

- AL Test #4: **Workload Evaluation**
  - Evaluate individual workload to ensure manageable levels and shift loads if necessary
- AL Test #5: **Safety Evaluation**
  - Evaluation of proper techniques /procedures and potential hazards prior to lab usage
- AL Test #6: **Delivery Receipt Log**
  - Delivery receipt sent and logged by email system when requested data is received by users
- AL Test #7: **Website Functionality Test**
  - Extensive testing of website to ensure all required capabilities are functional

Acceptance Level Testing

- AL Test #8: **Website Compliance Test**
  - Tests/checks to ensure website complies with 508 Technical Standards
- AL Test #9: **Scientific Value Survey Analysis**
  - Survey given to assess the scientific value gained by users receiving the data
- AL Test #10: **Day-in-the-Life Test (DITL)**
  - Full-mission bench test of system ops, telemetry comm, and data collection/correlation
  - Simulated TLE's generated on ground station
  - Evaluate tumbling comm effectiveness

Acceptance Level Testing

- AL Test #11: **Continuous Transmission Test**
  - Bench test to ensure comm break after 10 mins of continuous data transmission
- AL Test #12: **Ground Station Back-up Test**
  - Outdoor comm tests to ensure both permanent and back-up ground stations are functional
- AL Test #13: **Analytical Analysis of Disintegration Energy**
  - Calculate min size rock that could hit the earth at given orbital parameters (>>10cm^3)

Acceptance Level Testing

- AL Test #14: **Physical Measurements**
  - Each dimension of the OC-Flight-1 s/c will be physically measured to ensure design specifications are met
- AL Test #15: **Visual Inspection**
  - All metal and PCB components will be visually inspected for sharp edges/burrs and filed/sanded when discovered prior to shipment of s/c
- AL Test #16: **Vibrations Test**
  - Sine sweep and 3-axis vibrations testing will be performed on assembled s/c from 20-1280 Hz and 40-2000 Hz for 30sec and stepping by factor of 2

Acceptance Level Testing

- AL Test #17: **Power Switch Reliability Test**
  - Statistically sufficient number of tests to ensure confidence in reliability of power switch
  - Cold testing of power switch held at sub-zero temperature for 45 mins (worse case)
- AL Test #18: **Transceiver Test**
  - Bench testing of transceiver and ground station comm using AX-25 protocol
- AL Test #19: **Payload Test**
  - Bench testing of payload devices taking measurements and writing data to micro-SD memory

Acceptance Level Testing

- AL Test #20: **Low Charge Test**
  - Bench testing to ensure software turns off payload subsystem when voltage reaches cut-off limit
- AL Test #21: **Thermal Bake-out Test**
  - S/c will be tested in a near vacuum environment with temp increasing from ambient to 70° C in timed intervals
  - Max temp held constant for 1 hour
  - Temp decreased back to ambient in timed intervals

Acceptance Level Testing

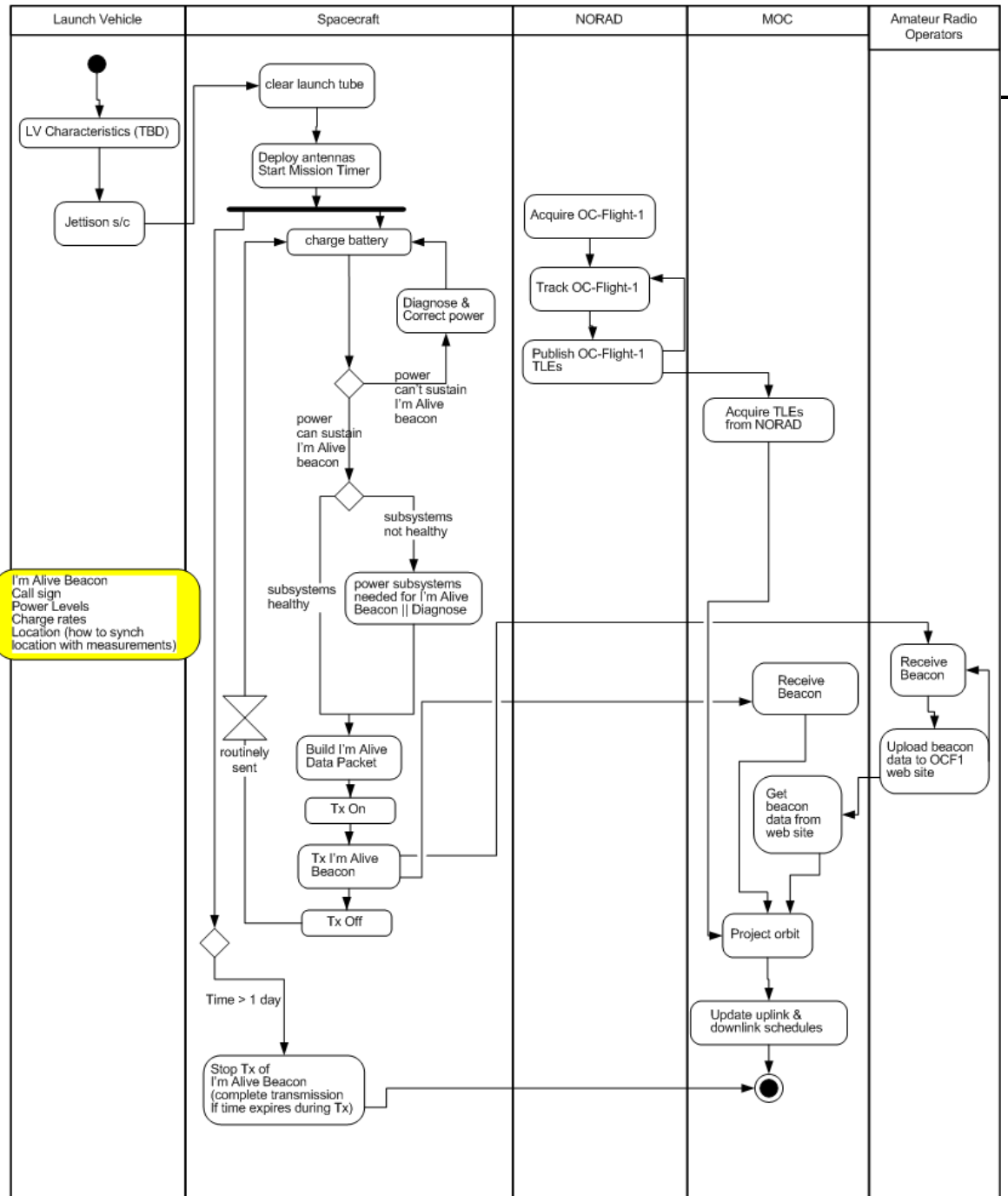
- AL Test #22: **Sounding Rocket Testing**
  - Fully assembled and equipped s/c ejected from rocket at ~160 km
  - Payload operation testing in upper atmosphere
  - Long distance transceiver/ground station testing
  - Tumble and charge profiles recorded to gain a better understanding of deployment dynamics and power availability

System Architecture

- Scenario-based sequence diagrams for each phase
  - Separation & Acquisition
  - On-orbit Checkout
  - Payload Operations

