

MAGNETO

Orbital Debris Assessment Report (ODAR)

Revision A
10/31/2019

Prepared By

Approved By



Recoverable Signature

X David Barnhart

David Barnhart

Signed by: df8e1c8b-ff41-4d7d-96b0-a6068fbec379

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Assessment Report Format

ODAR Technical Sections Format Requirements:

This ODAR follows the format NASA-STD-8719.14 Appendix A.1 and includes the content indicated at a minimum for each section 2 to 8 below for MAGNETO satellite. Sections 9 - 14 apply to launch vehicle ODAR and are omitted.

ODAR Section 1: Program Management and Mission Review

Mission Description:

Our mission is to support scientific understanding of magnetic fields in low earth orbit and the launch vehicle environment. The primary goal is to use commercial off the shelf sensors (COTS) to measure the Earth's Magnetic Field in Low Earth Orbit (LEO). The secondary goal is to use an Ephemeris, a sun sensor, and gyros to measure the satellite's pose/position in orbit.

Launch Vehicle and Launch Date:

Proposed Launch date: June/July 2020

Mission Duration: 60 days

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

MAGNETO Orbital Elements:

Apogee: 300km

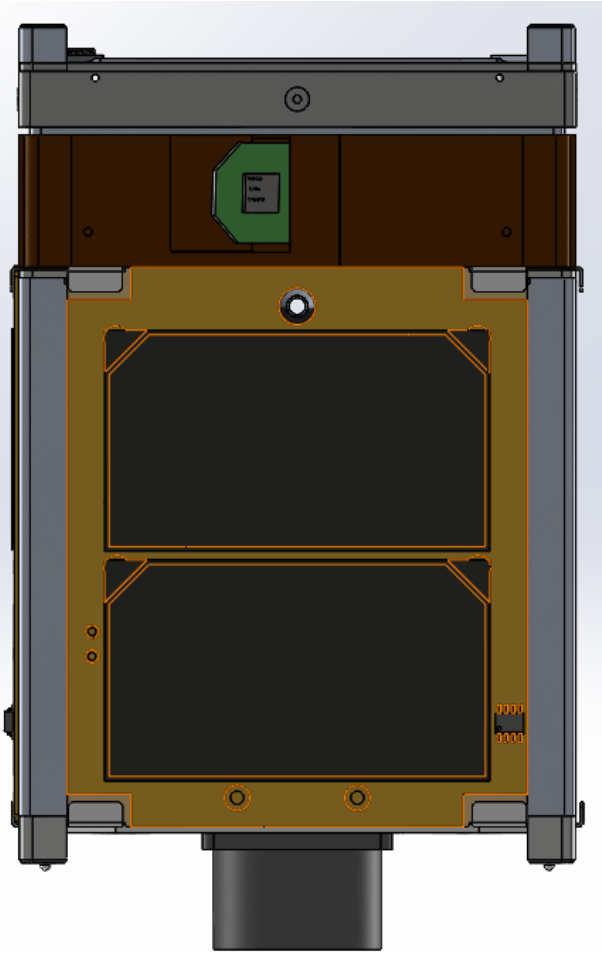
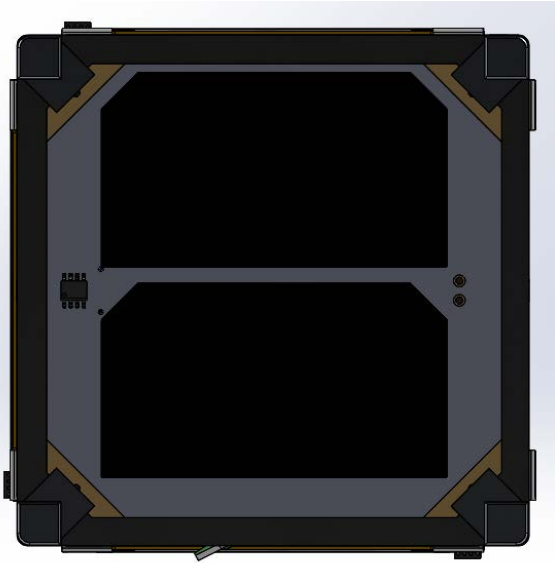
Perigee: 300km

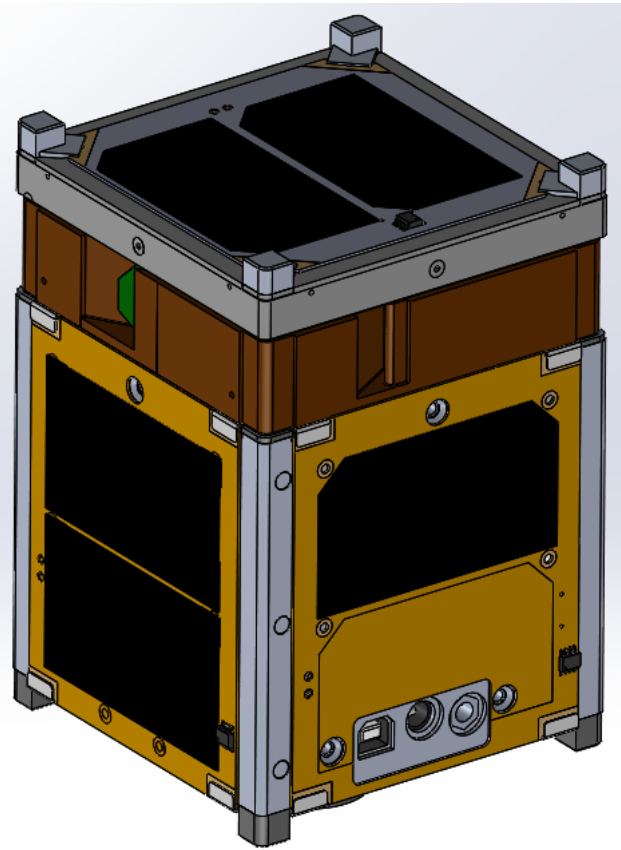
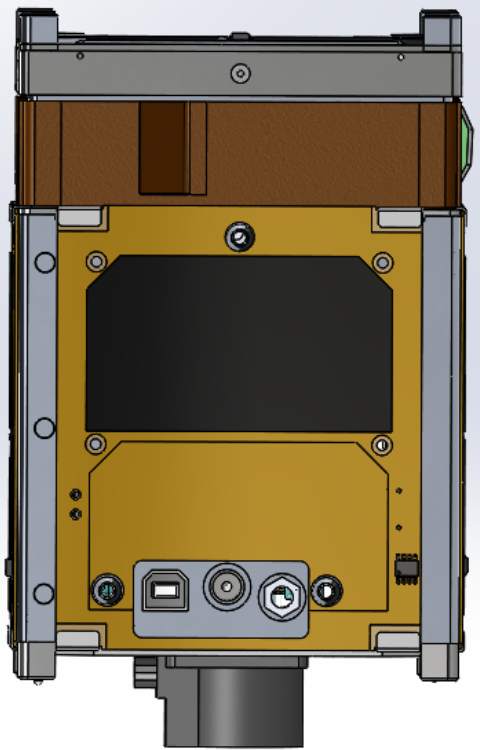
Inclination: 137 deg

Due to absence of propulsion system, MAGNETO does not actively change orbits. No parking or transfer orbit.

