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| **Small Spacecraft Technology Program Orbital Debris Assessment Report & End of Mission Plan Instructional Guide** |
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DOCUMENT HISTORY LOG

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This document is a template to be used for projects when they need to create a ODAR. All the text, testing and figures following are an EXAMPLE ONLY and must be modified for the specific mission, launch vehicle or integrator. Please refer to listed example for more specific documentation. Some roles being specified may not be applicable to your organization and should be tailored as such. Shall and should (Shall: requirement, Should: Goal) statements are used in this example, however, requirements and goals should be tailored to your project (technical scope, resources, risk posture, etc.). Projects shall tailor the content of this document to the relevant risk posture / needs for the project / organization.. ODARs are public information and many may be found online. Many projects will incorporate EOMP into their ODAR when / if applicable.

TechEdSat: { <https://apps.fcc.gov/els/GetAtt.html?id=125551&x=>. }

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# Purpose

The Small Spacecraft Technology Program (SSTP) for Orbital Debris Assessment Report (ODAR) and End of Mission Plan instructional guide and template is for the spacecraft developer outside of NASA and is intended to provide guidance and thought process when designing small satellites for space. This ODAR guide establishes and describes the process in meeting the requirements for the spacecraft as defined in NASA-STD-8719.14.

## Scope

This ODAR follows the format in NASA-STD-8719.14, Appendix A.1 and includes the **orbital debris mitigation requirements for the spacecraft** captured in sections 1 through 8 below for the {Project Name}. Sections 9 through 14 apply to the launch vehicle ODAR and are not covered in thisdocument. Text in curly brackets “{text}” represent information to be captured (e.g., {Project Name}) when preparing the project-specific ODAR, and italic text in curly brackets “*{text}”* represents guidance/information for a section being prepared and should be deleted from the document prior to release. An example of the content to be captured is provided throughout the template. Where applicable, reuse/reference of material to relevant project-specific documents (e.g., Project Management Plan, etc) is encouraged; refer to the SSTP Guidebook for Technology Development Projects for an outline of expected project documents to be completed when designing small satellites for space.

# 2.0 Cover and Front Matter {Template}

The following information details the content that should be captured on the cover and front matter sections (e.g., title page, signature page, revision log, table of contents, etc). The title page should include, at a minimum, the title of the document, the document release date, and the document version. The following statement shall be captured after the title: In accordance with NPR 8715.6A, this report is presented as compliance with the required reporting format per NASA-STD-8719.14, Appendix A. The title page shall also include the DAS software used in the analysis, captured as following: DAS Software used in this analysis: DAS vX.X.X.

Header should include the {Project Name} logo, {Project Name} Orbital Debris Assessment Report (ODAR) title, and document number (identifying number) and version (e.g., “Rev –“ to indicate baseline). Example as follows:

|  |  |  |
| --- | --- | --- |
| {Logo of Project} | ***{ABC Program}***Orbital Debris Assessment Report (ODAR) | **{PROJECT DOC #}**{Rev} |

Footer should include the following statement: Distribution authorized by the {Project Name} Project Office and / or {Organization Name} and capture the page number.

Document History Log should be captured for version control. Example as follows:

|  |  |  |
| --- | --- | --- |
| **Document****Revision** | **Effective****Date** | **Description of Change** |
| Draft | MM/DD/YYYY | *{if recording draft versions}* |
| Rev - | MM/DD/YYYY | Initial Release |
| Rev A | MM/DD/YYYY | Change document name and corrected codes on pages x-z. |
|  |  |  |

Signature page should include names, titles, and affiliations of individuals that prepared the document, and names, titles, and affiliations of individuals that reviewed and approved the document.

A table of contents should also capture any tables/figures and appendices relevant to the document.

## 2.1 Self-assessment and OSMA assessment of ODAR

Following the table of contents, the front matter should include the following:

**Self-assessment and OSMA assessment of ODAR using the format in Appendix A.2 of NASA-STD-8719.14:**

*{Self-assessment of given criteria can be an internal or external document, example as follows; Note that in the final ODAR document, this assessment will reflect any inputs received from OSMA, and also serves as the pre-launch End of Mission Plan (EOMP)}.* A self-assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14. In the final ODAR document, this assessment will reflect any inputs received from OSMA as well.