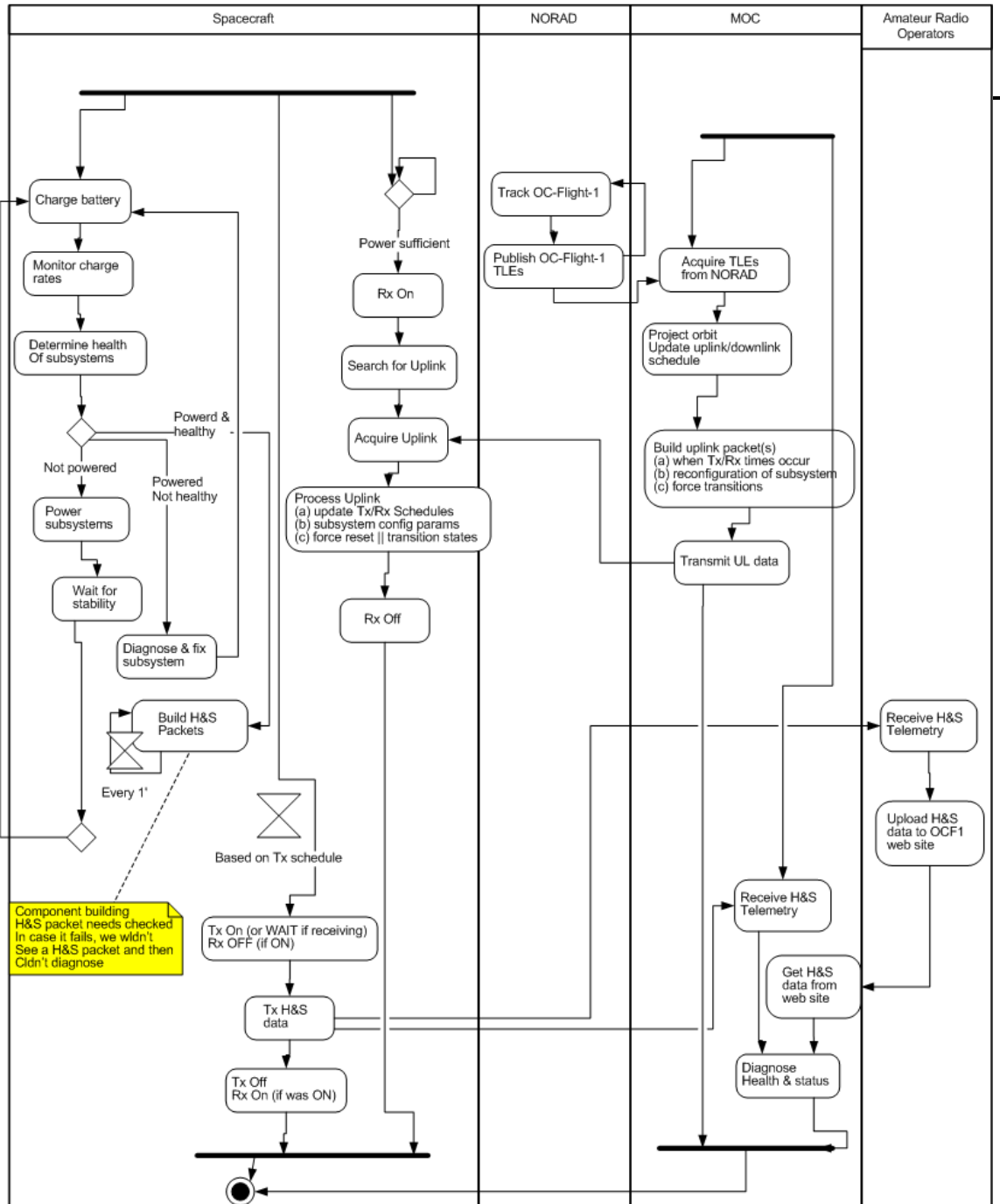
- Shows subsystem interaction relative to each other
  - Launch vehicle, spacecraft, MOC(s), NORAD

Separation & Acquisition Phase
Goal: (1) Survive Launch (2) Find Spacecraft

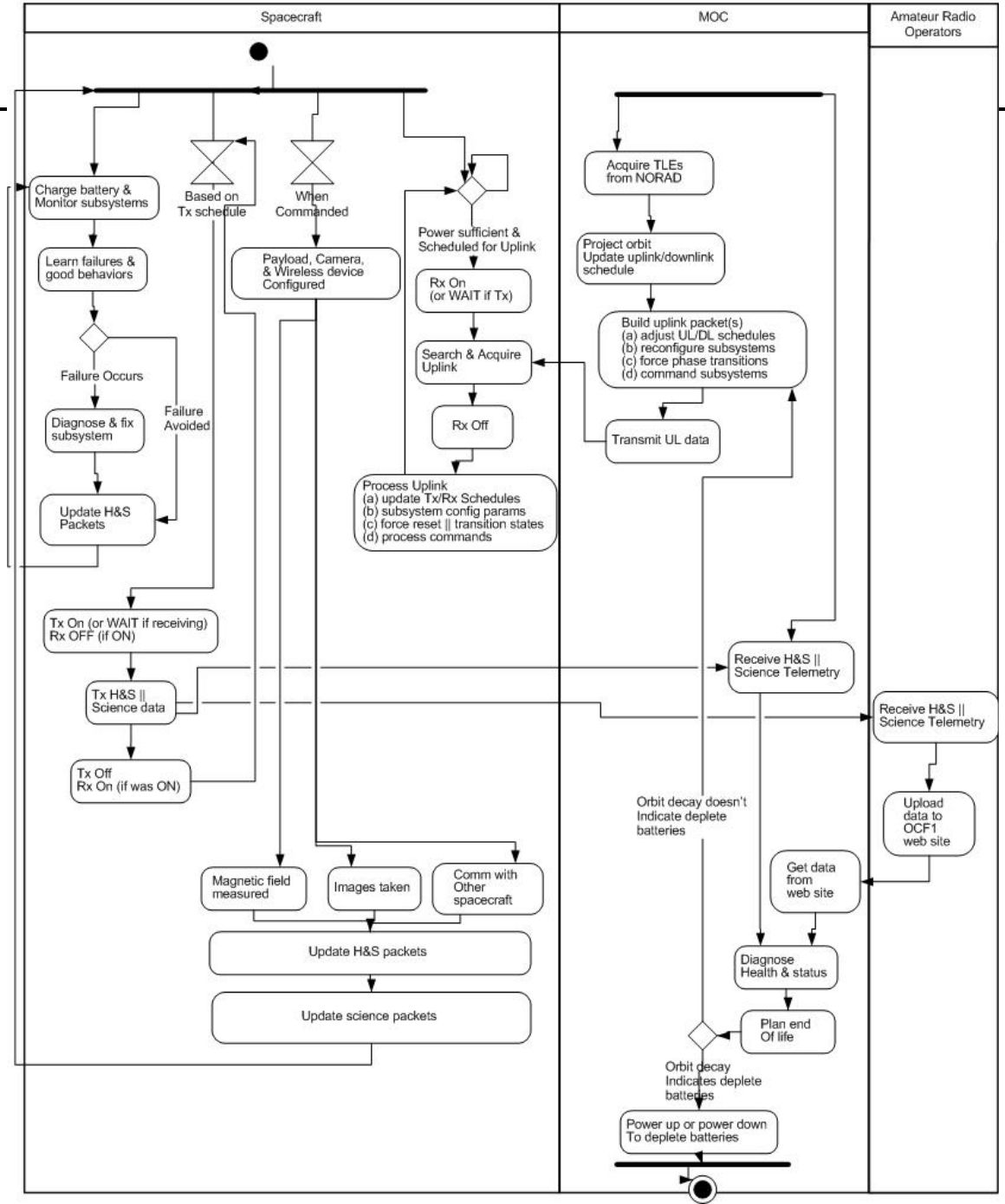


This is the connection to the scenarios from concept of operations (The state machine connects the scenarios already developed with the system level information)

