SLS EM-1 Secondary Payload Phase X Safety Review for Payload Name

Date Here (month & year)

Safety Review Agenda- Phase X

- **10:00 A.M.-10:10 A.M., Introduction**
  - Introduction and Opening Remarks by Panel Chairperson
- **10:10 A.M.- 11:00 P.M. , Payload Name Overview**
  - Mission Overview
  - Spacecraft Design Overview (includes Battery Concepts)
- **11:00 P.M.- 12:00 P.M., Payload Name Safety**
  - Payload Safety Engineer Preliminary Safety Assessment
  - Compliance with SLS Safety Requirements
  - Anticipated Hazards
- **12:00 P.M.- 12:30 P.M., Closing**
  - Actions/Discussion
  - Closing

Note: Times can be adjusted based on payload time zone. This example reflects a PDT payload.

*All times noted in Central Time.

Payload Name

Presenter(s): Presenter Name(s)

Note: The following is a set of suggestions (outlines) to aid in describing the payload. More charts can be added to express the payload design and any potential hazards.

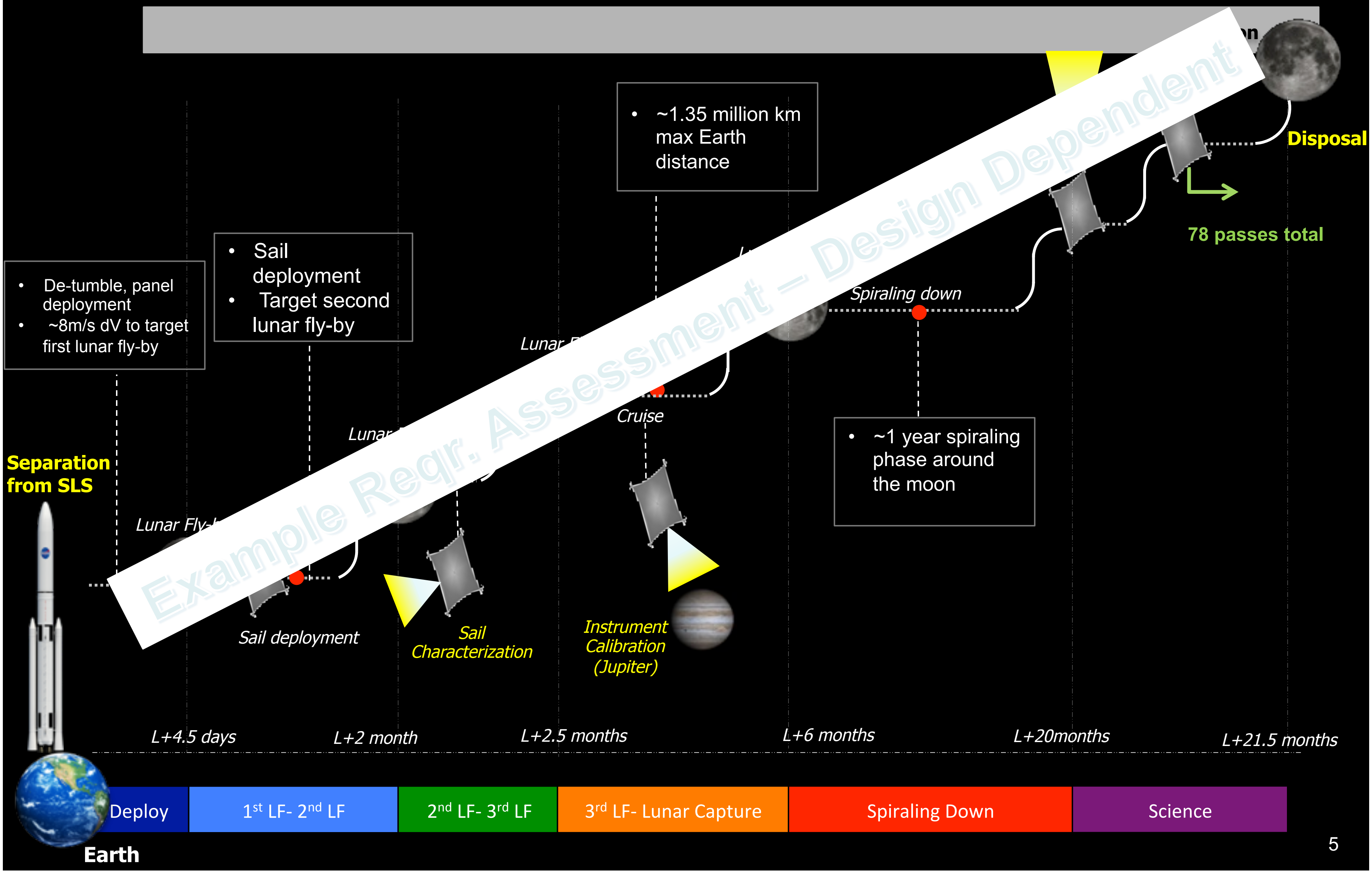
Payload Name Objectives

- **SKG Addressed**: Understand the quantity and distribution of water and other volatiles in lunar cold traps
- Look for surface ice deposits and identify favorable locations for in-situ utilization
- Recent robotic mission data (Mini-R… LCROSS) strongly suggest th… presence of ice deposit… permanently shad… …ers.
- Locations w… …er measures the coldes… …nd temperatures also h… …alous reflectivity in LOLA an… …AMP data, suggesting water frost

Sunlight is specularly reflected off the sail down to the lunar surface in a 3 deg beam. Light diffusely reflected off the lunar surface enters the spectrometer to distinguish water ices from regolith.

Example Reqr. Assessment – Design Dependent

Payload Name
Concept of Operations



Payload Name Flight System Overview

Payload	• NEA Scout: Malin Space Science Systems ECAM-M50 imager w/NFOV optics w/ Static color filters (400-900 nm) • Lunar Flashlight: Custom spectrometer
Mechanical & Structure	• "6U" CubeSat form factor (~10x20x30 cm) • <12 kg total launch mass • Modular flight system concept
Propulsion	• ~85 m^2 aluminized Kapton solar sail (based on NanoSail-D2)
Avionics	• Radiation tolerant LEON3-FT architecture
Electrical Power System	• Simple deployable solar arrays with UT... cells (~35 W at 1 AU solar distance... • 6.8 Ah Battery (3s2p 18650 L... • 10.5-12.3 V unregulat... ...ulated
Telecom	• JPL Iris 2.0 X-... ...er; 2 W (NEA Scout) a... ...ashlight) RF supports do... ...D-DOR • ...IRE-heritage LGAs (RX/TX) • ...ashlight: ~500 bps to 34m DSN at all ...es • NEA Scout: 8x8 element microstrip array HGA (TX); ~500 bps to 34m DSN at 0.8 AU
Attitude Control System	• 15 mNm-s (x3) & 100 mNm-s RWAs • Zero-momentum slow spin during cruise • VACCO R-236fa (refrigerant gas) RCS system • Nano StarTracker, Coarse Sun Sensors & MEMS IMU for attitude determination