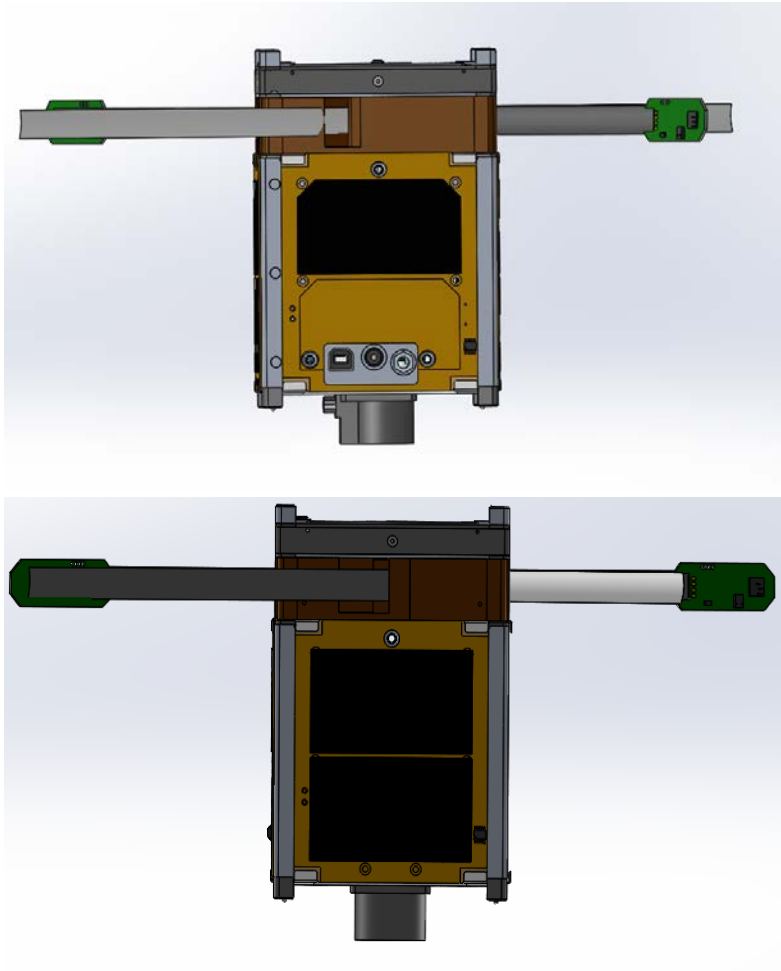
At present, there is no potential interaction or physical interaction between MAGNETO and any other operational spacecraft.

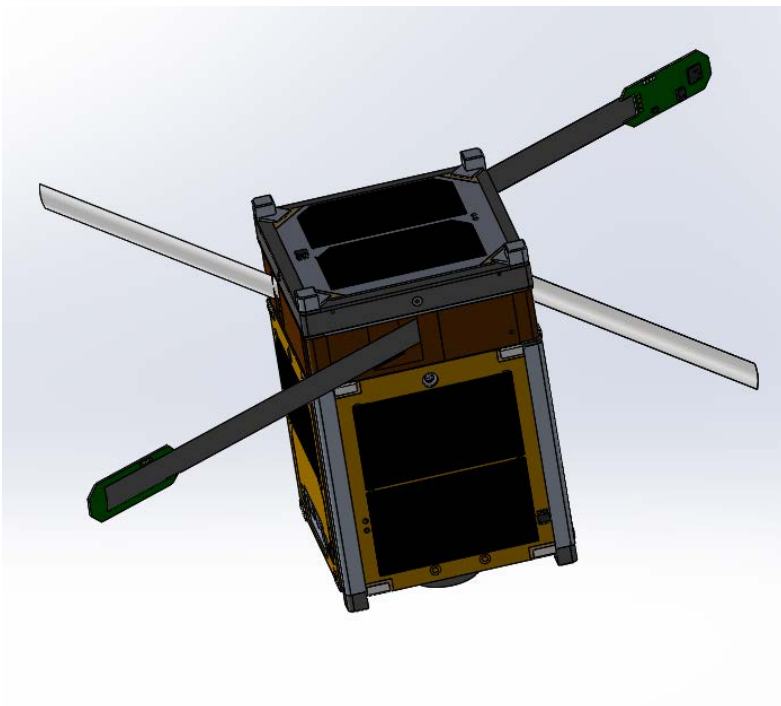
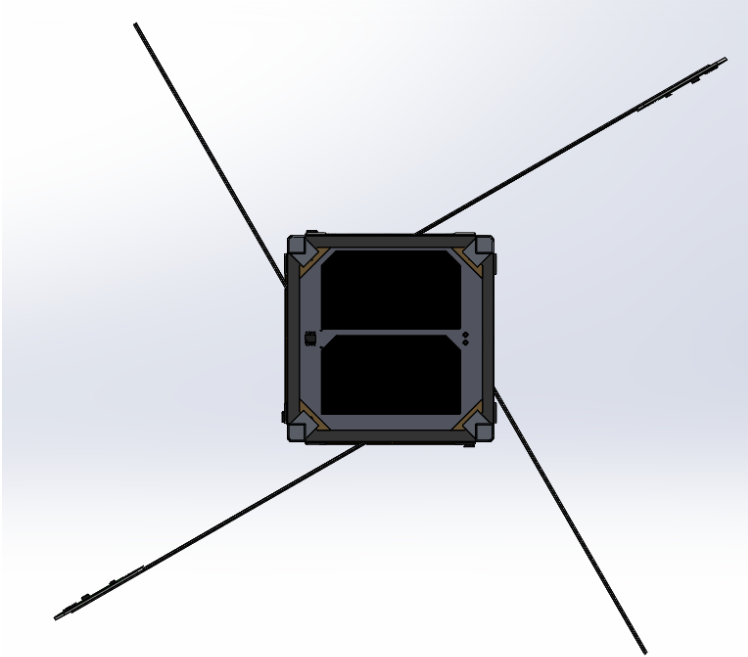
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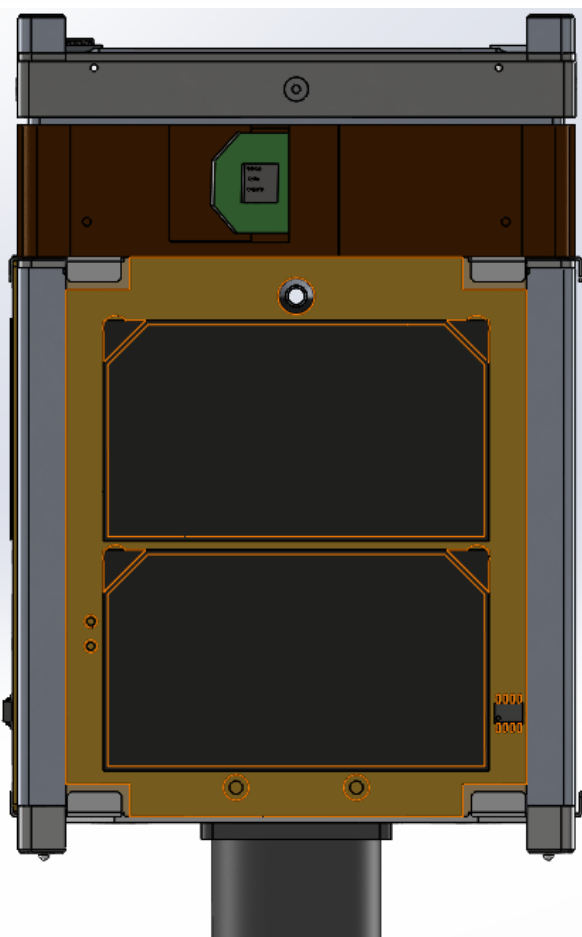
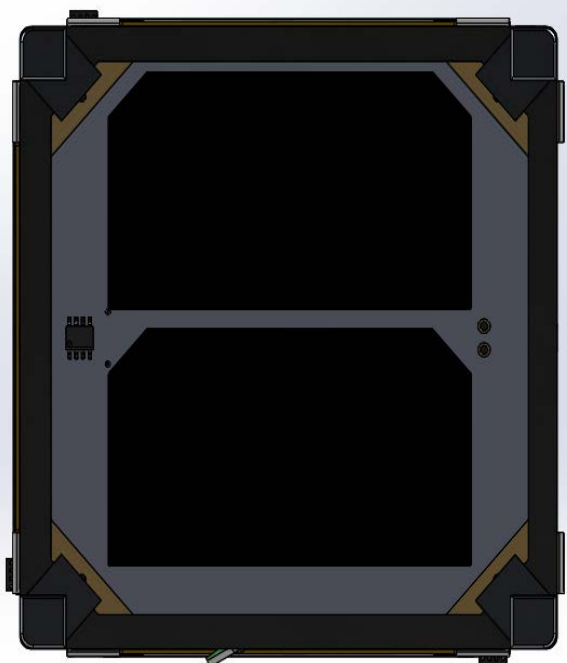