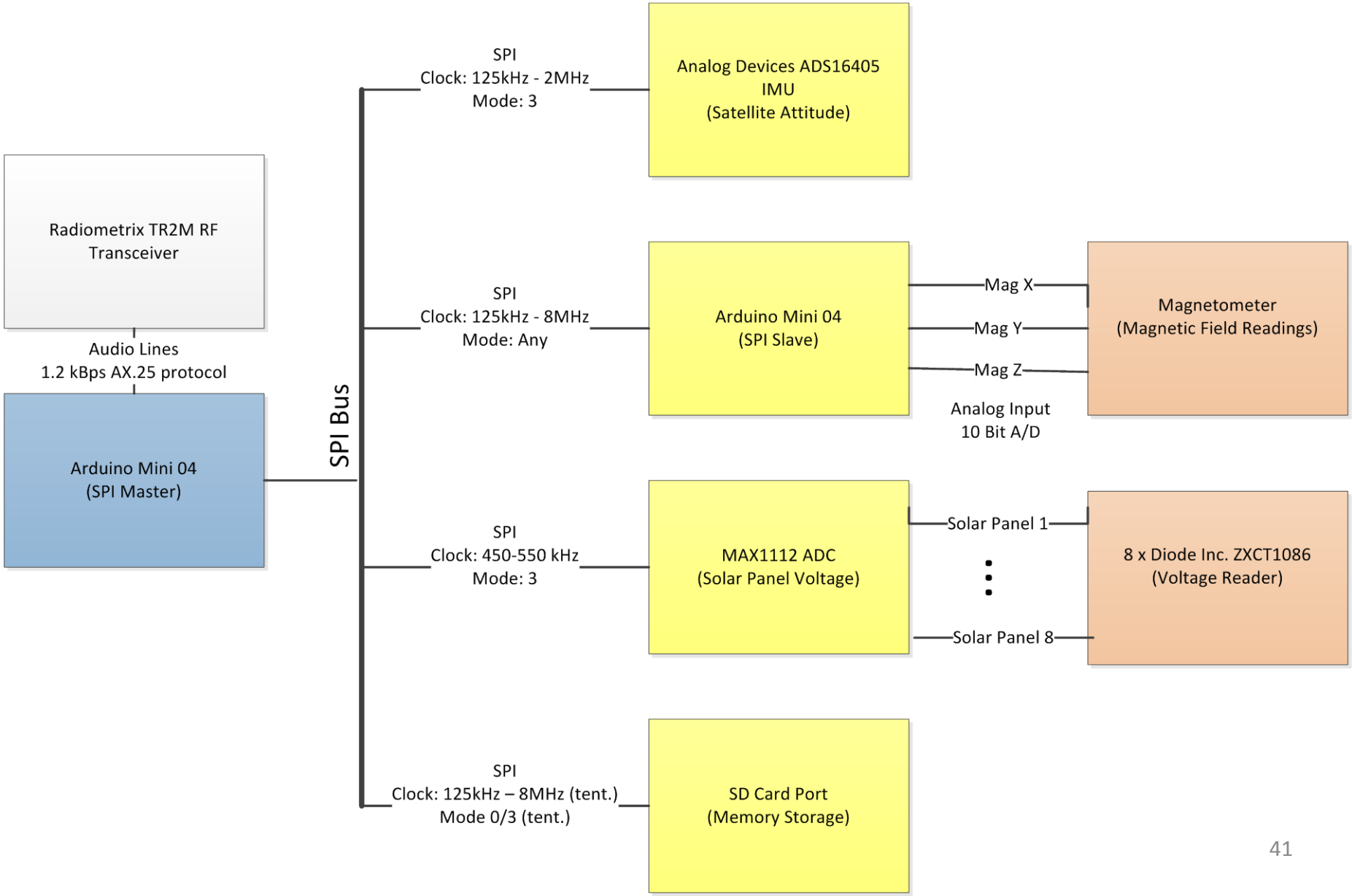
On Orbit Checkout Phase
Objective: (1) Battery charged & charging rates consistent (2) Communications Healthy (3) Uplink/Downlink Schedules established (4) subsystems healthy (support OPS)



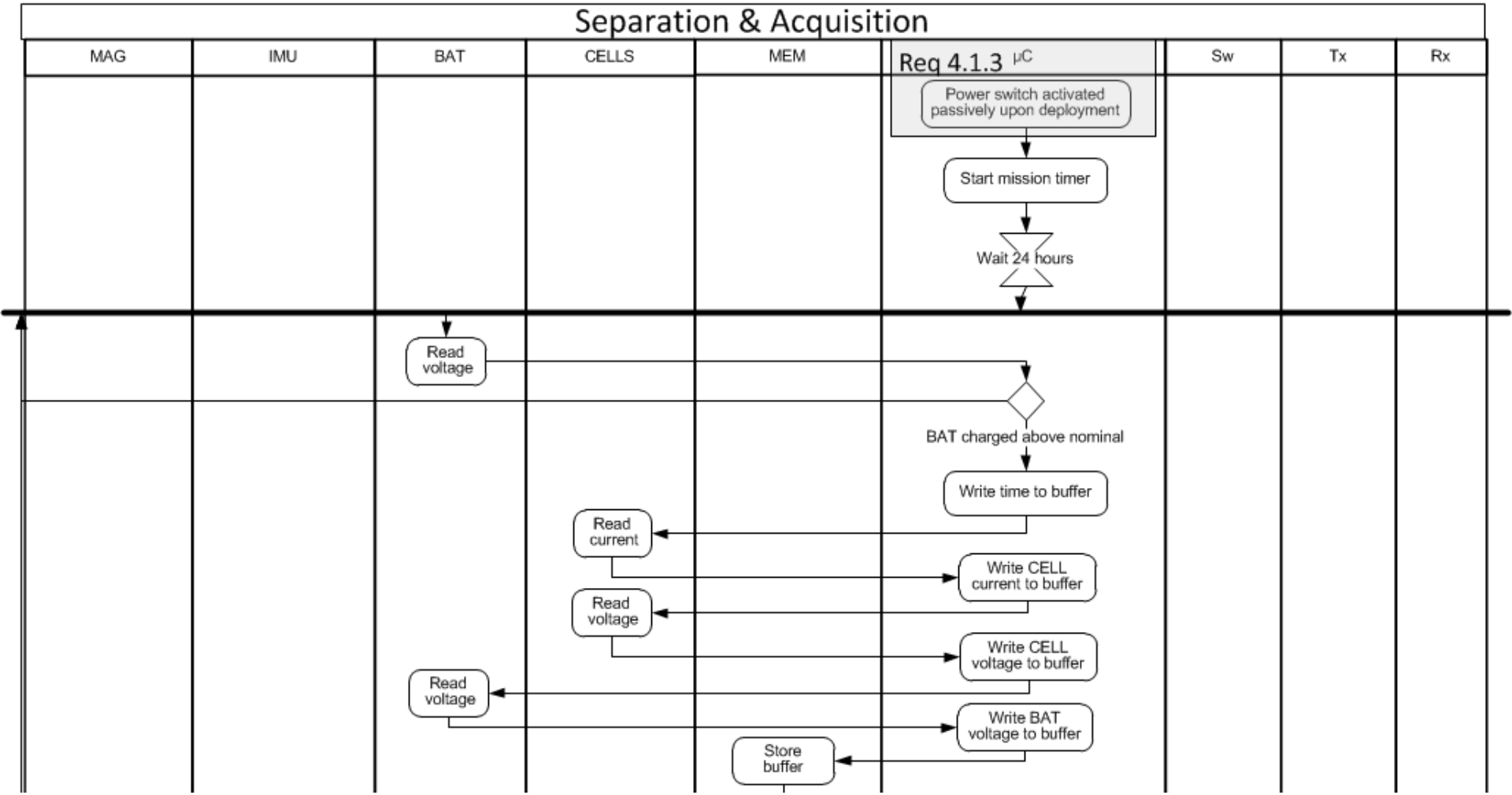
Operations Phase
Objective: (1) Science data received on ground (2) Communications between spacecraft (3) Subsystems updated & up/downlink schedules adjusted
(4) Failures are predicted and avoided