**Orbital Debris Self-Assessment Report Evaluation: {Project Name} Mission**

|  |  |  |  |
| --- | --- | --- | --- |
| **Reqm’t #** | **Launch Vehicle** | **Spacecraft** | **Comments** |
| Compliant | N/A | Not Compliant | Incomplete | Standard Non-Compliant | Compliant | N/A | Not Compliant | Incomplete | For all incompletes, include risk assessment (low, Medium, or high risk) of non-compliance& Project Risk Tracking # |
| **4.3-1.a**25 years |  |  |  |  |  |  |  |  |  |  |
| **4.3-1.b**<100 object year limit |  |  |  |  |  |  |  |  |  |  |
| **4.3-2**GEO +/- 200Km |  |  |  |  |  |  |  |  |  |  |
| **4.4-1**< 0.001 Explosion Risk |  |  |  |  |  |  |  |  |  |  |
| **4.4-2**Passive Energy Source |  |  |  |  |  |  |  |  |  |  |
| **4.4-3** Limit Long-Term Risk  |  |  |  |  |  |  |  |  |  |  |
| **4.4-4**Limit BU Short term Risk |  |  |  |  |  |  |  |  |  |  |
| **4.5-1**<0.001 10cm Impact Risk |  |  |  |  |  |  |  |  |  |  |
| **4.5-2**Postmission Disposal Risk |  |  |  |  |  |  |  |  |  |  |
| **4.6-1(a)** Atmosphere Energy Option |  |  |  |  |  |  |  |  |  |  |
| **4.6-1(b)**Storage Orbit |  |  |  |  |  |  |  |  |  |  |
| **4.6-1(c)**Direct Retrieval |  |  |  |  |  |  |  |  |  |  |
| **4.6-2**GEO Disposal |  |  |  |  |  |  |  |  |  |  |
| **4.6-3**MEO Disposal |  |  |  |  |  |  |  |  |  |  |
| **4.6-4**Disposal Reliability  |  |  |  |  |  |  |  |  |  |  |
| **4.6-5**Summary of DeOrbit |  |  |  |  |  |  |  |  |  |  |
| **4.7-1**Ground Population Risk  |  |  |  |  |  |  |  |  |  |  |
| **4.8-1**Tethers Risk |  |  |  |  |  |  |  |  |  |  |

An in-flight EOMP review check sheet shall also be completed in accordance with the format provided in Appendix B.2 of NASA-STD-8719.14

**In-Flight EOMP Evaluation: {Project Name} Mission**

|  |  |  |
| --- | --- | --- |
| **Reqm’t #** | **Spacecraft** | **EOMP Comments** |
| **Compliant** | **N/A** | **Not Compliant** |  |
| **4.3-1.a**25 years |  |  |  |  |
| **4.3-1.b**<100 object year limit |  |  |  |  |
| **4.3-2**GEO +/- 200Km |  |  |  |  |
| **4.4-1**< 0.001 Explosion Risk |  |  |  |  |
| **4.4-2**Passive Energy Source |  |  |  |  |
| **4.4-3** Limit Long-Term Risk  |  |  |  |  |
| **4.4-4**Limit BU Short term Risk |  |  |  |  |
| **4.5-1**<0.001 10cm Impact Risk |  |  |  |  |
| **4.5-2**Postmission Disposal Risk |  |  |  |  |
| **4.6-1(a)** Atmosphere Energy Option |  |  |  |  |
| **4.6-1(b)**Storage Orbit |  |  |  |  |
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| **4.6-2**GEO Disposal |  |  |  |  |
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| **4.6-4**Disposal Reliability  |  |  |  |  |
| **4.6-5**Summary of DeOrbit |  |  |  |  |
| **4.7-1**Ground Population Risk  |  |  |  |  |
| **4.8-1**Tethers Risk |  |  |  |  |

# 3.0 Assessment Report Format

ODAR Technical Sections 1 through 8 (spacecraft) Format Requirements are as follows:

## 3.1 ODAR Section 1: Program Management and Mission Overview

*{Define management and mission overview, more or less as necessary, example as follows}:*

**Mission Directorate:** {Insert responsible entity}

**Engineer Director:** {Insert name and affiliation}

**Mission Design Division, Division Chief:** {Insert name and affiliation}

**Project Manager/Senior Scientist:** {Insert name and affiliation}

**Schedule of mission design and development milestones (if applicable) from NASA mission selection through proposed launch date, including spacecraft PDR and CDR (or equivalent) dates:**

Mission Selection: {Insert Date}

Mission Chief of Engineering Review: {Insert Date}

PDR {Insert Date}

CDR {Insert Date}

PSRP 0/I/II: {Insert Date}

PSRP III: {Insert Date}

Integration to X: {Insert Date}

Launch to X: {Insert Date}

Launch from X: {Insert Date}

**Mission Overview:**

*{High level overview of the project mission, example as follows}:* The {Project name} satellite will be hard-stowed onto the {Launch vehicle}. {Project Name} will test and validate three different technologies in Low Earth Orbit (LEO)…

**Launch vehicle and launch site:** X

**Proposed launch date:** {Insert date}

**Mission duration:** X

**Launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination:**

This system will allow {Project name} to be launched at a velocity of X cm/sec and at an angle of X degrees relative to the X into a circular orbit initially approximately X km relative to Earth’s surface.

The {Project name} orbit is defined as follows:

**Apogee:** X km

**Perigee:** X km

**Inclination:** X degrees

**Interaction or potential physical interference with other operational Spacecraft:** The main risks of this satellite are the {provide details}.

## 3.2 ODAR Section 2: Spacecraft Description

{Low level overview of the spacecraft / project hardware, example as follows}:

**Physical description of the spacecraft:** {Project Name} is a XU nanosatellite with dimensions of X cm x X cm x X cm and a total mass approximately equal to X.XX kg. {Project name} payload carries a {Payload name} as a technology demonstration.

{Project name} will contain the following systems: *{List main hardware and payloads…}*

{INSERT PHOTO}

**Figure X: {Project name} Fully Deployed View**

**Total satellite mass at launch, including all propellants and fluids:** X.XX kg

**Dry mass of satellite at launch, excluding solid rocket motor propellants**: X.XX kg

**Description of all propulsion systems (cold gas, monopropellant, bi-propellant, electric, nuclear):**

Example description: There will be no propulsion systems on {Project name}

**Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes.**

Example description: Not applicable, there will be no fluids or gasses on board.

**Fluids in Pressurized Batteries:**

Example description: None. {Project name} uses unpressurized standard COTS lithium-ion battery cells.

**Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector:**

Example description: {Project Name} will implement an attitude control system based off three single axis magnetorquers and an internal IMU to both determine and correct the attitude of the satellite when necessary.

**Description of any range safety or other pyrotechnic devices:**

Example description: None. The {project Name} will be launched powered off and a Remove-Before-Flight (RBF) pin is used to prevent accidental activation.

**Description of the electrical generation and storage system:**

Example description: The power will be generated by solar panels and lithium-ion batteries. The batteries that will be used are X, supplied by {Supplier name}. See attached data sheet (Appendix B). This battery is approved by the {name of Launch Vehicle} for flight. The dimensions of the battery are X x X x X cm and the weight is X kg.

**Identification of any other sources of stored energy not noted above:** {None.}

**Identification of any radioactive materials on board:** {None.}

## 3.3 ODAR Section 3: Assessment of Spacecraft Debris Released during Normal Operations

*{Example as follows based on debris analysis}:*

**Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material:** {None. There are no intentional releases.}

**Rationale/necessity for release of each object:** {N/A}

**Time of release of each object, relative to launch time:** {N/A}

**Release velocity of each object with respect to spacecraft:**

**Expected orbital parameters (apogee, perigee, and inclination) of each object after release:** {N/A}

**Calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO):**

{N/A}

**Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v2.1)**

***Requirement 4.3-1, Mission Related Debris Passing Through LEO:*** {COMPLIANT. No debris released >1mm, while passing through LEO.}