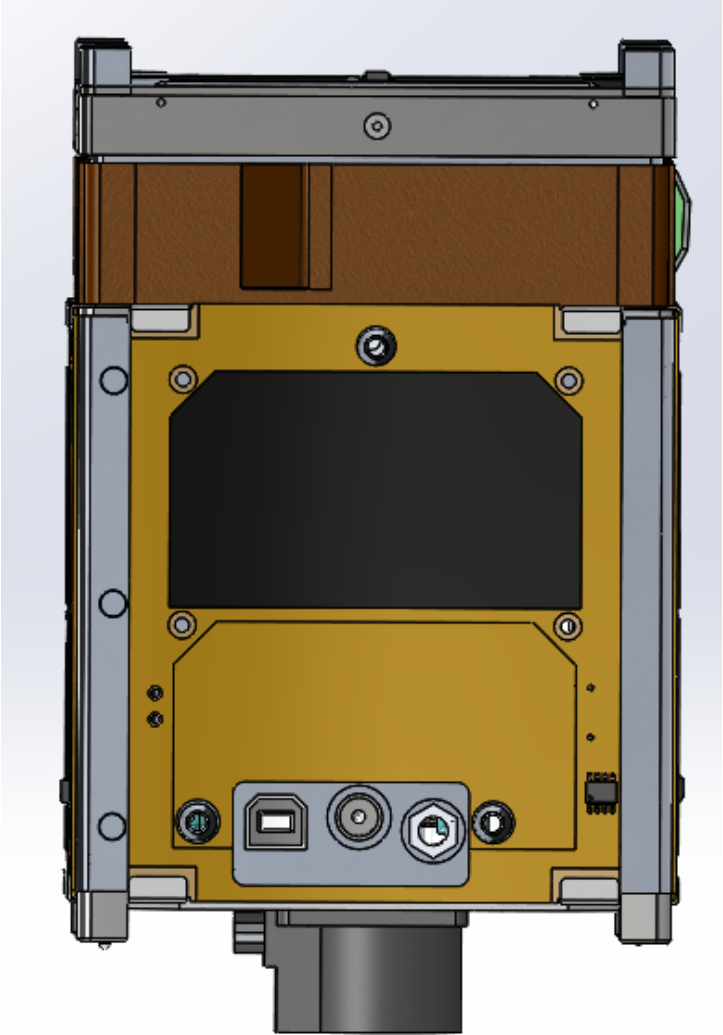
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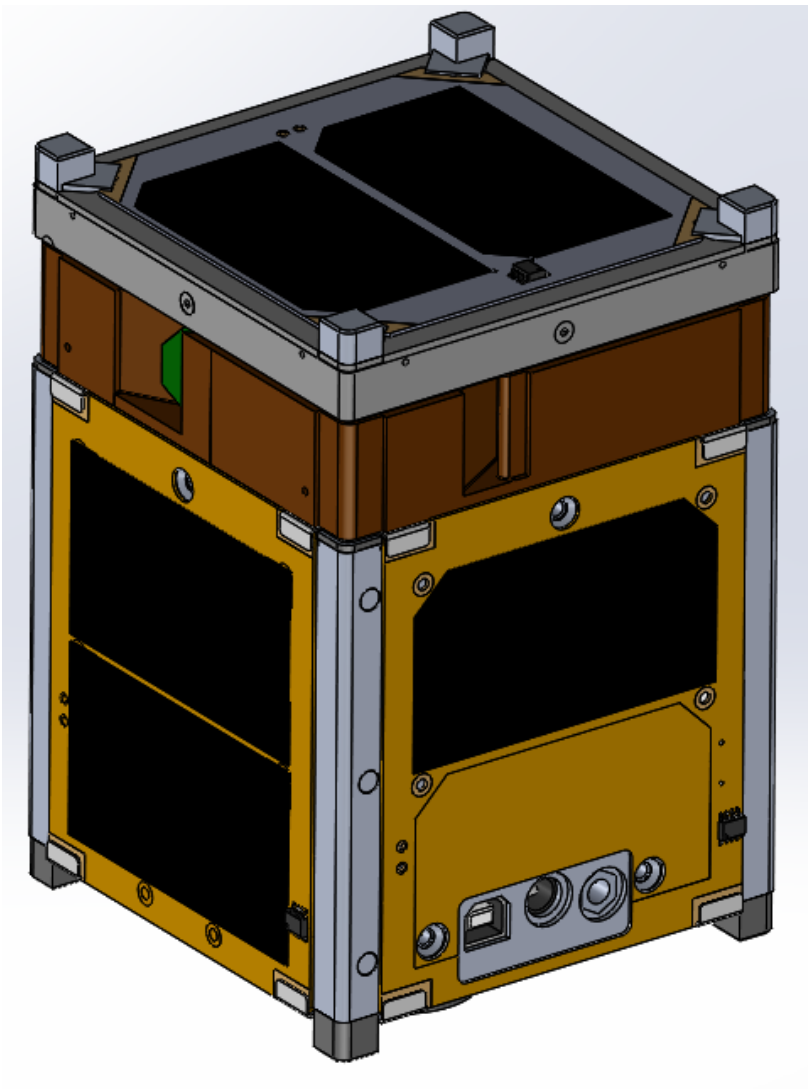