Hardware Architecture



Software Architecture: S&A



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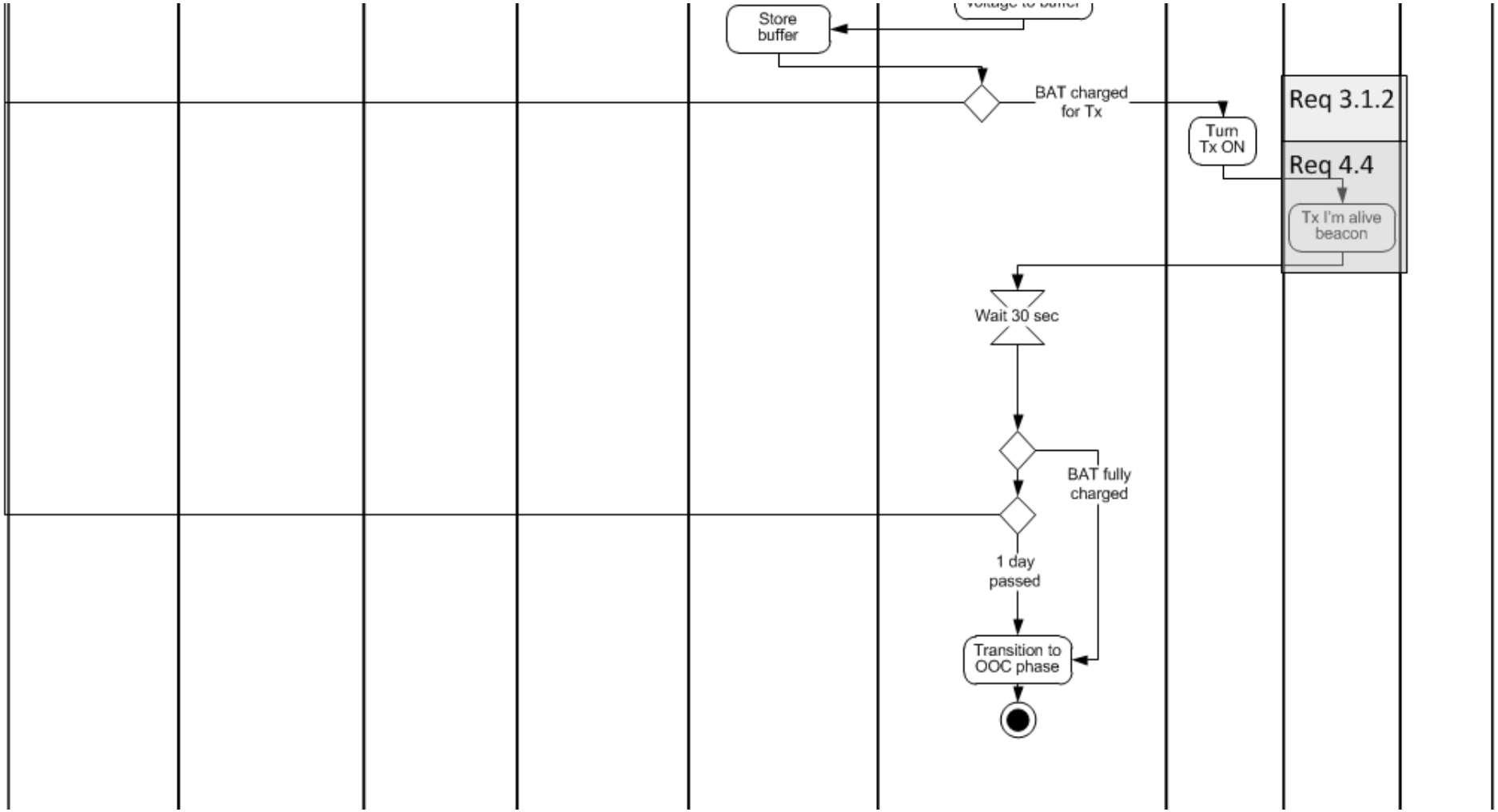
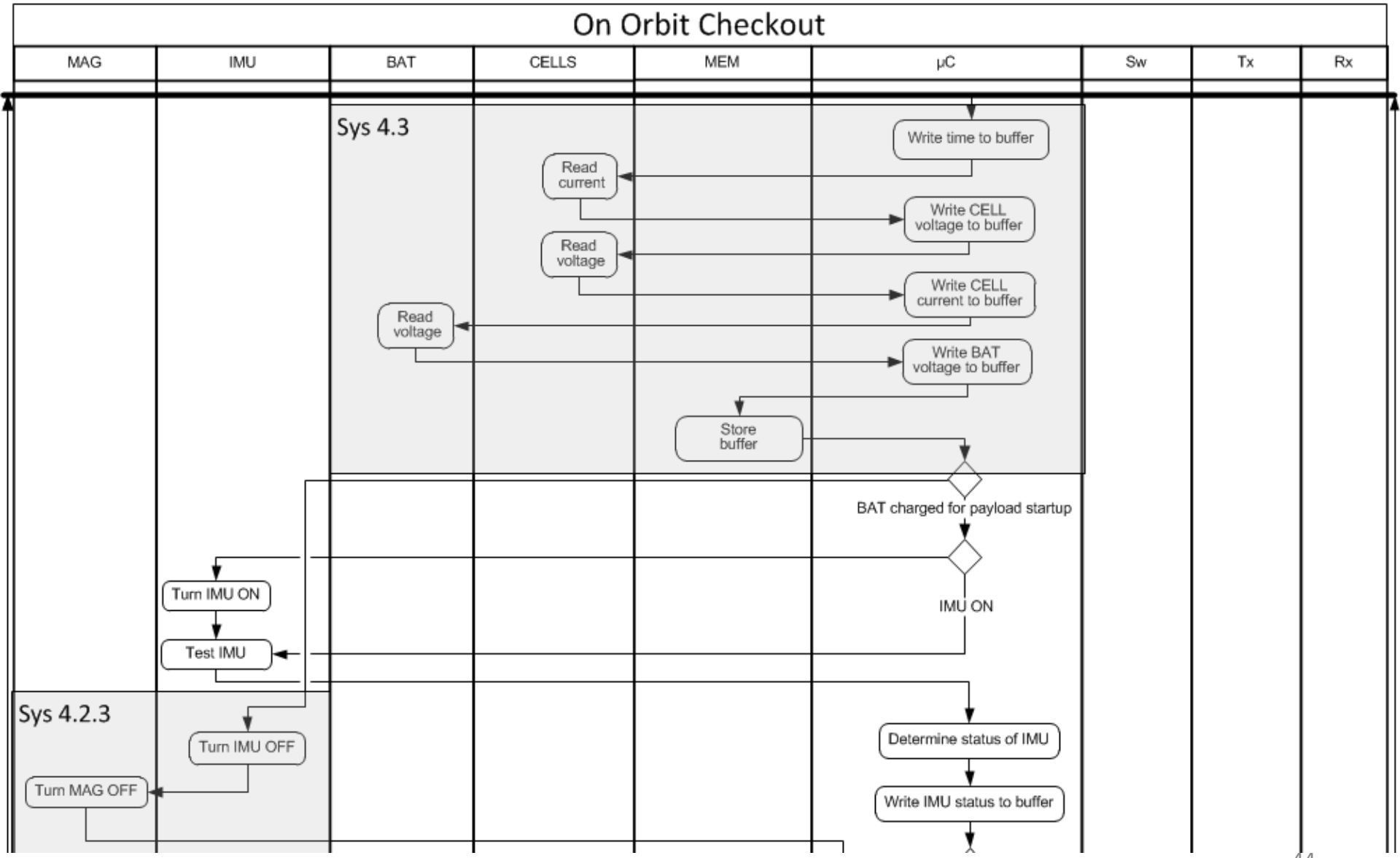


Software Architecture: OOC



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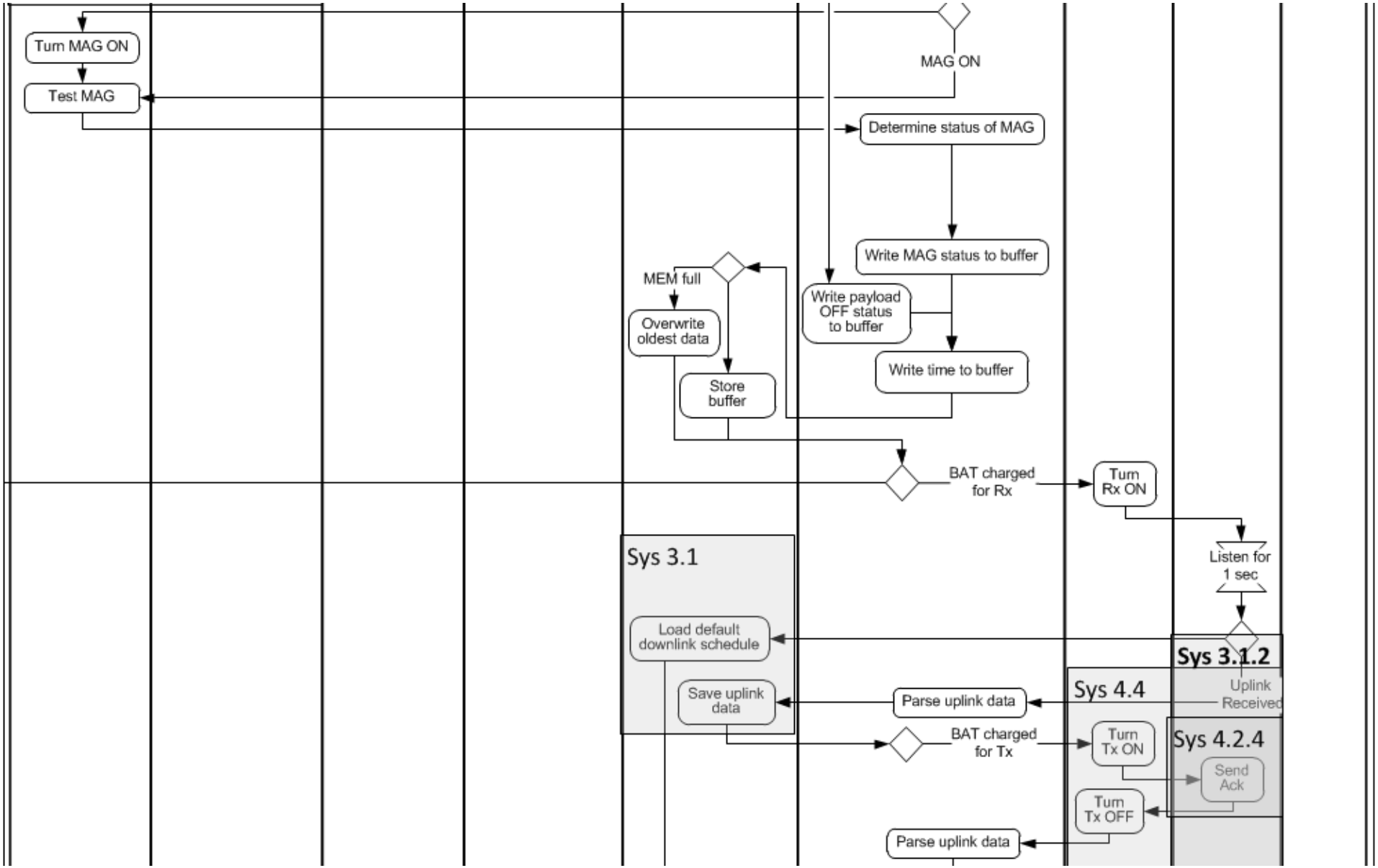