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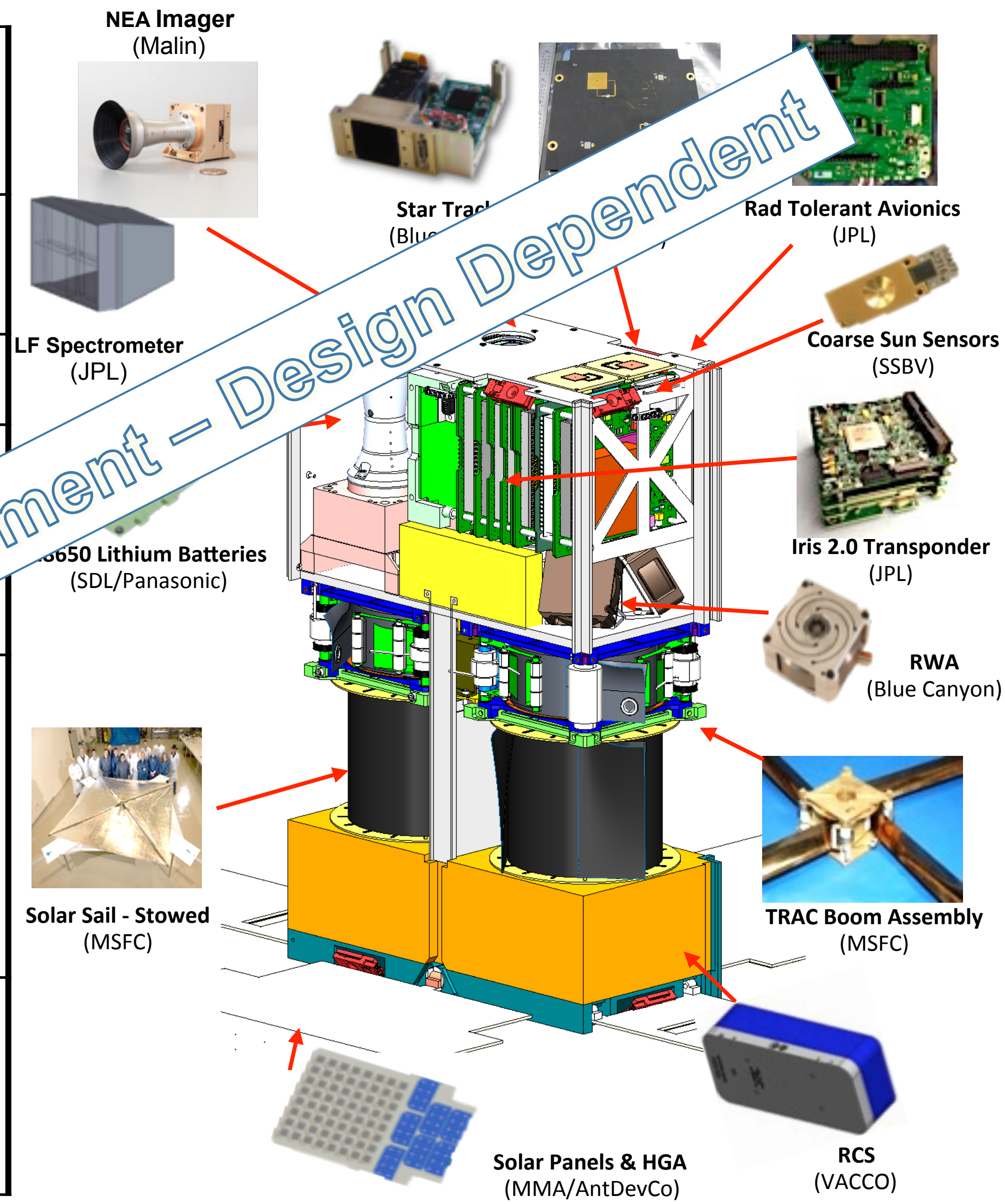
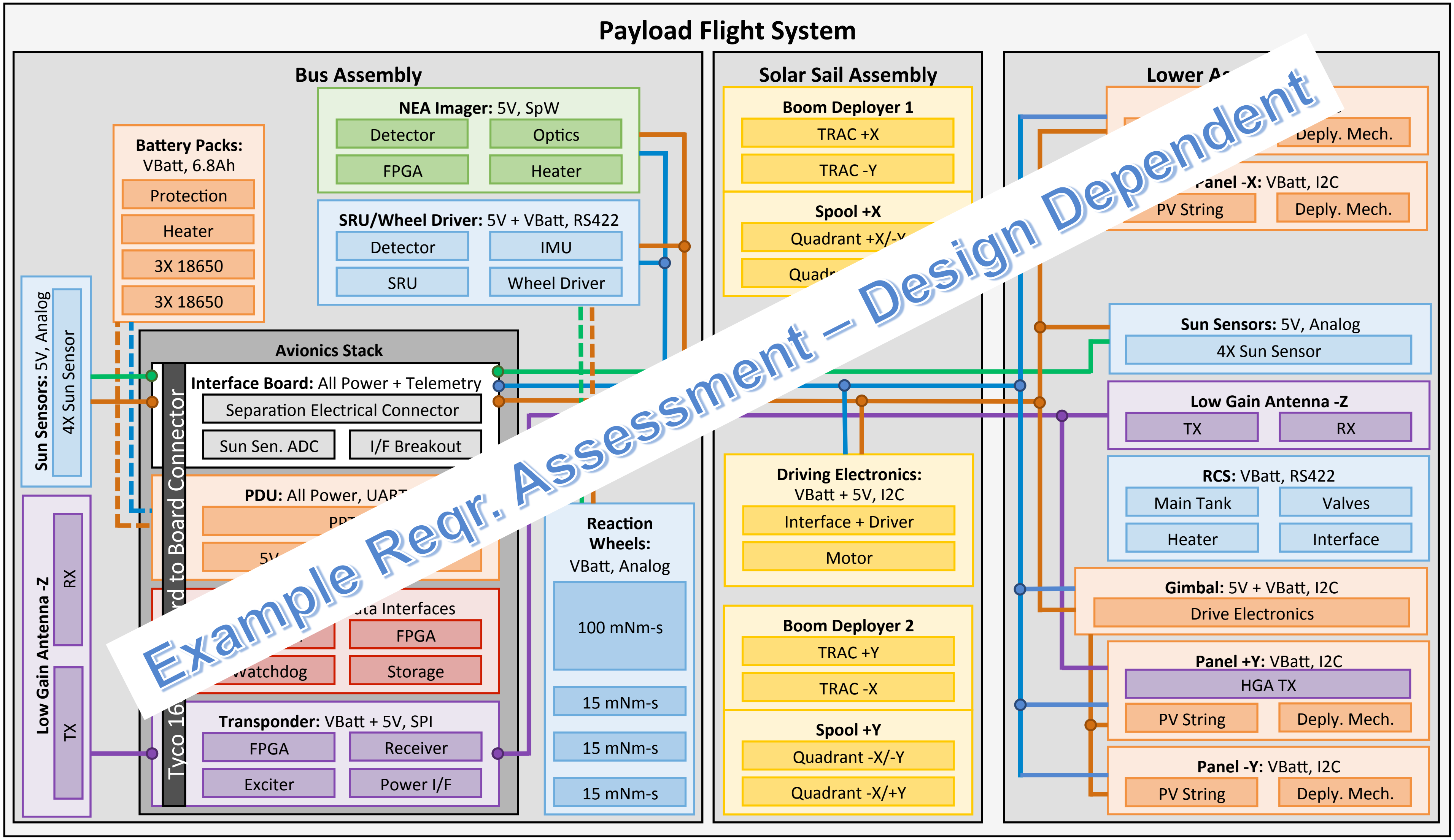
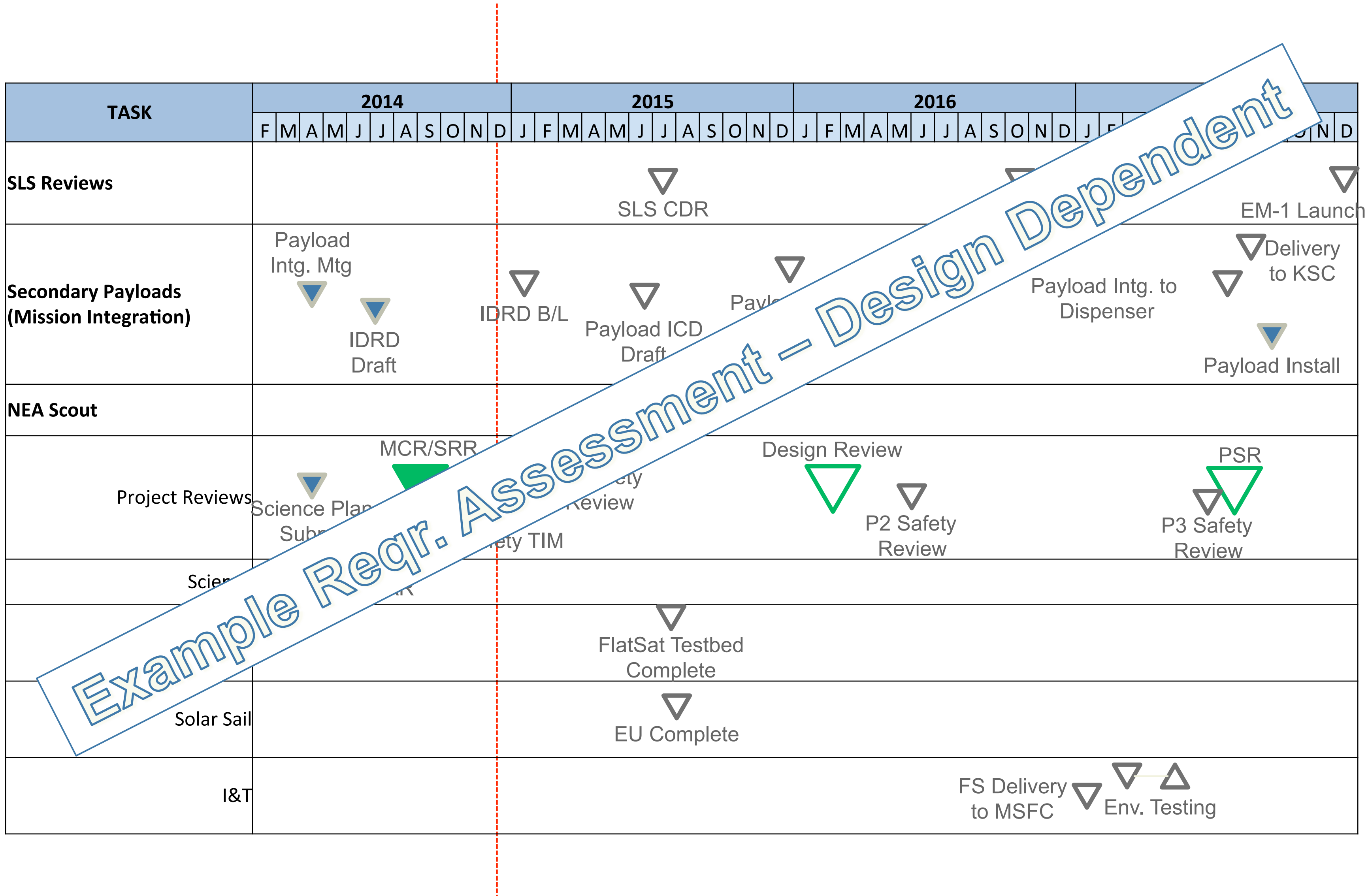
Example Reqr. Assessment – Design Dependent





