Mars Returned Sample Handling Architecture Overview

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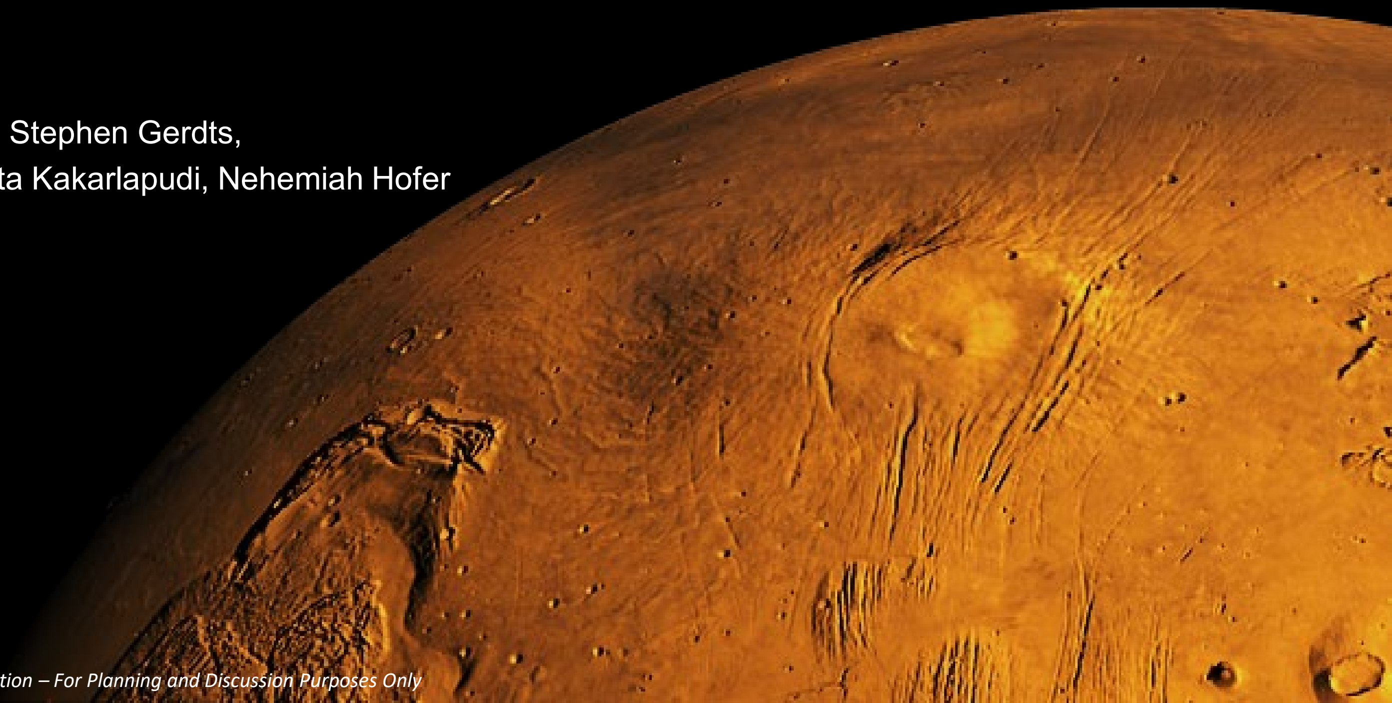

The decision to implement Mars Sample Return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.

CL#24-3615

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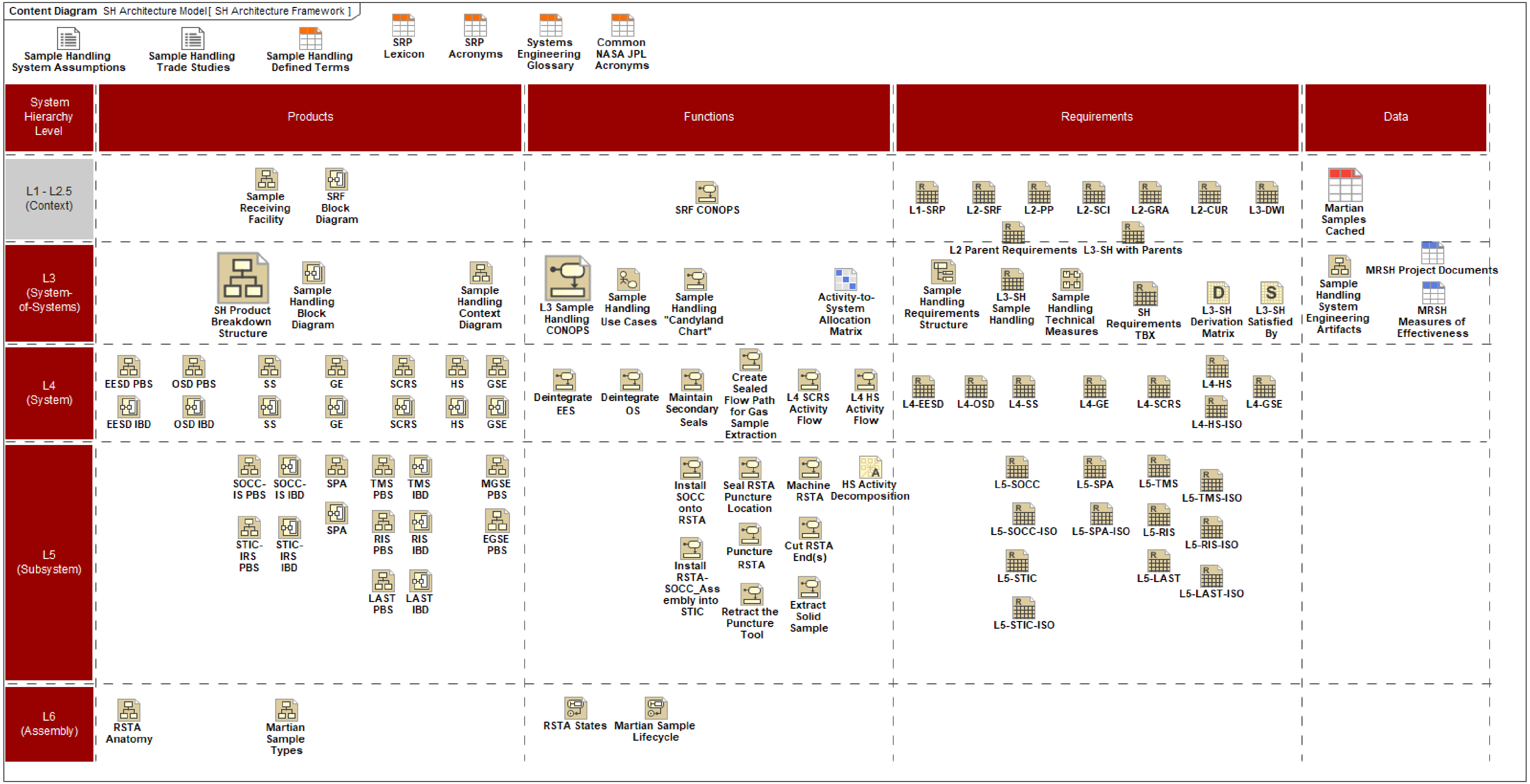
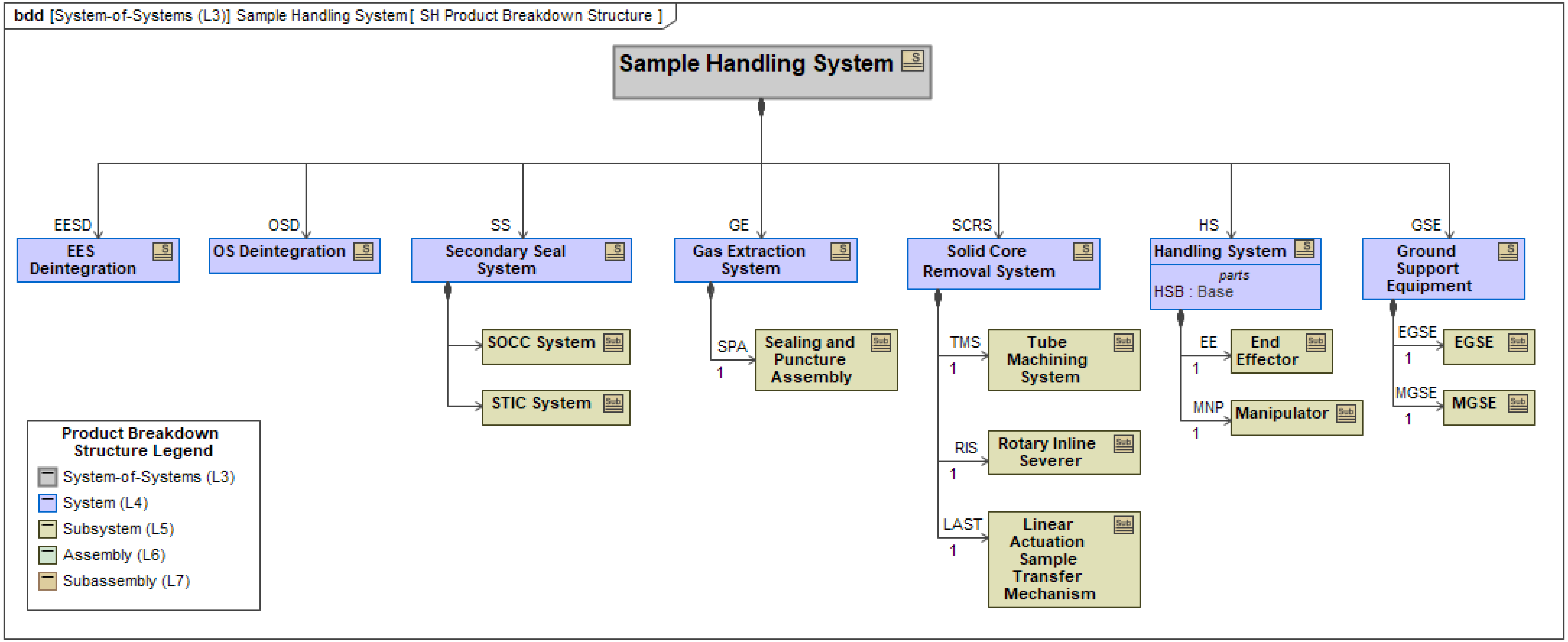
Sample Handling Architecture Overview

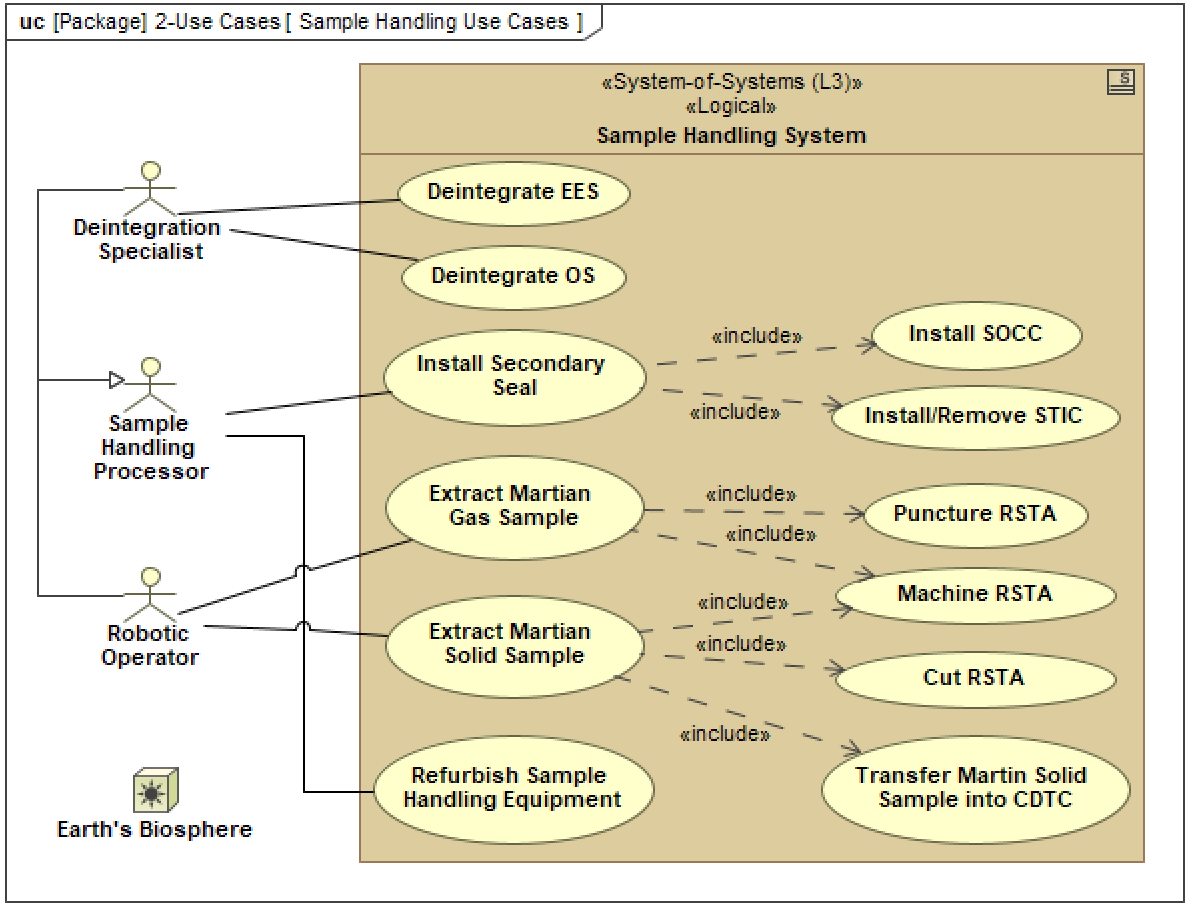
Sample Handling Architecture Framework



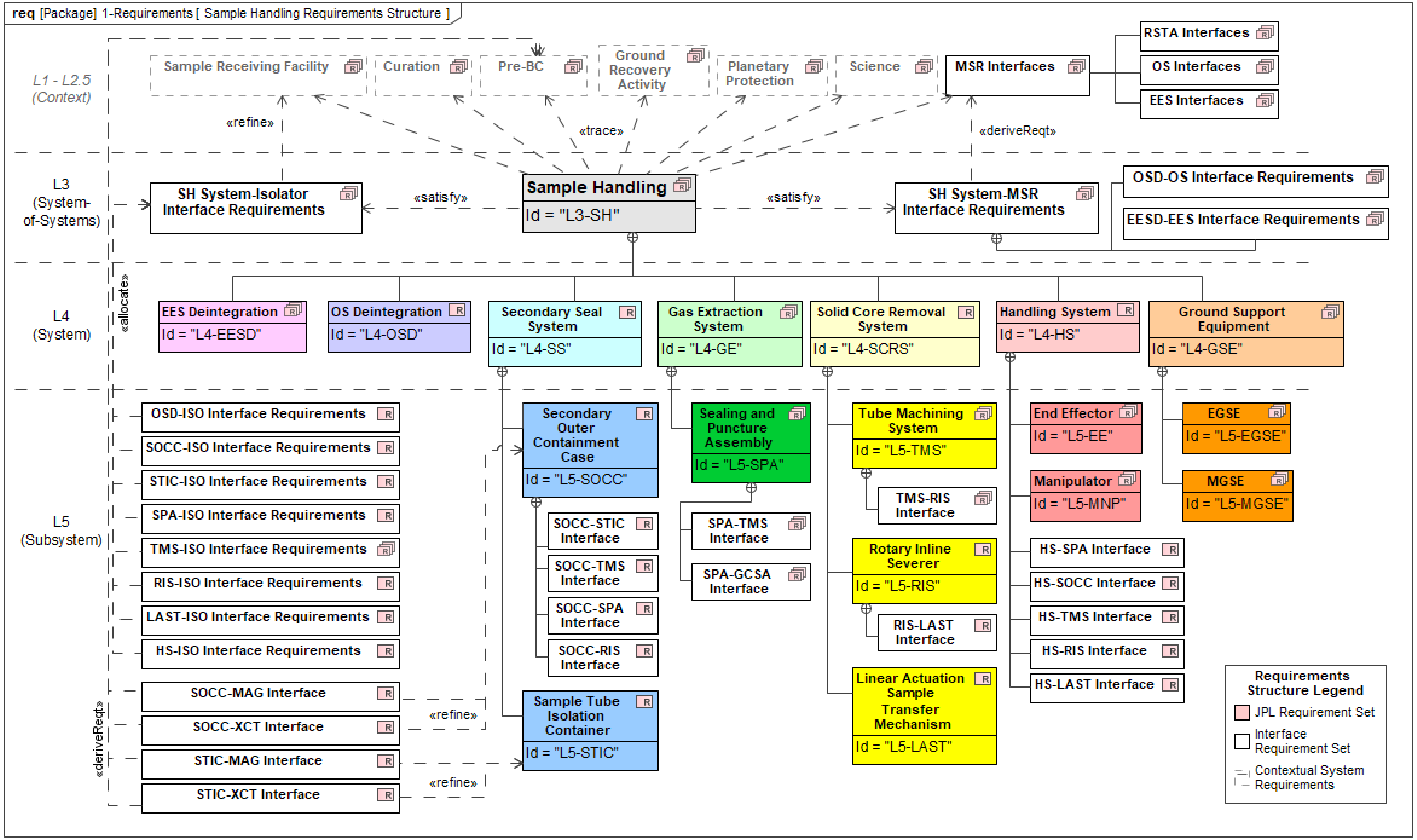
Sample Handling Product Breakdown Structure



Sample Handling Use Cases



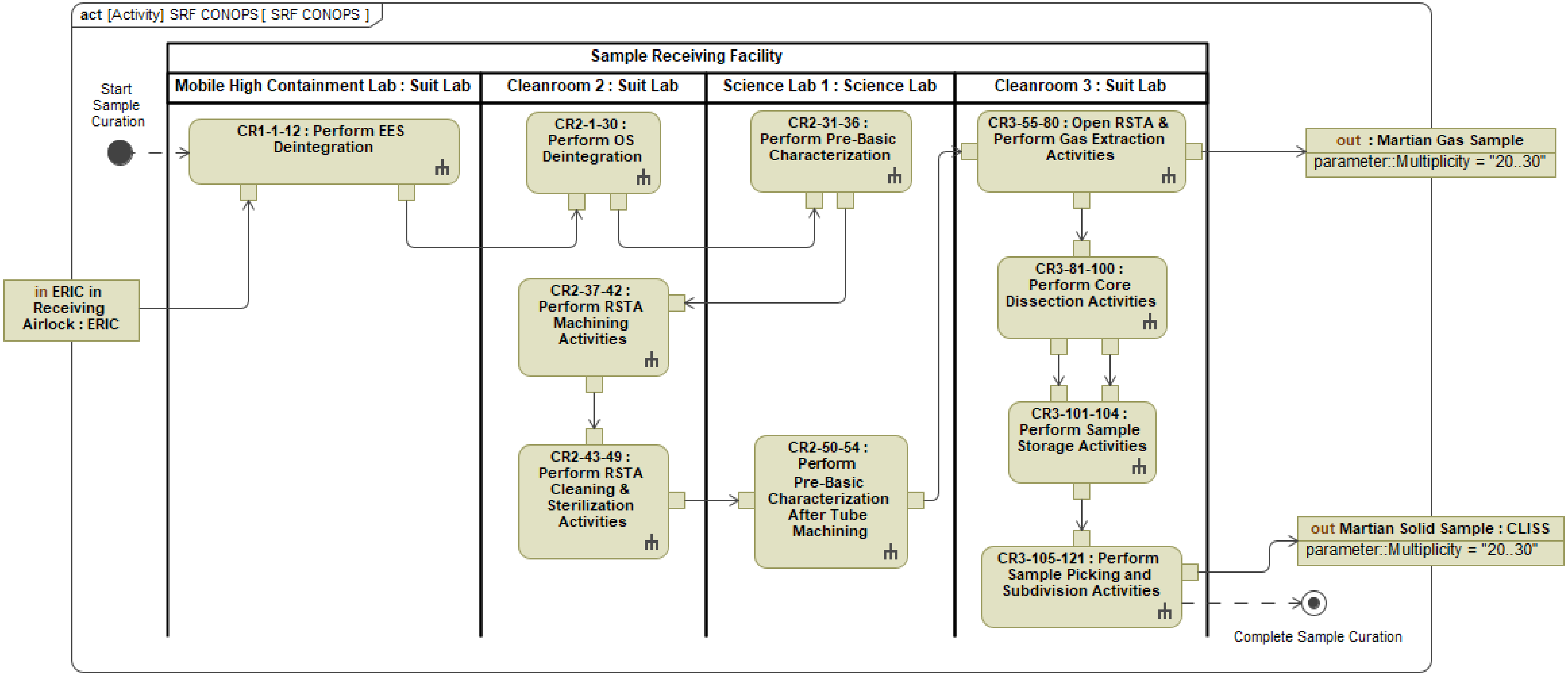
Sample Handling Requirements Structure

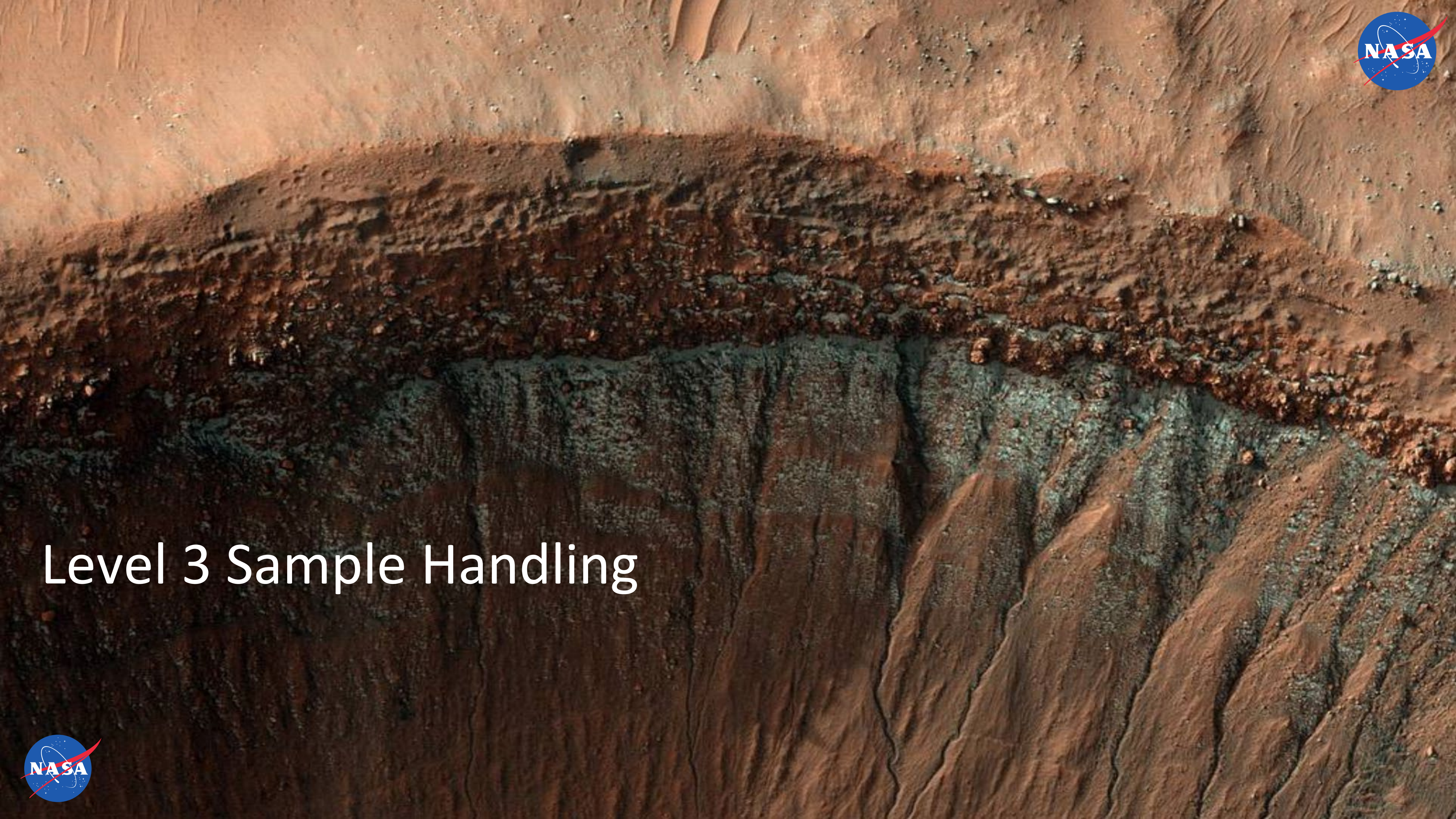


Level 2 Sample Receiving Facility

(System Context)