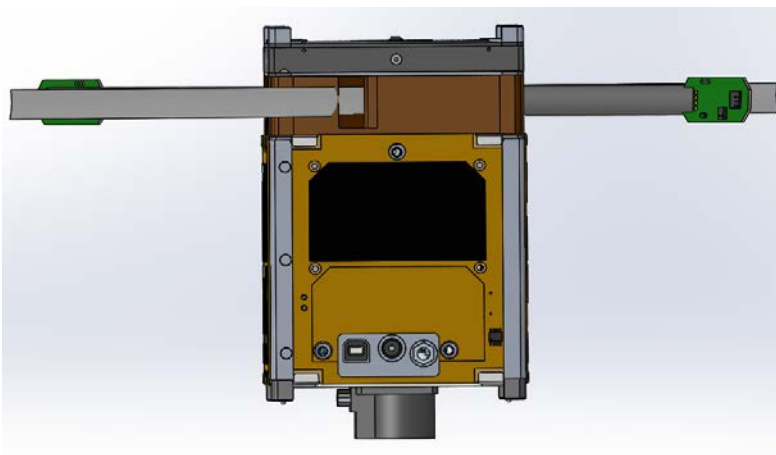
Undeployed configuration:

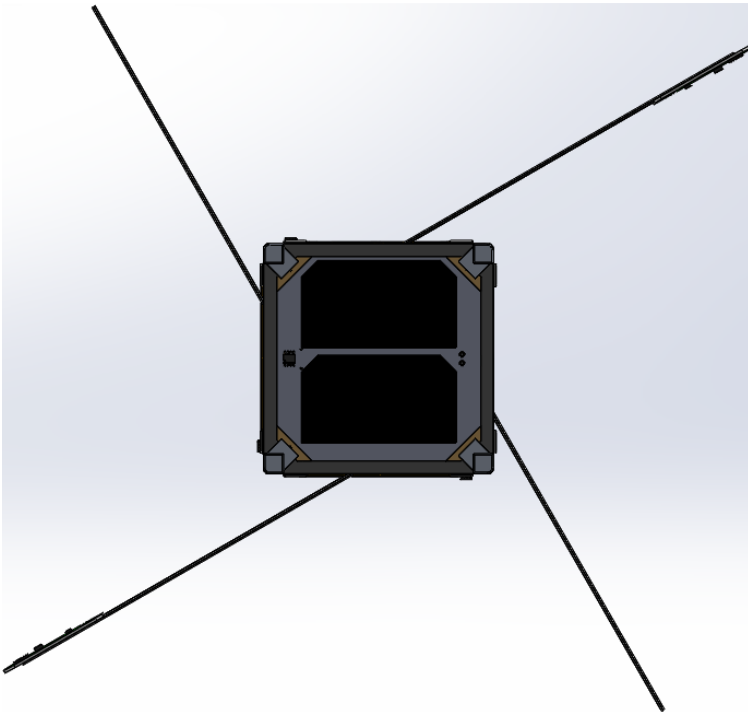
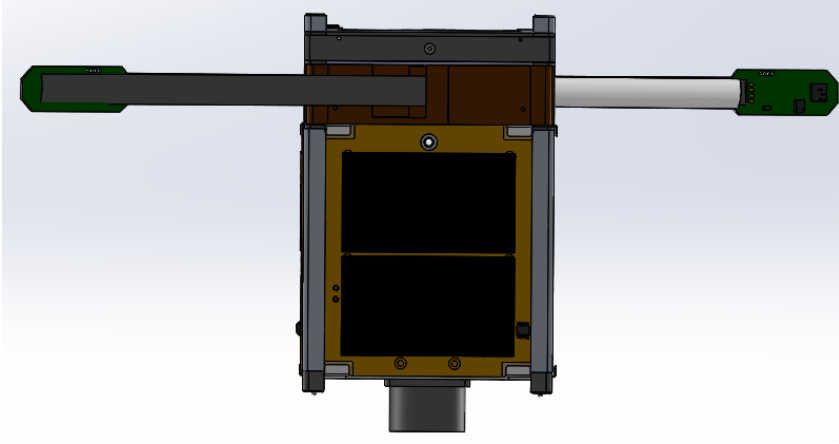


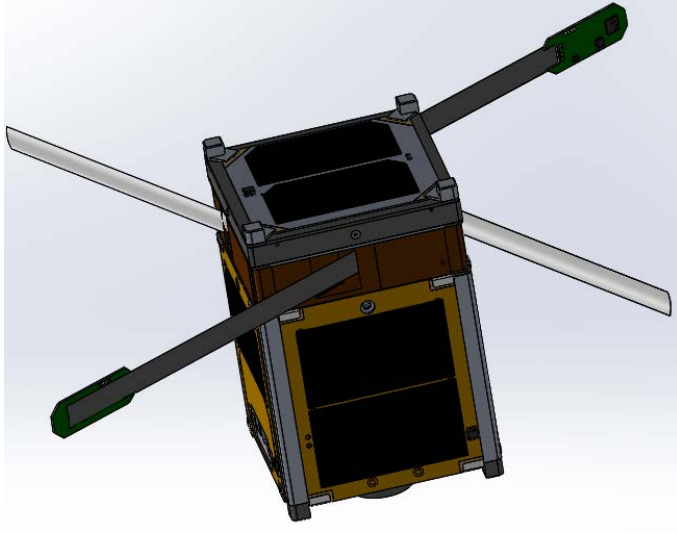




Deployed configuration:







Interaction or potential physical interference with other operational spacecraft:

There is no planned interaction with any other operational spacecraft.

Project Management:

- **Principal Investigator: David Barnhart**

Key Engineering Personnel:

- **Structures Lead: Abdul Eissa/Jessica Yuan**
- **Manufacturing Lead: José Anaya López/Aaron Chandra**
- **Flight Software Lead: Everett Manness/Austin Lamb**
- **C&DH and Electronics Lead: Yaashia Gautam/Eugene Park**
- **Integration & Test Lead: Lizvette Villafana**
- **System Engineering and Analysis: Taylor Gaines**
- **Power System Lead: Evan Gabrielson**
- **TT&C Lead: Soundarya Sampathkumar/Luis Ortiz**
- **Mission Ops Lead: Amrit Singh/Claire Carlton**
- **Thermal Simulations Lead: Dammy Adeoye**

Foreign Government or Space Agency participation:

- **No foreign agency participating in mission currently.**

Summary of NASA's responsibility under the governing agreement(s):

- **N/A**

Schedule of Mission design and Development Milestones:

Section 2: Spacecraft Description:

Physical Description of Spacecraft:

The overall dimensions of our CubeSat are 10 cm x 10 cm x 150.84 cm and a total mass of 1239g. This consists of a quad deployer, a shell/spacer, and a sun sensor, in addition to our main structure.