Payload Flight System
Bus Assembly
Battery Packs: VBatt, 6.8Ah
Protection
Heater
3X 18650
3X 18650
NEA Imager: 5V, SpW
Detector
Optics
FPGA
Heater
SRU/Wheel Driver: 5V + VBatt, RS422
Detector
IMU
SRU
Wheel Driver
Sun Sensors: 5V, Analog
4X Sun Sensor
Avionics Stack
Interface Board: All Power + Telemetry
Separation Electrical Connector
Sun Sen. ADC
I/F Breakout
PDU: All Power, UART
Watchdog
FPGA
Storage
Transponder: VBatt + 5V, SPI
FPGA
Receiver
Exciter
Power I/F
Low Gain Antenna -Z
RX
TX
Reaction Wheels: VBatt, Analog
100 mNm-s
15 mNm-s
15 mNm-s
15 mNm-s
Solar Sail Assembly
Boom Deployer 1
TRAC +X
TRAC -Y
Spool +X
Driving Electronics: VBatt + 5V, I2C
Interface + Driver
Motor
Boom Deployer 2
TRAC +Y
TRAC -X
Spool +Y
Quadrant -X/-Y
Quadrant -X/+Y
Deply. Mech.
Panel -X: VBatt, I2C
PV String
Deply. Mech.
Sun Sensors: 5V, Analog
4X Sun Sensor
Low Gain Antenna -Z
TX
RX
RCS: VBatt, RS422
Main Tank
Valves
Heater
Interface
Gimbal: 5V + VBatt, I2C
Drive Electronics
Panel +Y: VBatt, I2C
HGA TX
PV String
Deply. Mech.
Panel -Y: VBatt, I2C
PV String
Deply. Mech.
Example Reqr. Assessment – Design Dependent

Schedule


TASK
2014
2015
2016
F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
SLS Reviews
SLS CDR
EM-1 Launch
Secondary Payloads (Mission Integration)
Payload Intg. Mtg
IDRD Draft
IDRD B/L
Payload ICD Draft
Delivery to KSC
Payload Intg. to Dispenser
Payload Install
NEA Scout
Project Reviews
MCR/SRR
Design Review
PSR
P2 Safety Review
P3 Safety Review
FlatSat Testbed Complete
Solar Sail
EU Complete
I&T
FS Delivery to MSFC
Env. Testing
Example Reqr. Assessment – Design Dependent

Launch Related Activities

Example Reqr. Assessment – Design Dependent

Ops Prior to Handover at KSC

- Cubesats will be turned over to the Launch Services Program dispenser integration contractor with bat[illegible] approximately 50% state of charge and prope[illegible]ded.
- Upon completion of cubesat-to-dispenser [illegible]on and required acceptance testing, dispen[illegible] transported to KSC for integration to the veh[illegible]
- Upon arrival at KSC, cubesa[illegible] final abbreviated functional test within th[illegible]yer (post-ship aliveness check).

Ops After H[illegible] at KSC

- In[illegible] system transferred to SLS/GSDO through a [illegible]49 for integration to the SLS MPCV Stage Adapter.
- [illegible]ubesats will be powered off during all remaining launch activities, with the exception of battery charging.
- Charge batteries to >95% SOC after integrated.