Sample Receiving Facility Activity Flow





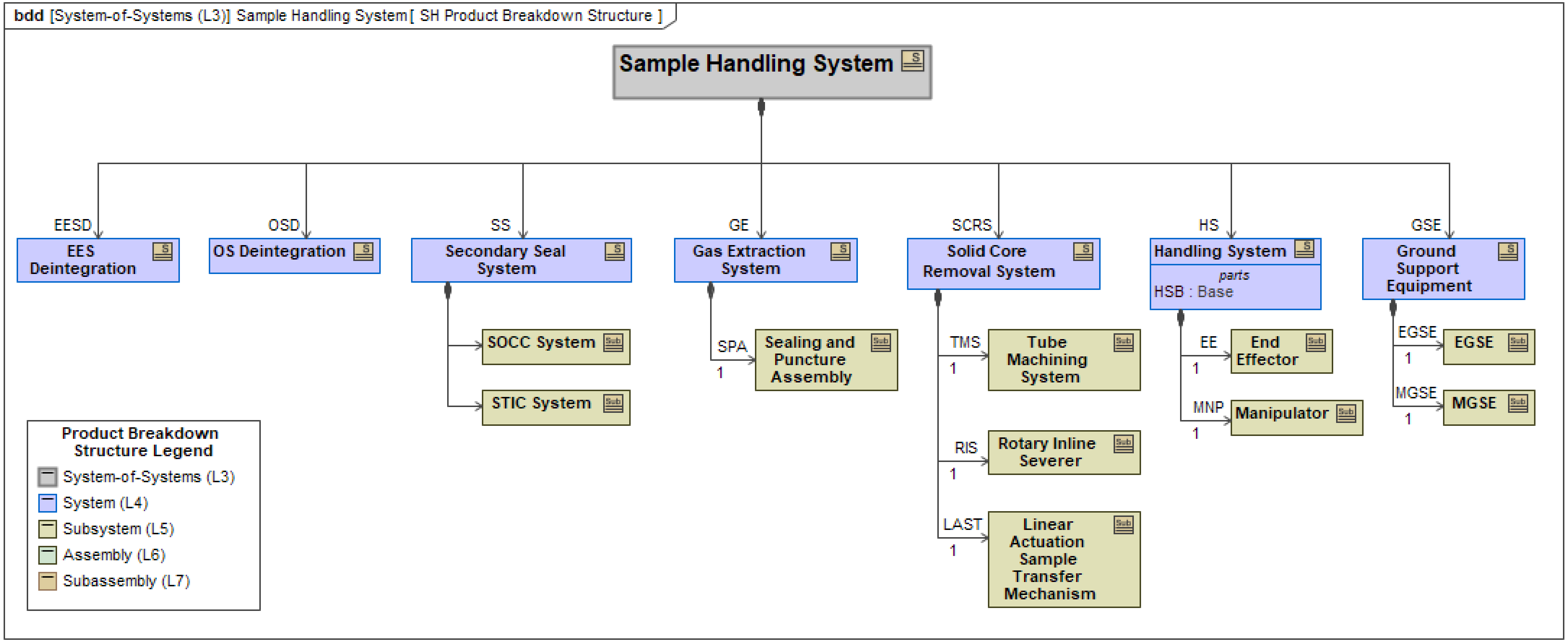
Level 3 Sample Handling

L3-Sample Handling Assumptions

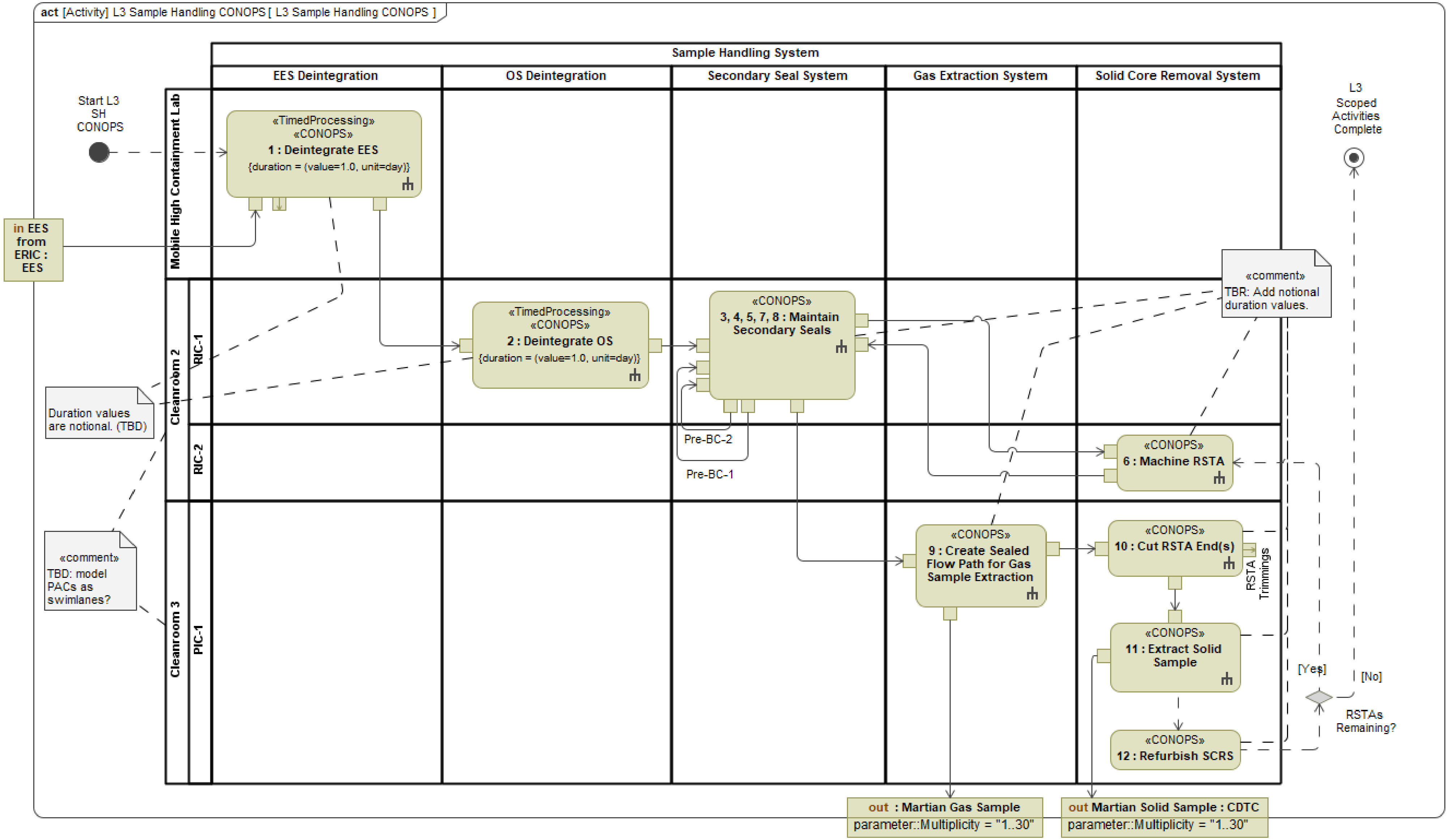
ID	Name	Text
A-L3-SH.1	EES Deintegration in Cleanroom	EES deintegration occurs in a cleanroom and is performed using half-suits or full-suits.
A-L3-SH.2	OS Deintegration and SH_Activities in DWI	OS deintegration and all subsequent sample handling activities occur within double walled isolators (DWI).
A-L3-SH.3	OS Deintegration and RSTA_Handling_Activities in Glovebox	OS deintegration and sample handling activities dealing with the RSTA prior to opening can be performed using gloves in a DWI.
A-L3-SH.4	Sample-Intimate_Activities using Remote Manipulation	Sample handing activities associated with opening the RSTA where the sample is exposed to the DWI environment and handling hardware must be performed using remote manipulation to mitigate risk of contamination of samples from gloves.
A-L3-SH.5	RSTA in STIC Outside of DWI	The RSTA must be fully encapsulated with a Sample Tube Isolation Container (STIC) if needed to be removed from a DWI or Isolator Lin.
A-L3-SH.6	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv

‘Key’ (K) indicates importance and high priority. 'Driving’ (D) indicates that the requirement 'drives up' cost, schedule, or risk.

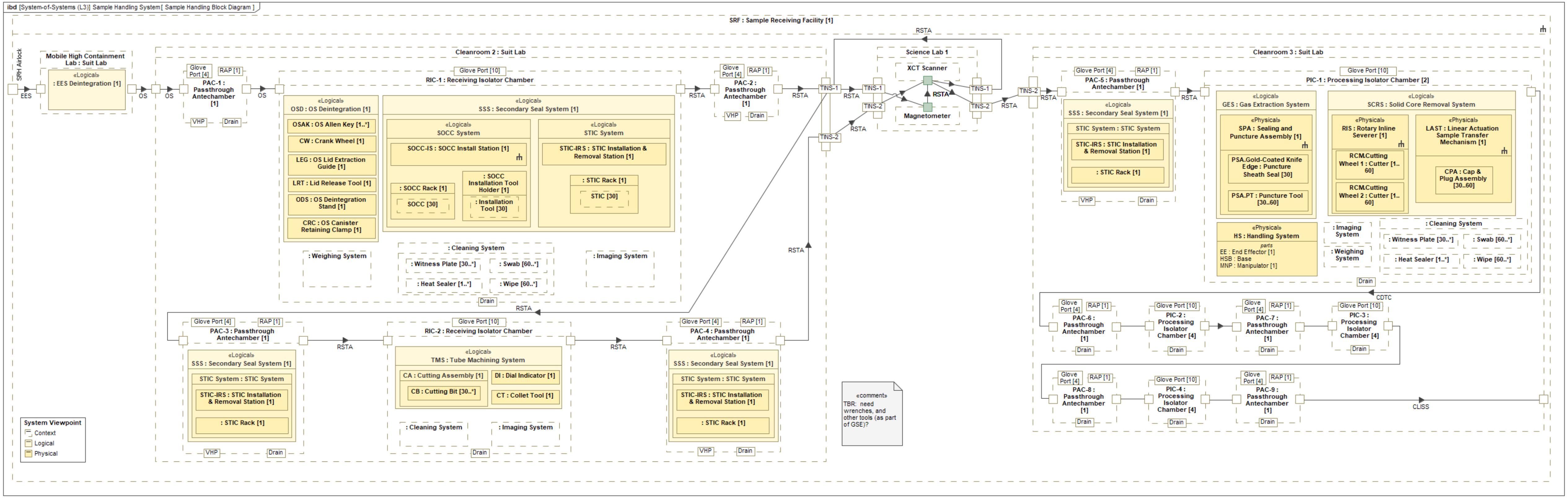
Sample Handling Product Breakdown Structure



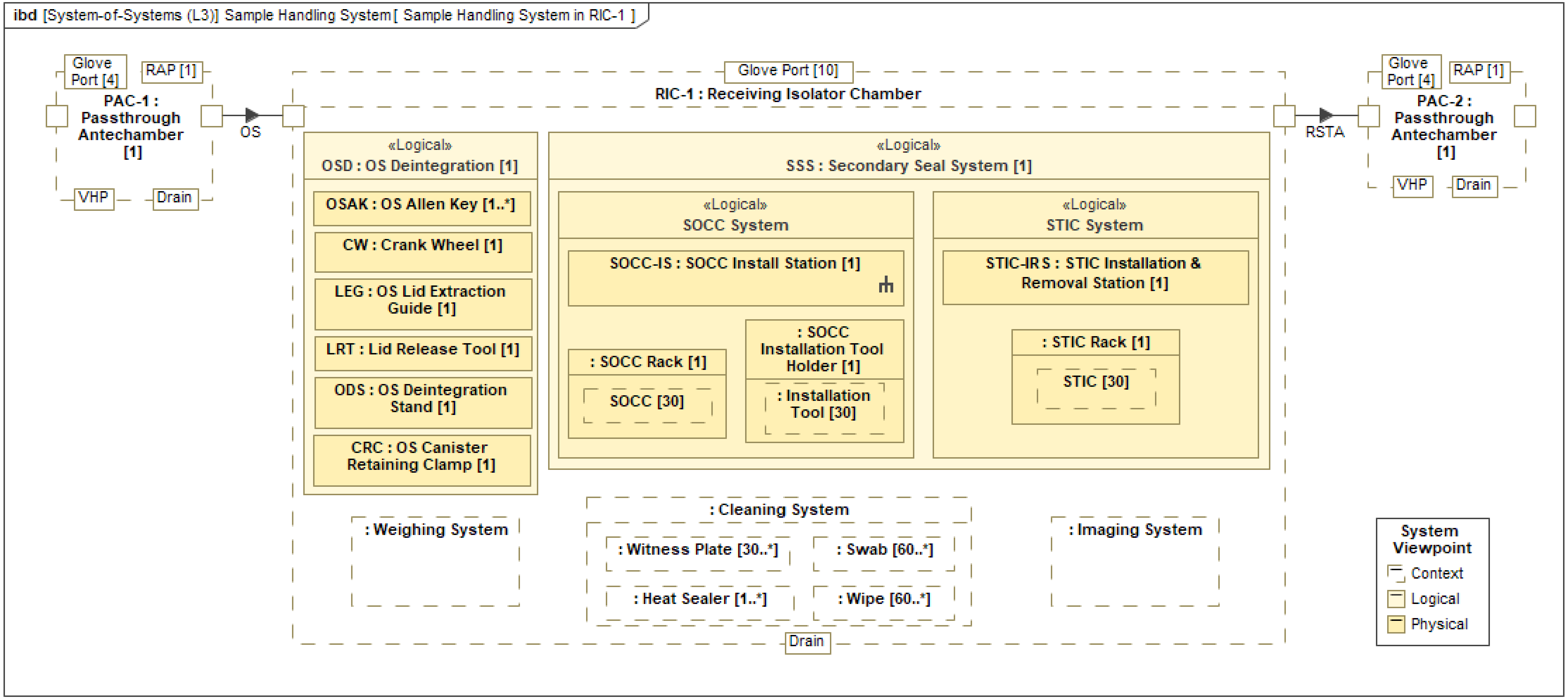
Sample Handling Activity Flow



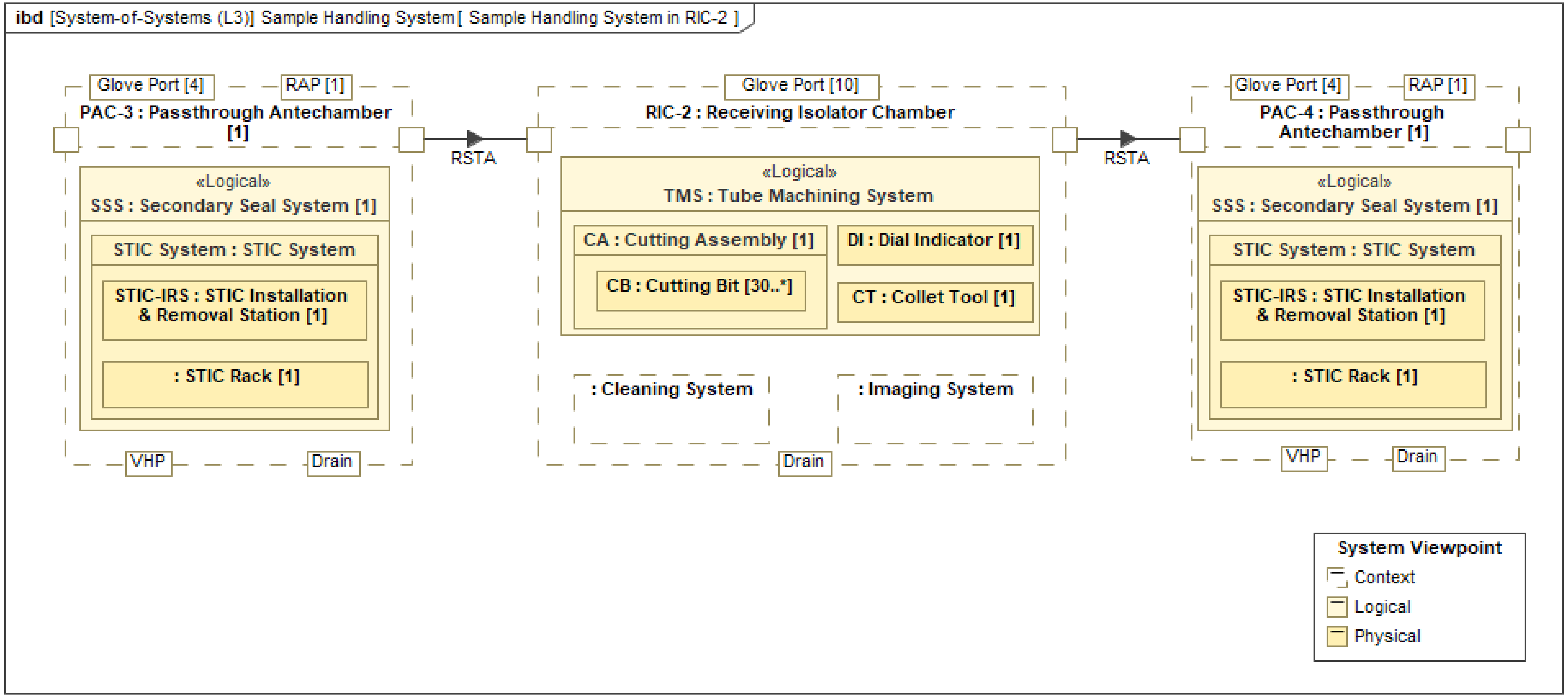
Sample Handling Block Diagram (Overview)



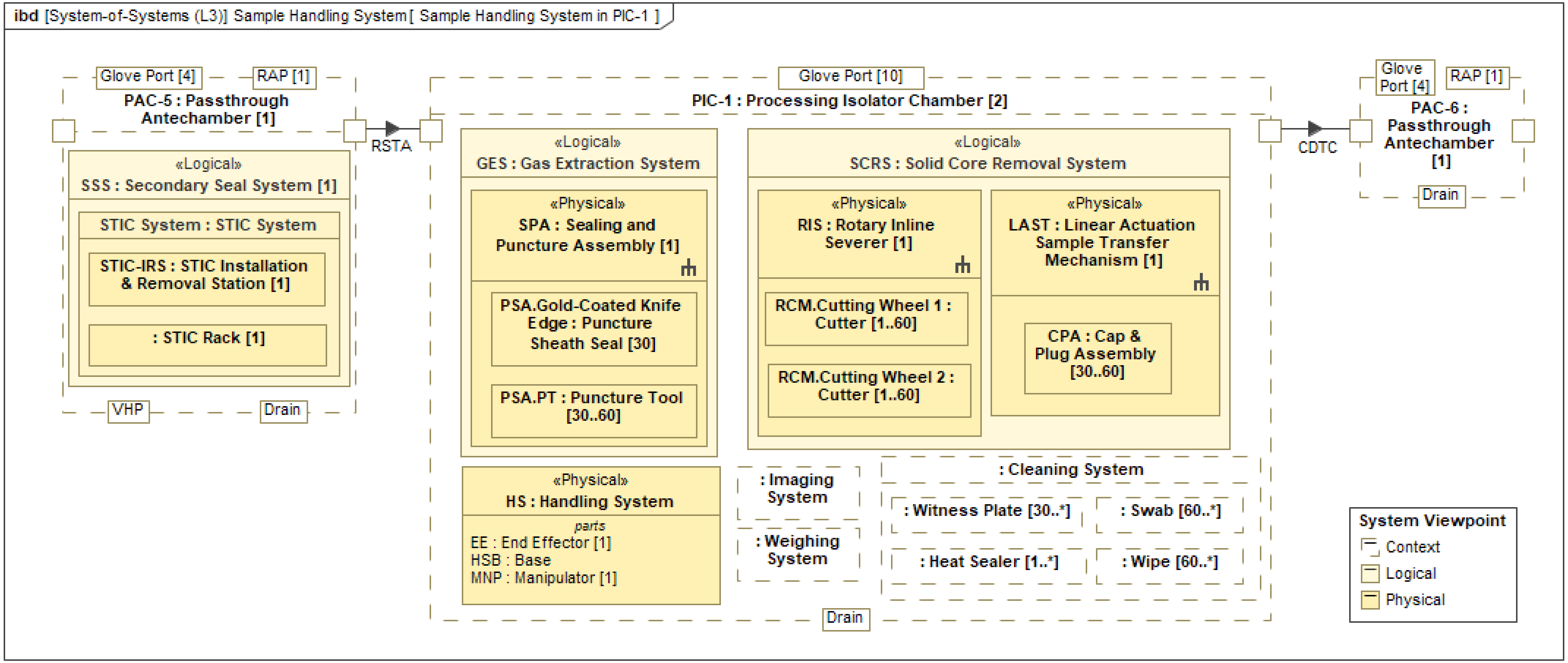
Sample Handling Block Diagram (RIC-1)



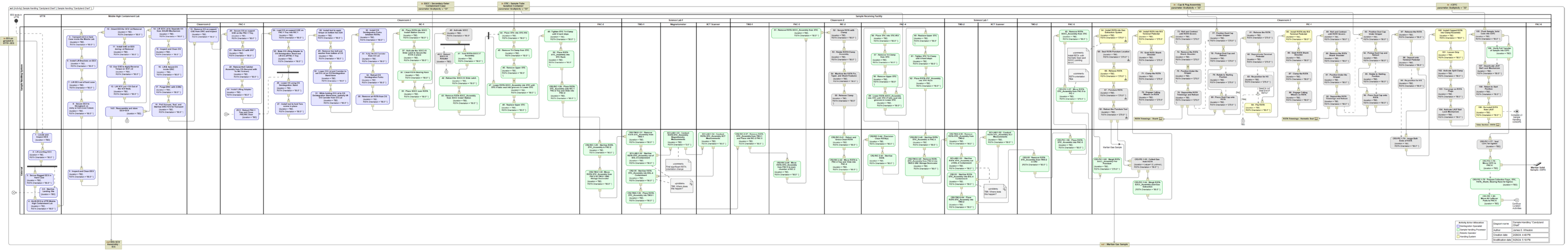
Sample Handling Block Diagram (RIC-2)



Sample Handling Block Diagram (PIC-1)



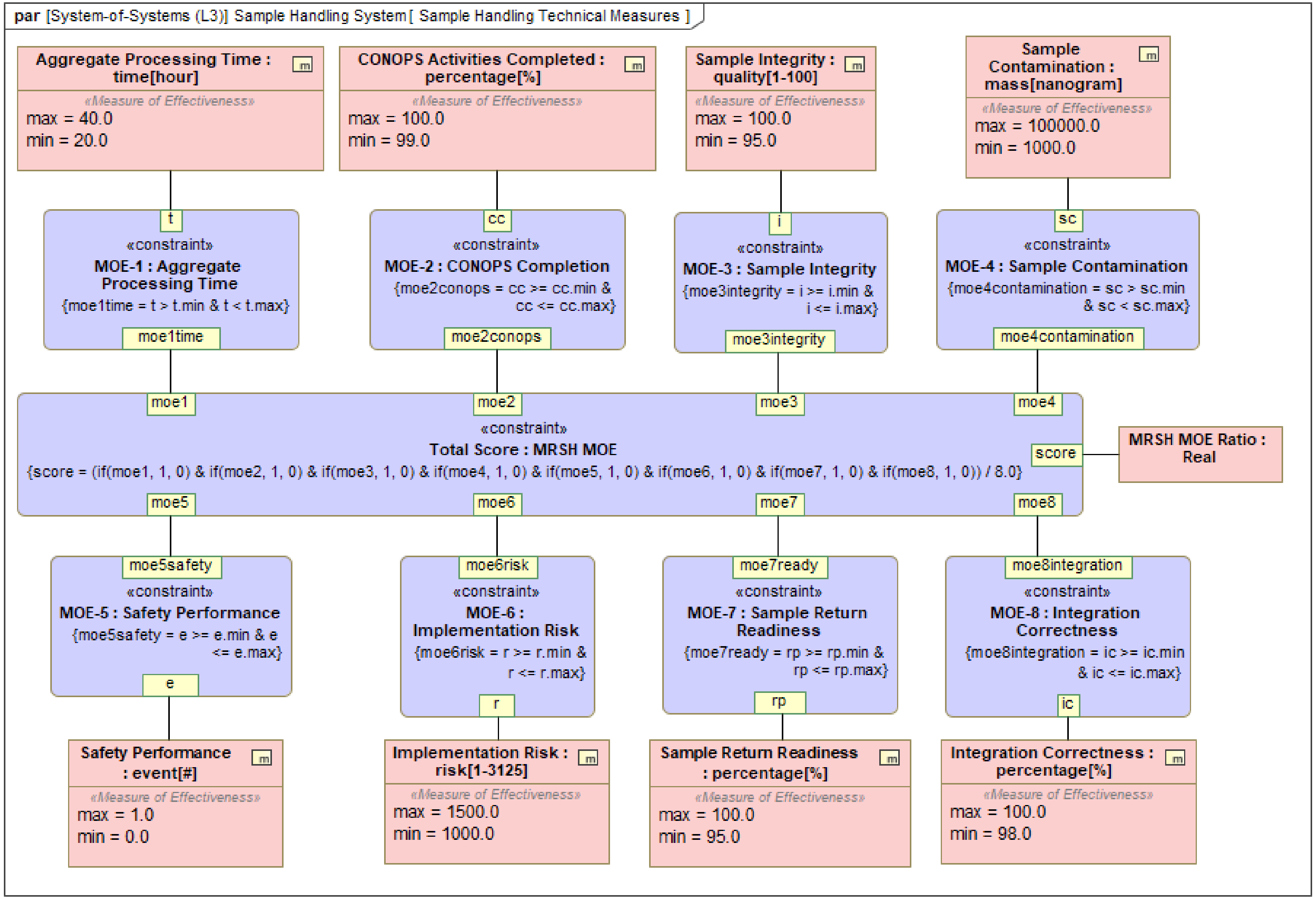
Sample Handling Complete Activity Flow



Sample Handling Measures of Effectiveness (1)

Name	Description	Metric	Minimum	Maximum	Trace to SRP MOE
Sample Integrity	Sum of sample handling activities which preserve the scientific value of the samples	time[hour]	20	40	Sample Integrity
Integration Correctness	Interface and integration compatibility with SRF cleanroom facilities and (double-walled) isolators. Measured in # of integration events that cause design change of MRSH system.	percentage[%]	99	100	SRF Construction
Implementation Risk	Risk of delivered system failing to meet project objectives	risk[1-3125]	1000	1500	Objective Implementation Risk
Aggregate Processing Time	Time it takes for all MRSH systems to complete their CONOPS, not including SRP/Curation activities	event[#]	0	1	Project Execution Duration
Safety Performance	OSHA regulations, NPR 8820 safety regulations, NPR 8715.3D or acceptable rate of injury TBD	mass[nanogram]	1000	100000	Personnel Safety Performance / Human Hazard Risk Factor
Sample Contamination	Amount of debris and other contaminants interacting with the sample directly	quality[1-100]	95	100	Sample Integrity
CONOPS Activities Completed	Percentage completion of planned activities to complete mission	percentage[%]	95	100	Planned Measurements Completed Planned Recovery Activities Completed
Sample Return Readiness	Percent of preparation activities successfully completed on time prior to sample arrival	percentage[%]	98	100	Sample Return Readiness

Sample Handling Measures of Effectiveness (2)



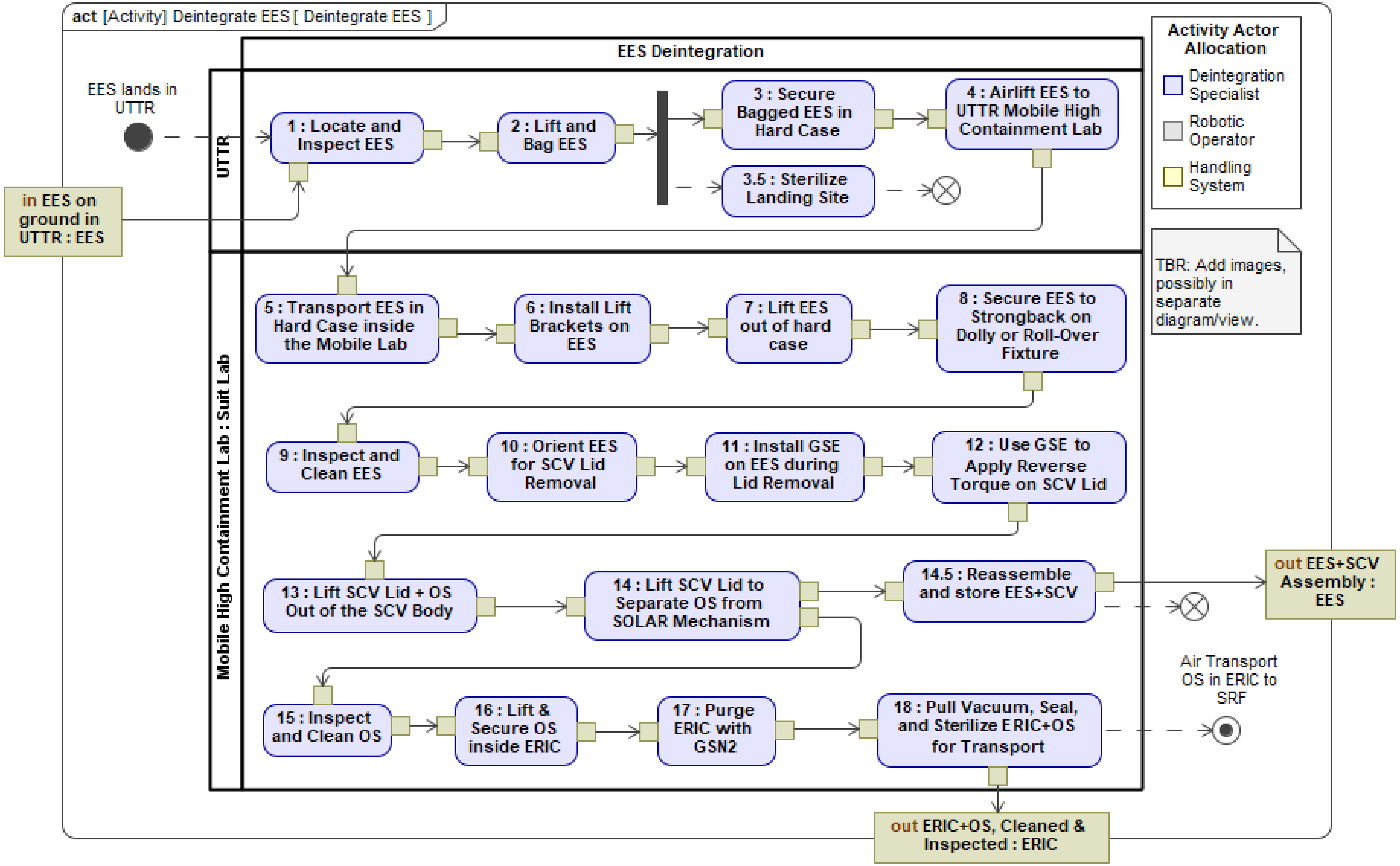
Level 4 EES Deintegration

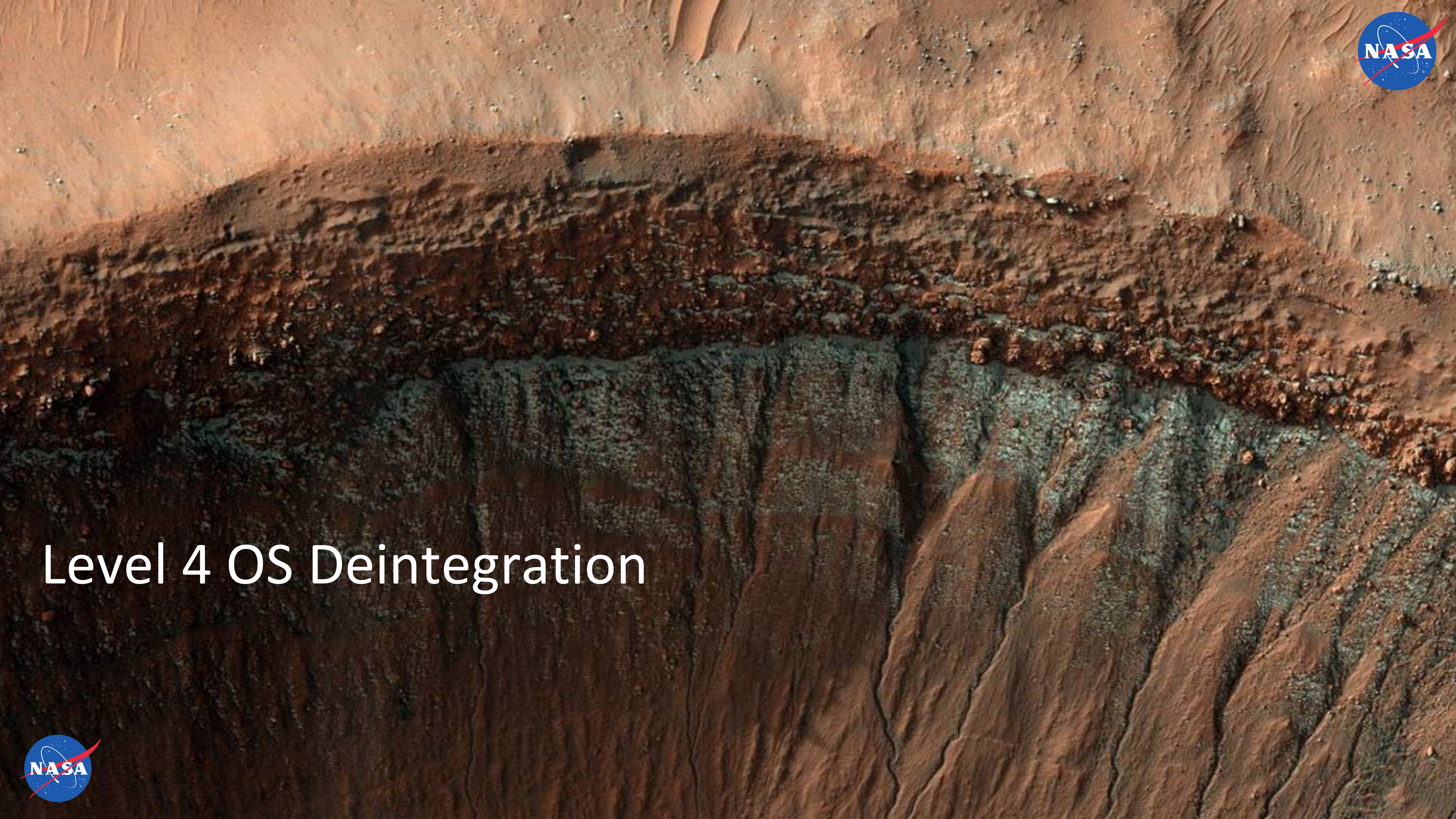
L4-EES Deintegration Assumptions

ID	Name	Text
A-L5-EESD.1	EES Decomposition	EES consists of the EEV (Earth Entry Vehicle) and the SCV (Secondary Containment Vessel) which contains the OS.
A-L5-EESD.2	UTTR Landing Site	The EES will land in Utah and will be secured in a container which will be airlifted to a nearby mobile laboratory at UTTR (Utah Test and Training Range).
A-L5-EESD.3	Mobile High-Containment Facility	UTTR Facility design is still TBD - currently assumed to be a mobile high containment test facility.
A-L5-EESD.4	Removable SCV Lid Assembly	The SCV body and lid assembly shall be designed to withstand impact forces such that the lid mechanism can still be untorqued and removed after re-entry.
A-L5-EESD.5	Robust EEV Interfaces	Handling interfaces on the EEV shall withstand re-entry and impact conditions.
A-L5-EESD.6	Bunny Suits	Personnel will be in full body suits and respirators and will have hands-on access to EEV.
A-L5-EESD.7	OS Extraction Location	SCV Lid opening and OS extraction and packaging for shipment occur in a 10K cleanroom environment within the UTTR Facility.