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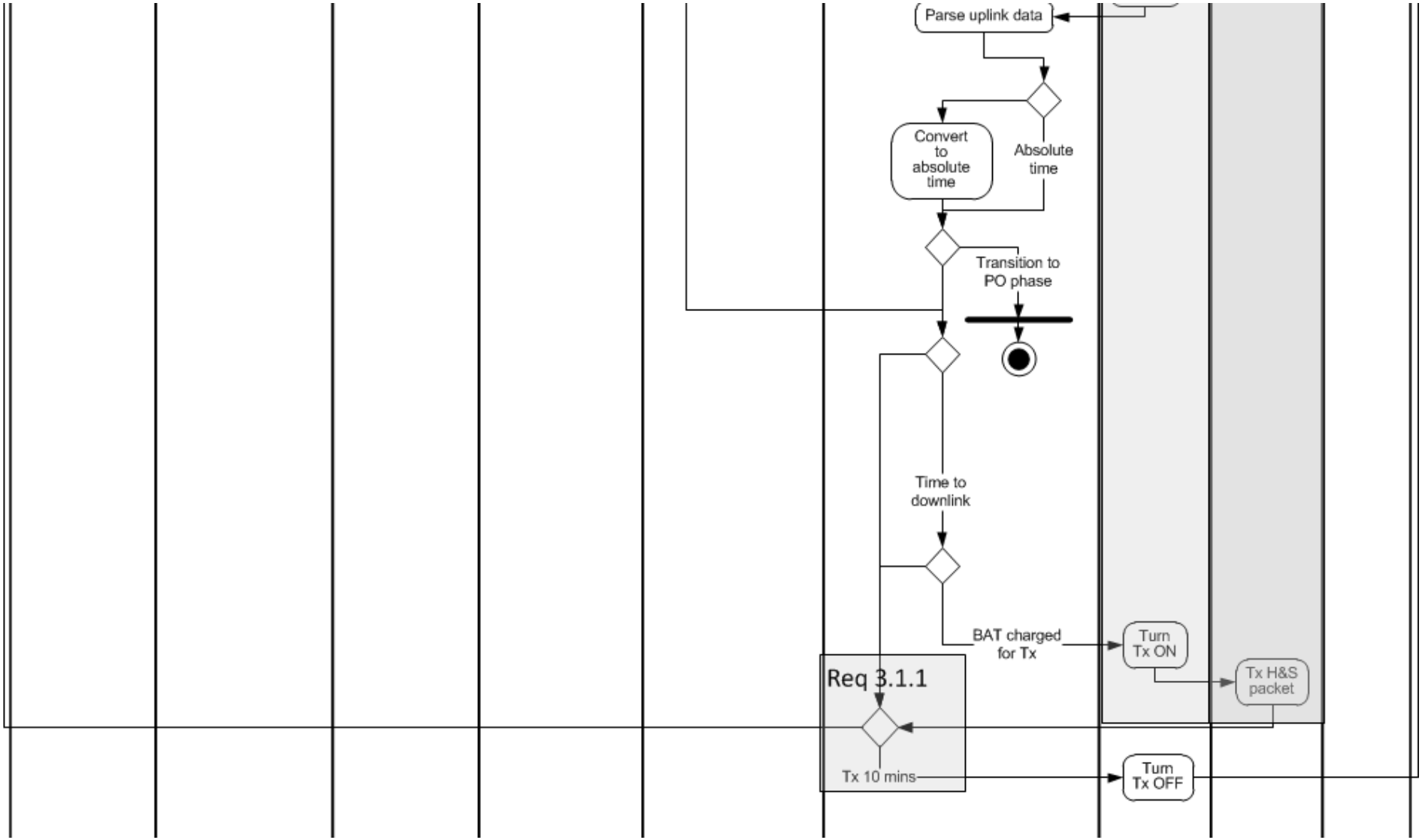
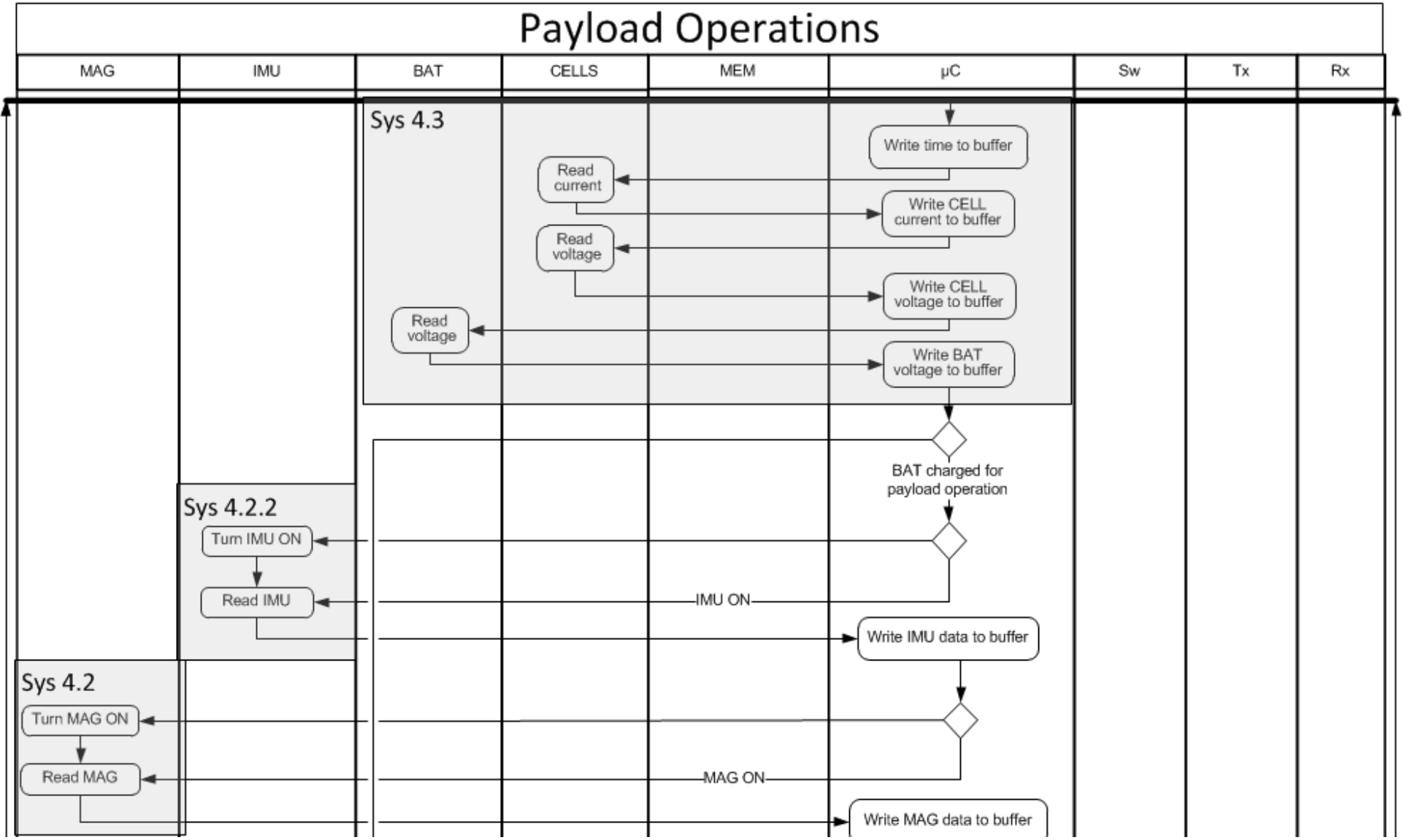