Spacecraft (SC) Operational Sequence

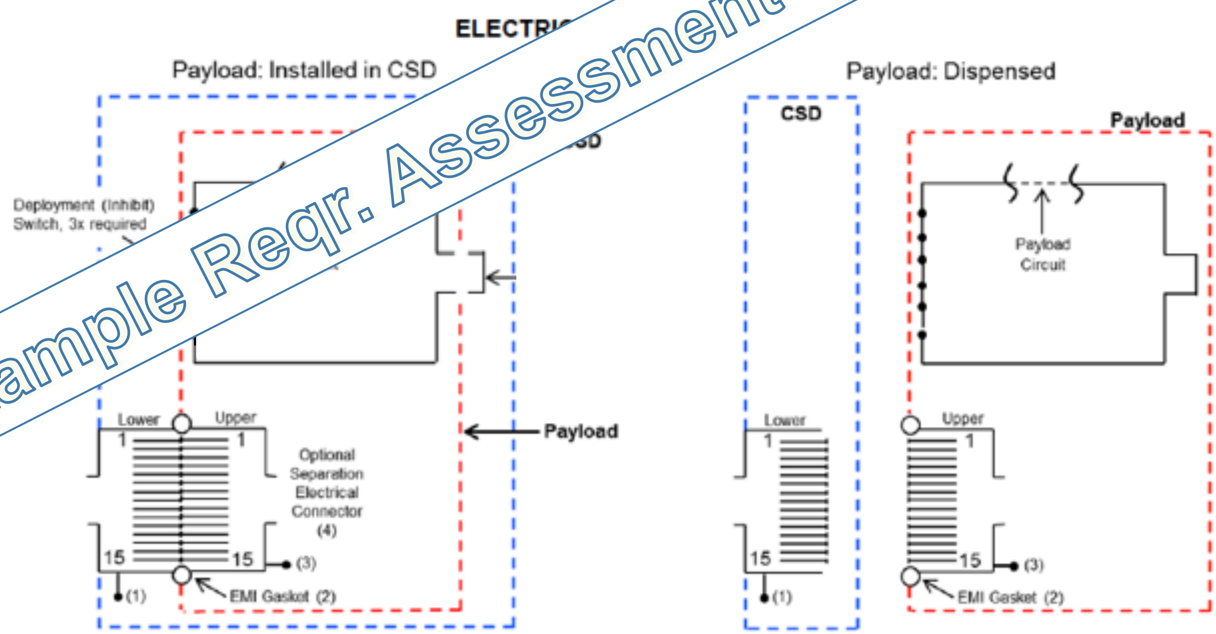
- SC is unpowered through ascent
- Once signal is sent to dispenser from sequencer, t... cubesat will separate.
- SC initiates autonomous power up sequ... ...ce the SC senses separation (through 2 mec... ...separation switches):
  - Power on
  - Boot up of flight softwa... ...y 2 minutes)
  - Close switch to al... ...ansmissions
  - Reaction wh... ...hrusters used to de-tumble spacecraft due to separati...
  - S... ...s deployed
  - ...transmitter beacon mode
- ...0 m/s Trajectory Correction Maneuver before L+24 hours
- Solar sail deployed at L+4 days (after first lunar flyby, depending on lunar transit time)

Example Reqr. Assessment – Design Dependent

Separation Switches

- Two mechanical switches provide two independent inh… to RF transmissions, solar array/sail deployment… …er firing, etc.
- Currently planning to put separations s… …n the sides of the spacecraft

Example Reqr. Assessment – Design Dependent



1) The metal shell conducts to the CSD via conductive surface treatments.
2) Required to assure electrical continuity between shells. Retained by Upper.
3) The metal shell conducts to the Payload via conductive surface treatments.
4) Optional connector is an in-flight disconnect. Produced by Planetary Systems Corp. See document 2001025 at www.planetarysys.com.

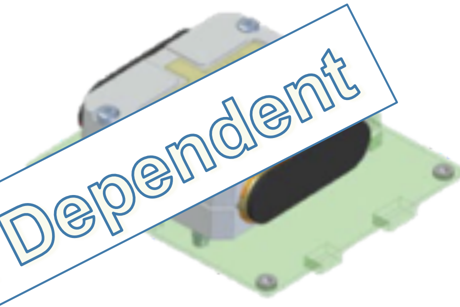
Figure 3: Electrical Schematic

Propellent Safety

- **Propellent is R-236fa**
  - 1,1,1,3,3,3-Hexafluoropropane
  - Link to Safety Data Sheet
  - Link to Safe Handling Instructions
  - SDS# 001163
- **Toxicity**
  - No known significant acute eff[illegible]ical hazards
  - LC50 inhalation dose of 9[illegible]m for 1 hour
  - AIHA WEEL expos[illegible]000 ppm for 8 hours
- **Hazards**
  - Can cau[illegible]e under rapid depressurization
    - ~S[illegible]Sentinel limits quantity required for coolant
  - [illegible]place oxygen
  - [illegible]y cause cardiac sensitization at 20000 – 150000 ppm
- **Propellant passed an ISS Safety Panel**

Example Reqr. Assessment – Design Dependent

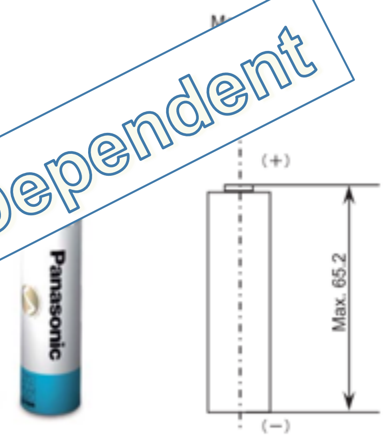
Payload Name Battery Concepts



- **Battery and hardware description**
  - Battery System description
    - Three series two parallel battery packs (6 cells total)
    - Full state of charge voltage of 12.3V
    - Max capacity of 6.8Ah
    - Battery pack has thermostatically c... survival heater set at -10°C
    - Battery voltage is meas... the full stack of both battery pa...
      - No indivi... oltage monitoring
      - Pro... ss to battery and temperatures ... ging in the dispenser at the VAB.
  - ...y packaging
    - Clam shell package design with integrated survival heater
    - Can be mounted to standard 96mm x 90mm PWB but may be used without the PWB by fastening the clamshell to the inside wall of the cubesat

Payload Name Battery Concepts

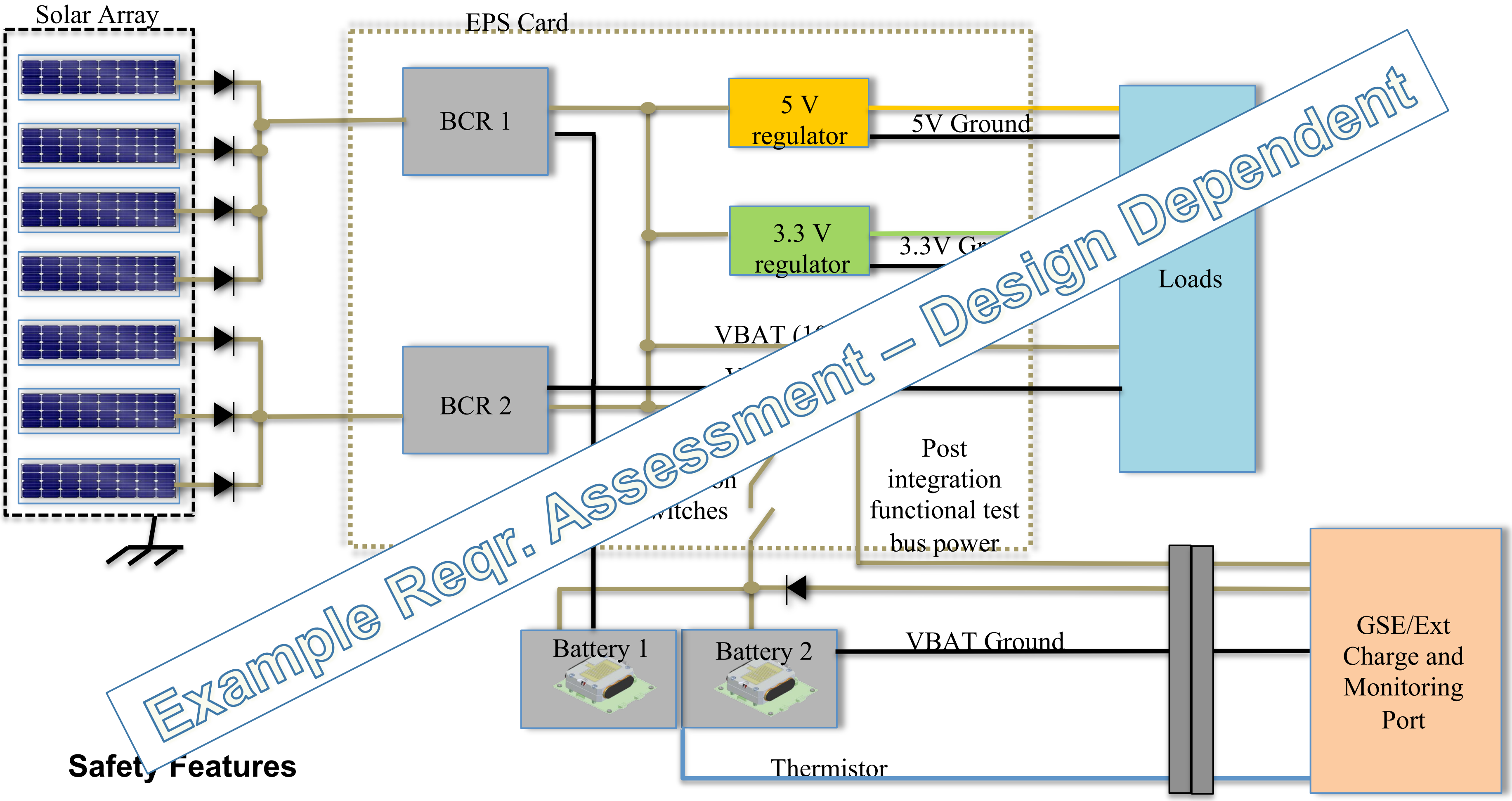
- **Battery and hardware description**
  - Battery cell description
    - Panasonic 18650 NCR B cells
    - Full charge voltage of 4.1V
    - Max capacity of 3.4Ah
    - Graphite/LiNiCoAlO2 (NCA) Chemistry
    - Temperature range from -10°C to +
  - Safety features
    - Positive temperature co TC) device
    - Current interrupt d)
    - Exhaust gas to each cell
    - Panaso s heat resistance layer (HRT) technology
      - g metal oxide layer on the surface of the electrodes
      - ery will not overheat even under short circuit conditions