‘Key’ (K) indicates importance and high priority. 'Driving’ (D) indicates that the requirement 'drives up' cost, schedule, or risk.

EES Deintegration Activity Flow





Level 4 OS Deintegration

L4-OS Deintegration Assumptions

ID	Name	Text
A-L5-OSD.1	No Detrimental Yielding	OS has not experienced detrimental yielding. •All bolts can be removed. •OS Bolt Catcher assembly can be removed. •OS Lid can separate smoothly from canister after releasing OS Lid Shaft.
A-L5-OSD.2	Glove Port Access	RIC 1 DWI has glove port access.

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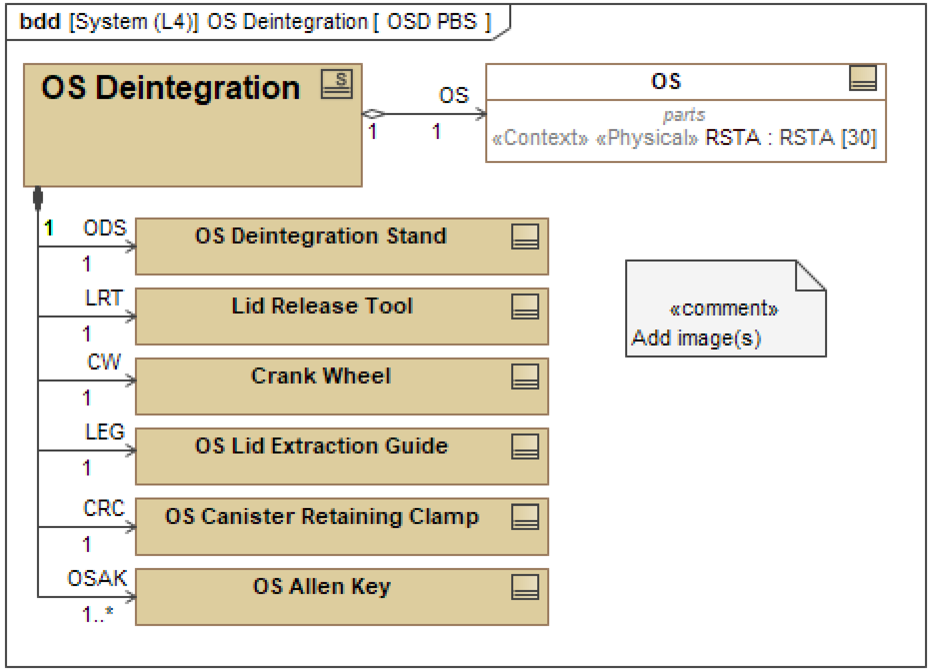
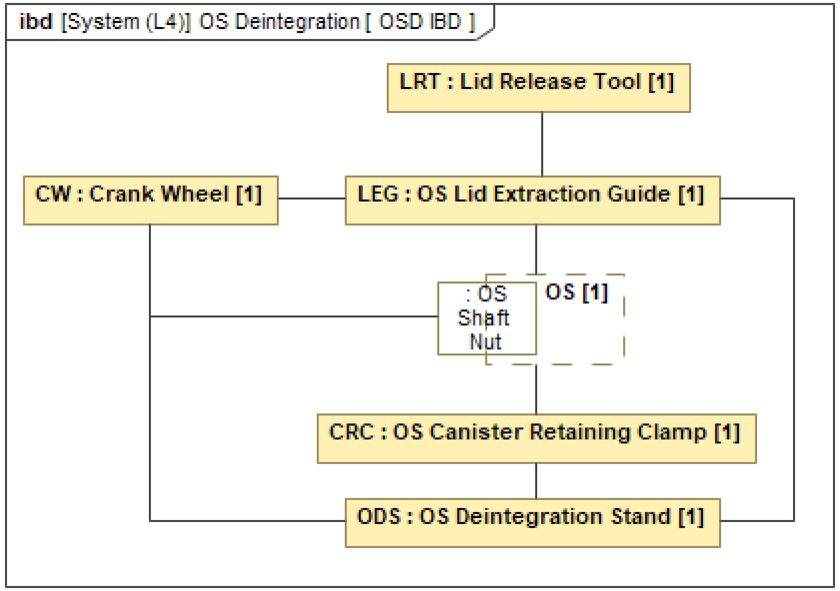
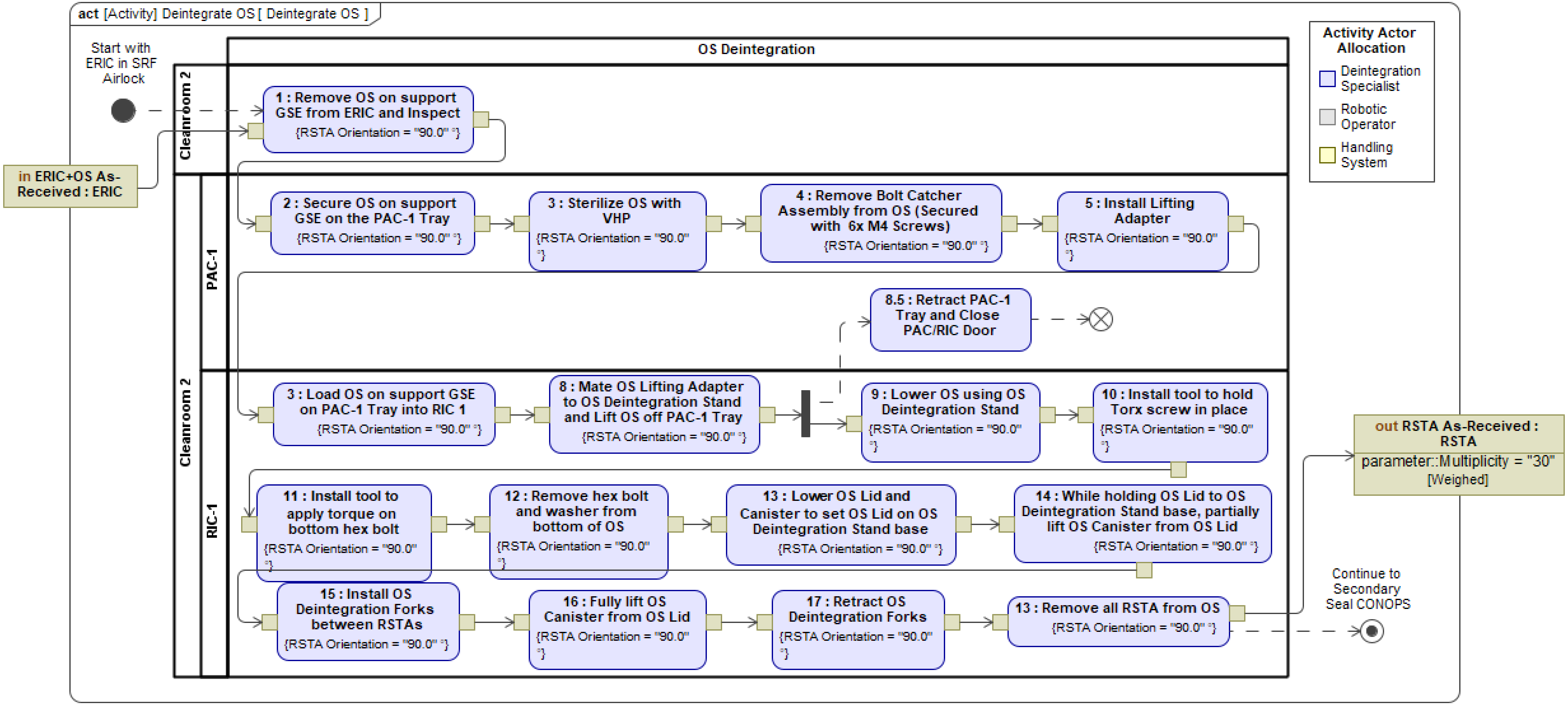
L4 OS Deintegration Product Breakdown Structure



L4 OS Deintegration Block Diagram



OS Deintegration Activity Flow



Pre-Decisional Information – For Planning and Discussion Purposes Only

Level 4 Handling System

L4-Handling System Assumptions

ID	Name	Text
A-L4-HS.1	End Effector Scope	Only interaction with the stations inside the PIC-1 Glovebox is through the RSTA and/or STIC. End Effector grips around a cylindrical interface and moves it from station to station, picking up and dropping it off at discrete CSYS's (No applied force required during arm/station interactions).
A-L4-HS.2	Manipulator Paths	Manipulator path is pre-planned using the station CSYS's and intermediate waypoints (i.e. no real time path planning and obstacle avoidance is required).
A-L4-HS.3	RSTA Clocking	RSTA clocking orientation is currently only required for the SPA station. Tube can be pre-aligned to this orientation prior to pick up by the robotic arm (method TBD). As station designs mature, clocking orientation of the RSTA may become important and will need consideration with respect to the Manipulator/EE.
A-L4-HS.3	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv

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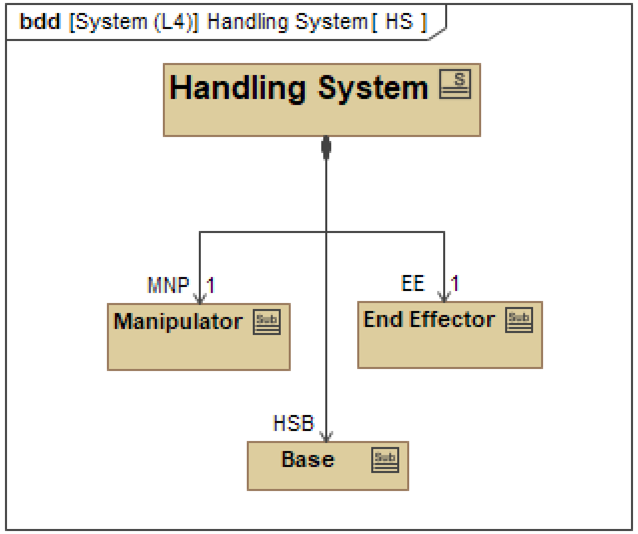
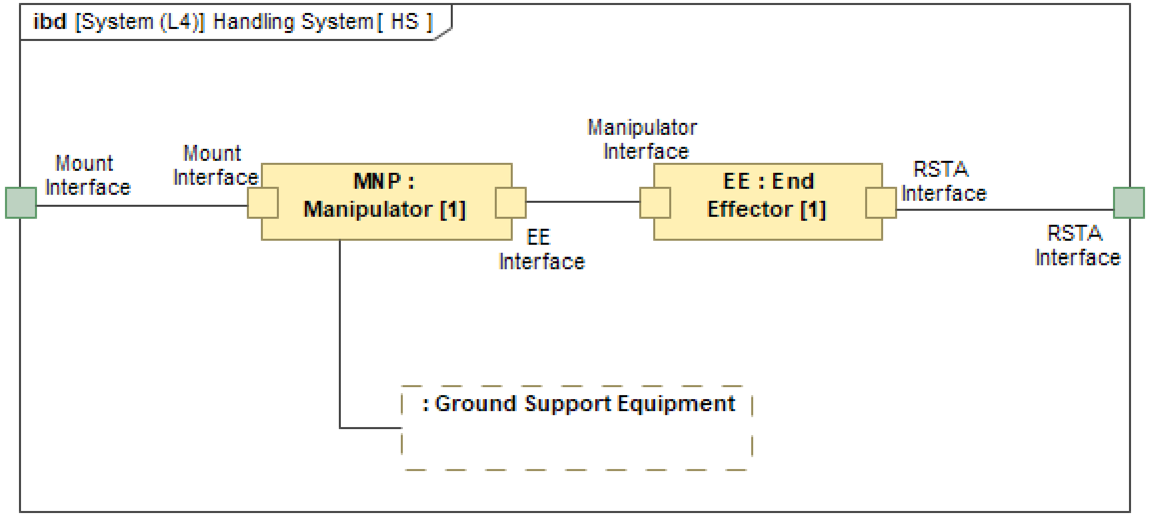
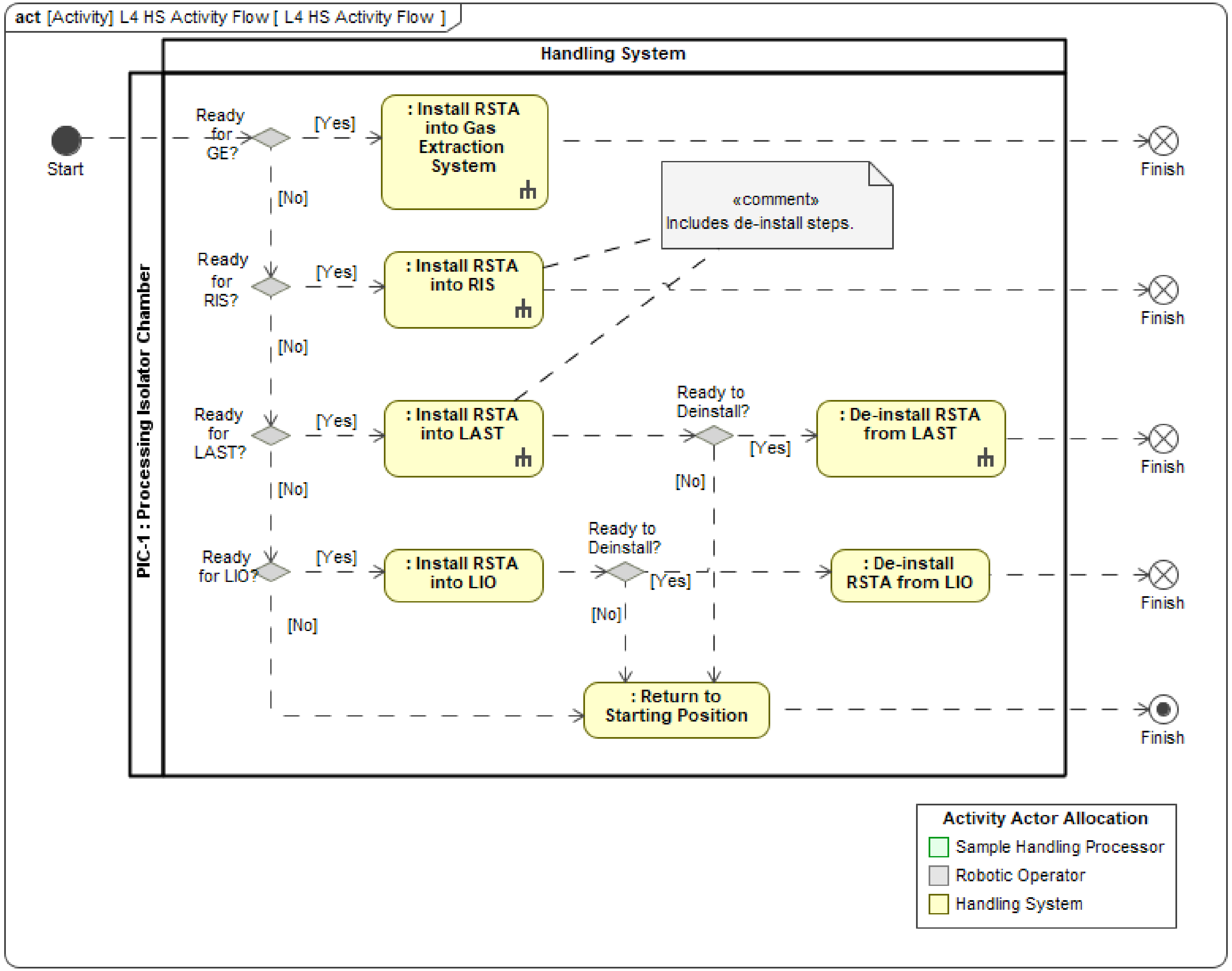
Handling Product Breakdown Structure



Handling Block Diagram



Handling System Activity Flow

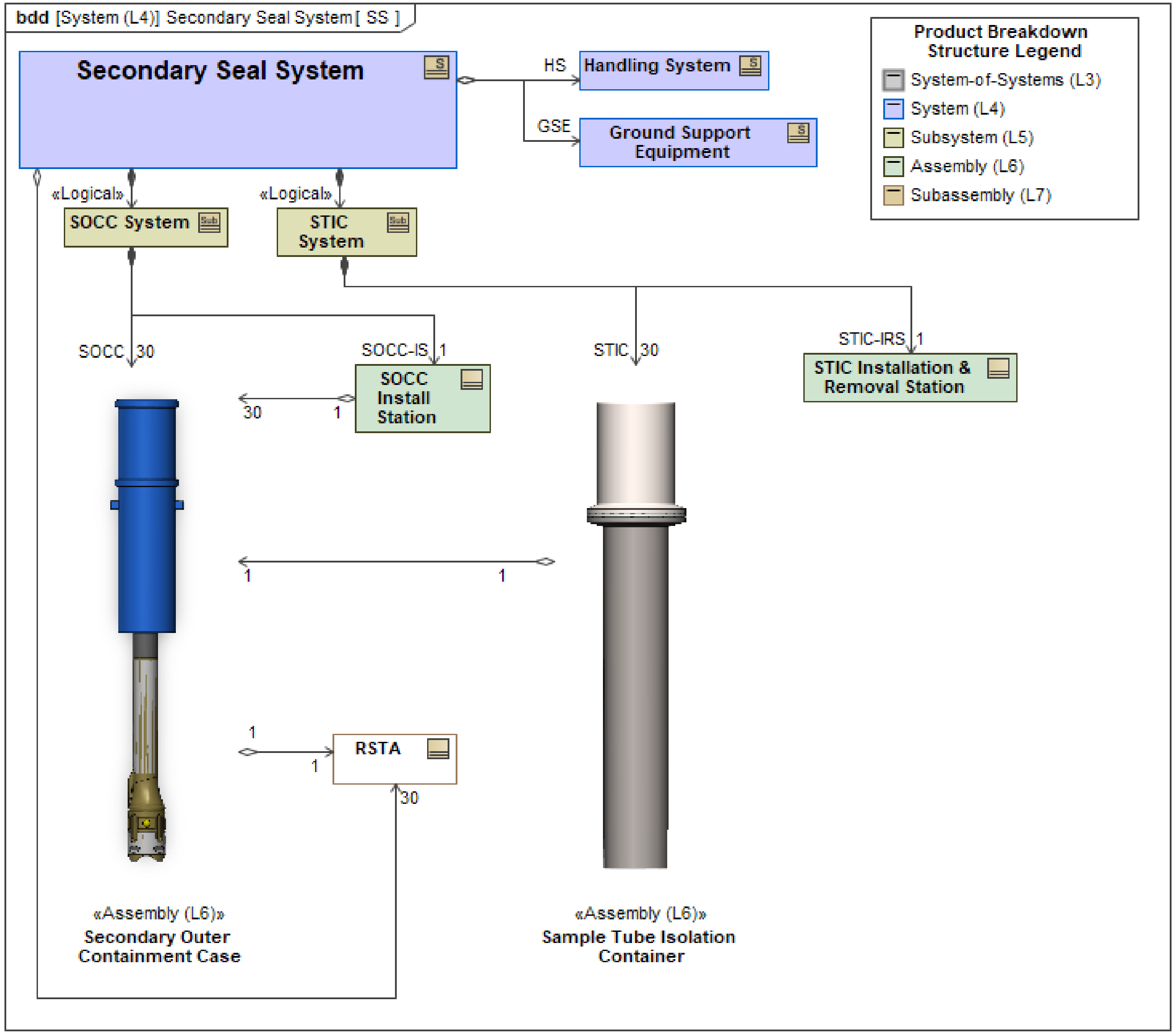


Level 4 Secondary Seal System

L4-Secondary Seal System Assumptions

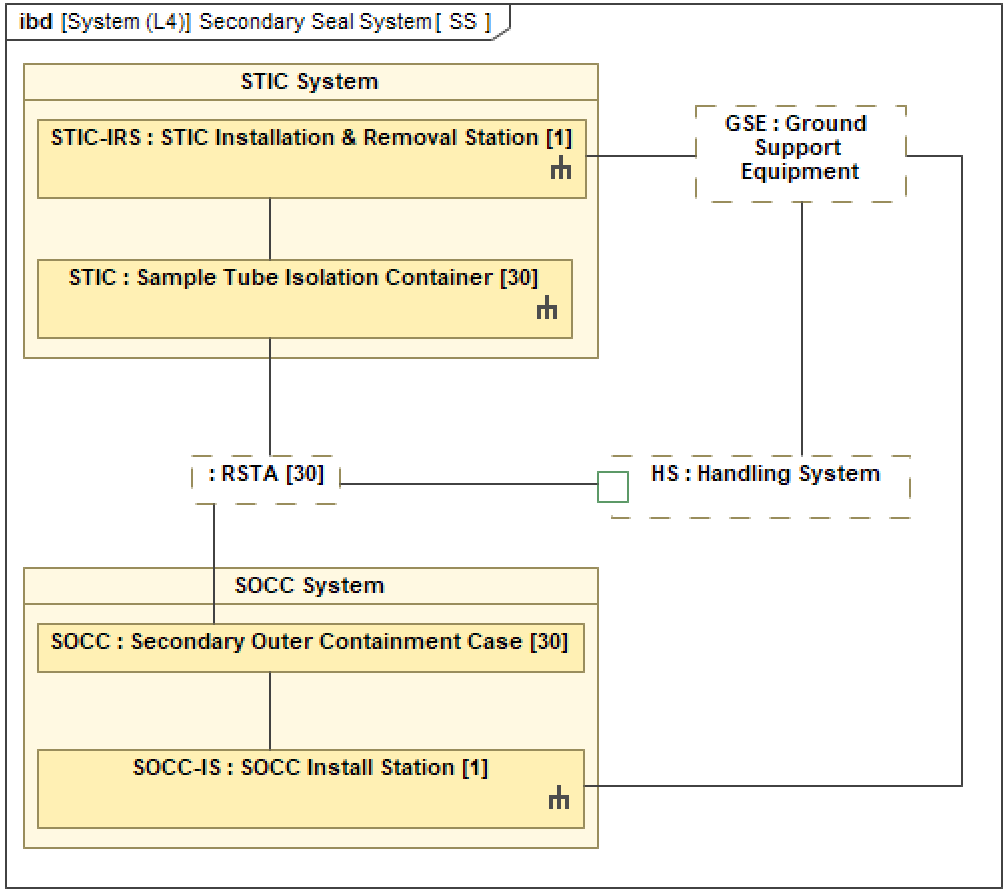
ID	Name	Text
A-L4-SS.1	SSS Decomposition	**Secondary Sealing System (SSS)** is composed of two seals: •**Secondary Outer Containment Case (SOCC):** a cup seal applied on the bearing race of RSTA •**Sample Tube Isolation Container (STIC):** a container where the RSTA+SOCC get placed to be removed from DWI
A-L4-SS.2	SOCC ASAP	RSTAs removed from OS need SOCC seal as soon as possible.
A-L4-SS.3	STIC for Outside DWI	STIC is how the RSTA is allowed to leave the Double-Walled Isolator (DWI).
A-L4-SS.5	Gloved SS Installation	SOCC and STIC can be (de-)installed with human gloved hands.
A-L4-SS.6	Robotics De-scoped	Robotics de-scoped in RIC1 and RIC2 to save cost.
A-L4-SS.7	SOCC Remains	SOCC remains installed throughout the entire sample removal process.
A-L4-SS.8	Installation Stations	The SOCC and STIC have their own installation stations to relax the requirements on the robotic arm and operator.
A-L4-SS.9	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv
A-L4-SS.10	XCT Reference Unit	XCT dimensions based on actual unit @ UT Austin
A-L4-SS.11	Magnetometry Constraints	Avoid Fe and Ni content in SS