MAGNETO satellite will contain the following systems

- Solar Panels
- EPS
- Whip antennas
- Magnetometers

Total Satellite mass at launch, including propellant and fluids:

- 1239g

Dry mass of satellite at launch

- 1239 g

Description of all propulsion system

- No propulsion system on MAGNETO

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:

- N/A

Fluids in Pressurized Batteries: None. Cells flown previously on USC AENEAS, intermediary was Varda Rechargeable Lithium -Polymer

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

There is no active ACS system onboard the satellite. Once released from the P-POD, the satellite will form a natural tumble or rotation about its central axis. There is no normal attitude anticipated with respect to the velocity vector.

Description of any range safety or other pyrotechnic devices:

There are no fail safe range safety systems onboard the Satellite. There are no pyro technical devices onboard the satellite. The only device that releases energy through heat are two small gumstick sized boards that have nichrome burn wires wrapped around nylon fishing line, that are used to release the antenna booms inside a quad aperture housing.

Description of the electrical generation and storage system:

- Magneto utilizes the COTS Clyde Space Deployable 3U EPS (DEPS) power system. The DEPS is a Peak Power Tracking (PPT) design and provides unregulated battery voltage and regulated +5V and +3.3V to the CubeSat Kit bus. The DEPS contains a 8W Battery Charge Regulator (BCR). The BCR is paired with four solar array panels, where only one can be lit by sunlight at any time.
- The CubeSat is powered by 5 solar panels manufactured by Pumpkin, each containing 2 Spectrolab UTJ-class solar cells. This system of panels is connected to the BCR which delegates where the power will be distributed via the DEPS power system.

Identification of any other sources of stored energy not noted above:

- Upon launch MAGNETO has 4 small booms that are wound around a drum, that release upon a burn wire release mechanism. The release is done through the stored spring energy of the aluminum booms. This stored energy is kinetic and not electrical.

Identification of any radioactive material on board:

- N/A

ODAR Section 3: Assessment of Spacecraft debris released during normal operations

Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material:

- None

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: N/A. 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:

- **4.3-1, Mission Related Debris Passing Through LEO: COMPLIANT**
- **4.3-2, Mission Related Debris Passing Near GEO: COMPLIANT**

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

In case of MAGNETO, no intentional breakup is planned during deployment

**Potential causes of spacecraft breakup during deployment and mission operations:
Summary of failure modes and effects analyses of all credible failure modes which may lead to an accidental explosion:**

Very low possibility of battery explosion . Owing to very small mass of the satellite and their short orbital lifetimes, effect of explosion is very minute/negligible.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:

No plans for designed spacecraft breakups, explosions or intentional collisions on MAGNETO mission.

List of components which shall be passivated at the End of Mission (EOM) including method of passivation and amount of which cannot be passivated:

No passivation of components planned at EOM.

Rationale for all items which are required to be passivated, but cannot be due to their design:

N/A

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 Moon:

Compliance statement:

Required Probability: 0.001

Expected Probability:0.000

Supporting Rationale and FMEA details:

Battery Explosion

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. Less than 0.01% given that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect(explosion).

Failure mode 1: Internal short circuit.

Mitigation 1:

Combined faults required for realized failure:

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

Mitigation 2:

Combined faults required for realized failure:

Failure Mode 3: Overcharging and excessive charge rate

Mitigation 3:

Combined faults required for realized failure:

Failure Mode 4: Excess temperatures due to orbital environment and high discharge combined.

Mitigation 8: 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** over- current monitoring and control must all fail for this failure mode to occur.

ODAR Section 5: Assessment of Spacecraft Potential for On-Orbit collisions

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2:

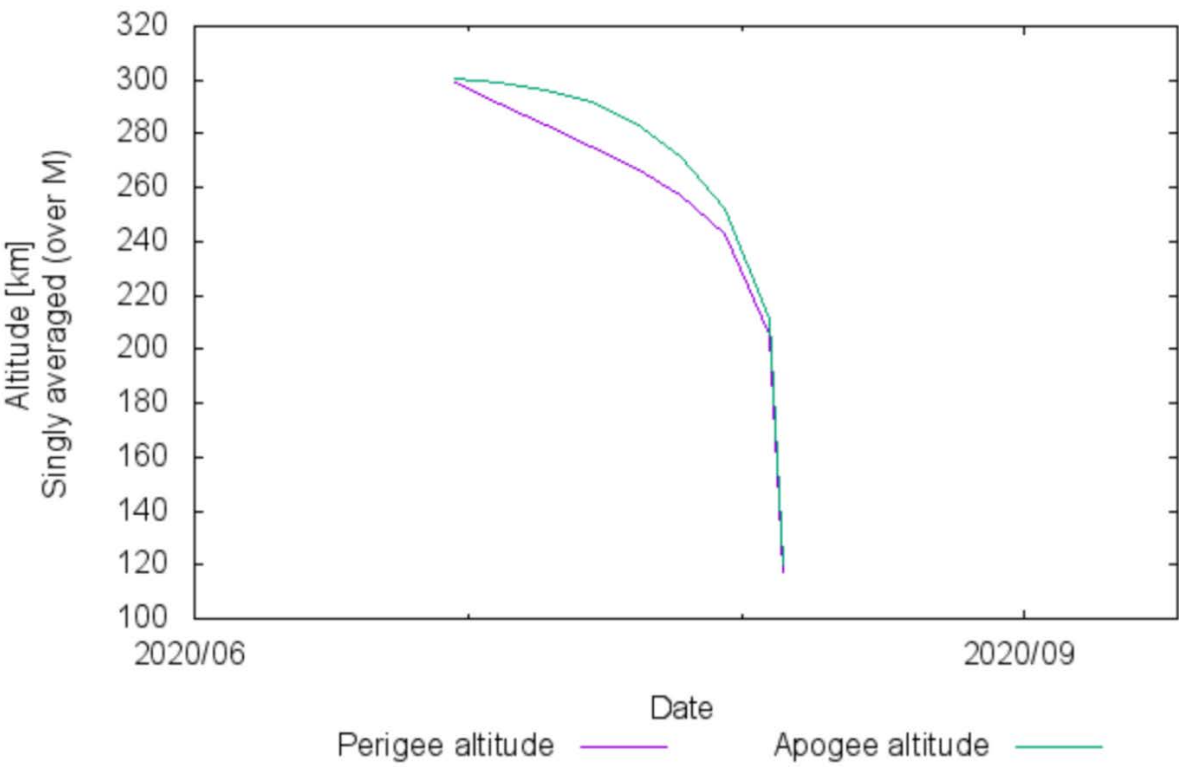
- **Requirement 4.5-1. Limiting debris generated by collisions with large objects when operating in Earth orbit:**

Large Object Impact and Debris Generation Probability:

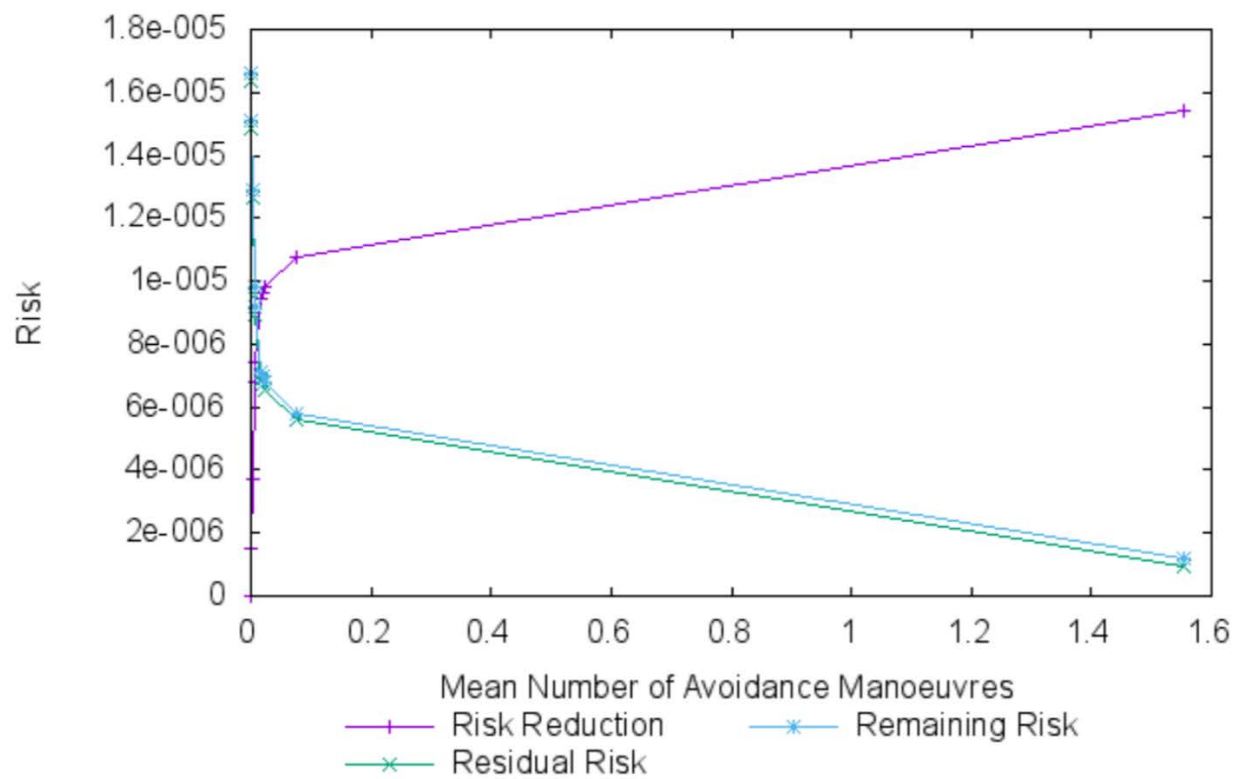
- **Requirement 4.5-2. Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit:**

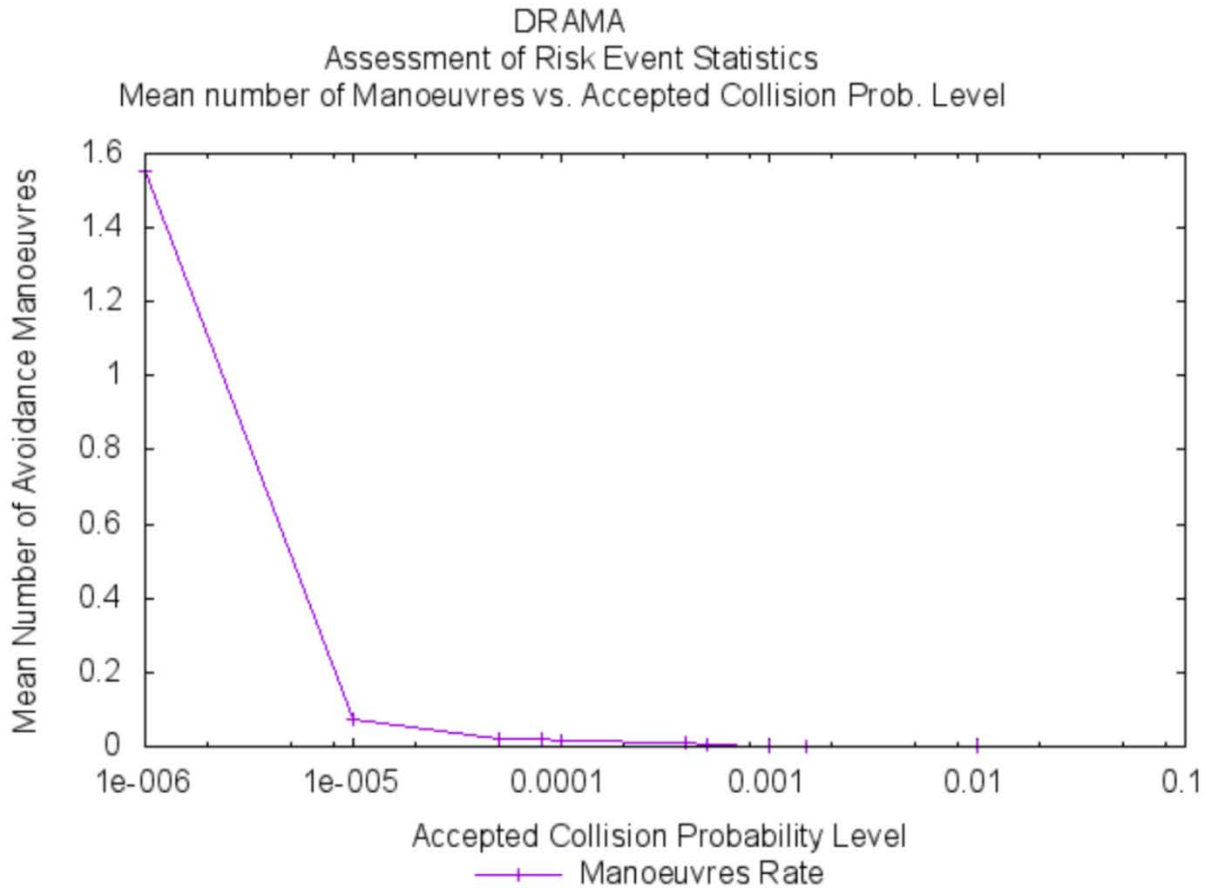
Small Object Impact and Debris Generation Probability:

DRAMA
OSCAR - Orbital Spacecraft Active Removal
Altitude vs. Time



DRAMA
Assessment of Risk Event Statistics
Residual, Remaining and Reduced Risk vs. Mean Number of Av. Man.





ODAR Section 6: Assessment of Spacecraft Postmission Disposal Plans and Procedures:

6.1 Description of spacecraft disposal option selected:

- The satellite will de-orbit naturally by atmospheric re-entry. There is no propulsion system.