- **S considering use of Orbtronics cells (adds Seiko protection IC to Pa sonic cells) which adds the following safety features:**
  - Over-voltage/over-charge
  - Over-discharge/under-voltage
  - Over-current protection
  - Over-heating protection
  - Dual Short Circuit

Example Reqr. Assessment – Design Dependent

Battery System Diagram



Safety Features

System level features are not available during payload charging operations

- EPS card is powered off
- Only GSE protection and cell level protection is active

Cell Level (current):

- Over-current protection
- Over-temperature protection
- Cell short circuit protection

Cell level (if Orbtronics is selected):

- Over-voltage/over-charge
- Over-discharge/under-voltage
- Over-current protection
- Over-heating protection
- Dual Short Circuit protection

Compliance with Proposed Battery Charging Requirements

Example Reqr. Assessment – Design Dependent

#1 The payload battery needing a charge, while mounted in the vehicle, shall contain a diode on the positive leg of the charging circuit to the battery.
Status: Comply

#2 The payload battery needing a charge, while mounted in the vehicle, shall contain a 10K thermistor within the battery pack with the leads made avai… to an external connector.
Status: Comply. Working on packaging to allow measure… single thermistor.

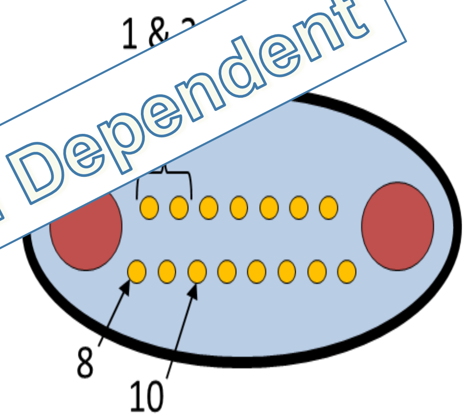
#3 The payload battery needing a charge, whil… the vehicle, shall use a separation connector pin-out as sh… x.xx.x-x.
Status: Comply.

#4 The payload battery n… ge, while mounted in the vehicle, shall have the charging c… from the payload system's circuit.
Status: Comp…

#5 Th… battery needing a charge, while mounted in the vehicle, shall use Li-io… 650 rechargeable batteries with built in protection listed below:

- Overcharge
- Overdischarge
- Overcurrent
- Overheating, and dual short circuit protection

Status: Partially comply. Cells do not have over discharge and over charge protection without EPS card powered. If Orbtronics cells are utilized, then NEAS/LF will comply fully.



Pins 1 & 2– Thermistor,
Pin 8 – Voltage +, Pin 10 – Voltage –
All other pins (3 thru 7, 9, & 11 thru 15) are spares (for payload use).

Figure x.xx.x-x Separation Connector Pin-Out Interface Configuration

Grounding/Bonding

- Internal electrical system is grounded to the cubesat structure/chassis
- Cubesat is grounded to the dispenser throu[illegible]cal connector and mounting
- Dispenser is grounded to the SLS-[illegible] bracket.
- Utilize class-S Bond per the S[illegible]
- If vibration isolation is u[illegible]een dispenser and SLS bracket, a groundi[illegible] will be used to ground the dispenser to t[illegible]et.

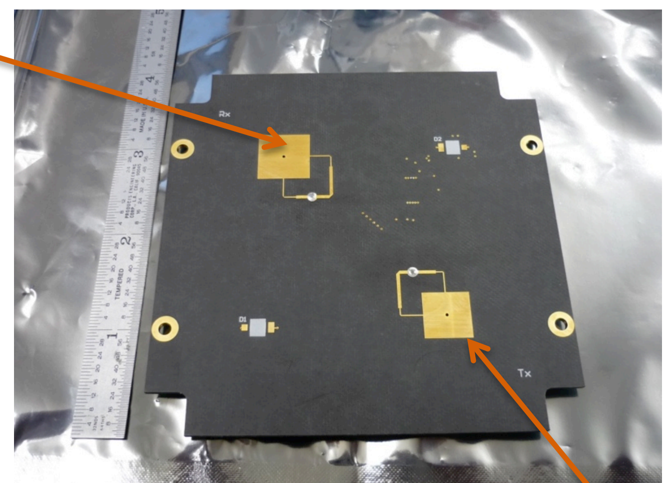
Example Reqr. Assessment – Design Dependent

RF System Overview

♦ **JPL IRIS 2.0 X-band Transponder and Low-Profile X-band patches as low gain antenna for receive and transmi**