Secondary Seal System Product Breakdown Structure

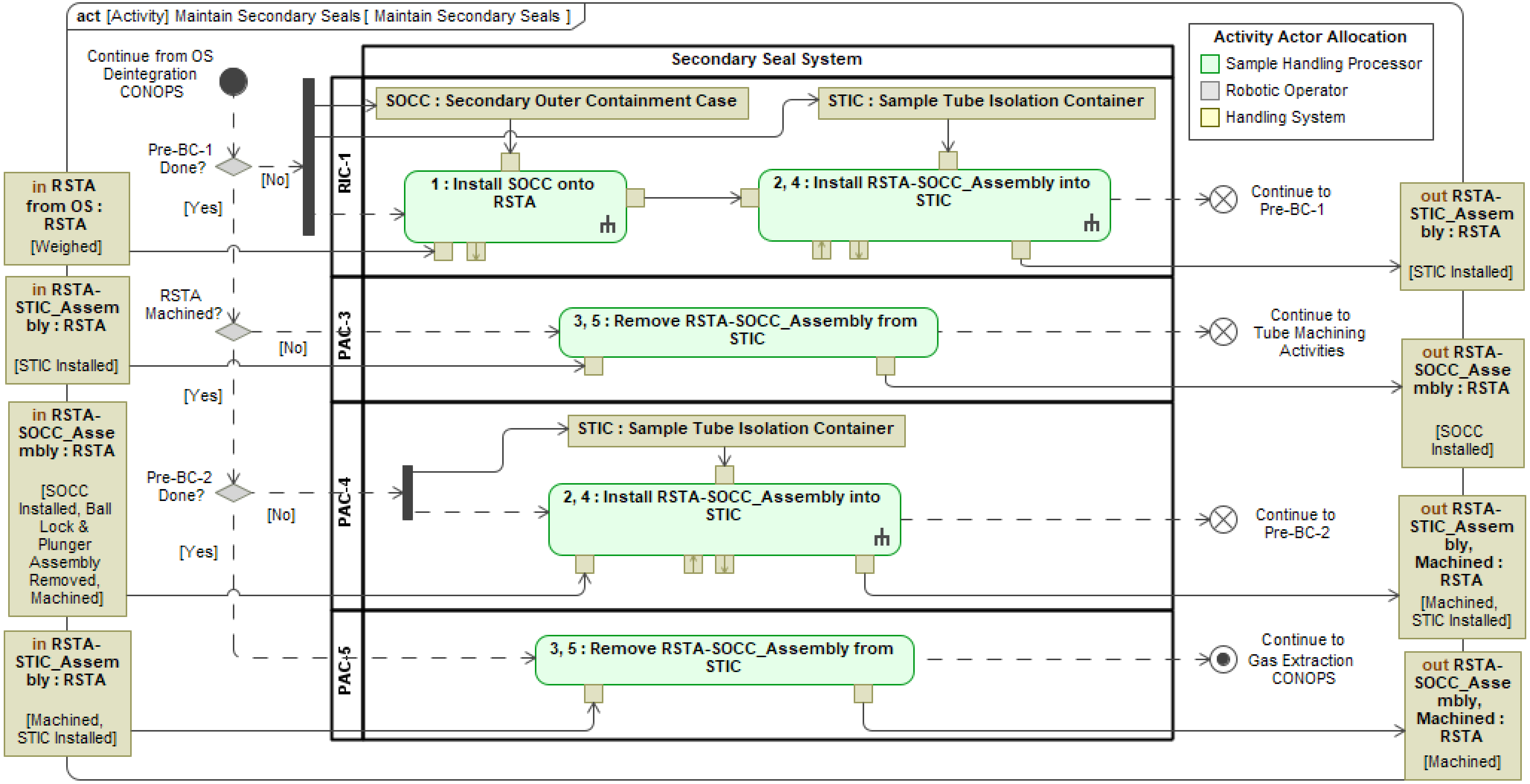


Pre-Decisional Information – For Planning and Discussion Purposes Only

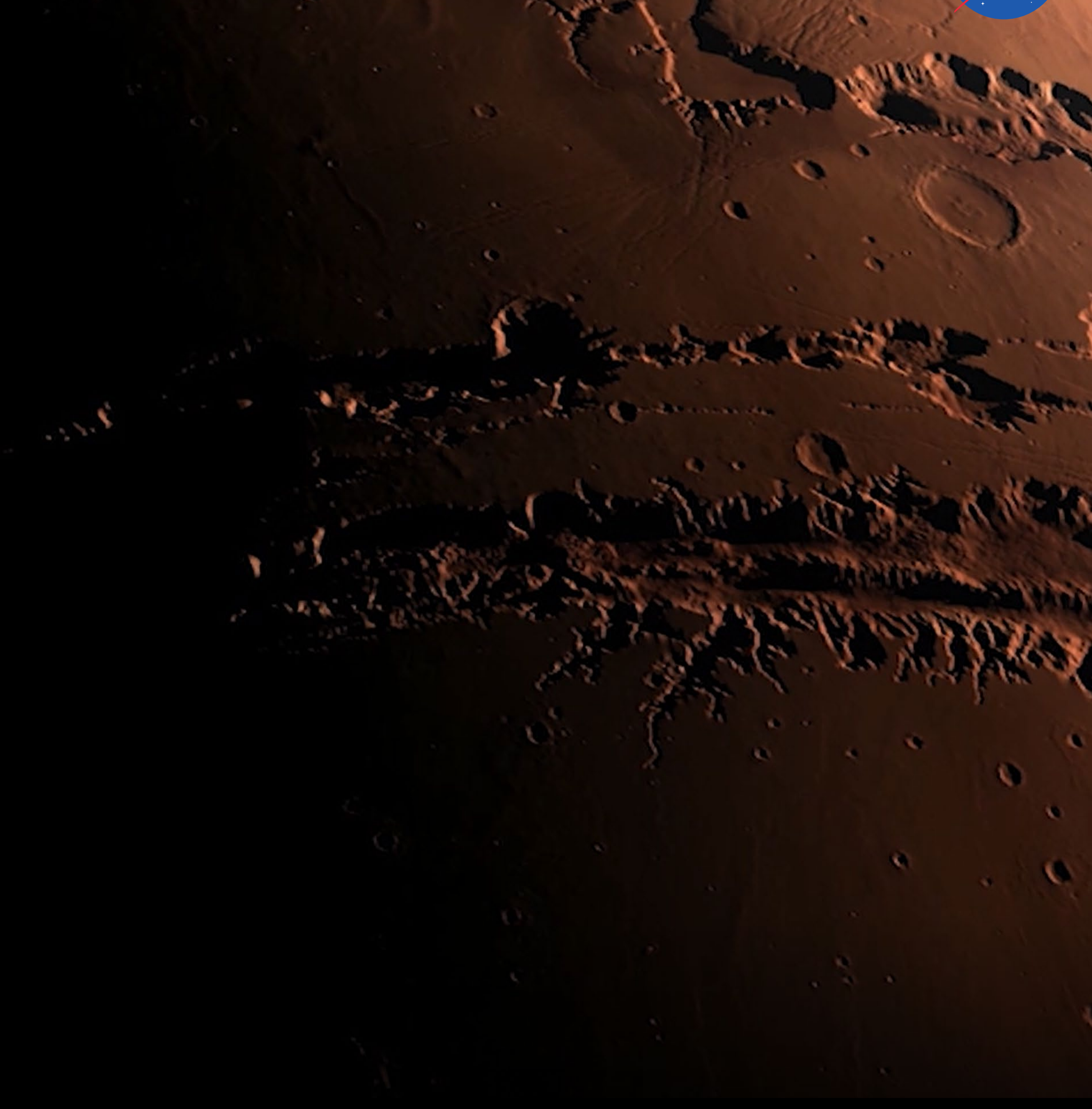
Secondary Seal System Block Diagram



Secondary Seal System Activity Flow



L5 Secondary Outer Containment Case System



L5-SOCC System Assumptions (1 of 2)

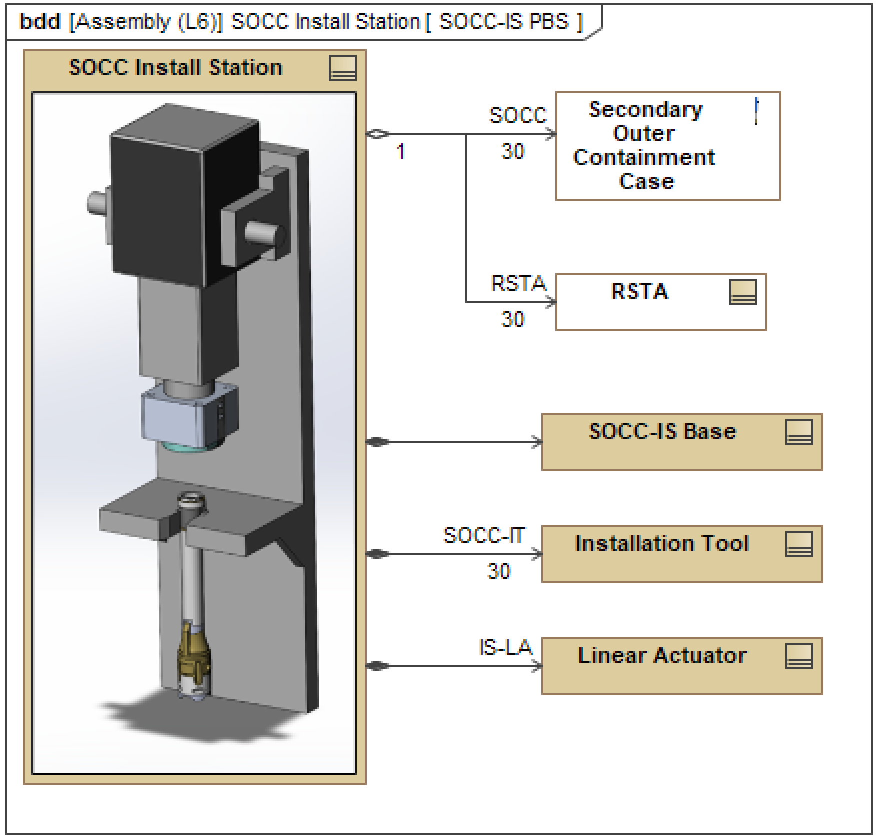
ID	Name	Text
A-L5-SOCC.1	Hermetic Seal Failed	RSTA M2020 Hermetic Seal has failed
A-L5-SOCC.2	Immediate Installation	SOCC is installed immediately after the RSTA is removed from OS
A-L5-SOCC.3	Seal Through Alumina	Break through the alumina to the titanium to make the seal • only removed if absolutely needed, determined through testing • alumina is brittle
A-L5-SOCC.4	No Seal Against Flats	Cannot seal against lower or upper flat surfaces of bearing race (not enough surface for a seal)
A-L5-SOCC.5	Permissible Grip Locations	Gloved hand can manipulate RSTA anywhere except for hermetic seal during SOCC installation
A-L5-SOCC.6	RSTA Shank Present	RSTA still has shank on during SOCC installation
A-L5-SOCC.9	Cameras Available	Cameras available to assist installation
A-L5-SOCC.11	No Elastomers	Elastomers (elastomeric seals) cannot be used for off-gassing and organic molecule contamination concerns
A-L5-SOCC.14	IT Not Clean	Not cleaning Installation Tool holder in between RSTA processing
A-L5-SOCC.15	Leak Rate Requirements	Leak rate requirements are reused from M2020 but may be relaxed if SOCC testing continues to result in elevated leak rates

L5-SOCC System Assumptions (2 of 2)

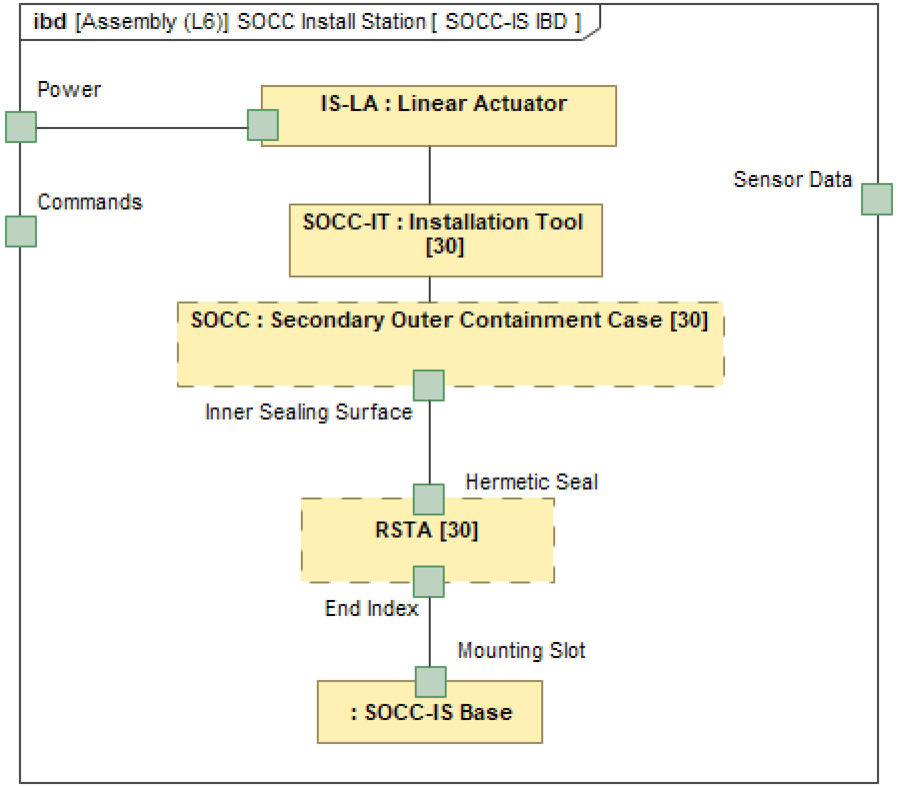
Auto-generated by architecture model

ID	Name	Text
A-L5-SOCC.16	Cleaning Before Install	Cleaning of particulate could be conducted on RSTA before SOCC installation
A-L5-SOCC.17	Duration of Use	SOCC remains installed until tube cutting for solid sample removal
A-L5-SOCC.18	Macro Imaging	Macro imaging of RSTA may be conducted before installation of SOCC
A-L5-SOCC.19	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv
A-L5-SOCC.20	Particle Shedding	Particle shedding from the RSTA alumina, SOCC Install Station Gate Latch, and others (TBD) is low risk
A-L5-SOCC.21	XCT Reference Unit	XCT dimensions based on actual unit @ UT Austin
A-L5-SOCC.22	Magnetometry Constraints	Avoid Fe and Ni content in SOCC

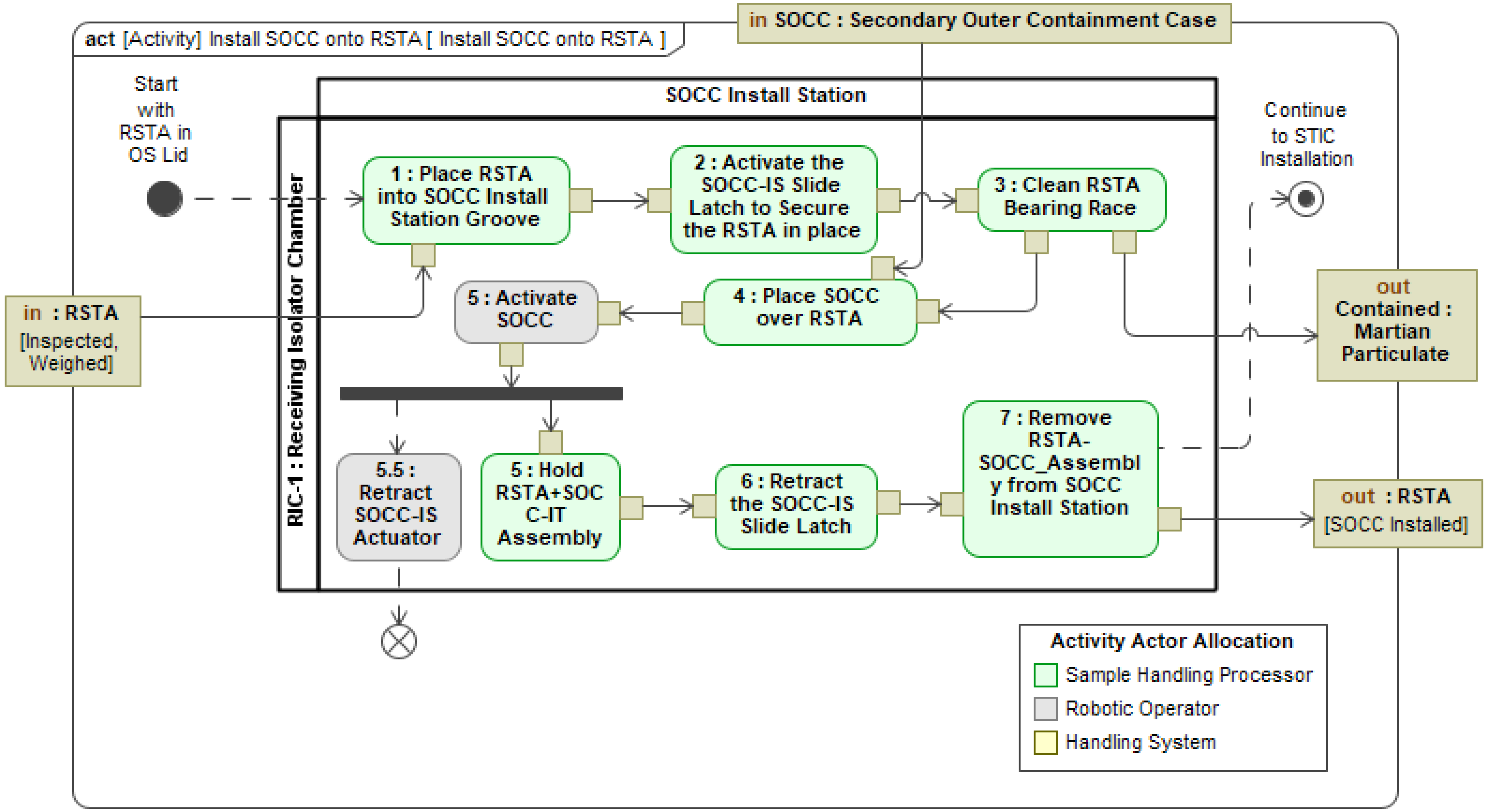
SOCC Install Station Product Breakdown Structure



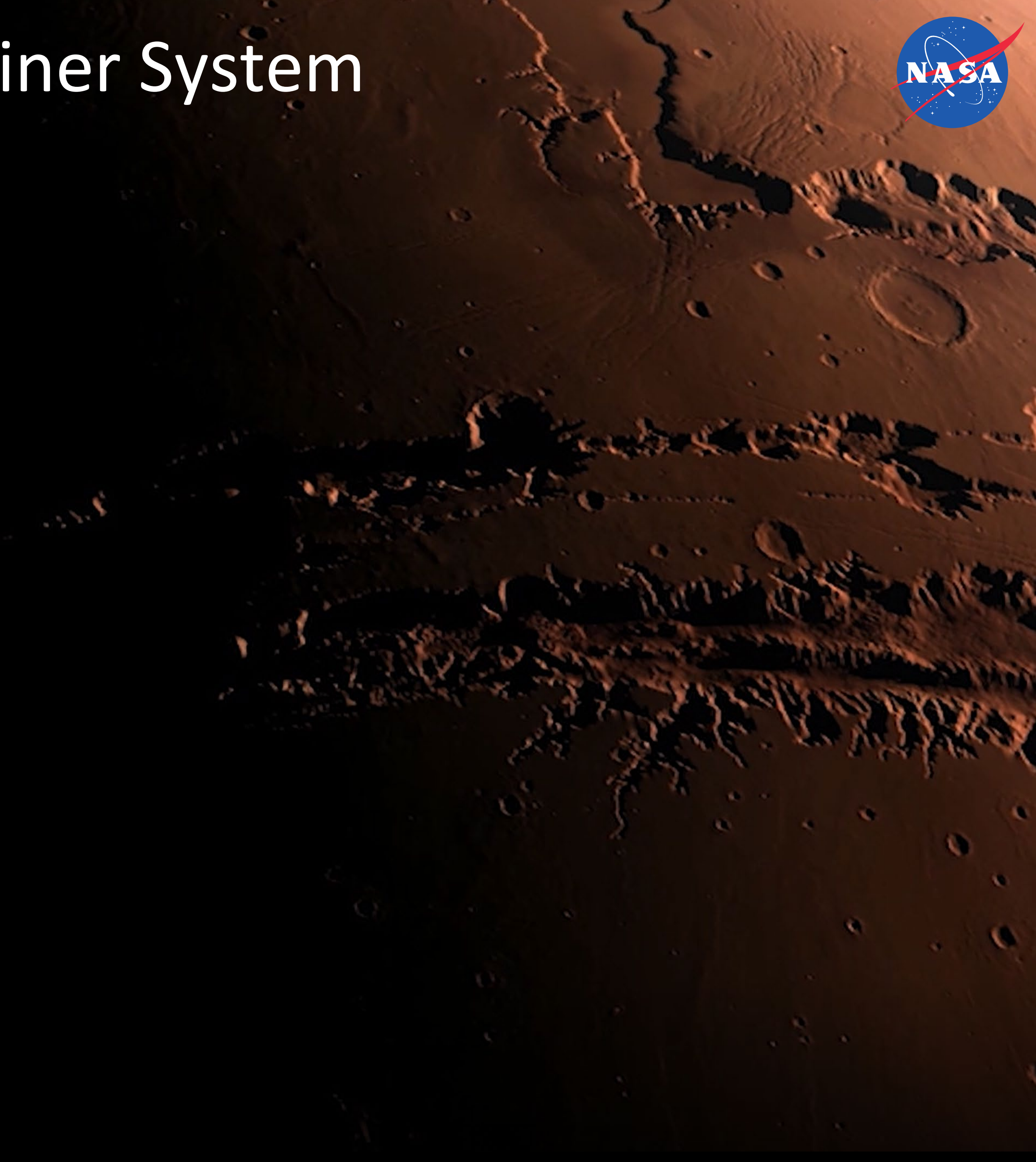
SOCC Install Station Block Diagram



SOCC Installation Activity Flow



L5 Sample Tube Isolation Container System



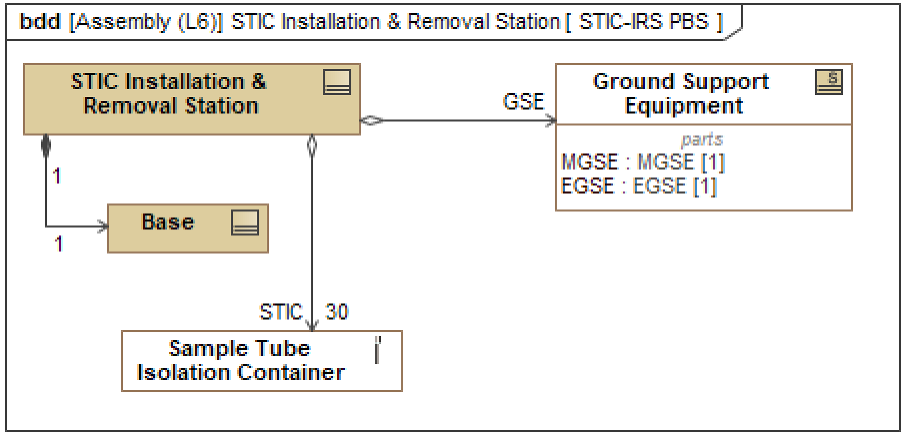
L5-STIC System Assumptions (1 of 2)

ID	Name	Text
A-L5-STIC.1	Redundant Seal Requirement	STIC is how project meets 2 level redundant seal requirement for removing RSTAs from the DWI
A-L5-STIC.2	Teflon Tri-Clamp Seal	Using Teflon Tri-Clamp seal because it is legacy hardware for JSC curation
A-L5-STIC.3	Accommodable STIC	STIC needs to be able to accommodate RSTA in different configurations (e.g., shank removed)
A-L5-STIC.4	Near X-ray Source	XCT X-ray source needs to be as close as possible to the OD of the STIC region housing the RSTA to maximize the penetration to ensure scan quality
A-L5-STIC.5	Magnetometry Spin Axes	During magnetometry STIC in need to spin about major and minor axes
A-L5-STIC.6	Thin Walls	STIC wall for region housing RSTA needs to be as thin as possible to minimize degradation of x-ray beam
A-L5-STIC.7	Sterilized STIC Exterior	Sterilization of STIC exterior before exit and after reentry into DWI happens with VHP
A-L5-STIC.8	Gloved Hands Installation	Installation of RSTA into STIC can be done by gloved human arm in RIC-2

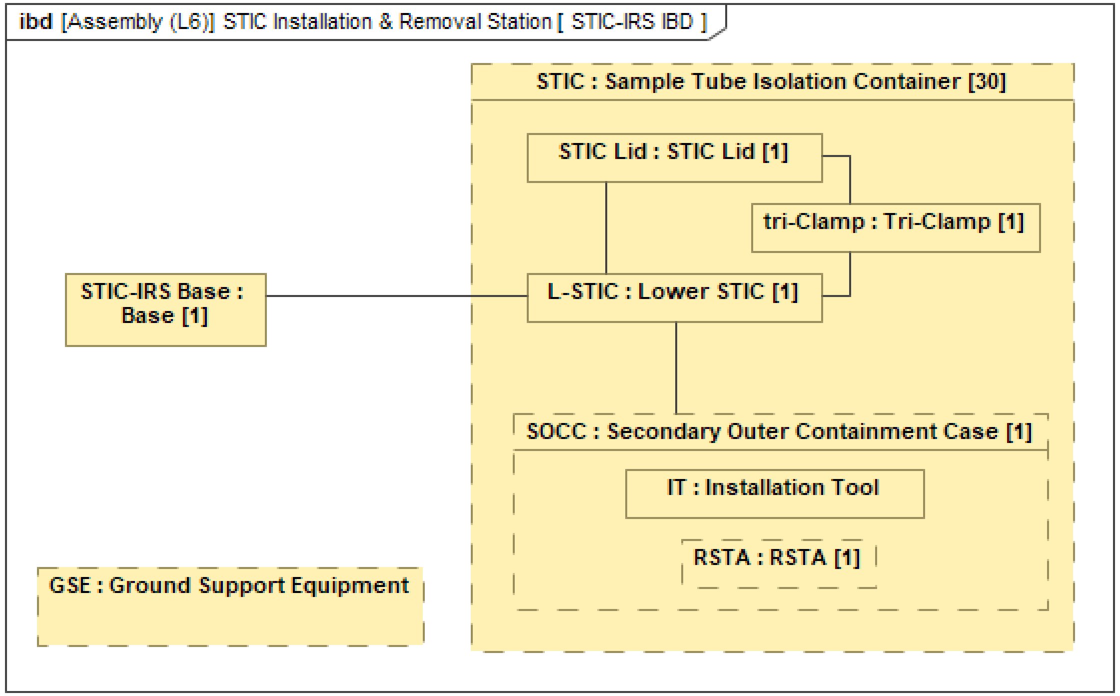
L5-STIC System Assumptions (2 of 2)

ID	Name	Text
A-L5-STIC.9	Robotic Deinstallation	Robotic removal of RSTA+SOCC is needed for operations in PIC-1
A-L5-STIC.10	Clean STIC Exterior	Cleaning happens via Teflon bristle brush
A-L5-STIC.11	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv
A-L5-STIC.12	XCT Reference Unit	XCT dimensions based on actual unit @ UT Austin
A-L5-STIC.13	Magnetometry Constraints	Avoid Fe and Ni content in STIC

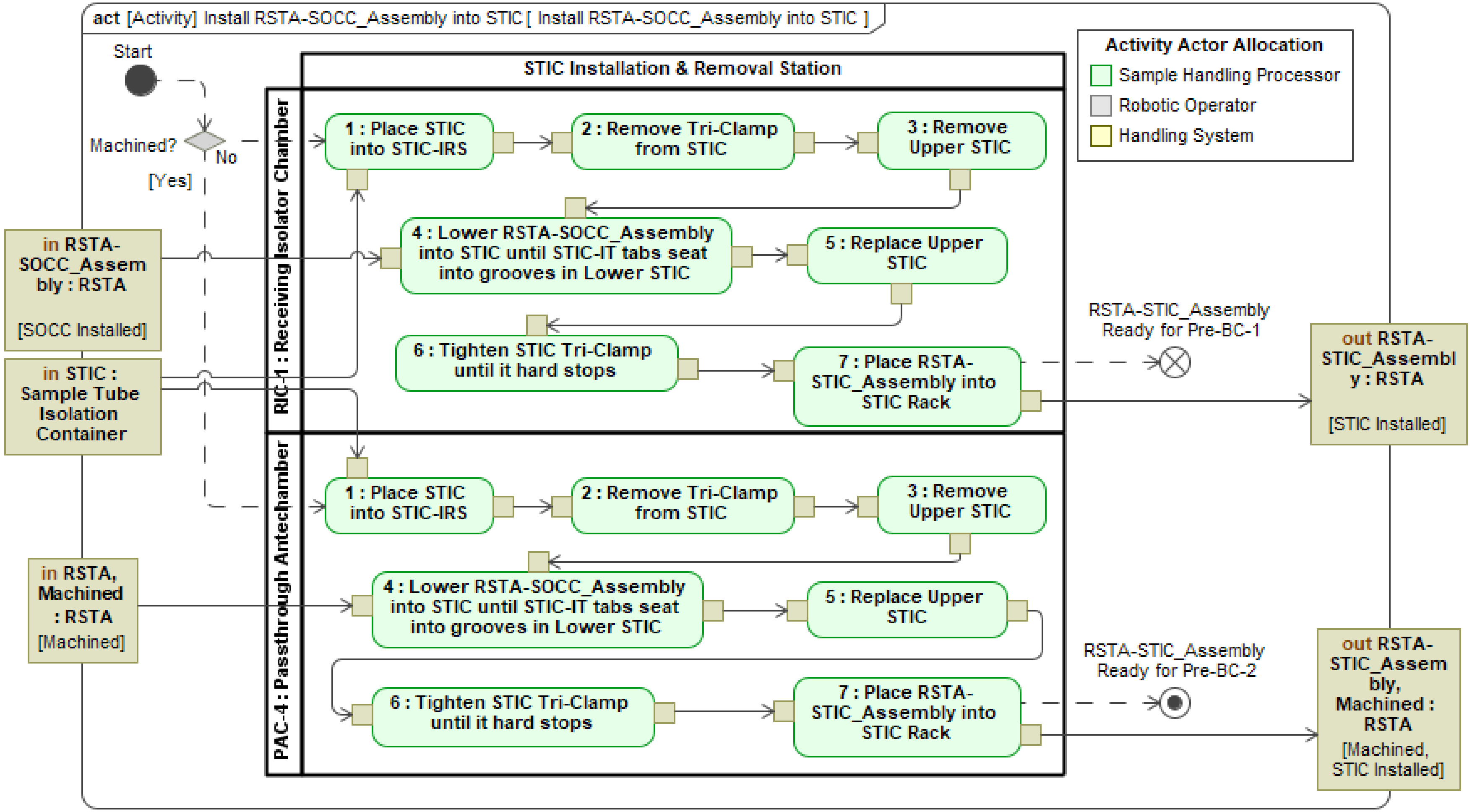
STIC Installation & Removal Station Product Breakdown Structure