***Requirement 4.3-2, Mission Related Debris Passing Near GEO******:*** {COMPLIANT. No debris released will transverse GEO.}

## 3.4 ODAR Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions

*{Example as follows}:*

**Potential causes of spacecraft breakup during deployment and mission operations:** {There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.}

**Summary of failure modes and effects analyses of all credible failure modes, which may lead to an accidental explosion:** {In-mission failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell explosion. The battery safety systems discussed in the FMEA (see requirement 4.4-1 below) describe the combined faults that must occur for any of nine (9) independent, mutually exclusive failure modes that could lead to a battery explosion.}

**Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:** {There are no planned breakups other than during atmospheric entry for disposal.}

**List of components which shall be passivated at End of Mission (EOM) including method of passivation and amount which cannot be passivated:** {Reaction Wheels, de-energizing control moment gyroscopes, …}

**Rationale for all items which are required to be passivated but cannot be due to their design:** {Project Name} will be in orbit for X weeks with successful deployment of the {Payload Name} based on the DAS analysis shown in this report. If the {Payload Name} fails to deploy, {Project Name} will be in orbit for X weeks based on the DAS analysis shown in this report.

**Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:**

***Requirement 4.4-1: Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon:***

For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).

**Compliance statement:**

**Required Probability:** 0.001.

**Expected Probability:** 0.000.

**Supporting Rationale and FMEA details:**

*Payload Pressure Vessel Failure:*

{Project Name} is vented per {name of Launch Vehicle} safety standards.

**Battery explosion** *{Depends on design, follow the example}***:**

**Effect:** All failure modes below might result in battery explosion with the possibility of orbital debris generation. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

**Probability:** Very Low. It is believed to be much less than the 0.0001% requirements given that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

Failure mode mitigations are specific to the Launch Vehicle / ISS / other form of deployment, must change accordingly:

*{EXAMPLE mitigations described for each failure mode, each project will be different}*

**Failure mode 1:** Battery Internal short circuit.

*Mitigation 1:* {Example} Complete proto-qualification and environmental acceptance tests of {Battery name}. The acceptance tests are shock, vibration, thermal cycling, and vacuum tests followed by maximum system rate-limited charge and discharge to prove that no internal short circuit sensitivity exists.

*Combined faults required for realized failure:* Environmental testing **AND** functional charge/discharge tests must both be ineffective in discovery of the failure mode.

**Failure Mode 2:** Internal thermal rise due to high load discharge rate.

*Mitigation 2:* {Example} Each cell includes a positive temperature coefficient (PTC) variable resistance device that ensures high-rate discharge is limited to acceptable levels if thermal rise occurs in the battery.

*Combined faults required for realized failure:* The PTCmust fail **AND** spacecraft thermal design must be incorrect **AND** external over current detection and protection must fail for this failure mode to occur.

**Failure Mode 3:** Overcharging and excessive charge rate.

*Mitigation 3:* {Example} The satellite bus battery charging circuit design reduces the possibility of the batteries being overcharged if circuits function nominally. This circuit has been proto-qualification tested for survival in shock, vibration, and thermal-vacuum environments. The charge circuit disconnects the incoming current when battery voltage indicates normal full charge at X V. If this circuit fails to operate, continuing charge can cause gas generation. The batteries include overpressure release vents that allow gas to escape, mitigating any explosion hazard.

*Combined faults required for realized battery rupture mitigation failure effect:*

 **1) For overcharging:**The charge control circuit must fail to function **AND** the PTC device must fail (or temperatures generated must be insufficient to cause the PTC device to modulate) **AND** the overpressure relief device must be inadequate to vent generated gasses at acceptable rates to avoid explosion.

 **2)** **For excessive charge rate:** {This is design specific and may not be appropriate mitigation for all designs, an example to be use}:The maximum charging rate from a single solar panel is X mA. The maximum charge rate the battery can accept is X A. The battery is a {Battery name}. The battery itself has two parallel cells connected in series, and thus having 4 cells. Due to solar panel current limits and their direction-facing arrangement on the satellite, there is no physical means of exceeding charging rate limits, even if only a single string from the battery was accepting charge. For this failure mode to become active one string must fail to accept a charge **AND** the charge control circuit on the remaining string fails. The overpressure relief vent keeps the battery cells from rupturing and is thus limited to worst-case effects of overcharging.