Software Architecture: PO



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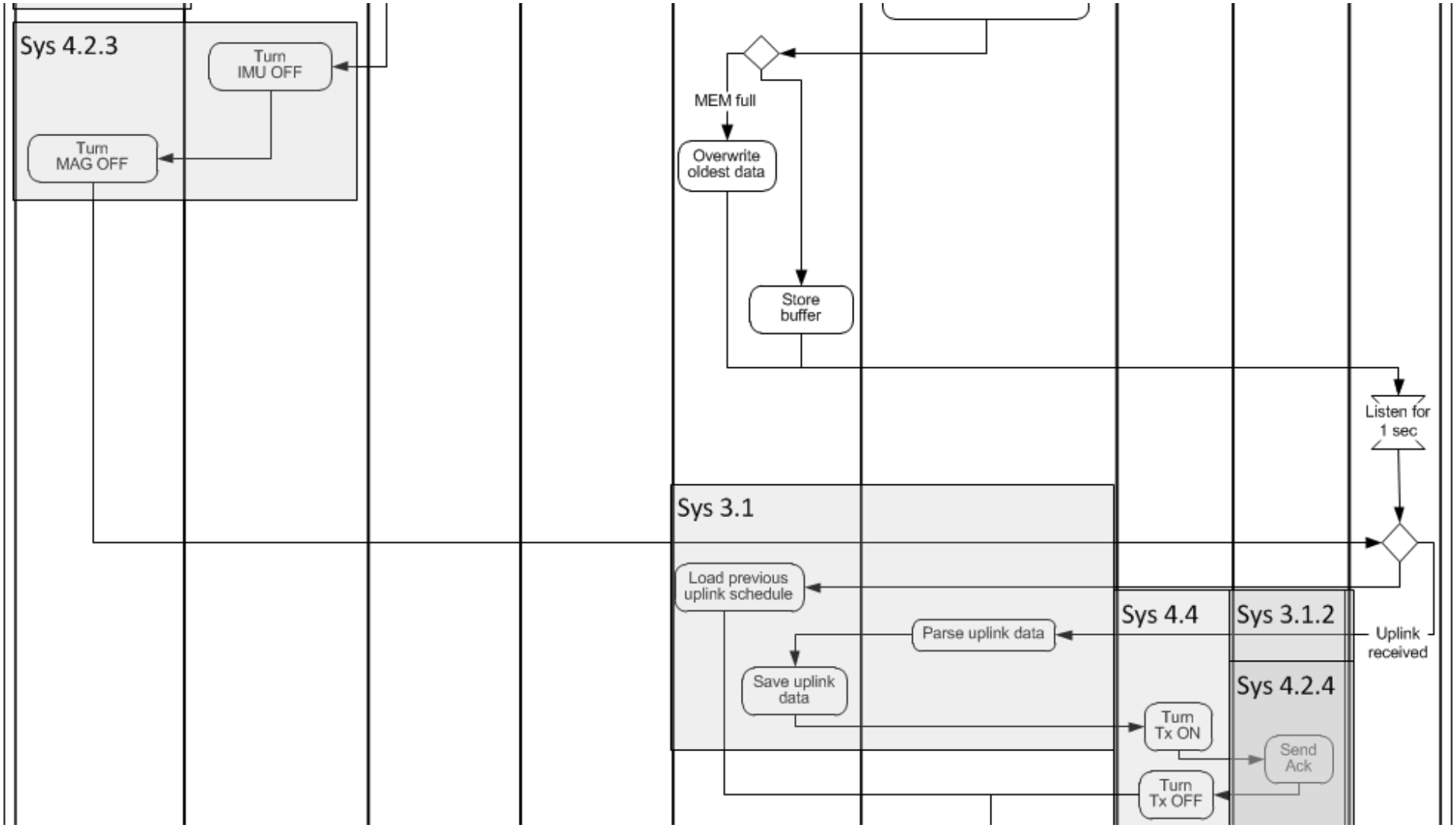
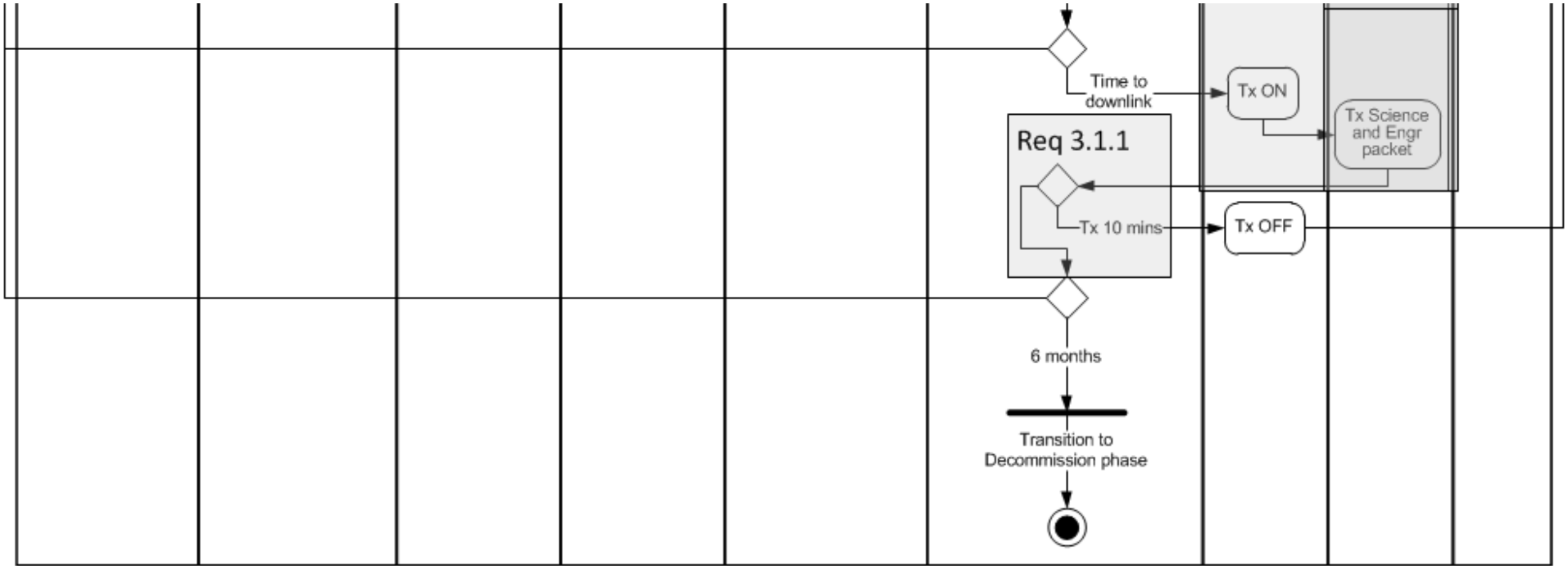


Software Architecture: PO



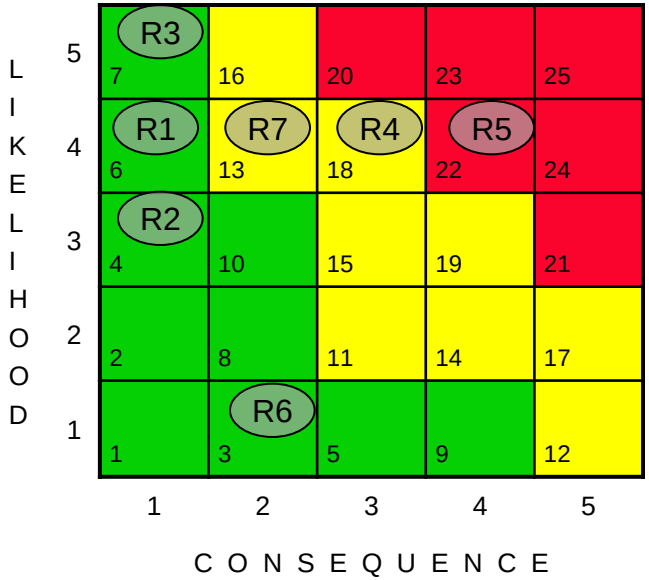
OC-Flight-1 Risk Summary

- 7 risks associated with system requirements have been identified
  - 1 High
  - 2 Moderate
  - 4 Low