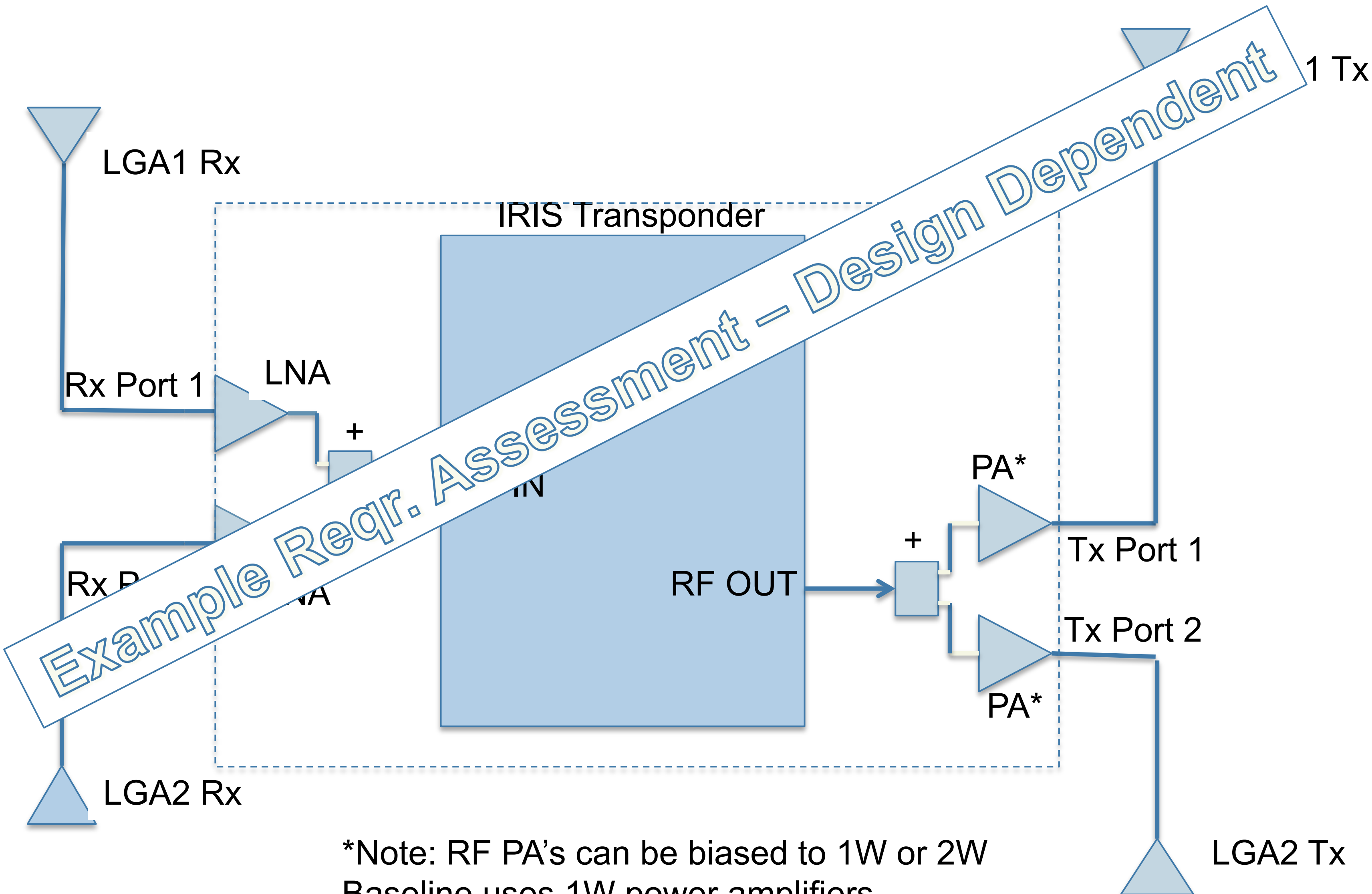
	Uplink Frequency	Downlink Frequency	Transmi
NEA Scout	7.1 GHz	8.4 GHz	
Lunar Flashlight	7.1 GHz	8.4 GH	1 W

atch



Transmit Patch

Telecom Subsystem: IRIS/Antenna Configuration



*Note: RF PA's can be biased to 1W or 2W
Baseline uses 1W power amplifiers.

Payload Name
Preliminary Safety Assessment

Name, Payload Safety Engineer

Preliminary Safety Assessment

- **Performed on the preliminary design and hazards identified**
  - Standardized Hazard Control Report (short form) used as a checklist
    - Short form will be prepared for each payload
  - Long Form will be used to document unique hazards.
    - Pressure System (Attitude Control System)
      - Rupture
      - Leakage
    - Batteries
      - Rupture
      - Leakage
      - Fire (ground)

Example Reqr. Assessment – Design Dependent

Payload Name Safety Assessment
Standard Hazards

- **1. Payload Deployment**
  - Meet deployment system requirements
- **2. Structural Failure**
  - Primary Structure – FoS of 1.4
  - Mounted in approved dispenser
- **3. Rotating Equipment**
  - Powered off
  - Contained
- **4. Structural Failure – Sealed Containers**
  - No Sealed Containers?
- **6. Structural Failure – Vented Containers**
  - Vent analysis/sizing
- **7. Materials - Biological**
  - Not applicable
- **8. Materials - Flammabili**
  - MAPTIS material eval
  - Cert MUA issue
- **9. Material ... g/Outgassing**
  - MAP ... luation
  - ... by M&P
- **1 ... yment Actuators**
  - ... s (no pyrotechnics)
  - Inadvertent operation assessment
- **11. Ionizing Radiation**
  - Not applicable
- **12. Electromagnetic Radiati ... ionizing)**
  - General
    - Powered off
    - EMI a
    - C
  - T
    - ... s
- **... rs**
  - Not applicable
- **14. Electrical Power – Causing damage to electrical equipment**
  - Powered off
  - Circuit protection/wire sizing
  - Bonding and grounding
- **15. Ignition of Flammable Atmospheres**
  - Powered off
  - Class S bond

Example Reqr. Assessment – Design Dependent

Payload Name Safety Assessment
Unique Hazards

- **Pressure System/Attitude Control System**
  - Warm Gas system (no combustion, no hypergolics)
  - MDP analysis/controls (rupture)
  - Leakage
- **Batteries**
  - System level safety features
  - Cell level safety features
  - Charging during ground processi[ng]

Example Reqr. Assessment – Design Dependent

Payload Name Safety

Approach to Meeting IDRD Safety Requirements

Example Reqr. Assessment – Design Dependent

SLS-RQMT-216, Safety Req.	**Req ID: [SPDS.PL.###]**	**Section / Requirement Title**	Payload	Deployer	Approach
TECHNICAL INTERFACE REQUIREMENTS					
	9	Powered Off	X		Battery chargi[illegible] off at all other times.
6.3.2	10	Radio Frequency Output Less Than 1.5 W	X		LF w[illegible] to inadvertent transmissions [illegible]ocessing and ascent. Upon deployment, [illegible] at least 1 inhibit (time required to boot up the [illegible] software) through the 15 sec requirement.
6.3.2	11	Radio Frequenc[illegible] Greater Th[illegible]	X		NEAS will have >2 inhibits to inadvertent transmissions during ground processing and ascent. Upon deployment, NEAS will have at least 2 inhibits (time required to boot up the flight software and a switch to turn on the transmitter) through the 15 sec requirement.
	20	Payload Activation	X		The only deployable that meets the 3x launch envelope criteria is the solar sail. The flight software boot up time will require minutes, which will serve as an inhibit. Also a command from the ground is required to deploy the sail. This is nominally planned 4 days after deployment. A retention mechanism (e.g., burn wire) will be in place to prevent inadvertent deployment.
	21	Payload Transmission	X		Once deployed the flight software will require on the order of minutes to boot up. Once the boot up sequence must be closed to allow transmissions.
6.3.1	22	Payload Deployments	X	X	LF and NEAS plan to deploy as early as allowed by SLS (anticipate prior to L+24 hours).
6.3.1	23	Payload Co-Deployments	NA	NA	N/A

Approach to Meeting IDRD Safety Requirements

SLS-RQMT-216, Safety Req.	Req ID: [SPDS.PL.###]	Section / Requirement Title	Payload	Deployer	A[illegible]
TECHNICAL INTERFACE REQUIREMENTS					
6.3.3	26	Gas or Fluid Release	X		Levy re[illegible]esign. Perform co[illegible]ysis of leakage (in a failure
6.5	27	Failure Propagation	[illegible]	[illegible]	[illegible]sail and solar array deployment will be contained by the dispenser.
6.7.1	28	Structural De[illegible] Safety	X	X	Inadvertent solar sail and solar array deployment would be contained by the dispenser. Propulsion analysis from IRD requirement 26.
6.7.1	2[illegible]	St[illegible] and Test [illegible]ce	X	X	Primary structure will comply with NASA-STD-5001.
6.7.1	[illegible]	Fracture Control	X	X	Will comply with NASA STD-5019 for primary structure.
6.7.1	31	Fasteners	X	X	Will comply with NASA-STD-5020 for critical fasteners in primary structure.