**Failure Mode 4:** Excessive discharge rate or short circuit due to external device failure or terminal contact with conductors not at battery voltage levels (due to abrasion or inadequate proximity separation).

*Mitigation 4:* {Example} This failure mode is negated by a) circuit protection on each external circuit, b) design of battery packs and insulators such that no contact with nearby board traces is possible without being caused by some other mechanical failure, c) obviation of such other mechanical failures by proto-qualification and acceptance environmental tests (shock, vibration, thermal cycling, and thermal-vacuum tests).

*Combined faults required for realized failure:* The PTCmust fail **AND** an external load must fail/short-circuit **AND** external over-current detection and disconnect function must fail to enable this failure mode.

**Failure Mode 5**: Inoperable vents.

*Mitigation 5:* {Example} Battery vents are not inhibited by the battery holder design or the spacecraft.

*Combined effects required for realized failure:* The manufacturer fails to install proper venting and Launch vehicle environmental stress screening fails to detect failed vents.

**Failure Mode 6:** Crushing.

*Mitigation 6:* {Example} This mode is negated by spacecraft design. There are no moving parts in the proximity of the batteries.

*Combined faults required for realized failure:* A catastrophic failure must occur in an external system **AND**the failure must cause a collision sufficient to crush the batteries leading to an internal short circuit **AND** the satellite must be in a naturally sustained orbit at the time the crushing occurs.

**Failure Mode 7:** Low level current leakage or short-circuit through battery pack case or due to moisture-based degradation of insulators.

*Mitigation 7:* {Example} These modes are negated by a) battery holder/case design made of non-conductive plastic, and b) operation in vacuum such that no moisture can affect insulators.

*Combined faults required for realized failure:* Abrasion or piercing failure of circuit board coating or wire insulators **AND** dislocation of battery packs **AND** failure of battery terminal insulators **AND** failure to detect such failures in environmental tests must occur to result in this failure mode.

**Failure Mode 8:** {Mission specific, where an orbit could be exposed to full sunlight, some may be cold environments}: Excess temperatures due to orbital environment and high discharge combined.

*Mitigation 8:* {Example} The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that batteries do not exceed normal allowable operating temperatures, which are well below temperatures of concern for explosions.

*Combined faults required for realized failure:* Thermal analysis **AND** thermal design **AND** mission simulations in thermal-vacuum chamber testing **AND** the PTC device must fail **AND** over-current monitoring and control must all fail for this failure mode to occur.

**Failure Mode 9:** Polarity reversal due to over-discharge caused by continuous load during periods of negative power generation vs. consumption.

*Mitigation 9:*  {Example} In nominal operations, the spacecraft EPS design negates this mode because the processor will stop when voltage drops too low, below X V assuming the charge circuit does not fail. This disables ALL connected loads, creating a guaranteed power-positive charging scenario. The spacecraft will not restart or connect any loads until battery voltage is above the acceptable threshold. At this point, only the safe mode processor is enabled and charging the battery commences. Once the battery reaches 90% of the peak voltage (around X V), it will switch to nominal mode and will be able to receive ground commands for continuing mission functions.

*Combined faults required for realized failure:* The microcontroller must stop executing code **AND** significant loads must be commanded/stuck "on" **AND** power margin analysis must be wrong **AND** the charge control circuit must fail for this failure mode to occur.

**Failure Mode 10:** Excess battery temperatures due to post mission orbital environment and constant solar panel overcharge while satellite is powered off.

*Mitigation 10:* {Example} Selection of the {Battery Name} battery packs. There are no plans to power off the satellite, operations should continue until spacecraft deorbits. These battery packs have battery protection circuits, which prevent over-charge and over-heating.  They are lot-tested and supplied by {Supplier Name}.  In terms of the orbit environment, the {Previous project name} in the same orbit and environment (using the same packaging and battery pack) showed no signs of over-heating from environmental heating. There are no plans to power off the satellite, operations should continue until spacecraft deorbits: In all cases orbital life is fairly short, less than 25 years limiting exposure to full sun orbits.