- Risks have been reviewed against a set of recommended controls/mitigations to minimize inherent risk when feasible

- Currently evaluating major concerns regarding launch provider

- Further risk analysis in-progress
  - Utilizing internal Risk Management Process



Risk Analysis

- Sys_1.0: Knowledge Management
  - R1: Quantitative gain vs. qualitative gain (Sys_1.1)
- Sys 2.0: Provide Science Data
  - R2: Getting a stand-alone website in place by launch (Sys_2.2)
  - Data may not be found useful (Sys_2.3)
- Sys 3.0: Standards & Laws
  - R3: Tumbling s/c may cause discontinuous radio communication (Sys_3.1)

Risk Analysis

- Sys 4.0: Acquiring Data
  - **R4: Launch provider is still in testing/development phase (Sys_4.1.2)**
  - **R5: NORAD tracking error (Sys_4.2.1)**
- Sys 5.0: Environments
  - R6: Using COTS and non-radiation hardened PCBs/components (Sys_5.1)

Exit Criteria

- System Requirements established
  - Strategy for development presented
- Acceptance Level Testing plan established
  - Strategy for ensuring requirements presented
- System Architecture defined
  - Scenario-based diagrams presented
  - Requirements mapped to spacecraft subsystem architecture
- Risks acknowledged and assessed
  - Further analysis on-going

Q & A

Questions?

PHA Results

Frequency of Occurrence	Hazard Categories			
	I Catastrophic	II Critical	III Marginal	IV Negligible
(A)Frequent	1A	2A	3A	4A
(B) Probable	1B	2B	3B	4B
(C) Occasional	1C	2C	3C	4C
(D) Remote	1D	2D	3D	4D
(E) Improbable	1E	2E	3E	4E

Hazard Risk Index	HRI	Suggested Criteria
1A,1B, 1C, 2A, 2B, 3A	1	Unacceptable
1D, 2C, 2D, 3B, 3C	2	Undesirable (Management Decision Required)
1E, 2E, 3D, 3E, 4A, 4B	3	Acceptable with review by Management
4C, 4D, 4E	4	Acceptable without review

CONTROL NUMBER	HAZARD DESCRIPTION	CAUSES	EFFECTS	S-P 1	HRI 1	RECOMMENDATIONS	S-P 2	HRI 2
1	Dipole antennas injure personnel	• Inadvertent contact with sharp corners/edges on the dipole antennas	• **Minor personnel laceration or puncture**	IV-D	4	• File/sand the corners of antennas	IV-E	4
2	On Board Batteries explode, catch fire, or rupture and leak toxic gas	• Incorrect charging of battery (over charging, charge rate) • Incorrect discharge of battery (rapid discharge rate) • Short circuit • Manufacturing defect	• **Moderate injury/burn of personnel** • Damage to surrounding hardware	III-D	3	• Source Li-ion battery will internally protect against overcharging • Solar array charging is incapable of exceeding safe charge rate or charge level • Document charging procedure and train operators • Maximum nominal power consumption of all boards will not exceed safe discharge rates • Circuit breaker and power regulation switches are used to remove power if the current draw rises above the set point • Keyed connectors (to prevent reverse polarity) • Use of insulated wiring and connections (to avoid short circuits) • Source battery from well known/reliable manufacturer	III-E	3
3	Yagi antenna injures personnel	• Inadvertent contact with sharp corners	• **Minor personnel laceration or puncture**	IV-D	4	• File/sand the corners of antenna directors	IV-E	4

Software Safety Criticality Assessment

PURPOSE AND SCOPE OF ASSESSMENT						
Assessment Purpose		☒ Initial assessment		☐ Update to previous assessment		
Assessment Type	☐ Facility	☐ System	☐ Contract	☐ Program	☐ Project	☒ Other
Description		Perform assessment in support of the NASA IVV OCF1 outreach project				

CSCI/ CSC/ Application Identity	**Software Classification**	**Software Safety Criticality**
On Board Flight Software	D	No
Ground Software	E	No
Test/Simulation Software	E	No

Impact To Existing requirements		
☒ N/A (initial assessment)	☐ No change	☐ Update required (describe changes in comments)

Rationale and Comments:
OC-Flight-1 has a primary mission of outreach and teaching. Complete failure of the spacecraft during flight does not constitute a failure of the primary mission, thus safety-criticality does not include damage to flight hardware. OC-Flight-1 software (ground and on-board) does not influence any identified hazards and, thus, has been determined to not be safety-critical. The onboard flight software has been classified as D because Class E can not include any space flight systems. The ground and test software meets the criteria for class E software as defined in NPR 7150.2A.

OC-Flight-1 Risk 1– Internal

Risk Title	Sys_1.0: Knowledge Management- Qualitative Gain
Risk Statement	Given that results from questionnaires and surveys tend to be more qualitative than quantitative, there is a risk that the knowledge gained by participants will be hard to gauge quantitatively.
Context Statement	The OC-Flight-1 Mission is the first increment of a series of missions in the NASA IV&V Space Flight Design Challenge to achieve a set of over-arching goals and objectives.
Closure Criteria	A quantitative assessment of knowledge gained is not considered as a success criterion for knowledge management of first increment.

LIKELIHOOD	1	2	3	4	5
5	7	16	20	23	25
4	R1 6	13	18	22	24
3	4	10	15	19	21
2	2	8	11	14	17
1	1	3	5	9	12

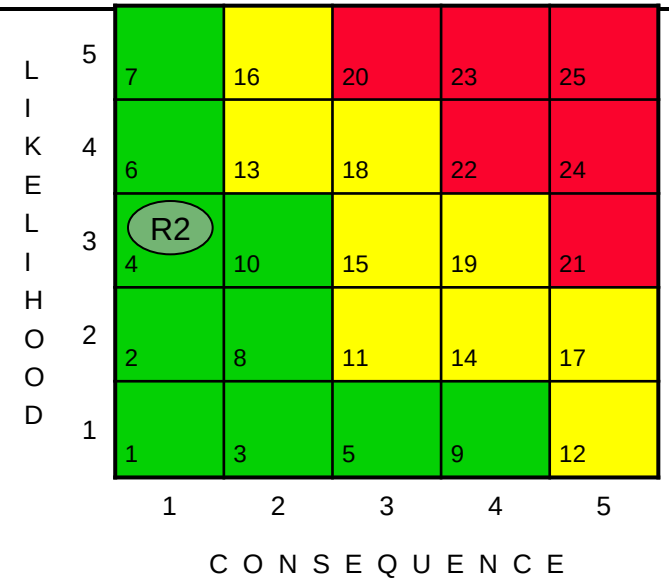
CONSEQUENCE

	Date
Sunrise	9/1/2011
Sunset	12/1/2013
Impact Horizon	Long

Consequence	Rationale	Likelihood	Rationale
1	While a qualitative assessment of knowledge gained does not provide a numerical value to index individual performance, it does provide tangible evidence that positive learning was realized ensuring the requirement.	4	The implementation plan for knowledge management currently focuses on the use of questionnaires/surveys to capture the knowledge gained. Graded assessments will not be performed

OC-Flight-1 Risk 2 – Internal

Risk Title	Sys_2.0: Provide Science Data – Stand-Alone Website
Risk Statement	Given that the workload of the students supporting project development decreases drastically when classes are in session, there is a possibility that a stand-alone website may not be put in place.
Context Statement	The purpose of the website is to satisfy the requirements for receiving and providing science data to the public while ensuring authorized use and integrity of data.
Closure Criteria	The system requirements can still be met using the standard emailing system and adding information to existing web pages



	Date
Sunrise	9/1/2013
Sunset	12/1/2014
Impact Horizon	Long

Consequence	Rationale	Likelihood	Rationale
1	While having a stand-alone website to handle data requests and to ensure documentation is completed correctly before providing data would lessen the workload of personnel, these tasks could still be performed through a structured data request process managed by assigned team members.	3	The website architecture and layout has not yet been designed, however links on existing Space Grant website could be put in place whenever a design has been established and students supporting the project can implement the webpage.