Example Reqr. Assessment – Design Dependent

Approach to Meeting IDRD Safety Requirements

SLS-RQMT-216, Safety Req.	[SPDS. PL.###]	Section / Requirement Title	Payload	Deployer	Approach
TECHNICAL INTERFACE REQUIREMENTS					
6.7.1.1, #1	32	Safety Critical Fasteners	X	X	NEAS and LF will ut[illegible] and verifible locking featu[illegible]ning could create a catastr[illegible]
6.7.1.1, #1	33	Locking Devices	X		[illegible]mply for any necessary locking devices.
6.7.1.1, #2	34	Rot[illegible]		X	X	Only rotation joints are the solar array articulation and the solar sail. They are prevented from rotating in the launch configuration. They require deployment in order to rotate. The dispenser would also contain the rotation.
6.7.1.1, #3	[illegible]	[illegible] Locking [illegible]	X	X	Plan to comply.
6.7.1.1, [illegible]	[illegible]36	[illegible]astener Installation Preload Torque	X	X	Plan to comply.
6.7.1.1, #5	37	Fastener Installation Running Torque	X	X	Plan to comply.
6.7.1.1, #6	38	Thread Locking Compounds	X	X	Plan to comply.
6.7.1.1, #7	39	Stacking Compounds	X	X	Plan to comply.
6.7.2	40	Stress Corrosion	X	X	Plan to comply.

Example Reqr. Assessment – Design Dependent

Approach to Meeting IDRD Safety Requirements

SLS-RQMT-216, Safety Req.	**Req ID: [SPDS. PL.###]**	**Section / Requirement Title**	Payload	Deployer	Approa...
TECHNICAL INTERFACE REQUIREMENTS					
6.7.2	41	Alloy Material Usage	X	X	NEAS and LF will ... 6651 for the primary str...
6.7.4	42	Maximum Design Pressu...			Table ... ed as a requirement on design ... nk is designed for positive margin ... timate strength under burst pressure ... itions (2.5x 110psia). Due to its rectangular cross-section the tank will plastically deform and leak rather than burst.
6.7.4	43	Pressure Control T...			no information on regulators, relief devices, etc
6.7.4.1	44	Pressure Rel...	NA		N/A, all one pressure system
6.7.4.2	45	Pressu... als	X		Plan to comply.
6.7.4.2	4...	M... cted ... Pressure	X		Comply.
6.7.4.2.2		...mposite Overwrapped Pressure Vessels	NA	[redacted]	
6.7.4.3	48	Pressure Stabilized Vessels	X		Comply.
6.7.4.4,#1	49	Pressurized Lines, Fittings and Components	X		Table 3-7 will be levied as a requirement on design of tank.
6.7.4.4, #2	50	Secondary Volume Pressure Factors of Safety	X		Plan to comply, if applicable.
6.7.4.4, #2	51	Secondary Volume Vent or Relief Provision	X		Plan to comply, if applicable.

Approach to Meeting IDRD Safety Requirements

SLS-RQMT-216, Safety Req.	**Req ID: [SPDS.PL.###]**	**Section / Requirement Title**	Payload	Deployer	Approach
TECHNICAL INTERFACE REQUIREMENTS					
6.7.4.5, #1	52	Burst Disc with Reversing Membrane	NA	[redacted]	
6.7.4.5, #2	53	Burst Disc Design	NA		
6.7.4.5, #3	54	Stress Corrosion Resistant Materials	NA		
6.7.4.5, #5	55	Burst Disc Design Part Qualification	NA		
6.7.4.5, #6	56	Burst Disc Membrane Actuation Pressure Verification			
6.7.4.6, #1	57	Sealed Con[illegible]	X		tank will be designed to accommodate more than 15.2psia due to primary function as RCS system
6.7.4.6, #2	58	[illegible]ors	X	X	can be levied as requirement on design
6.7.5.1	[illegible]	[illegible]s Material [illegible]ainment	X	X	can be levied as requirement on operations
6.7.5.1	60	Hazardous Fluid Systems	X	X	can be levied as requirement on operations
6.7.5.1	61	Toxic or Hazardous Chemical Containment	X	X	RF236 is low toxicity and hazard, will be contained within pressure vessel
6.7.5.2	62	Hazardous Fluid Systems	X	X	RF236 can not physically degrade system or cause exothermic reaction
6.7.5.3	63	Chemical Releases	X	X	will be approved pressure vessel

Example Reqr. Assessment – Design Dependent

Approach to Meeting IDRD Safety Requirements

Example Reqr. Assessment – Design Dependent

SLS-RQMT-216, Safety Req.	Req ID: [SPDS.PL.###]	Section / Requirement Title	Payload	Deployer	Appro[illegible]
TECHNICAL INTERFACE REQUIREMENTS					
6.7.5.4	64	Biological Materials Classification	NA	[redacted]	
6.7.5.4	65	Biological Material Containment	NA		
6.7.6	66	Fire Hazard	X		
6.7.6	67	Flammable Materials	[illegible]	X	[illegible]sofa is a non-flammable material per the MSDS. Will perform MAPTIS material evaluation and have a certification MUA issues by M&P.
6.7.6	68	Flammability Evalu[illegible]	X	X	Plan to comply.
6.7.7	69	Materia[illegible]	X	X	Plan to comply.
6.7.8	[illegible]	[illegible]gassing	X	X	Will perform MAPTIS material evaluation and have a certification MUA issues by M&P.
[illegible]	[illegible]	[illegible]rotechnic Devices	NA	[redacted]	
[illegible]	71	Pyrotechnic Hazards	NA		
6.9.1	72	Radioactive Material Licensing	NA		
6.9.2	73	Emissions and Susceptibility	X	X	Perform analysis to demonstrate design is not susceptible.

Approach to Meeting IDRD Safety Requirements

Example Reqr. Assessment – Design Dependent

SLS-RQMT-216, Safety Req.	Req ID: [SPDS.PL.###]	Section / Requirement Title	Payload	Deployer	[illegible]oach
TECHNICAL INTERFACE REQUIREMENTS					
6.9.3	74	Lasers	NA		
6.10.1	75	Electrical Circuit Protection	X		[illegible]lan to comply.
6.10.1	76	Electrical Design	[illegible]		Plan to comply.
6.10.2	77	Battery Complian[illegible]	[illegible]		Designing to JSC safety requirements.
6.10.3	78	Circuit Ups[illegible] Lightn[illegible]	X	X	Plan to comply.
6.13	7[illegible]	[illegible]d Commanding	X		NEAS and LF will not perform commanding prior to deployment from SLS.
6.14	80	Flammable Atmospheres	X	X	Powered off during ascent with 2 inhibits to inadvertent power-on. Class S bond to launch vehicle/dispenser.
6.14	81	Conductive Surfaces	X	X	Utilize Class S bonds.
	82	Ground Hazards	X	X	Battery charging activities will comply.

Anticipated Hazards

Example Hazards – Design Dependent

- **Inadvertent RF transmissions**
  - Anticipated controls: Two inhibits through separation swi[illegible] for pre-launch and during ascent. Two inhibits in place afte[illegible]nt from the dispenser.
- **Pressure vessel over pressurization/[illegible]**
  - Anticipated controls: Design for mi[illegible]. Leak before burst design.
- **Over charge of lithium [illegible]eries**
  - Anticipated contro[illegible] battery controls, GSE, human in the loop monitoring.
- **Pre-mat[illegible]oyment of solar arrays/solar sail**
  - Ant[illegible] controls: Two inhibits through separation switches. Disp[illegible]er will contain solar arrays and sail if deployed prior to cubesat deployment. Post-cubesat deployment, flight software boot up time serves as inhibit.

Candidate Design Options Assessed Prior to Phase 1 and Phase 2 Safety Reviews

- Payload can list any design options/trades being planned which might affect a hazard

(example: propulsion – presented a cold gas system but you're considering an Ion thruster or chemical engine)

Questions

- Payloads can ask the PSRP specific safety questions which might cause design changes or change planned operations.