Magneto Orbit Decay Analysis Using STK's Lifetime Tool:

Assumptions

- Drag coefficient $C_d = 2.2$ (suggested value by STK)
- $C_r = 1$ for total absorption of solar radiation pressure, $C_r = 1.33$ for specular reflection of SRP
- Mass = 1.3232 kg
- Area exposed to sun would be same as cross-sectional area since spacecraft will likely be tumbling and therefore constantly changing orientation with respect to sun (so assume greatest cross-sectional area exposed to sun for worst case, at any given moment)
- Solar Flux File was updated in STK using Data Update Utility

Orbit epoch and simulation start time: 30 June 2020 20:00:00.000 UTC

Orbit parameters:

Orbit Epoch:	30 Jun 2020 20:00:00.000 UTCG	Apoqee Altitude	300 km
Coord Epoch:	30 Jun 2020 20:00:00.000 UTCG	Periqee Altitude	300 km
Coord Type:	Classical	Inclination	137 deg
Coord System:	TrueOfDate	Argument of Perigee	0 deg
Prop Specific:	Special Options...	RAAN	274 deg
		True Anomaly	143 deg

Various Scenarios

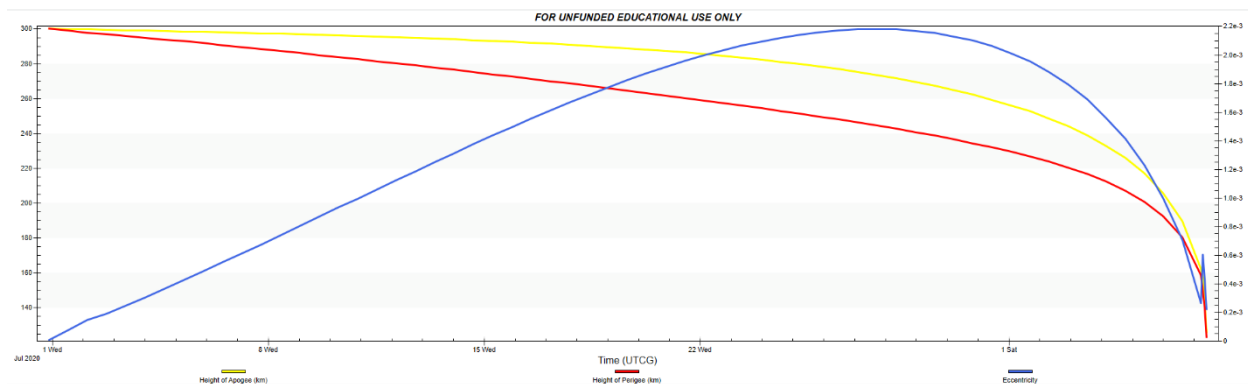
Varying Solar Flux Sigma

Lifetime for Magneto

Satellite Characteristics	Solar Data
Cd: 2.20000000	Solar Flux File: SolFix_CSS1.dat
Cr: 1.33333333	Solar Flux Sigma: 0
Drag Area: 0.01803 m^2	Advanced...
Area Exposed to: 0.01803 m^2	Compute
Mass: 1.3232 kg	Report ...
Atmospheric Density	☒ Show Graphics
Model: NRLMSISE 2000	Graph ...

Information

Magneto decay is estimated to be on 7 Aug 2020 09:33:30.904 after 612 orbits. The lifetime is 38 days.



Lifetime for Magneto

Satellite Characteristics

Cd:

Cr:

Drag Area:

Area Exposed to:

Mass:

Atmospheric Density
Model:

Solar Data

Solar Flux File:

Solar Flux Sigma:

Advanced... **Compute** Report ...

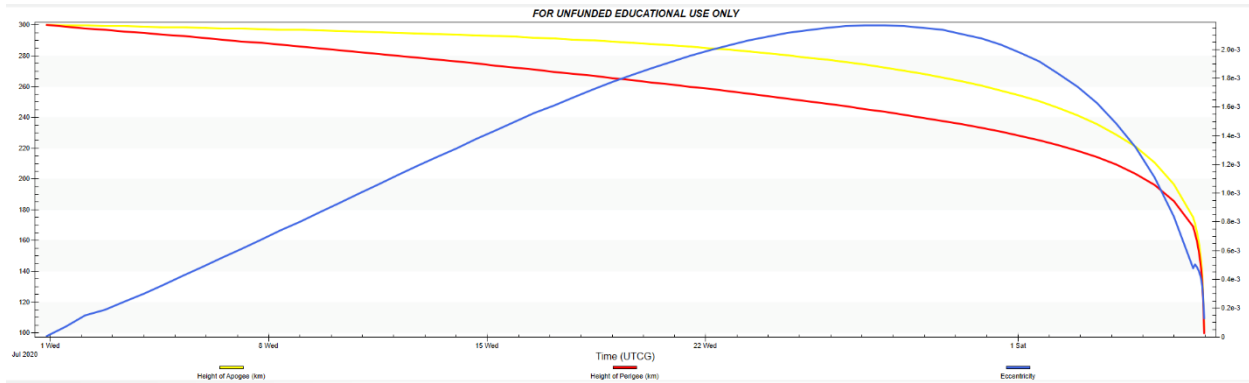
☒ Show Graphics **Graph ...**

Information

Magneto decay is estimated to be on 6 Aug 2020 23:06:20.189 after 605 orbits. The lifetime is 37 days.

OK

Close Apply Help



Lifetime for Magneto

Satellite Characteristics

Cd:

Cr:

Drag Area:

Area Exposed to:

Mass:

Atmospheric Density

Model:

Solar Data

Solar Flux File:

Solar Flux Sigma:

Advanced... Compute Report ...

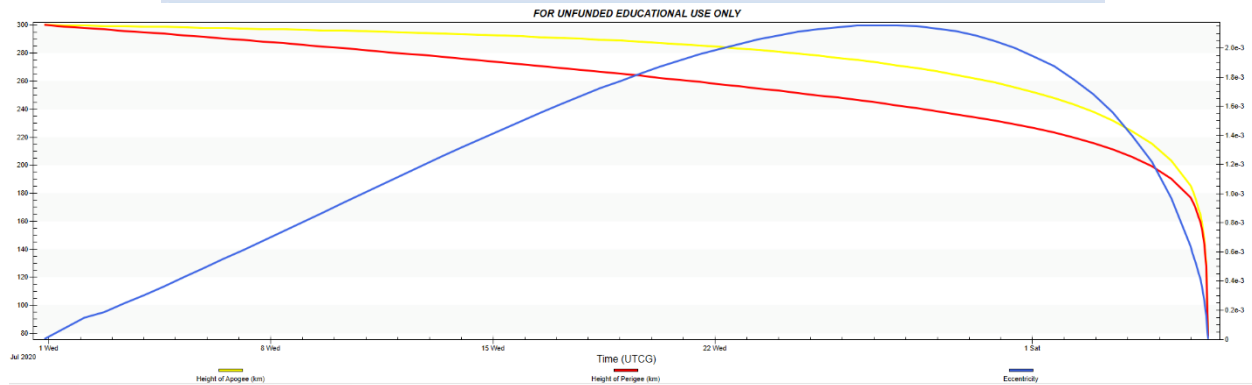
☒ Show Graphics Graph ...