**Reaction Wheel Explosion:**

 **Effect:**

 **Probability:**

**Failure Mode 1:**

*{EXAMPLE compliance statements described for requirements; each project will be different}*

***Requirement 4.4-2: Design for passivation after completion of mission operations while in orbit about Earth or the Moon:***

Design of all spacecraft and launch vehicle orbital stages shall include the ability to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or post mission disposal or control to a level which can not cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).

**Compliance statement:**

Example statement, must cater to each project specifically: {Project Name} will be in orbit for X weeks with successful deployment of the {Payload Name}. If the {Payload Name} fails to deploy, {Project Name} will be in orbit for approximately X weeks based on the DAS analysis shown in this report. Therefore, no post-mission passivation will be performed, as the satellite will burn up on re-entry at the end of the mission. Therefore, the {Project Name} battery will meet the above requirement.

***Requirement 4.4-3: Limiting the long-term risk to other space systems from planned breakups:***

**Compliance statement:**

Example statement, must cater to each project specifically: This requirement is not applicable. There are no planned breakups.

***Requirement 4.4-4: Limiting the short-term risk to other space systems from planned breakups:***

**Compliance statement:**

Example statement, must cater to each project specifically: This requirement is not applicable. There are no planned breakups.

## 3.5 ODAR Section 5: Assessment of Spacecraft Potential for On-Orbit Collisions

**Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v2.1, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):**

***Requirement 4.5-1: Limiting debris generated by collisions with large objects when***

***operating in Earth orbit:***For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001 (Requirement 56506).

**Large Object Impact and Debris Generation Probability: {DAS analysis output value}**

***Requirement 4.5-2: Limiting debris generated by collisions with small objects when***

***operating in Earth or lunar orbit:***For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post mission disposal requirements is less than 0.01 (Requirement 56507).

**Small Object Impact and Debris Generation Probability:** {DAS analysis output value}

## 3.6 ODAR/EOMP Section 6: Assessment of Spacecraft Post-mission Disposal Plans and Procedures

*{Example as follows}:*

**Description of spacecraft disposal option selected:** Two cases will be considered for this section. The first case is called “Nominal Deployment” in which…

Case 1: *Nominal Deployment*The satellite will de-orbit due to the deployed {Payload Name}. There is no propulsion system and burn at re-entry {Some may have propulsion systems, change according to your project}.

Case 2: *Failed Deployment*The satellite will de-orbit naturally by atmospheric re-entry. There is no propulsion system and burn at re-entry.

**Plan for any spacecraft maneuvers required to accomplish post mission disposal:** None.

**Calculation of area-to-mass ratio after post mission disposal, if the controlled reentry option is not selected:**

Case 1: *Nominal Deployment*

**Spacecraft Mass:**  X kg

**Cross-sectional Area:** X m^2

**Area to mass ratio:** X / X = X m^2/kg

Case 2: *Failed Deployment*

**Spacecraft Mass:**  X kg

**Cross-sectional Area:** X m^2

**Area to mass ratio:** X / X = X m^2/kg

**Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-4 (per DAS v 2.1 and NASA-STD-8719.14 section):**

***Requirement 4.6-1: Disposal for space structures passing through LEO:*** A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods: (Requirement 56557)

a. Atmospheric reentry option:

* Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or
* Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.

b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.

c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after completion of mission.

**Analysis:**

Case 1: *Nominal Deployment*

{Project Name} satellite reentry is COMPLIANT using Method “a.” {Project Name} re-enter in X years after launch with orbit history shown in Figure X.

Case 2: *Failed Deployment*

{Project Name} satellite reentry is COMPLIANT using Method “a.” {Project Name} will re-enter in X years after launch with orbit history as shown in Figure X (analysis assumes an approximate random tumbling behavior).