STIC Installation & Removal Station Block Diagram



STIC Installation Activity Flow

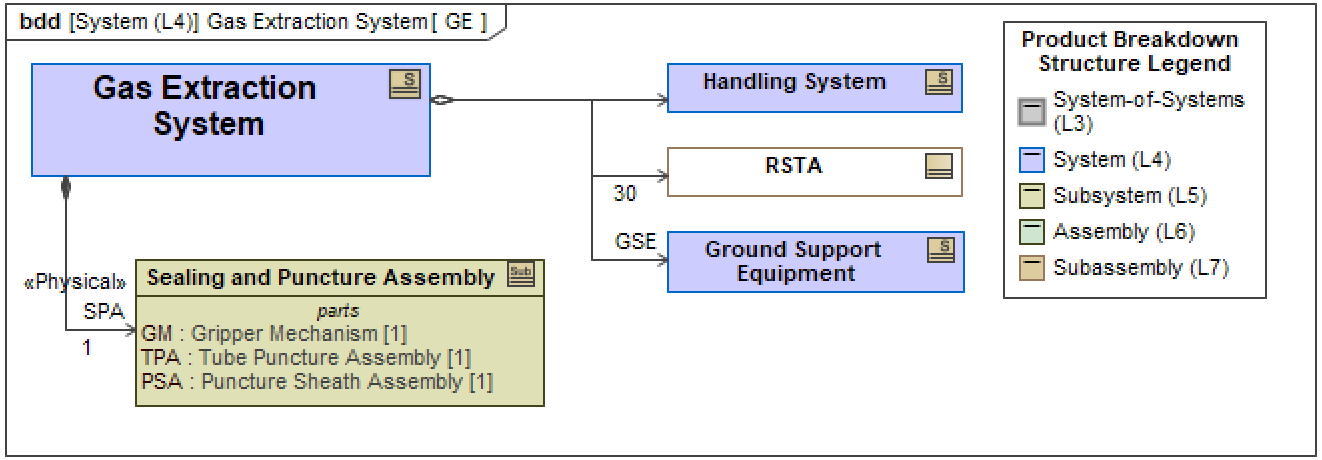


Level 4 Gas Extraction System

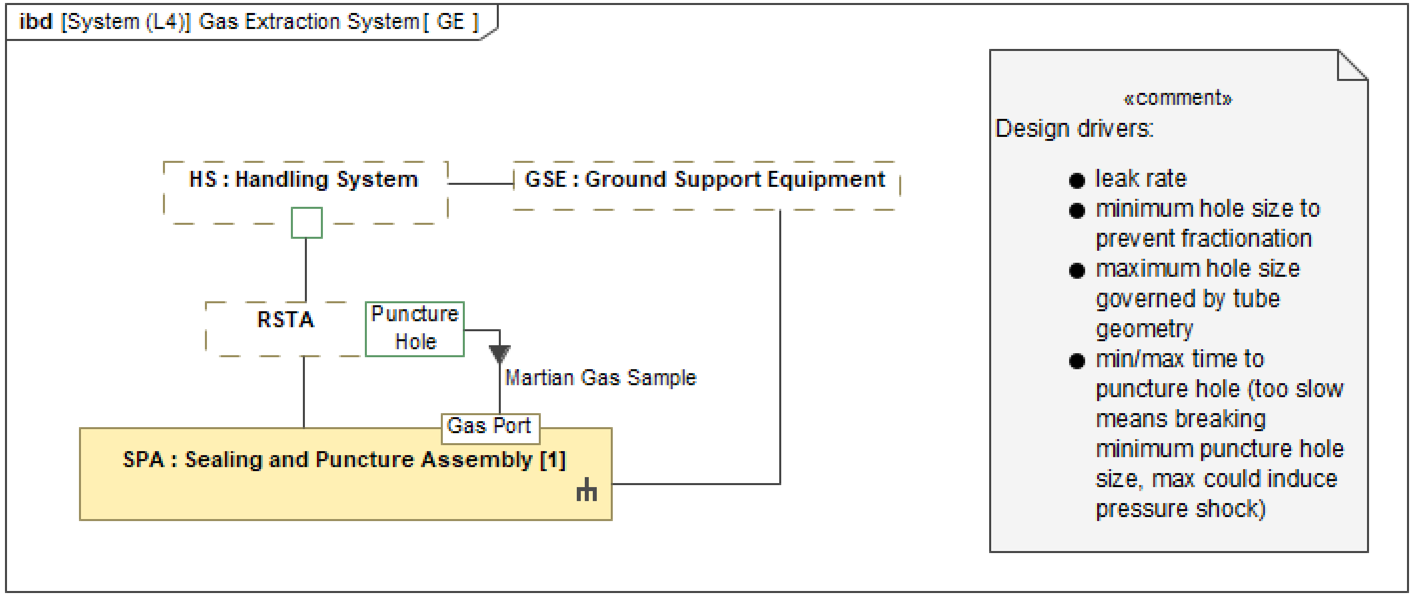
L4-Gas Extraction System Assumptions

ID	Name	Text
A-L4-GE.1	SPA Scope	JPL is responsible for the delivery of the Sealing and Puncture Assembly (SPA). The SPA provides a means for: •Puncturing the RSTA, to release the trapped head gas within. •Maintaining a local seal around the area of puncture. •Gripping the tube during sealing and puncture. •The ability to interface to the Gas Collection and Storage Apparatus (GCSA).
A-L4-GE.2	GCSA Delivery	The Gas Science team is responsible for delivering the GCSA.
A-L4-GE.12	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv

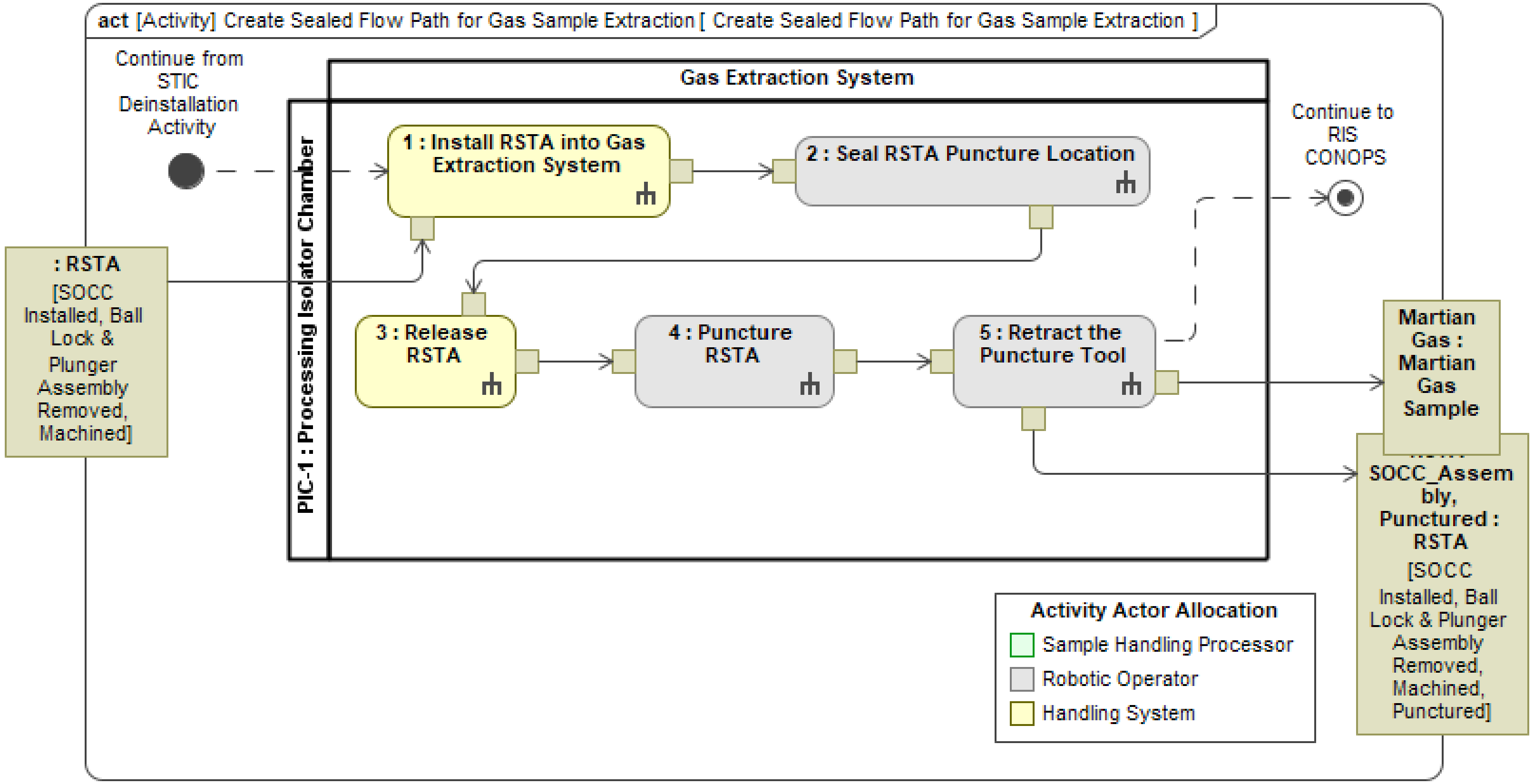
Gas Extraction System Product Breakdown Structure



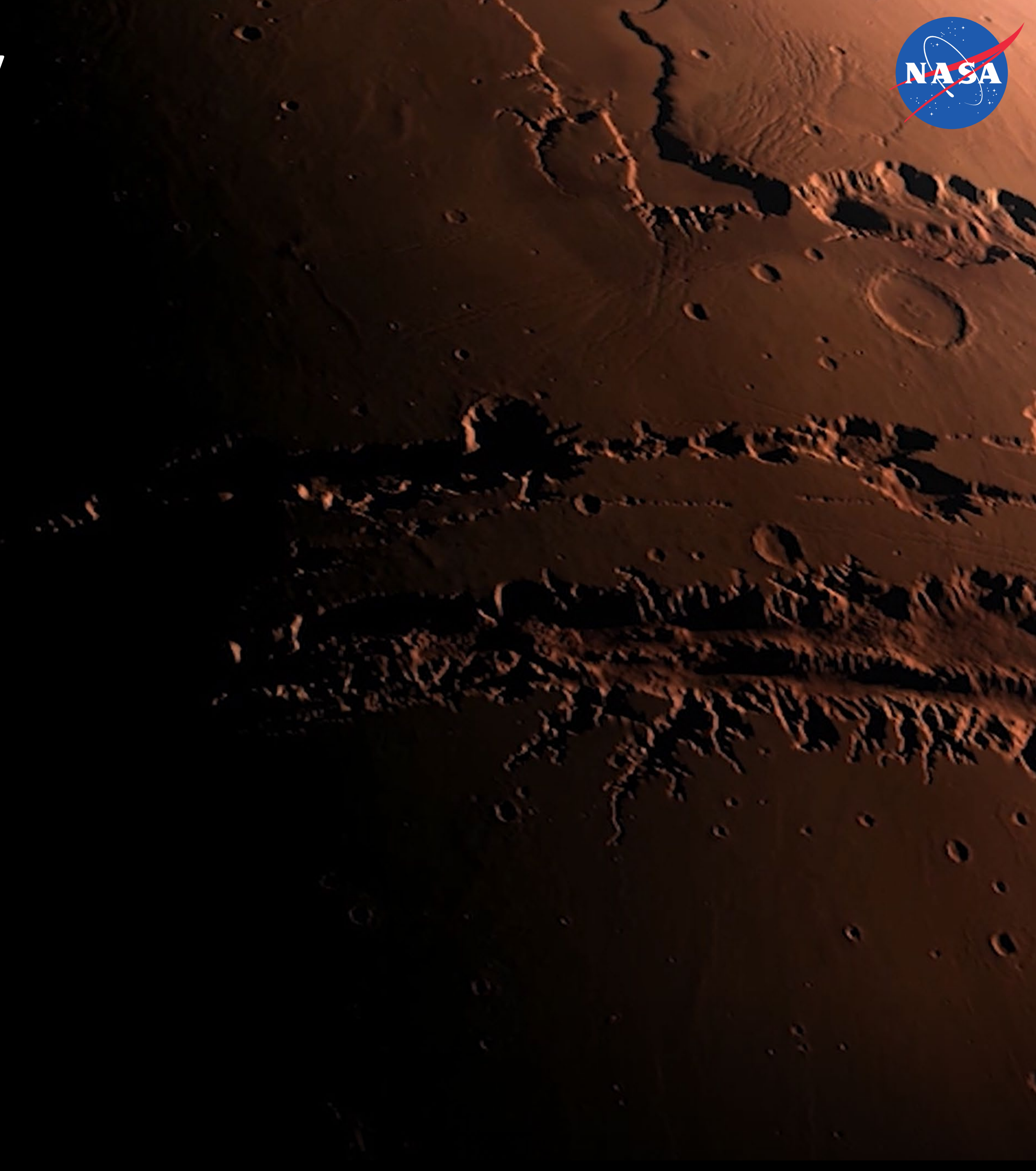
Gas Extraction System Block Diagram



Gas Extraction System Activity Flow



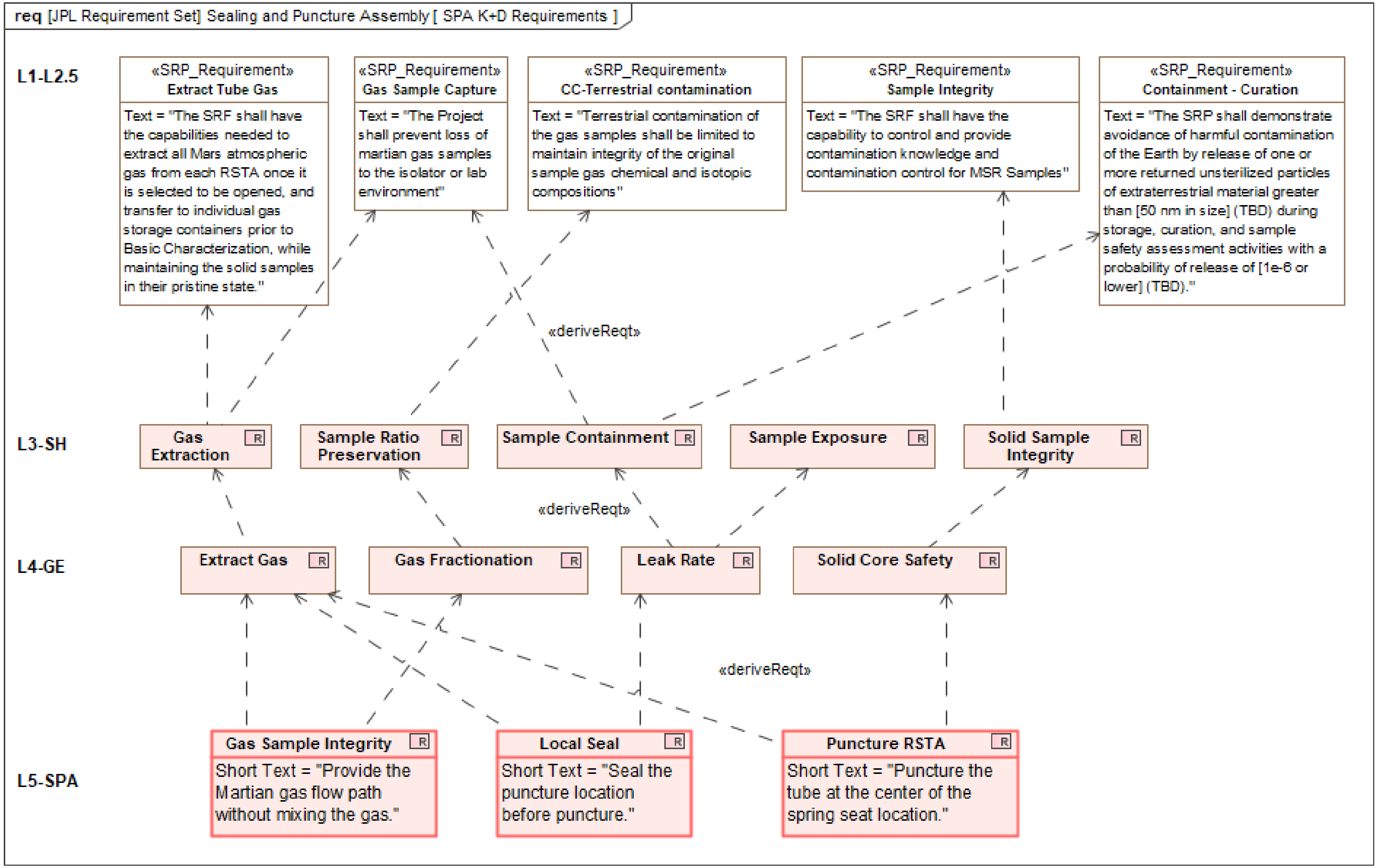
L5 Sealing & Puncture Assembly



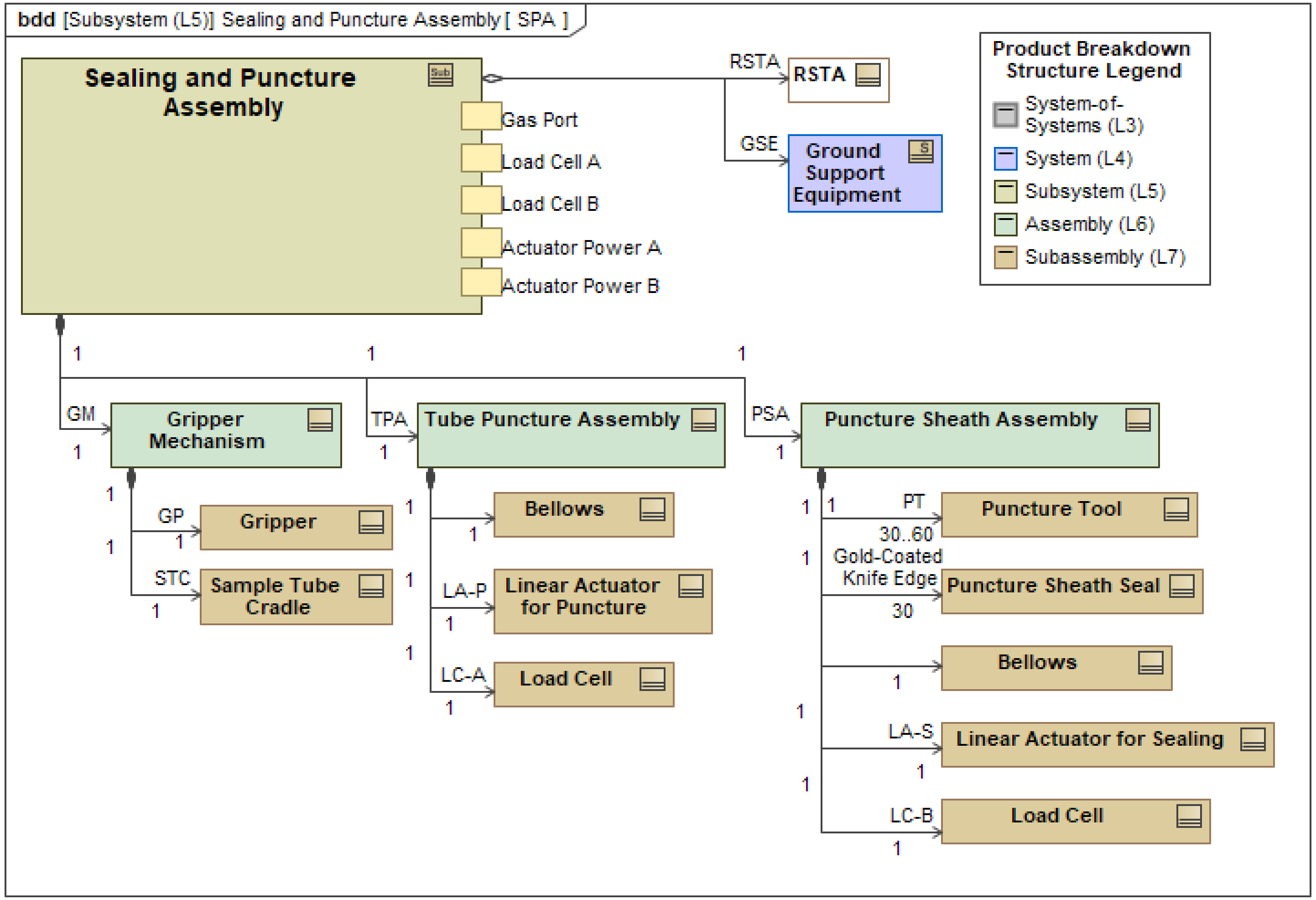
L5-SPA System Assumptions

ID	Name	Text
A-L5-SPA.1	RSTA Contains Gas	RSTA contains Martian Gas (the M2020 Hermetic Seal is intact and functioning).
A-L5-SPA.2	Contact the Solid Sample	Puncture tool tip is allowed to contact the solid sample inside the RSTA.
A-L5-SPA.3	Slug Created	A slug of the Sample Tube Spring Seat will be generated during puncture and will contact solid sample.
A-L5-SPA.4	RSTA Arrival State	RSTA will arrive at the Gas Extraction Station in the following state: •Clocked appropriately to the puncture location •Shank, Ball Lock & Plunger assembly removed •“Step” machined into tube around puncture region •SOCC Installed •Spring seat area and puncture location are clean
A-L5-SPA.5	Delivery by Handling System	The Handling System will deliver the RSTA to the SPA within the positional accuracy required for: – Successful handoff to the Gripper Assembly. – Clocked such that the shank end center axis is aligned to the Seal and Puncture Manifold center axis.
A-L5-SPA.6	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv
A-L5-SPA.7	Refurbishment	Refurbishment may be done by gloved hand or robotics
A-L5-SPA.8	Minimize Sealing Sheath Volume	Minimize the sealing sheath volume to avoid mixing the gas sample

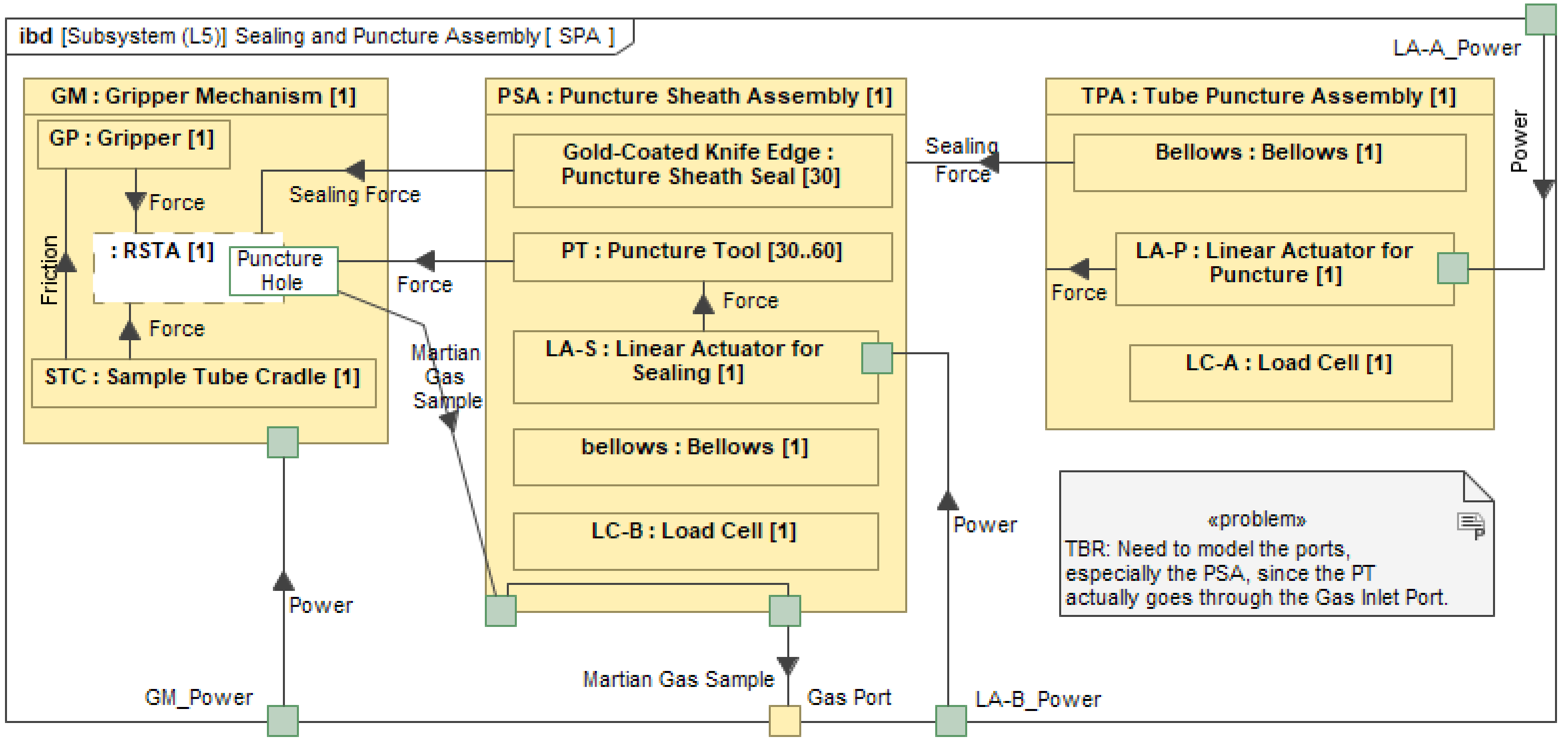
SPA Key and Driving Requirements



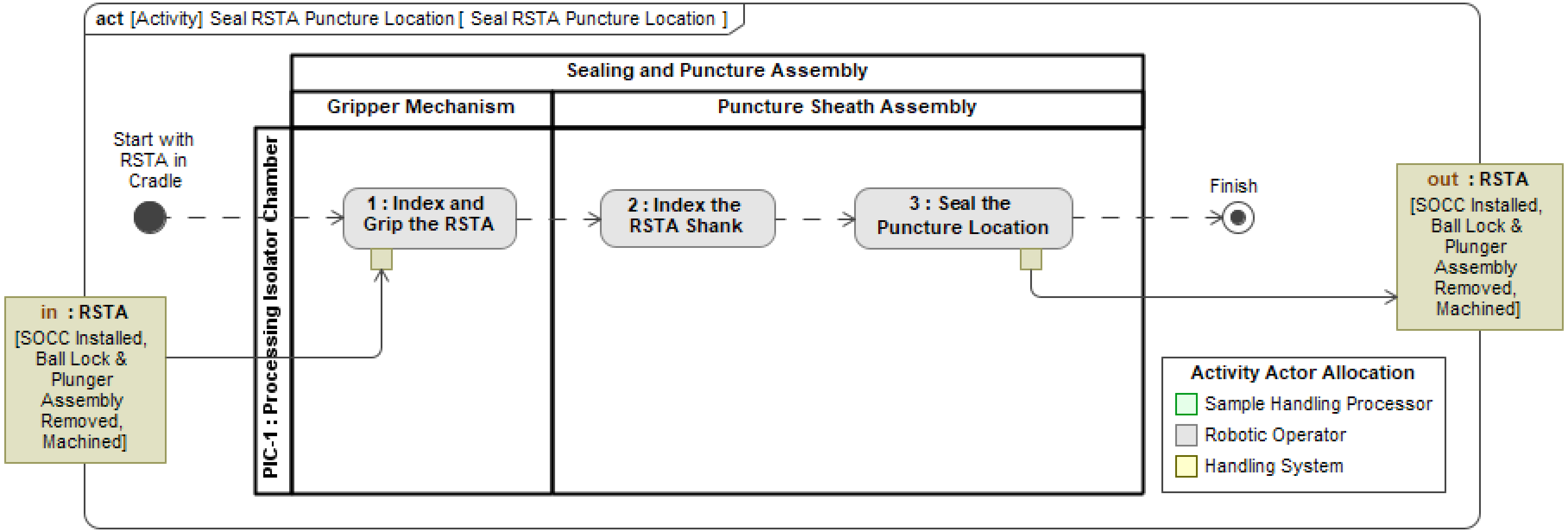
Sealing & Puncture Assembly Product Breakdown Structure