BACKUP

Add any informational charts you
feel could be relevant to the review
in answering potential questions.

Payload and SPDS Battery Charging Requirements

Battery Charging Requirements

#1 The payload battery needing a charge, while mounted in the vehicle, shall contain a diode on the positive leg of the charging circuit to the battery.

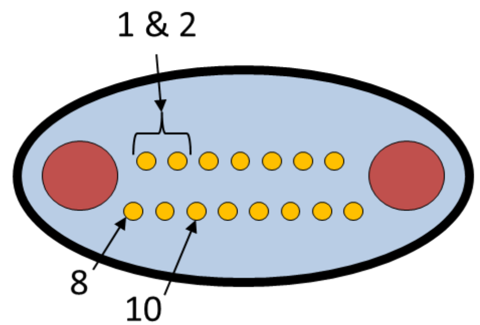
Verification by: Inspection

#2 The payload battery needing a charge, while mounted in the vehicle, shall contain a 10K thermistor within the battery pack with the leads made available to an external connector.

Verification by: Inspection & Test

#3 The payload battery needing a charge, while mounted in the vehicle, shall use a separation connector pin-out as shown in the figure.

Verification by: Inspection



Pins 1 & 2– Thermistor,
Pin 8 – Voltage +, Pin 10 – Voltage –
All other pins (3 thru 7, 9, & 11 thru 15) are spares (for payload use).

Separation Connector Pin-Out Interface Configuration

#4 The payload battery needing a charge, while mounted in the vehicle, shall have the charging circuit separate from the payload system's circuit.

Verification by: Inspection

#5 The payload battery needing a charge, while mounted in the vehicle, shall use Li-ion 18650 rechargeable batteries with built in protection listed below:

- Overcharge
- Overdischarge
- Overcurrent
- Overheating, and dual short circuit protection

Verification by: Inspection

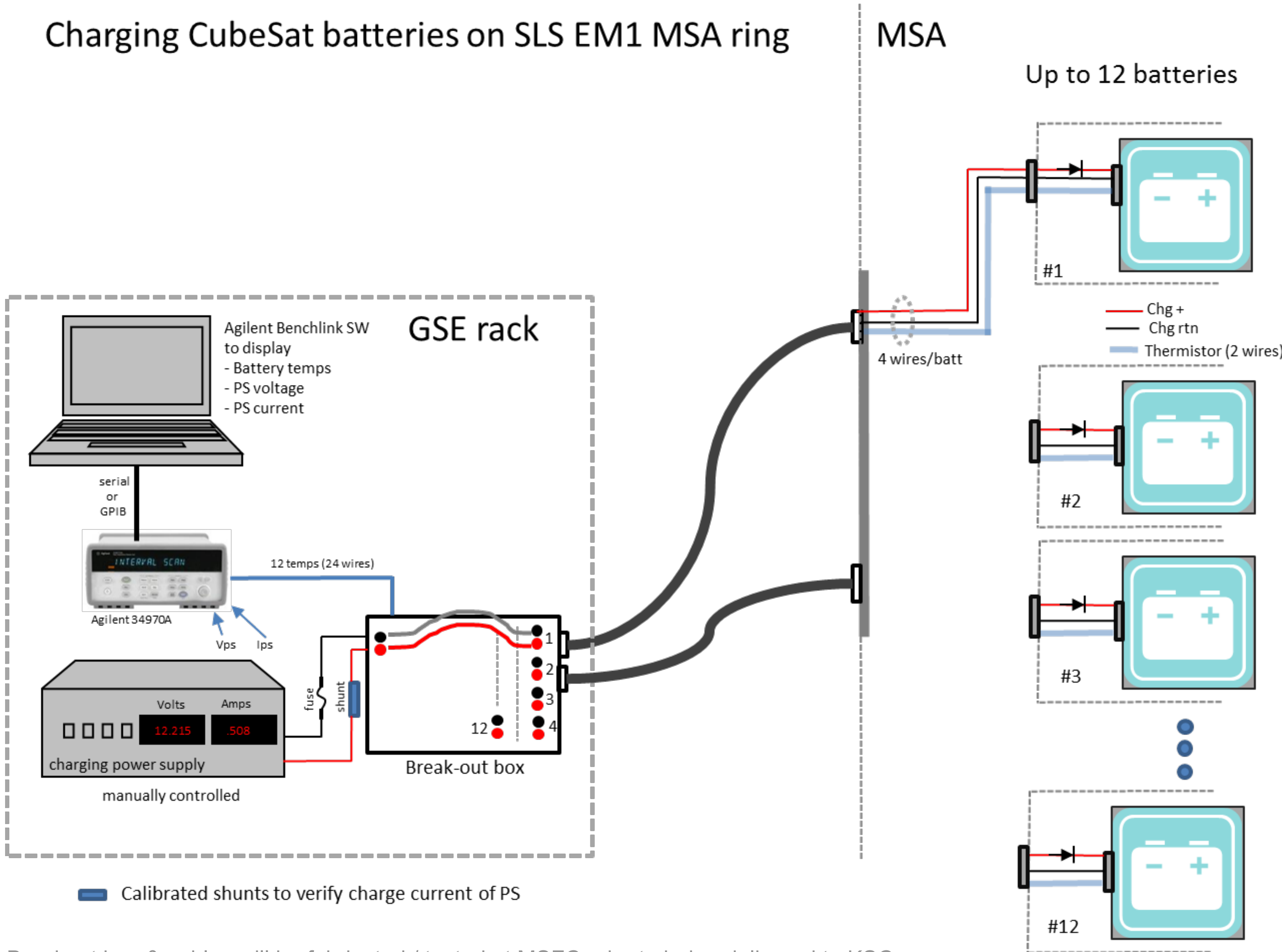
Secondary Payloads Battery Charging Concept Update

Secondary Payloads Battery Charging Concept

Charging Concept for CubeSat Batteries:

- Secondary Payloads can be charged similar to the avionics system's battery.
- Up to 12 batteries would be part of the secondary payload charging scheme on the SLS EM-1 MSA ring . 11 secondary payload batteries and 1 avionics system battery.
- Ground power will need to be provided by drag–on GSE (GSE tentatively provided by MSFC).
- Battery Cell health will no longer need to be monitored through an RS 422 connection.
- Battery Cell health during charging will be monitored as follows:
  - Proposed setup allows monitoring of all battery temperatures when the cables are connected & Agilent Benchlink Software is operating.
  - 4 wires are required per battery for charging and monitoring the batteries.
  - One battery voltage and current will be monitored at a time.
  - Using the known line resistances from the power supply to the CubeSat charge ports the voltage at the input to the CubeSat can be calculated and displayed during charging.
  - Voltage will be limited to the maximum battery charge voltage + .7V.
  - The voltage will be displayed on the data monitoring screen along with the battery temperature
- Cubesat VAB charging
  - The charge path will need a diode on the positive leg & a 10K thermistor centrally located inside the cell stack.

Battery Charging Concept Sketch



Calibrated shunts to verify charge current of PS

Breakout box & cables will be fabricated / tested at MSFC prior to being delivered to KSC.

Safety Features

Secondary Payload GSE features are:

- The voltage limit on the power supply (PS) will be set to prevent battery from overcharging.
- The current limit on the PS will be set to the specified trickle charge limit.
- The negative leg of the PS will be fused at approx. 1.5X the charge current.
- The positive leg of the power supply will have a current monitoring shunt to verify current displayed on the front panel of the PS.
- The charger rack will be manned when batteries are charging.
- The data logger display screen will provide digital displays and strip chart plotting of the battery voltage, current, and temperature while undergoing charge.

Note: Not having battery voltage sense leads will prevent from having hot pins on MSA ring & on the CubeSat separation connector.