***Requirement 4.6-2: Disposal for space structures near GEO.***

**Analysis**: {Not applicable. {Project Name} orbit is in LEO.}

***Requirement 4.6-3: Disposal for space structures between LEO and GEO.***

**Analysis:** {Not applicable. {Project Name} orbit is in LEO.}

***Requirement 4.6-4: Reliability of Post mission Disposal Operations.***

**Analysis:**

Case 1: *Nominal Deployment*

{Project Name} de-orbiting relies on the {Payload Name} de-orbiting device. Release of the {Payload Name} will result in de-orbiting in approximately X weeks with no disposal or de-orbiting actions required.

Case 2: *Failed Deployment*

{Project Name} de-orbiting does not rely on de-orbiting devices. Release from the {name of Launch Vehicle} with a downward, retrograde vector will result in de-orbiting in approximately X years with no disposal or de-orbiting actions required.

## 3.7 ODAR/EOMP Section 7: Assessment of Spacecraft Reentry Hazards

{Example as follows}:

***Assessment of spacecraft compliance with Requirement 4.7-1:***

***Requirement 4.7-1: Limit the risk of human casualty:***The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules:

4.7-1, a) For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

**Summary Analysis Results {This is unknown until real analysis is done}:** *{Example Summary:}*DAS v2.1 reports that {Project Name} is compliant with the requirement.It predicts that no component on board has more than 15 joules of impact kinetic energy. The majority of {Project Name} including its components and the {Payload Name} will burn up on re-entry. As seen in the analysis outputs below, the highest impact kinetic energy is 2 Joules. Also, there are no titanium or stainless steel {Reaction wheels may present a re-entry hazard} components that will be used on {Project Name}.

4.7-1, b) **NOT APPLICABLE.** For controlled reentry, the selected trajectory shall ensure that no surviving debris impact with a kinetic energy greater than 15 joules is closer than 370 km from foreign landmasses, or is within 50 km from the continental U.S., territories of the U.S., and the permanent ice pack of Antarctica (Requirement 56627).

4.7-1 c) **NOT APPLICABLE.** For controlled reentries, the product of the probability of failure of the reentry burn (from Requirement 4.6-4.b) and the risk of human casualty assuming uncontrolled reentry shall not exceed 0.0001 (1:10,000) (Requirement 56628).

### 3.7.1 ODAR/EOMP Section 7A: Assessment of Spacecraft Hazardous Materials

{Example as follows}:

The only hazardous materials used in the {Project Name} satellite are …

No materials are expected to survive reentry. {Must identify if anything will reenter the atmosphere to drive the hazardous materials section.}

**Hazardous materials EXAMPLE table**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| A | B | C | D | E | F | G |
| Chemical and commercial name of the material | Hazard | Estimated material state (gas/liquid/solid/powder), amount/quantity/activity/pressure at launch | Estimated state/quantity/pressure of the material onboard when the space structure reaches operational orbit | Estimated state/quantity/pressure of the material onboard at expected EOM. | Estimated state/quantity/pressure of the material onboard at expected end of passivation | Estimated state/quantity/pressure of the material expected to survive reentry |
| Lithium-Ion batteries(LiCoO2) |  |  |  |  |  |  |
| Lithium Manganese Dioxide batteries(LiMnO2) |  |  |  |  |  |  |

## 3.8 ODAR Section 8: Assessment for Tether Missions

{Example as follows}:

Not applicable. There are no tethers in the {Project Name} mission.

# 4.0 Orbital Debris Mitigation Requirements for Launch Vehicle

## 4.1 ODAR Sections 9-14: Launch Vehicle

*{Example as follows:}*

Since the {Project Name} launch vehicle is managed by {Launch Provider} the orbital debris assessment for the launch vehicle will be performed by {Launch Provider}. The following note from NPR 8715.6A, Paragraph P.2.2, is applied, “*Note: It is recognized that NASA has no involvement or control in the design or operation of Federal Aviation Administration (FAA)-licensed launches or foreign or Department of Defense (DoD)-furnished launch services, and, therefore, these are not subject to the requirements in this NPR for the launch portion.”*

**END of ODAR for {Project Name}.**

# Appendix

{Add / remove appendices as necessary}

Appendix A: Acronyms

Appendix B: Battery / Hardware Data Sheets

Appendix C: Wiring Schematics

Solar Panel Circuits:

Charge Control Circuits:

Disconnect Features:

Appendix D: ODAR Output Screen