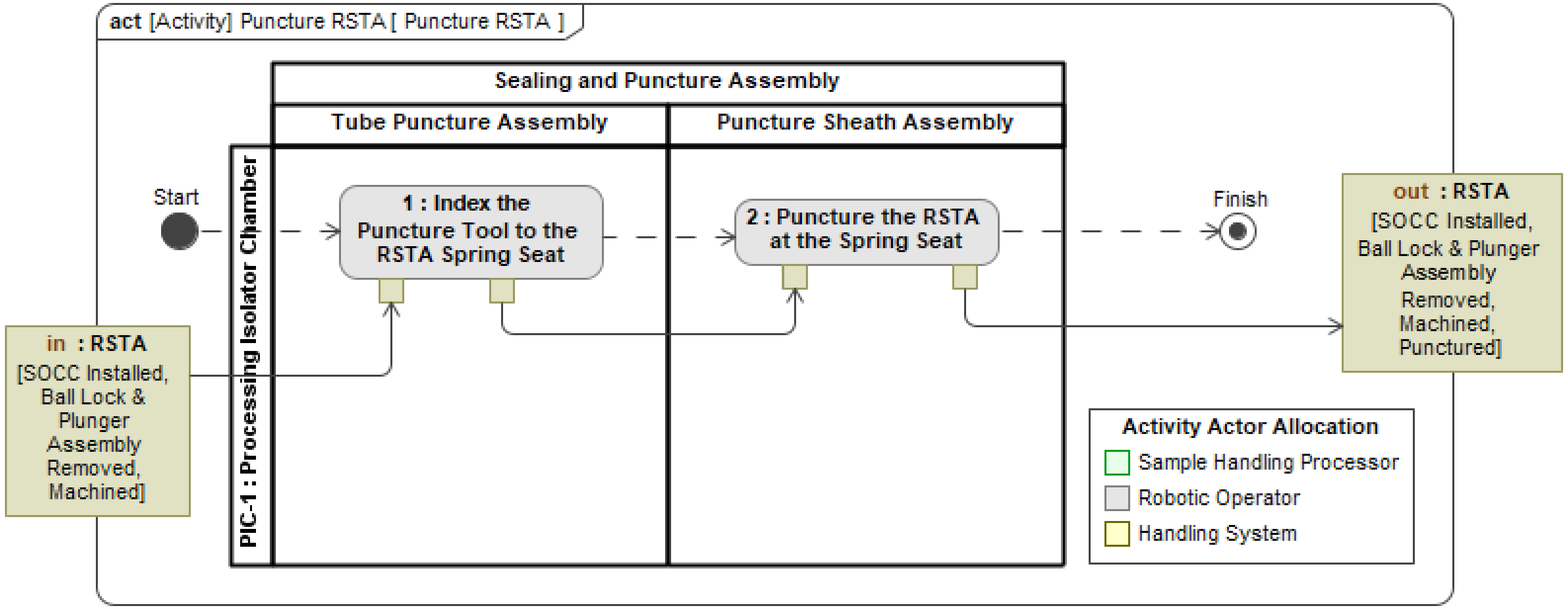
Sealing & Puncture Assembly Block Diagram



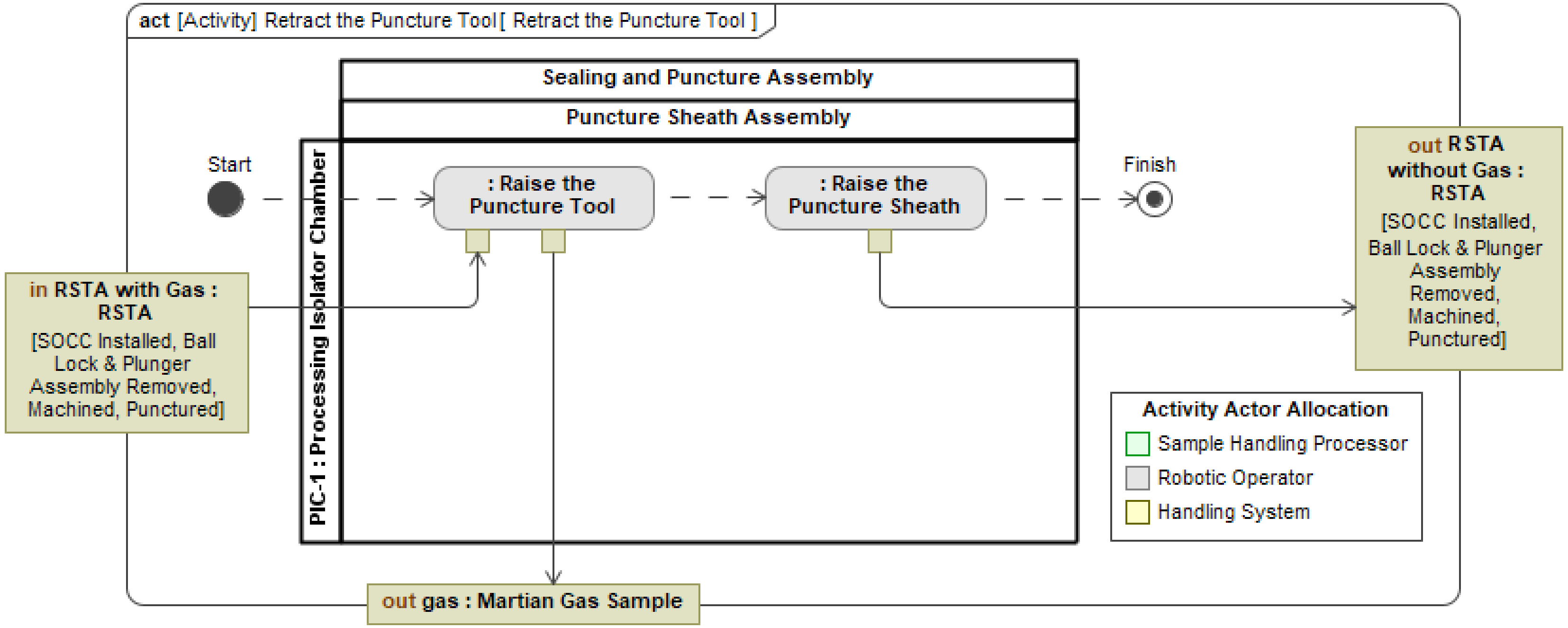
Seal RSTA Puncture Location Activity Flow



Puncture RSTA Activity Flow



Retract the Puncture Tool Activity Flow

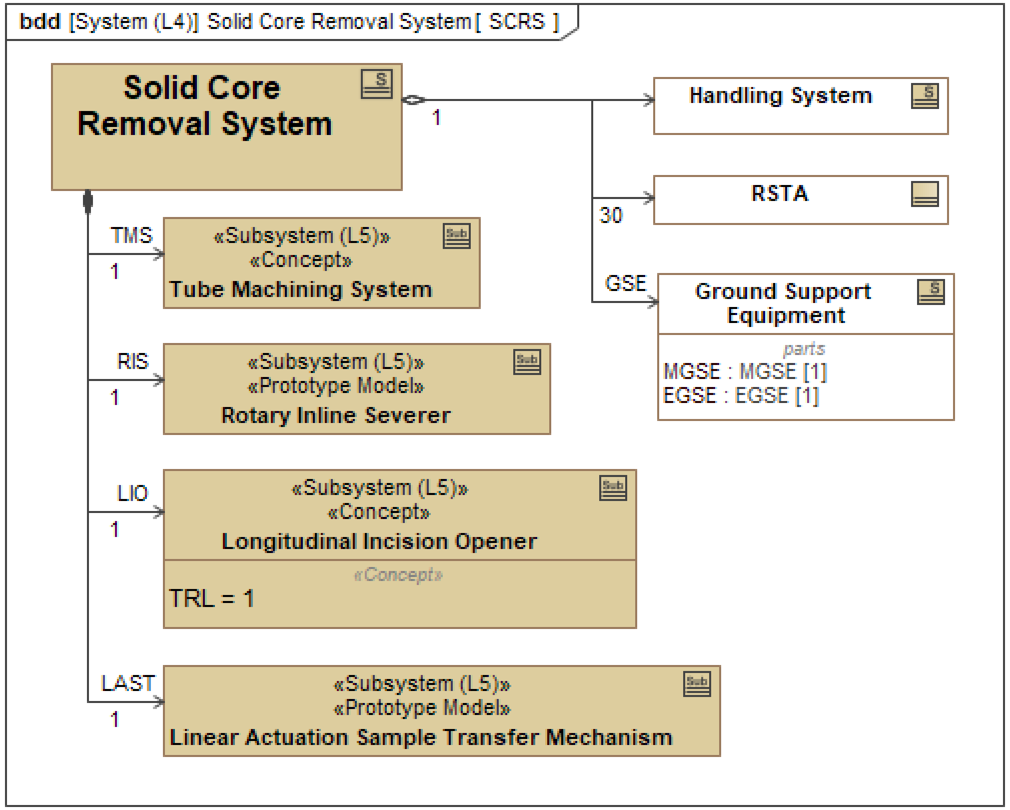


Level 4 Solid Core Removal System

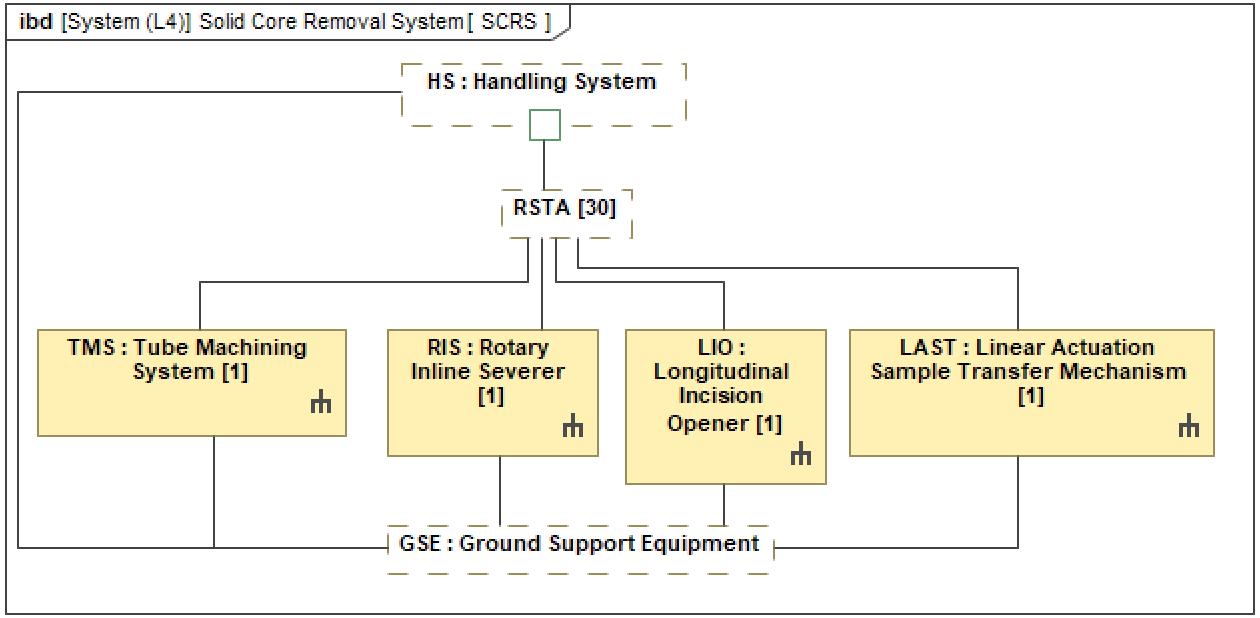
L4-SCRS Assumptions

ID	Name	Text
A-L4-SCRS.1	Hermetic Seal Present	The hermetic seal has not been removed.
A-L4-SCRS.2	Gas Extracted	The gas has been extracted through the RSTA Shank.
A-L4-SCRS.3	Alumina Not Removed	The bulk removal of Alumina is too risky.
A-L4-SCRS.4	RSTA Pre-Processed	The RSTA can be pre-processed in RIC 2 prior to cleaning.
A-L4-SCRS.5	RSTA Not Deformed	The RSTA has not deformed significantly from launch/landing.
A-L4-SCRS.6	SOCC Installed	The SOCC has been installed and the activation sleeve remains attached.
A-L4-SCRS.7	Keep Out Zones	The M2020-defined keep out zones for the hermetic seal are still active.
A-L4-SCRS.8	RSTA Material Collection	All RSTA material must be collected.
A-L4-SCRS.9	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv
A-L4-SCRS.10	Refurbishment	Refurbishment may be done by gloved hand or robotics

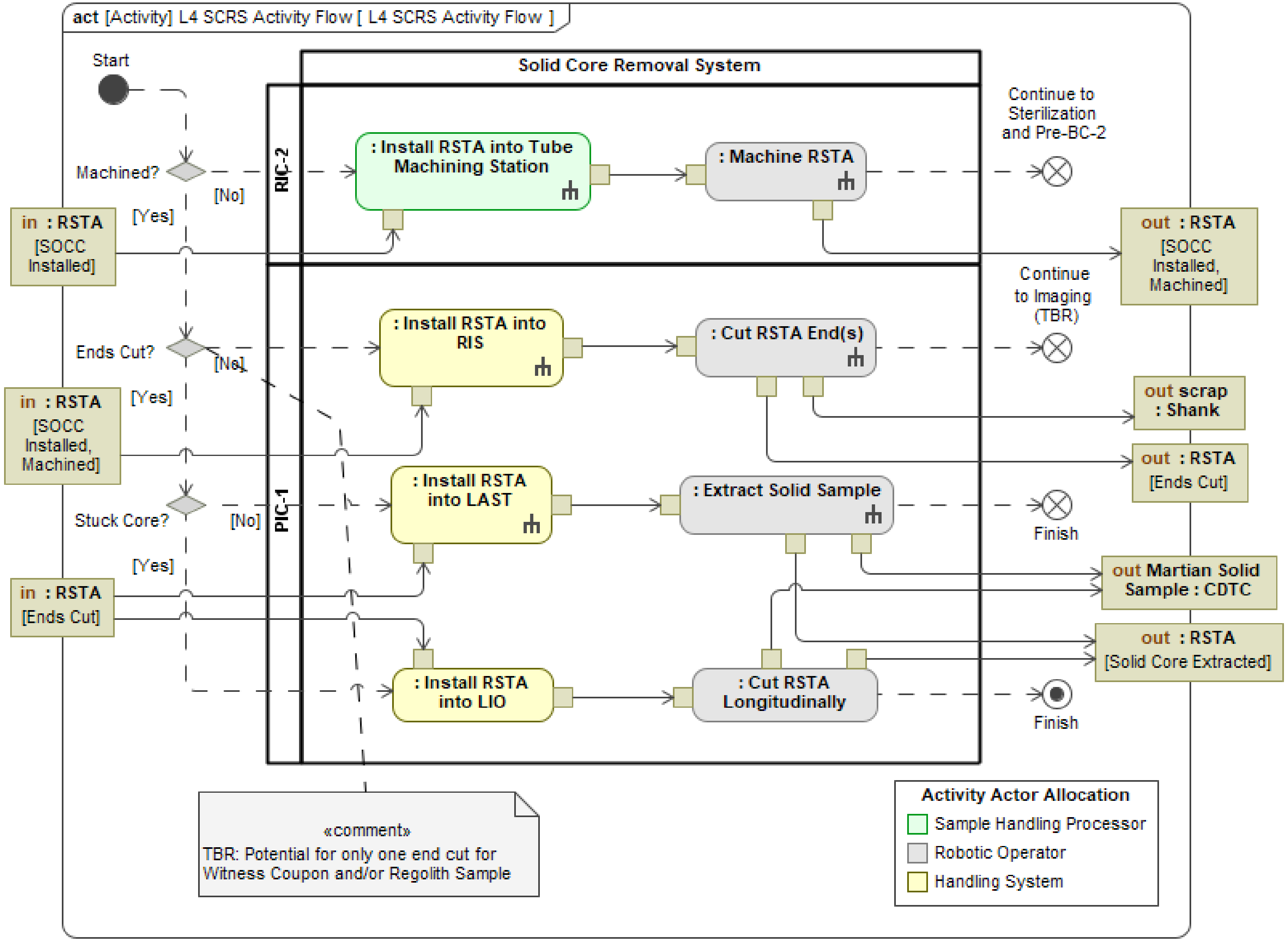
Solid Core Removal System Product Breakdown Structure



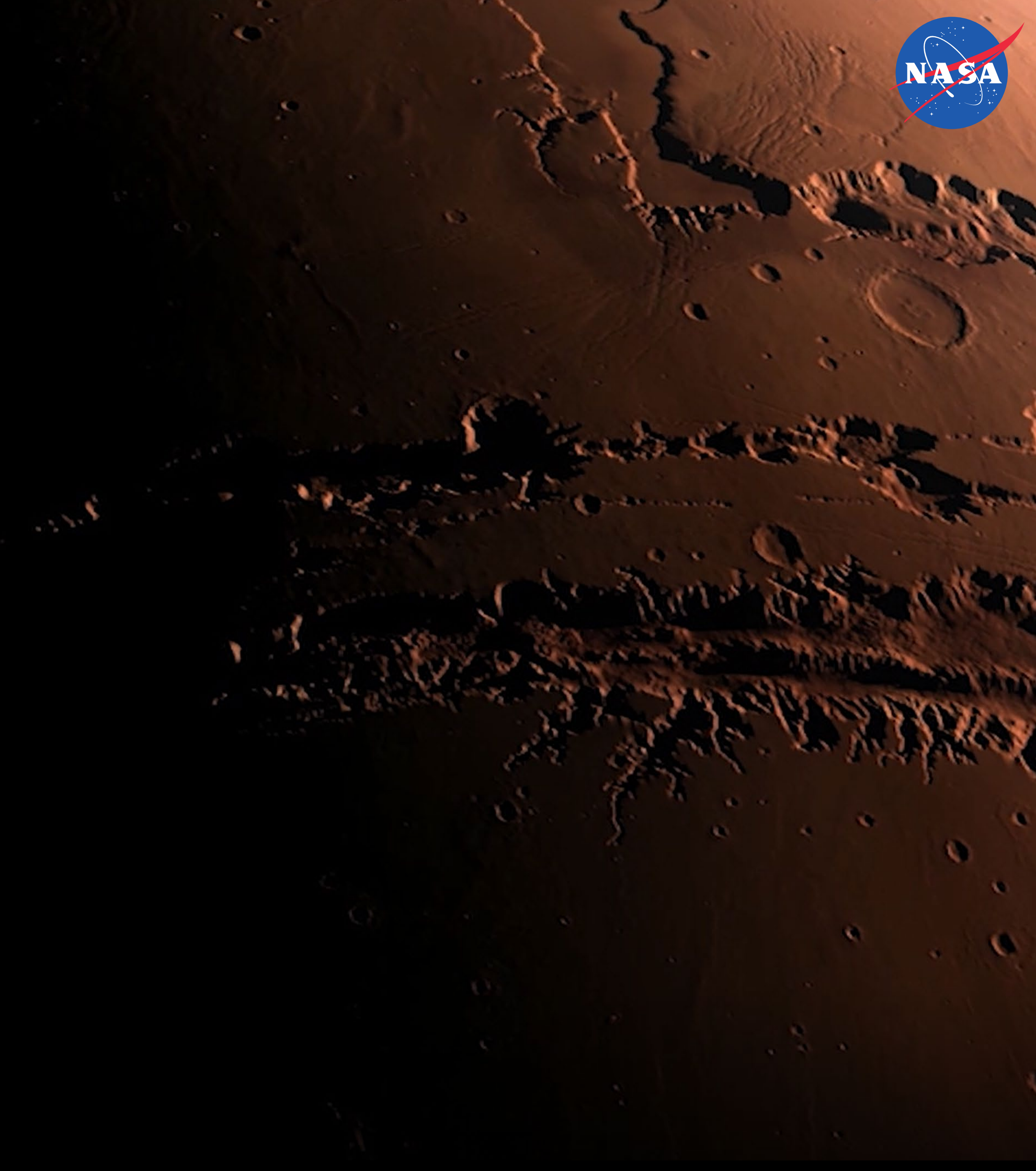
Solid Core Removal System Block Diagram



Solid Core Removal System Activity Flow



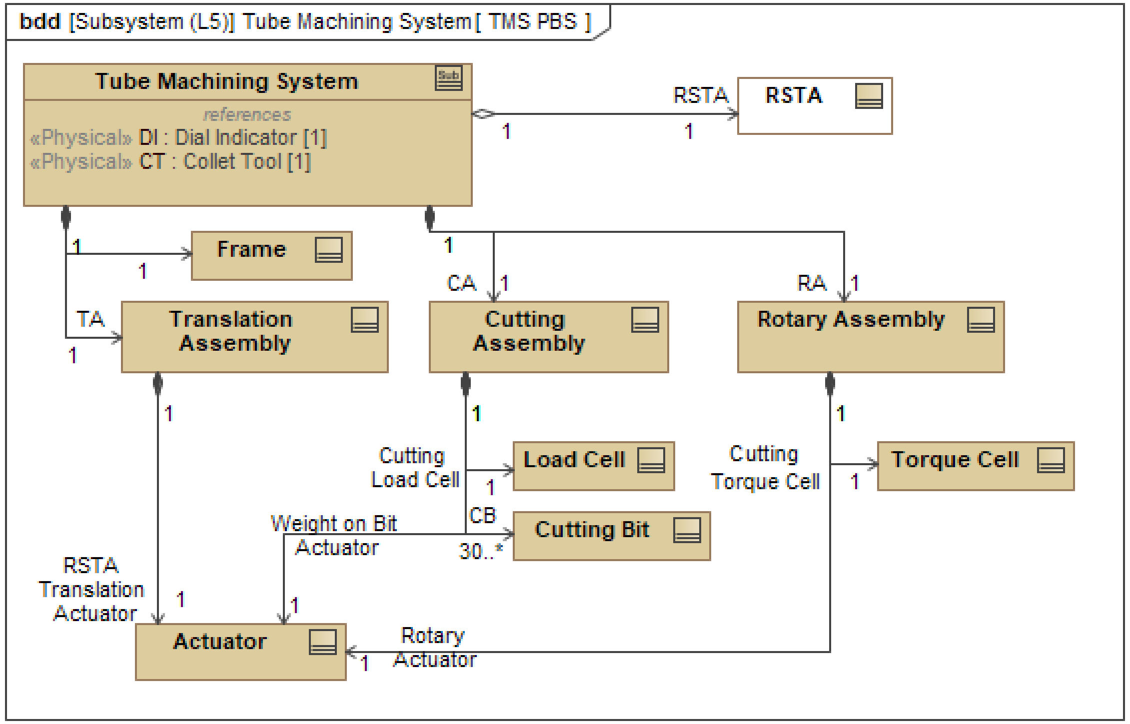
L5 Tube Machining



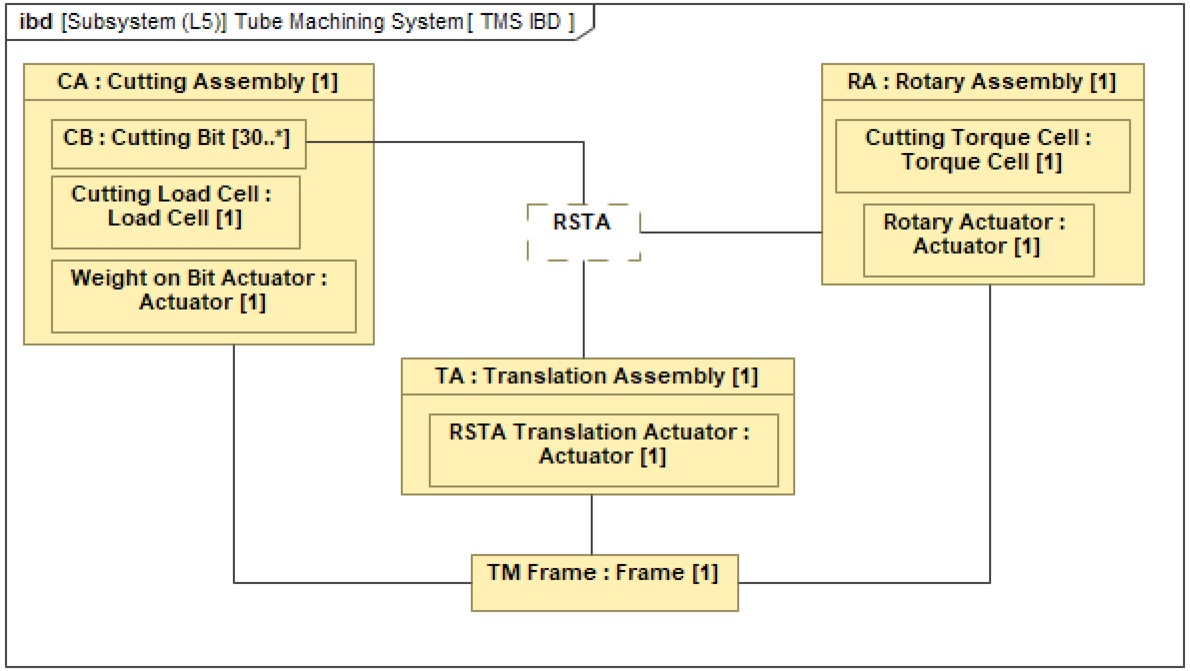
L5-TMS Assumptions

ID	Name	Text
A-L5-TMS.1	Before Puncture	Machining the RSTA before puncture is allowed since volume containing the sample is still intact
A-L5-TMS.2	No LASERs	No lasers will be used in machining due to heat and time constraints (for pulsed)
A-L5-TMS.3	Cutting Fluid	Isopropyl alcohol may be used as a cutting fluid
A-L5-TMS.4	RSTA Manually Loaded	RSTA is loaded manually into the machining station