Close Apply Help

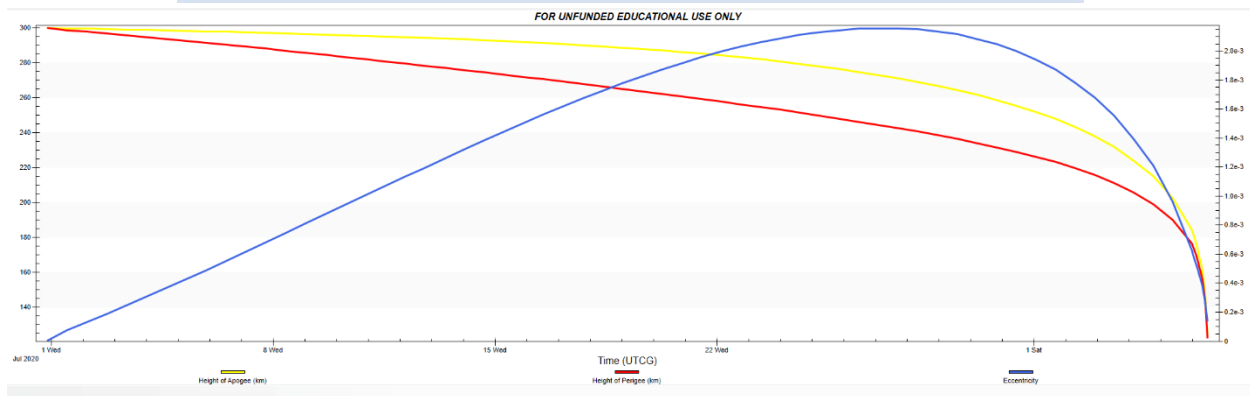
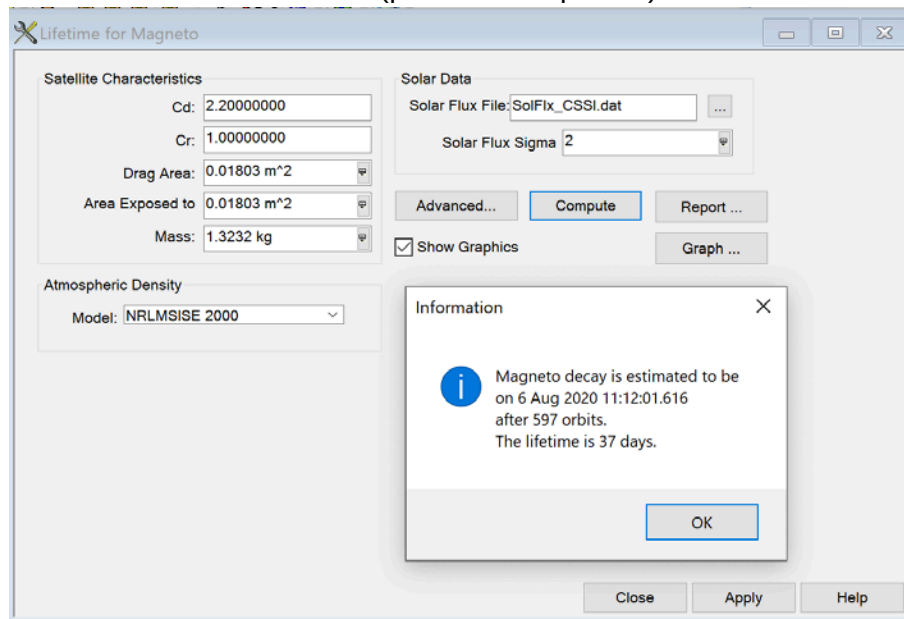
Information

 Magneto decay is estimated to be on 6 Aug 2020 12:39:18.444 after 598 orbits. The lifetime is 37 days.

OK



$C_r = 1.0$ (perfect absorptance)



6.2 Plan for any spacecraft maneuvers required to accomplish postmission disposal:

- None

6.3 Calculation of area-to-mass ratio after postmission disposal, if the controlled reentry option is not selected:

- Spacecraft Mass: 1.32323 kg

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

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 ----- Joules:

#--<DRAMA/OSCAR/oscar.oop>-----<TUBS-ILR/VB>-<11/2012>---

#


```

#      _/_  _/_/_  _/_/_  _/_  _/_/_
#      _/  _/  _/    _/    _/  _/  _/
#      _/  _/  _/_  _/    _/_/_/_  _/_/_
#      _/  _/    _/  _/    _/  _/  _/
#      _/_  _/_/_  _/_/_  _/  _/  _/
#
#      Debris Risk Assessment and Mitigation Analysis Tool Suite
#              Orbital Spacecraft Active Removal
#              DRAMA - OSCAR (v2.3.1)
#-----
# This file was generated by the program OSCAR
# on 2020-03-10 at 17:55:18.727
#-----
# Comment:
# DRAMA
# OSCAR - Orbital Spacecraft Active Removal
#-----
# Input data:
#
# Begin date (YYYY-MM-DD hh:mm:ss): 2020-06-30 12:00:00
#
# Target orbit :
# 6678.000 - semi-major axis [km]
# 0.000100 - eccentricity [-]
# 137.00000 - inclination [deg]
# 0.00000 - right ascension of the ascending node [deg]
# 0.00000 - argument of perigee [deg]
#
# Spacecraft parameters:
# 0.018 - cross-sectional area [m**2]
# 1.300 - dry mass [kg]
# 2.200000 - drag coefficient [-]
# 1.300000 - reflectivity coefficient [-]
#
# Disposal option: none
#
# 100.000000 - Propagation span [years]
#
# Solar and geomagnetic activity:
#
# Scenario: Latest prediction
# Solar & geomagnetic activity data used: ESA
#
#-----

```

```
#
# Title : General output
#
#-----
#
# Final date and singly averaged (wrt. M) Kepler elements:
#
# 2020-08-05 22:40:01 - Date (YYYY-MM-DD hh:mm:ss)
#      6496.71 - Semi-major axis (km)
#      0.0002209 - Eccentricity
#      136.98 - Inclination (deg)
#      230.12 - Right ascension of ascending node (deg)
#      287.14 - Argument of perigee (deg)
#      136.60 - Mean anomaly (deg)
#
#-----
#
# Force model used with FOCUS v2.5.4:
#
# Geopotential: GEM-T1 (6x6)
# Drag:      NRLMSISE-00
#
#-----
#
# 0.10 - Remaining lifetime of target orbit (yrs)
#      (incl. margin of 5.00 % according to ISO 27852:2011.)
#
#-----
#
# ESA Space Debris Mitigation Requirements compliance check:
#
# Compliant through natural orbital lifetime
#
#-----
#
```

ODAR SECTION 7A: Assessment of Spacecraft Hazardous Materials

// N/A : There are no hazardous materials contained on the spacecraft.

ODAR SECTION 8: Assessment of Tether Missions

// N/A. There are no tethers in the MAGNETO mission.

END OF ODAR FOR MAGNETO