OC-Flight-1 Risk 3 – Internal

Risk Title	Sys_2.0: Provide Science Data – Usefulness
Risk Statement	Given that the earth's magnetic field data is widely available at higher resolutions, there is a possibility that the scientists requesting the data may not find the data provided useful.
Context Statement	The OC-Flight-1 Mission is the first increment of a series of missions in the NASA IV&V Space Flight Design Challenge to achieve a set of over-arching goals and objectives. Future increments will focus on improving the datasets and pushing the envelope of game-changing technologies in software and systems engineering.
Closure Criteria	Further information will be gathered pertaining to why the data was not found useful (type of data, resolution, missing datasets, data corruption, etc) in effort to improve the current design for future increments.

LIKELIHOOD	1	2	3	4	5
5	R3 7	16	20	23	25
4	6	13	18	22	24
3	*4*	10	15	19	21
2	2	8	11	14	17
1	1	3	5	9	12

CONSEQUENCE

	Date
Sunrise	9/1/2013
Sunset	12/1/2014
Impact Horizon	Long

Consequence	Rationale	Likelihood	Rationale
1	While providing useful data to Scientist and Engineers is an over-arching goal of the NASA IV&V SFDC, it is not a main objective for this increment. However, the capturing the level of usefulness of the data is considered an objective for this increment.	5	The magnetic field of the earth is well-documented and readily available, therefore it is likely that some Scientists and Engineers will not find the provided data to be particularly useful.

OC-Flight-1 Risk 4 – External

Risk Title	*Sys_3.0: Standards & Laws – Intermittent Transmission*
Risk Statement	Given that the spacecraft is expected to be deployed in a tumbling state, there is a possibility that the tumbling of the spacecraft could cause discontinuous radio communication
Context Statement	The antenna type used on the spacecraft is a direction half-wave dipole antenna which transmits and receives signals most efficiently when pointed toward the source or ground station
Closure Criteria	There is no active attitude control system onboard the spacecraft to direct the antenna toward the desired ground station therefore communication will occur when permissible.

LIKELIHOOD	1	2	3	4	5
5	7	16	20	23	25
4	6	13	18 (R4)	22	24
3	4	10	15	19	21
2	2	8	11	14	17
1	1	3	5	9	12

CONSEQUENCE

	Date
Sunrise	8/1/2013
Sunset	12/1/2013
Impact Horizon	Mid

Consequence	Rationale	Likelihood	Rationale
4	While continuous transmission allows the maximum amount of data transfer and minimizes the possibility of missed uplinks, intermittent communication still allows for opportunities to uplink and downlink desired data.	3	The severity of the tumbling state in which the spacecraft is deployed on-orbit and the impact on the effectiveness of tumbling on data transmission is uncertain. However, it is known that the tumbling state will be dampened by the gravity gradient effect due to the center of mass being located close to the antenna.

OC-Flight-1 Risk 5 – External

Risk Title	Sys_4.0: Acquiring Data – Launch Provider
Risk Statement	Given that the launch provider is still in the testing/development phase, there is a possibility that the tentative launch date will slip indefinitely.
Context Statement	Interorbital Systems (IOS) is a rocket and spacecraft manufacturing company currently developing an innovative modular rocket system designed to send a multitude of TubeSats into LEO. IOS is currently the only launch provider that offers the TubeSat PS kit. Due to unforeseen complications with testing and development, IOS has already slipped from the tentative launch date from Summer 2012 to Summer 2013.
Closure Criteria	OC-Flight-1 development continues with a transition from the TubeSat design to a CubeSat design, allowing for alternative launch opportunities outside of IOS

LIKELIHOOD	1	2	3	4	5
5	7	16	20	23	25
4	6	13	18	R5 22	24
3	4	10	15	19	21
2	2	8	11	14	17
1	1	3	5	9	12

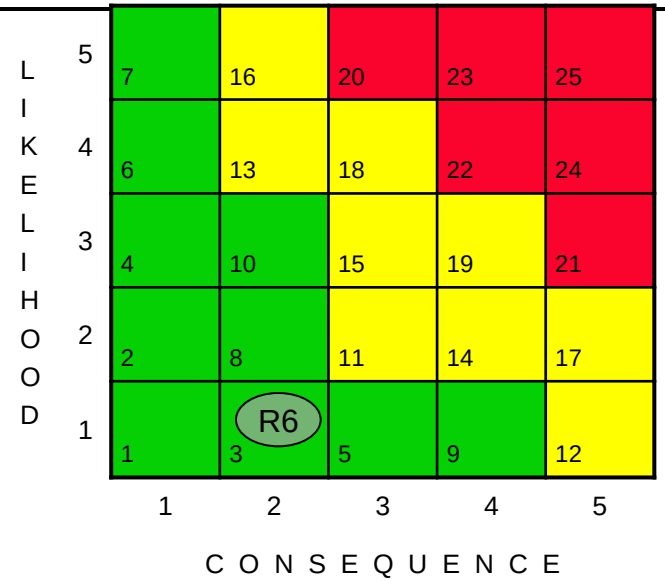
CONSEQUENCE

	Date
Sunrise	9/1/2012
Sunset	9/1/2013
Impact Horizon	Short

Consequence	Rationale	Likelihood	Rationale
4	While the TubeSat kit is less expensive than the CubeSat kit and a launch with IOS is already funded, alternative launch opportunities are available if the design transitions to CubeSat. This would allow the current project schedule to be maintained with funding for additional materials and launch provider.	4	The launch date has already slipped by 1 full year since project development began. Testing and development of IOS has been reported, however there is no evidence to support or even suggest that the current (tentative) launch date will not slip significantly (by quarter).

OC-Flight-1 Risk 6 – External

Risk Title	Sys_4.0: Acquiring Data – NORAD Error
Risk Statement	Given that the position of the spacecraft will be tracked via NORAD and that several TubeSats will be deployed on-orbit, there is a possibility that some amount of error will be introduced in the TLEs of OC-Flight-1 provided by NORAD.
Context Statement	Interorbital Systems (IOS) is a rocket and spacecraft manufacturing company currently developing an innovative modular rocket system designed to send a multitude of TubeSats into LEO. The spacing in the deployment of each TubeSat is currently unknown.
Closure Criteria	Uplink attempts will be initiated in advance in order to account for errors in position tracking.



	Date
Sunrise	8/1/2013
Sunset	12/1/2013
Impact Horizon	Mid

Consequence	Rationale	Likelihood	Rationale
1	While more accurate position fixes on the spacecraft would introduce more confidence in uplink timing, the amount of error should be within some seconds which should be easily managable.	2	The accuracy and resolution of NORAD tracking is currently unknown to the development team, however a high level of confidence is held in regards to the accuracy of the TLE's provided by NORAD.

OC-Flight-1 Risk 7 – External

Risk Title	Sys_5.0: Environments - Radiation
Risk Statement	Given that the spacecraft will utilize COTS and non-radiation hardened PCBs, there is a possibility that the lifespan of the spacecraft may be reduced significantly by subjection to high levels of radiation on-orbit.
Context Statement	The NASA IV&V Space Flight Design Challenge (SFCD) focuses on utilizing COTS and design kits to keep total costs to a minimum while achieving the over-arching goals and objectives. Using custom made (radiation hardened) components and performing acceptance level testing on radiation would drive the project cost up significantly thereby violating the spirit of the challenge/initiative.
Closure Criteria	The risk of high radiation levels is realized. Custom made components and radiation hardened materials will not be used on OC-Flight-1 in effort to maintain the spirit of the NASA IV&V SFDC

LIKELIHOOD	1	2	3	4	5
5	7	16	20	23	25
4	6	R7 13	18	22	24
3	4	10	15	19	21
2	2	8	11	14	17
1	1	3	5	9	12

CONSEQUENCE

	Date
Sunrise	8/1/2013
Sunset	12/1/2013
Impact Horizon	Mid

Consequence	Rationale	Likelihood	Rationale
2	While a shortened lifespan of the spacecraft would limit the total amount of data collected, any data collected and correlated on the ground can be considered as mission success.	4	The spacecraft will not be designed to withstand the radiation levels inherent in LEO for the entire duration of the orbital lifespan, therefore the spacecraft is not expected to be functional during the decommissioning phase. However, the exact lifespan of the spacecraft is currently unknown.