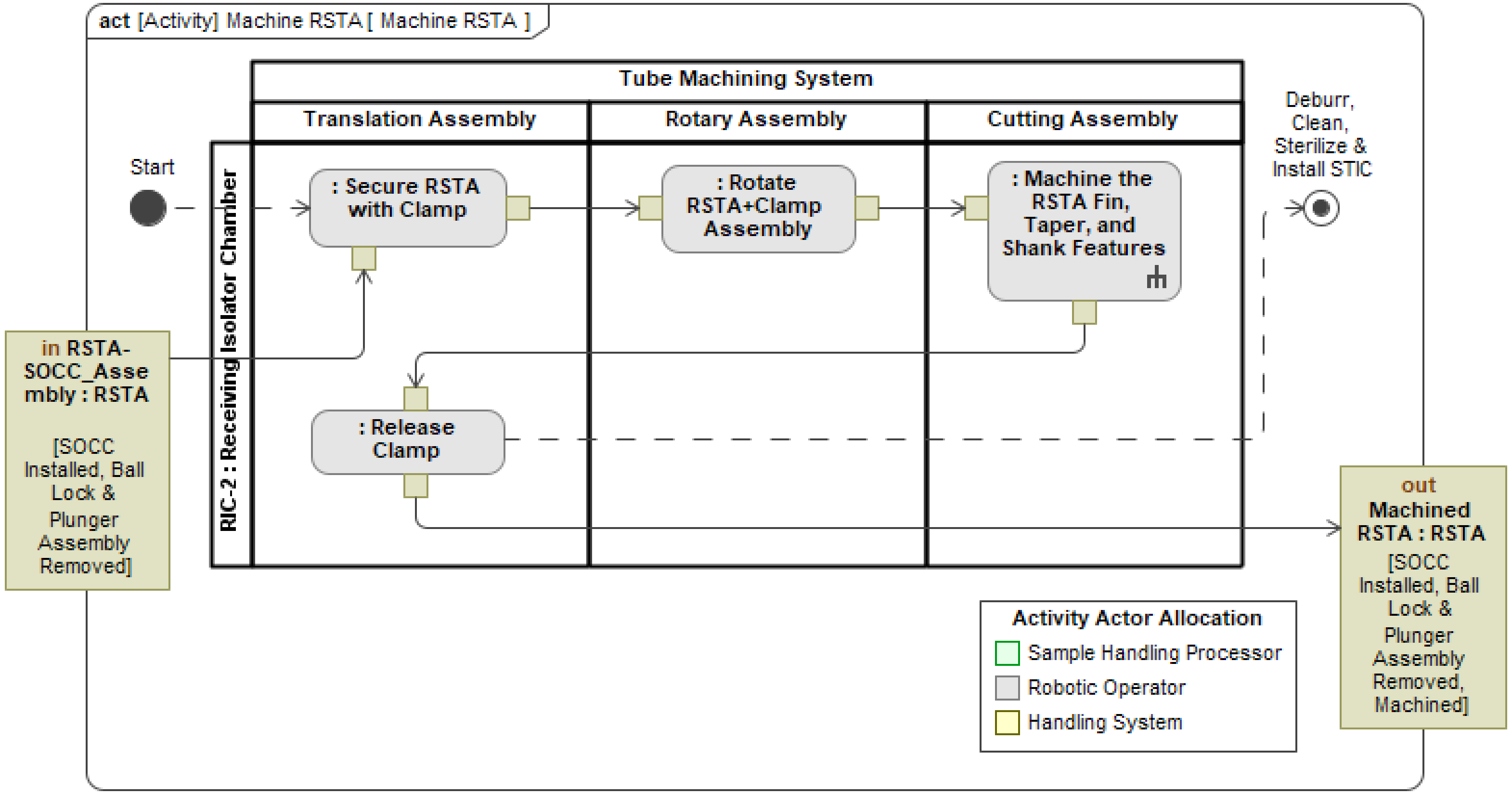
Tube Machining System Product Breakdown Structure



Tube Machining System Block Diagram



Tube Machining System Activity Flow



L5 Rotary Inline Severer

L5-RIS Assumptions (1 of 2)

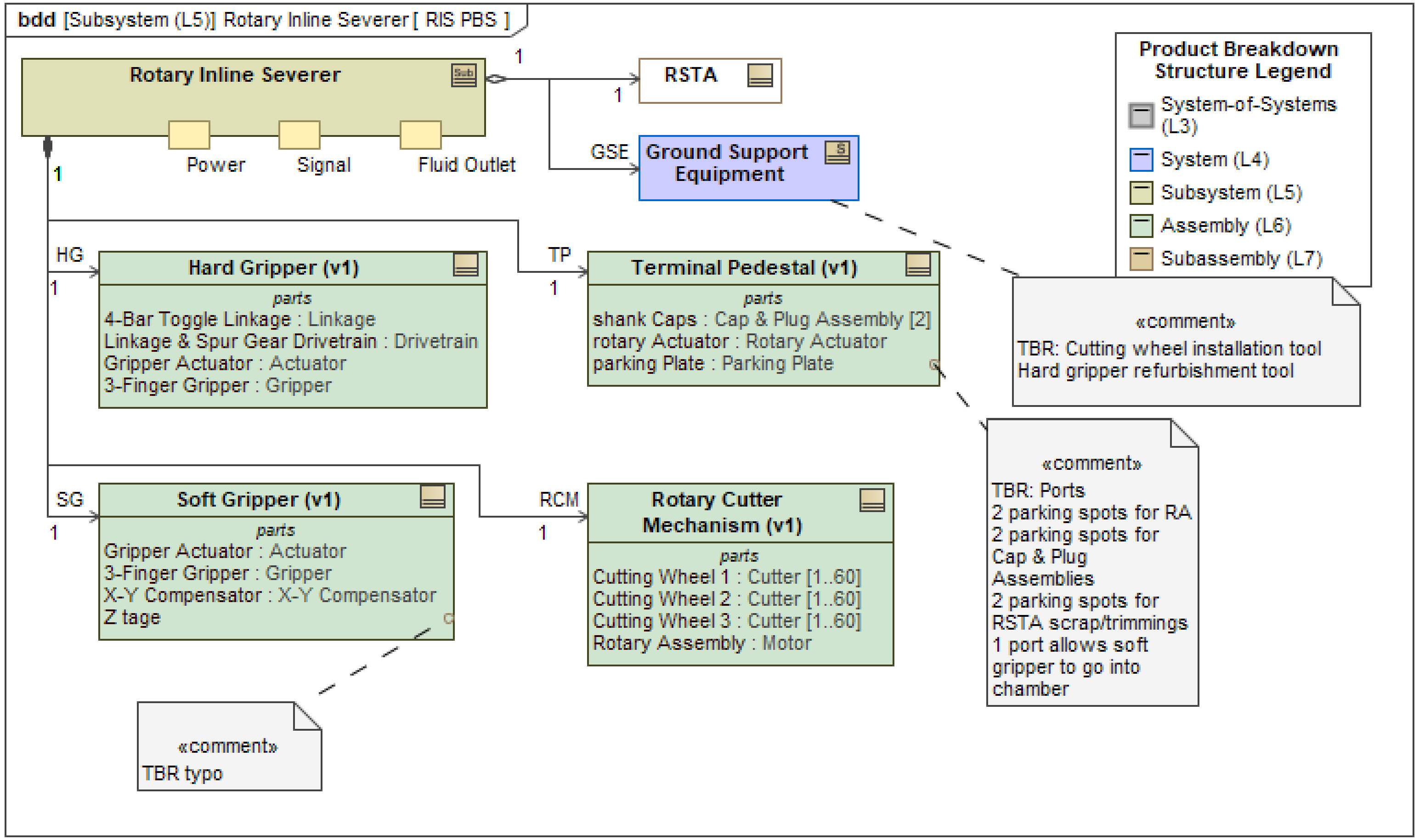
ID	Name	Text
A-L5-RIS.1	RSTA Pre-Modified	The RSTA shank and taper has been modified to include: •Removal of the shank at the circular groove •Removal of the taper and hardstop resulting in a constant tube profile up to the shank spring seat •Remaining shank OD is concentric to the tube diameter
A-L5-RIS.2	Alumina Safe	The alumina has not been removed completely and is safe to react cutting loads through
A-L5-RIS.3	Hermetic Seal Keep-Out Zones	The RSTA hermetic seal keep out zones are still active
A-L5-RIS.4	Safe Holding Zone	Safe to hold the SOCC Installation Tool (SMA, ferrule, other) to support the weight of the RSTA only •The SOCC activator will have a feature concentric to the tube The alumina can be held at this stage of processing
A-L5-RIS.5	Repositioning	Robotic arm (Handling_System) is capable of repositioning the RSTA to target the opposite end of the tube
A-L5-RIS.6	Remote & Manual	The system must allow for both remote and manual operations
A-L5-RIS.7	No Weight Limit	No weight limit
A-L5-RIS.8	Power Input	Limit power input to 110V 60Hz AC

L5-RIS Assumptions (2 of 2)

ID	Name	Text
A-L5-RIS.9	Out-of-Scope	Out-of-scope: Longitudinal cutting
A-L5-RIS.10	Refurbishment	Refurbishment may be done by gloved hand or robotics
A-L5-RIS.11	Cap Pressing	RIS cannot press Dust Cap Assembly onto RSTA
A-L5-RIS.12	Puncture Hole	The puncture hole has not been sealed
A-L5-RIS.13	Burrs	A margin of burr can be accommodated by the plunger action
A-L5-RIS.14	No Uncapped Movement	Dynamically maneuvering the tube while cut but not capped is unacceptable
A-L5-RIS.15	Particulate Migration	Particulate migration outside of the RIS to PIC 1 should be mitigated

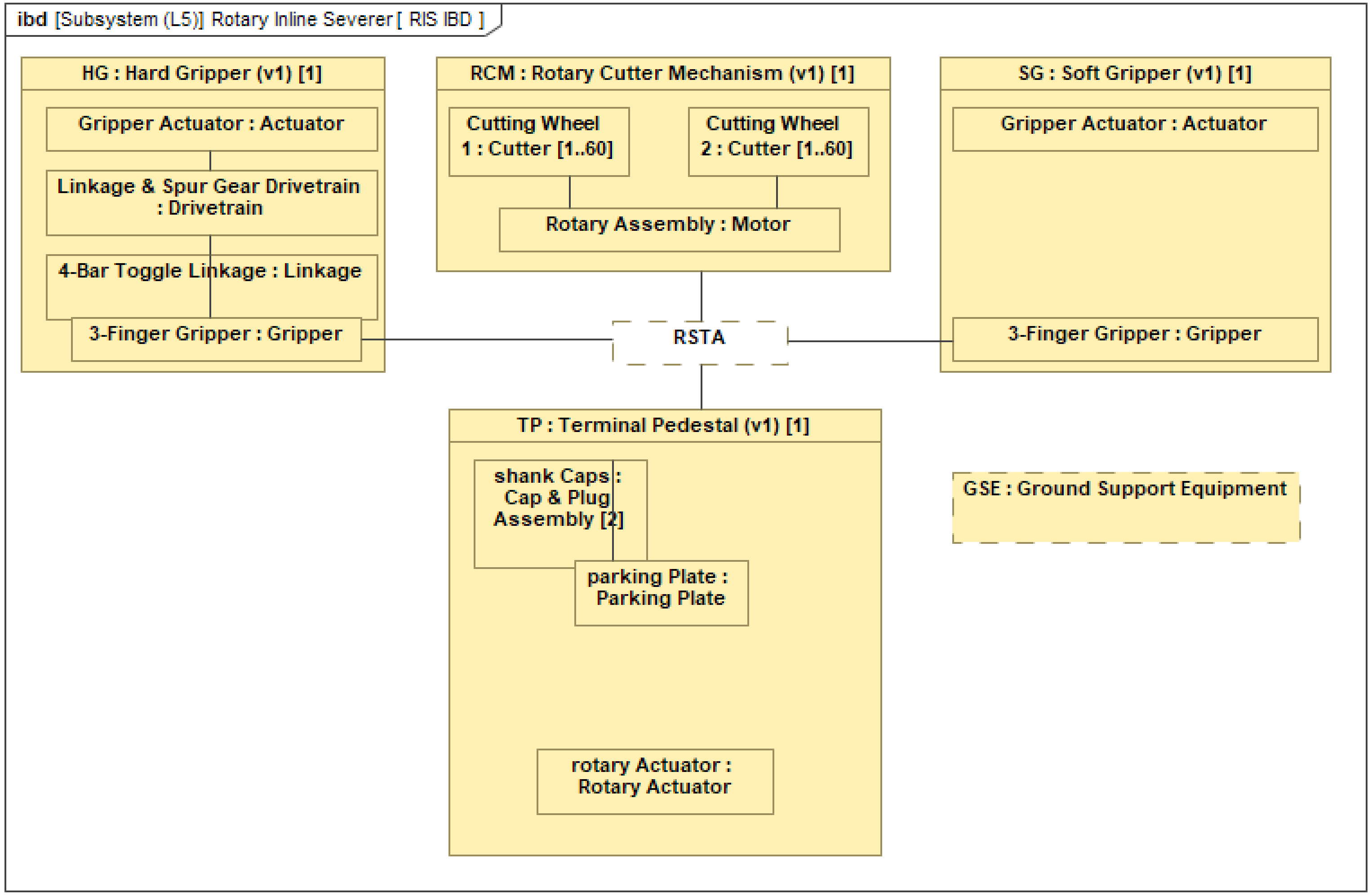
‘Key’ (K) indicates importance and high priority. 'Driving’ (D) indicates that the requirement 'drives up' cost, schedule, or risk.

Rotary Inline Severer Product Breakdown Structure

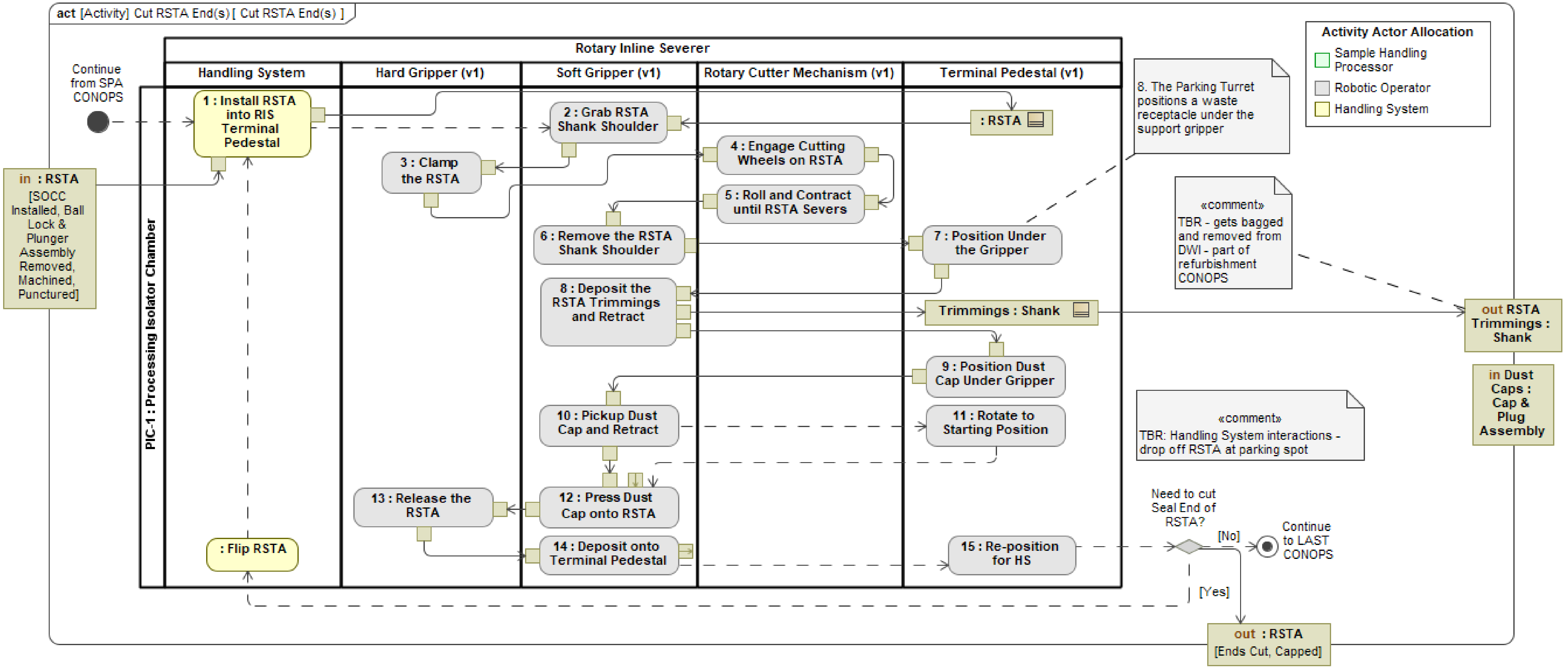


Pre-Decisional Information – For Planning and Discussion Purposes Only

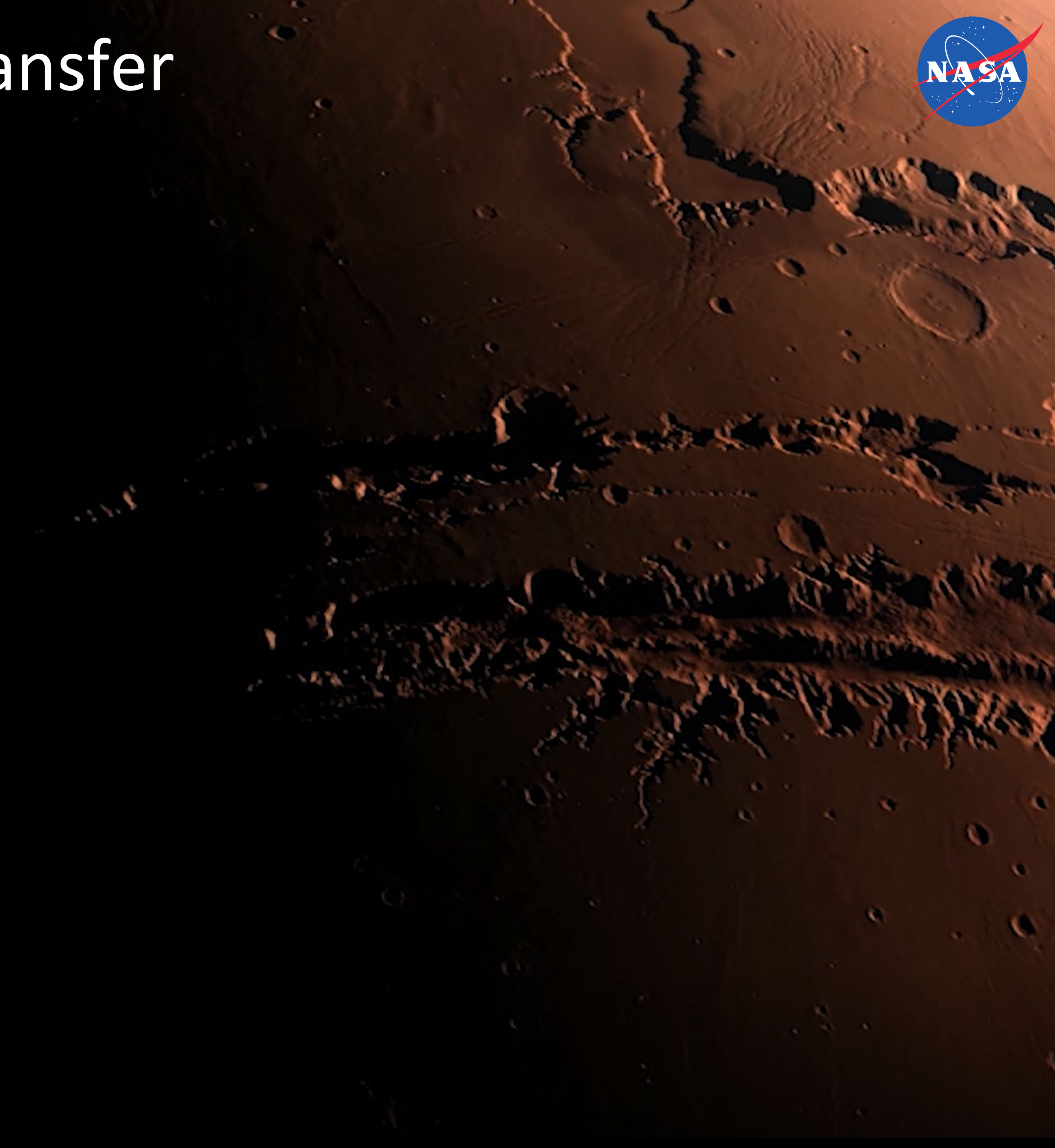
Rotary Inline Severer Block Diagram



Rotary Inline Severer Activity Flow



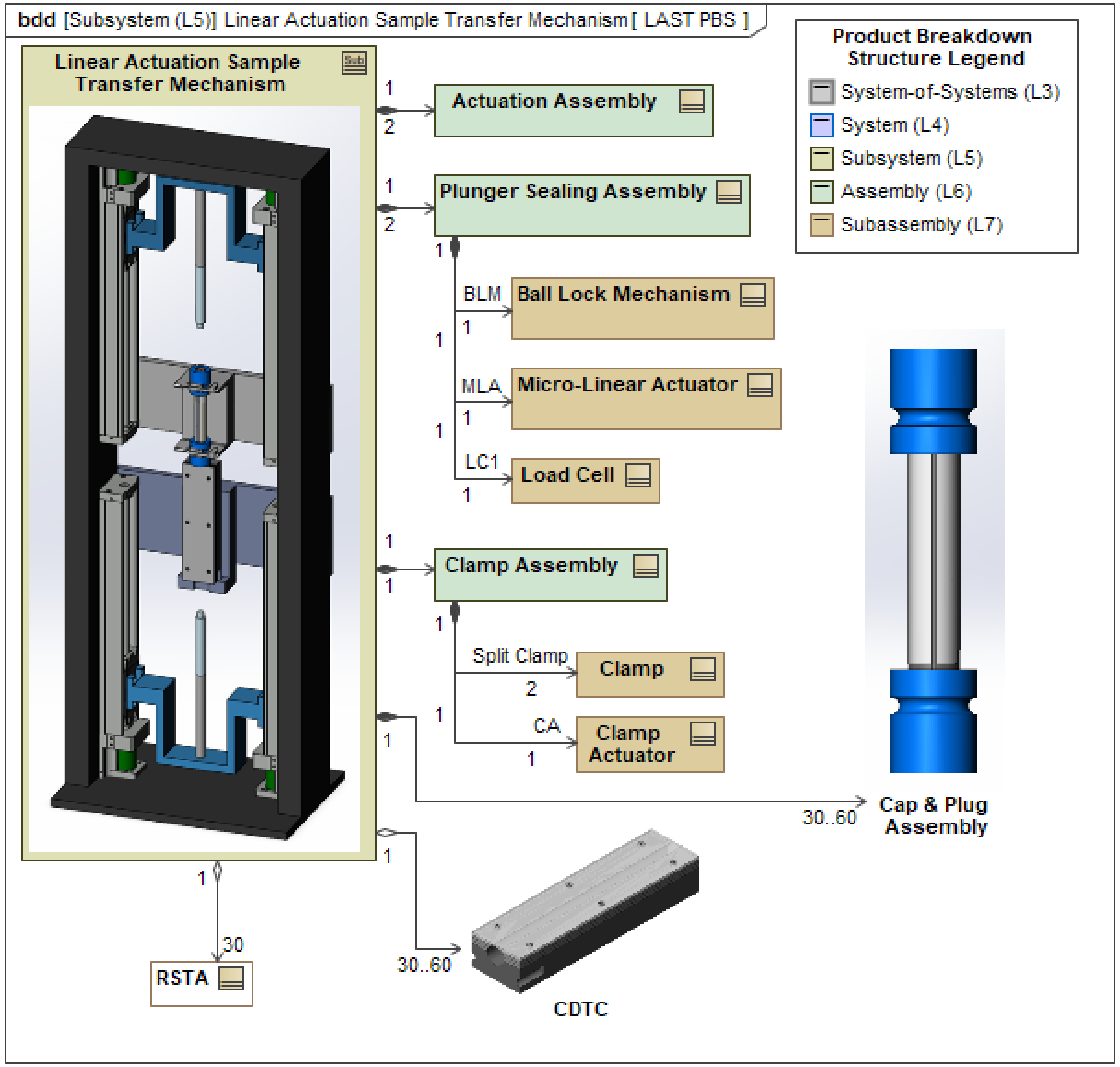
L5 Linear Actuation Sample Transfer



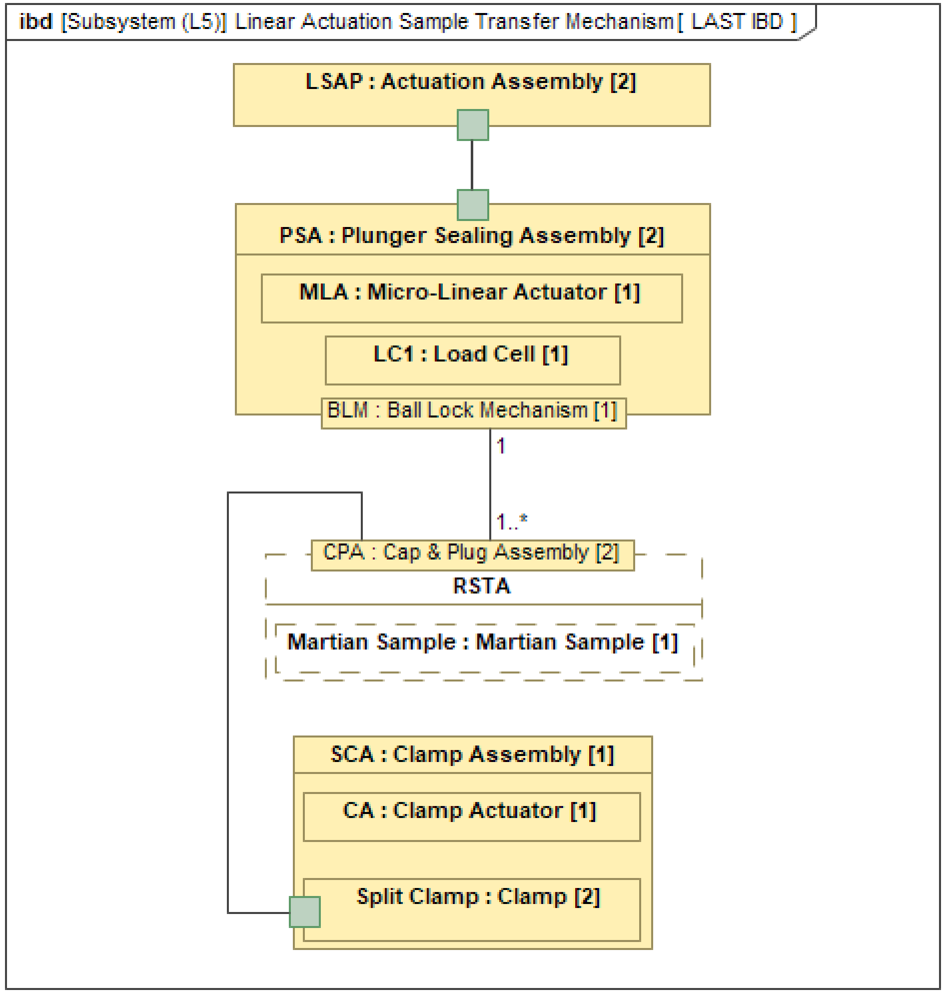
L5-LAST Assumptions (1 of 2)

ID	Name	Text
A-L5-LAST.1	RSTA Ends Open & Capped	LAST will receive an RSTA that is cut open on both ends, and capped off with a particle seal to retain sample
A-L5-LAST.2	Clam Shell Opening	Longitudinal cutting & clam shell opening the RSTA for core removal is not the current focus of this design, plans to explore later on
A-L5-LAST.3	Compressive Force on Solid Core	Permissible to exert a non-zero compressive force on the rock core Less than 10 Mpa (e.g. if contact surface is full cross sectional area ~1400 N)
A-L5-LAST.4	Into CDTC	LAST is pushing rock core from the RSTA into a Core Dissection Tray Container (CDTC) •No M2020 leak rate requirement •Particle seal •Removal from PIC
A-L5-LAST.5	Off-Nominal Cases	LAST has to be capable of removing solid sample in off-nominal cases •Force limit is reached, plungers get stuck, etc.
A-L5-LAST.24	Operational Environment	ISO Cleanliness Level: Class 3 • Pressure: -250 Pa with respect to external environment +/-2.5 Pa (101,075 Pa +/-2.5 Pa) • Temperature: 18 to 21 +/-1 C • Atmosphere: – Nitrogen – O2 Concentration: <0.2 ppmv – CO Concentration: <0.1 ppmv – CO2 Concentration: <0.1 ppmv – H20 Concentration: <0.2 ppmv
A-L5-LAST.25	Refurbishment	Refurbishment may be done by gloved hand or robotics

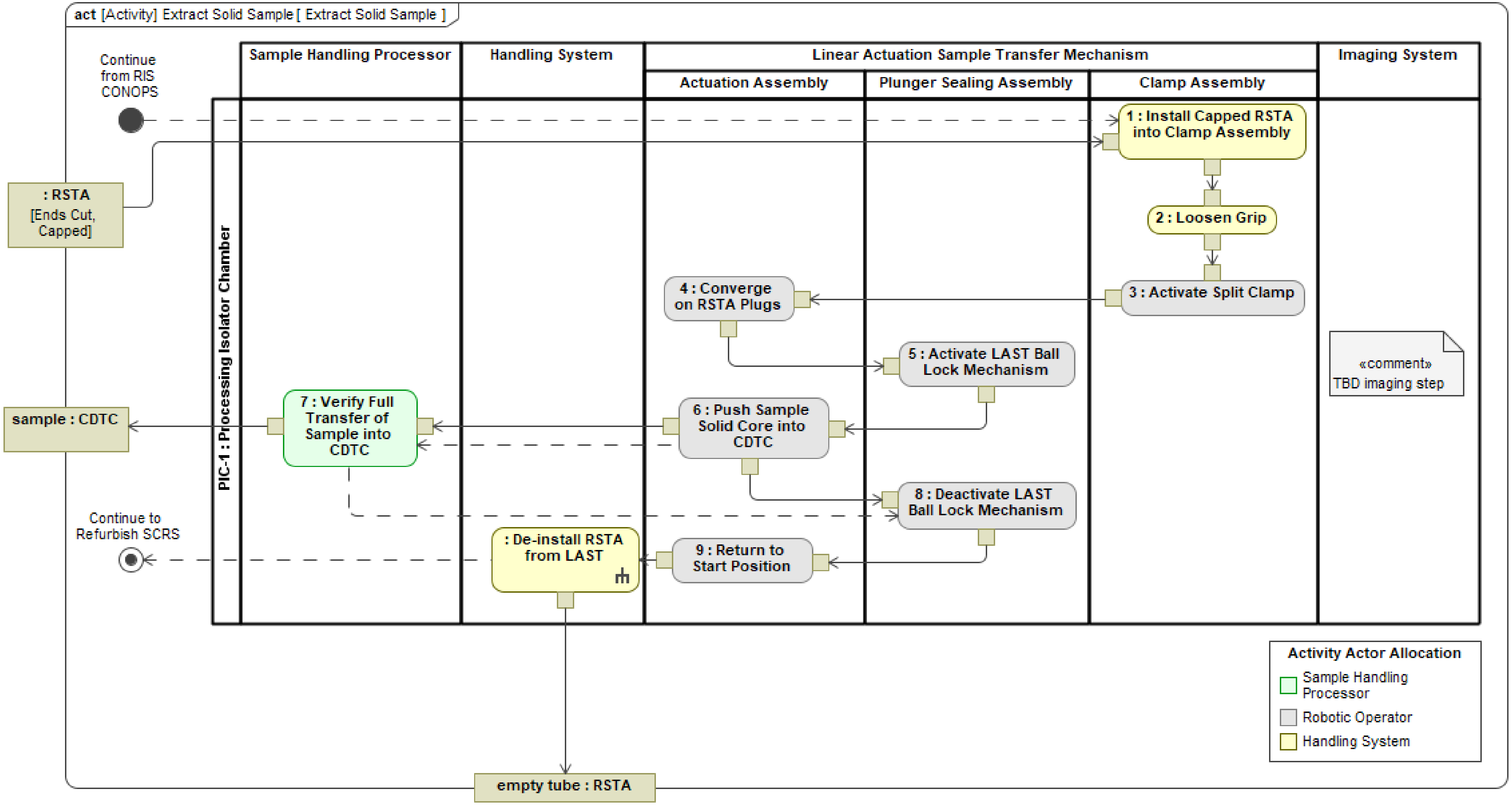
LAST Product Breakdown Structure



LAST Block Diagram

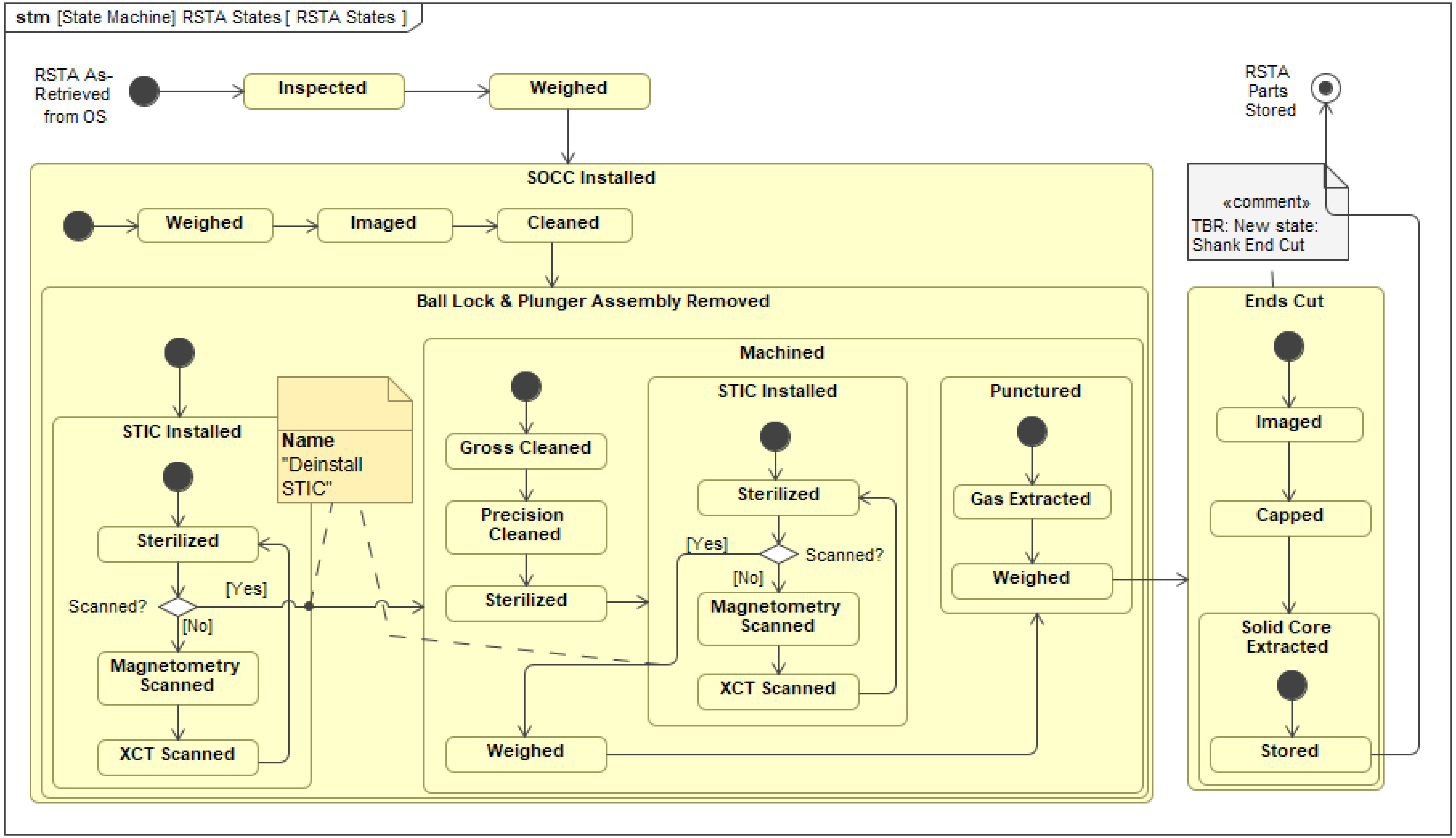


Solid Core Removal (LAST) Activity Flow



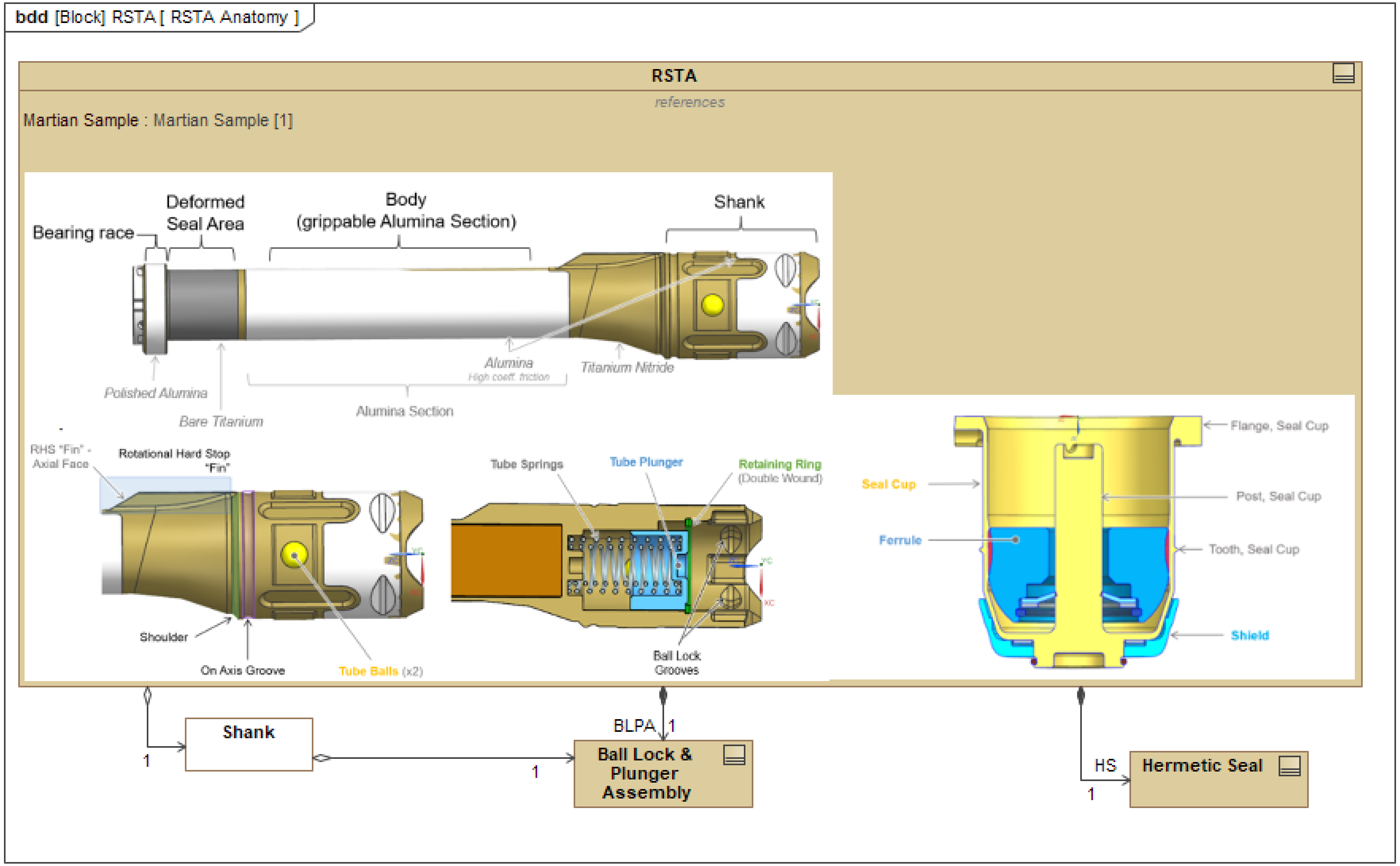

Backup

RSTA States

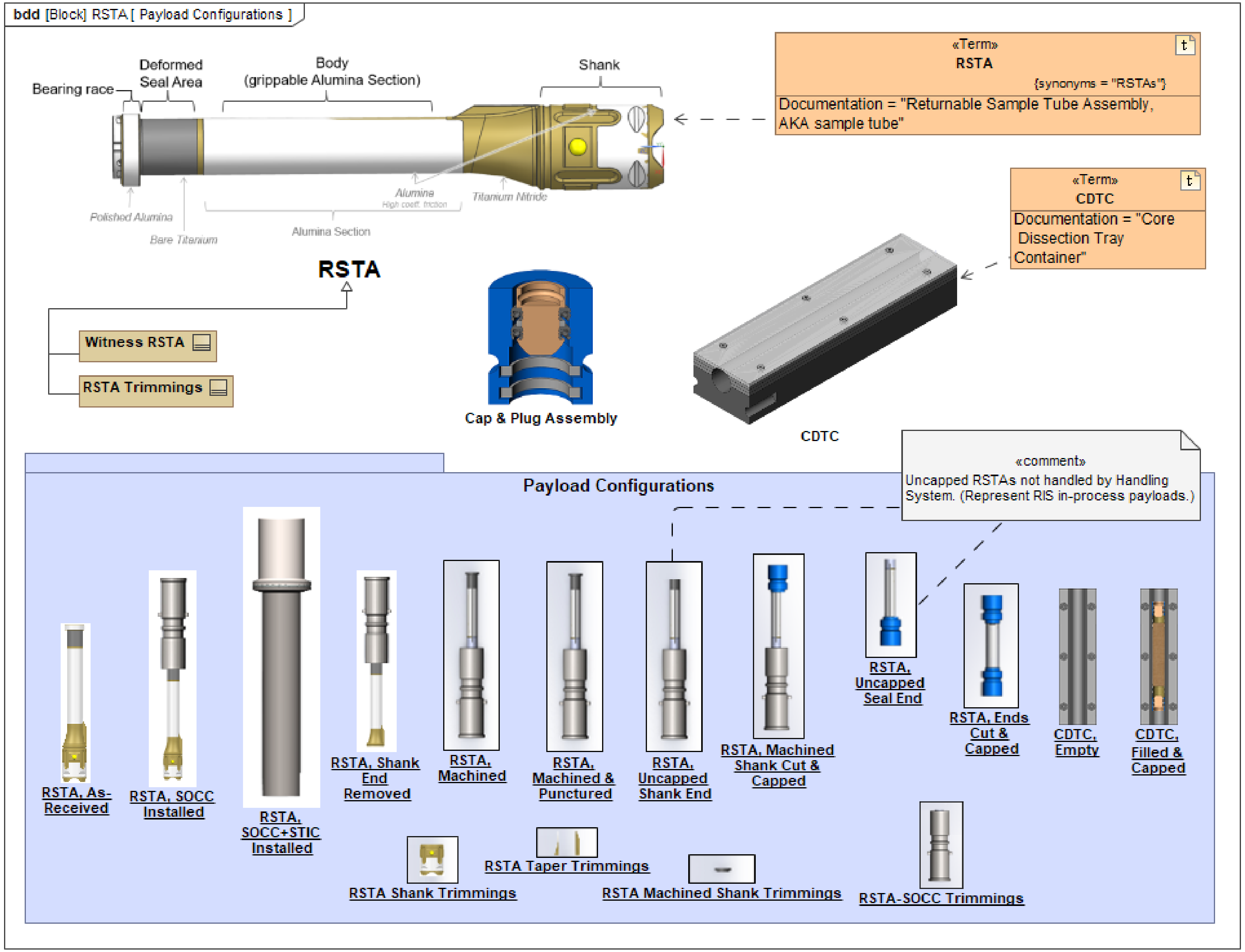


stm [State Machine] RSTA States [RSTA States]
RSTA As-Retrieved from OS
Inspected
Weighed
RSTA Parts Stored
SOCC Installed
Weighed
Imaged
Cleaned
«comment»
TBR: New state: Shank End Cut
Ball Lock & Plunger Assembly Removed
Machined
STIC Installed
Name
"Deinstall STIC"
Sterilized
Scanned?
[Yes]
[No]
Magnetometry Scanned
XCT Scanned
Gross Cleaned
Precision Cleaned
Sterilized
STIC Installed
Sterilized
[Yes]
Scanned?
[No]
Magnetometry Scanned
XCT Scanned
Weighed
Punctured
Gas Extracted
Weighed
Ends Cut
Imaged
Capped
Solid Core Extracted
Stored

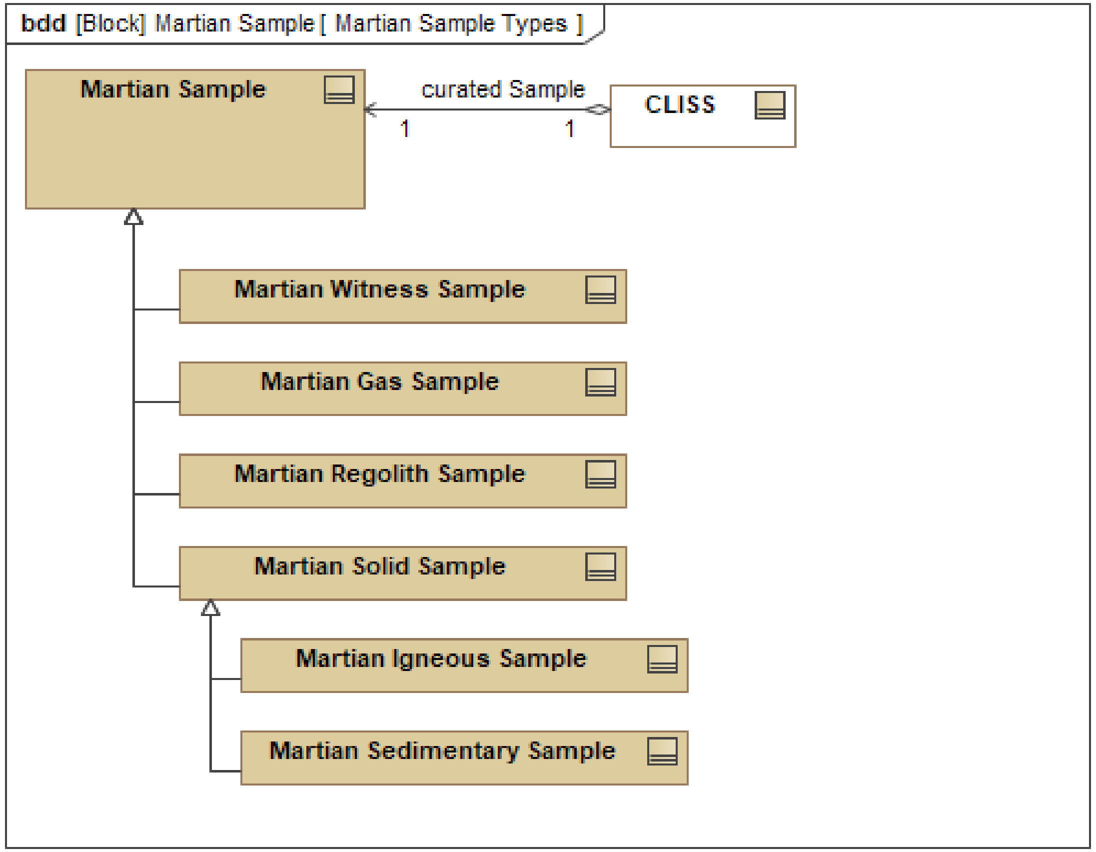
RSTA Anatomy



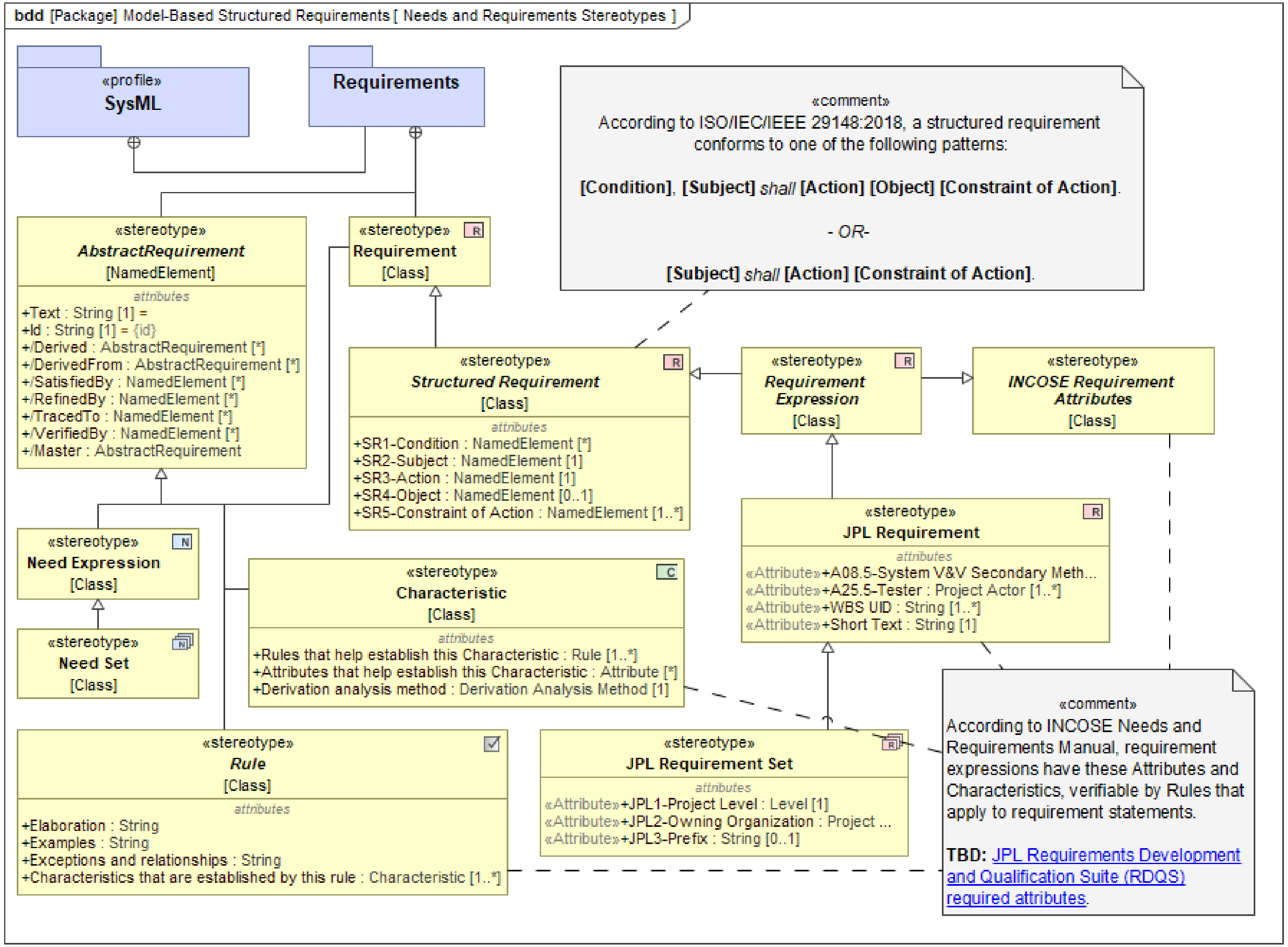
Payload Configurations



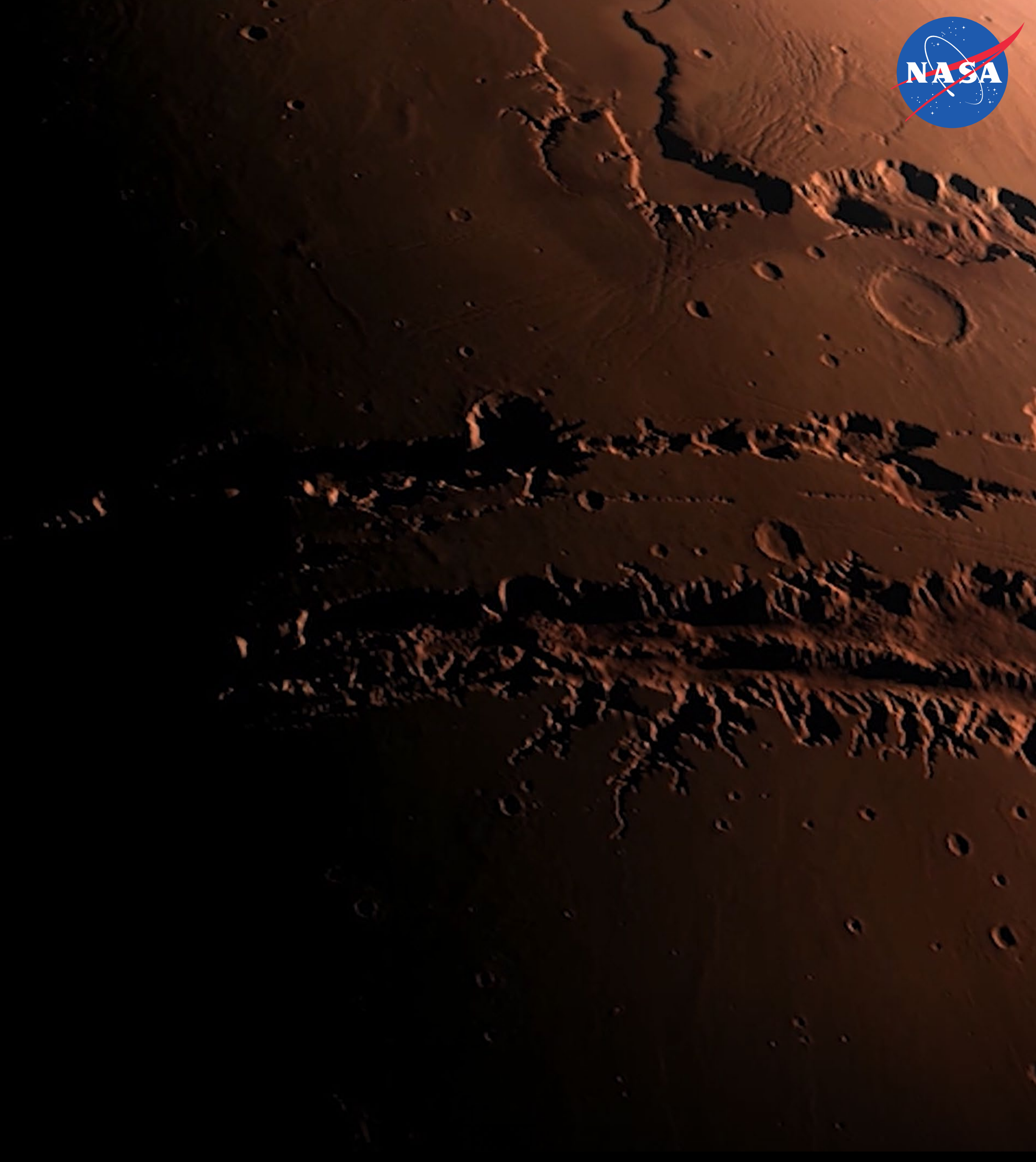
Martian Sample Types



Needs and Requirements Attributes



Acronyms and Glossary



Acronyms (1 – 50)

Term	Definition	Term	Definition	Term	Definition
BPP	Backward Planetary Protection	**MRSH**	Mars Returned Sample Handling	**SCV**	Secondary Containment Vessel
CC	Contamination Control	**MSR**	Mars Sample Return	**SH**	Sample Handling
CDTC	Core Dissection Tray Container	**NEPA**	National Environmental Policy Act. A procedural statute intended to ensure Federal agencies consider the environmental impacts of their actions in the decision-making process. NEPA for SRP will involve an environmental review culminating in an Environmental Impact Statement (EIS).	**SOCC**	Secondary Outer Containment Case
CLISS	Container for Long-term Individual Sample Storage	**OS**	Orbiting Sample Container	**SOCC-IS**	SOCC Install Station
CR	Cleanroom	**PAC**	Pass-through Antechamber	**SPA**	Sealing and Puncture Assembly
DWI	Double-Walled Isolator	**PC**	Passive Cutter	**SRF**	Sample Receiving Facility
EES	Earth Entry System	**PCV**	Primary Containment Vessel	**SRH**	Sample Recovery Helicopters
EGSE	Electrical Ground Support Equipment	**PIC**	Processing Isolator Chamber	**SRL**	Sample Retrieval Lander
ERIC	Earth Return Isolation Chamber	**PP**	Planetary Protection	**SRP**	Sample Receiving Project (part of the MSR mission)
ERO	Earth Return Orbiter	**PUC**	Planetary Utilization Container	**SS**	Secondary Seal (System)
FOD	Foreign Object Debris	**RAP**	Rapid Access Port	**SSAP**	Sample Safety Assessment Protocol
GE	Gas Extraction	**RIC**	Receiving Isolator Chamber	**STIC**	Sample Tube Isolation Container
GRA	Ground Recovery Activities	**RIS**	Rotary Inline Severer	**STIC-IRS**	STIC Install Station
IRS	Installation and Removal Station	**RSTA**	Returnable Sample Tube Assembly, AKA sample tube	**STM**	Science Traceability Matrix
LAST	Linear Actuation Sample Transfer	**RTP**	Rapid Transfer Port	**TCM**	Transfer Core Mechanism
LIO	Longitudinal Incision Opener	**SCRS**	Solid Core Removal System	**TIC**	Transportation Isolation Chamber
MGSE	Mechanical Ground Support Equipment			**TM**	Tube Machining

Acronyms (51 – 56)

Term	Definition
TMS	Tube Machining System
UCF	Uncontained Curation Facility
UTTR	Utah Test and Training Range
VHP	Vaporized Hydrogen Peroxide
WTA	Witness Tube Assembly
XCT	X-ray Computed Tomography