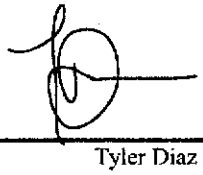
Orbital Debris Assessment Report

NOOR-1

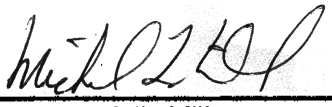
per NASA-STD 8719.14A

Signature Page



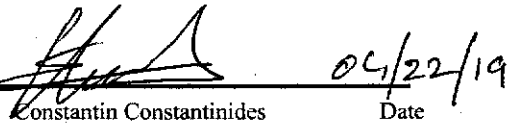
4/22/19

Tyler Diaz — Date
CEO, Stara Corporation



04/22/19

Mike Miller — Date
Licensing Coordinator, Sterk Solutions Corporation



Constantin Constantinides — Date
Senior RF Engineer, Alba Orbital Ltd.

04/19/2019

Michael H. Miller — Date
Licensing Analyst, Sterk Solutions Corporation

REFERENCES:

A. *NASA Procedural Requirements for Limiting Orbital Debris Generation,* NPR 8715.6A, *5* February 2008
B. *Process for Limiting Orbital Debris,* NAS A-STD-8719.14A, 25 May 2012
C. International Space Station Reference Trajectory, delivered May 2017
D. McKissock , Barbara, Patricia Loyselle, and Elisa Vogel. *Guidelines on Lithium-ion Battery Use in Space Applications.* Tech. no. RP-08-75. NASA Glenn Research Center Cleveland, Ohio
E. *UL Standard for Safety.for Lithium Batteries, UL 1642.* 1JL Standard. 4th ed. Northbrook, IL, Underwriters Laboratories, 2007
F. Kwas, Robert. Thermal Analysis of ELaNa-4 CubeSat Batteries, ELVL-2012-0043254; Nov 2012
G. Range Safety User Requirements Manual Volume 3- Launch Vehicles, Payloads, and Ground Support Systems Requirements, AFSCM 91-710 V3.
H. HQ OSMA Policy Memo/Email to 8719.14: CubeSat Battery Non-Passivation, Suzanne Aleman to Justin Treptow, 10, March 2014
I. HQ OSMA Emai1:6U CubcSat Battery Non Passivation Suzanne Aleman to Justin Treptow, 8 August 2017

This report is intended to satisfy the orbital debris requirements listed in *NASA Procedural Requirements for Limiting Orbital Debris Generation,* NPR 8715.6A, *5* February 2008, for the NOOR-1 mission.

Sections 1 through 8 of *Process for Limiting Orbital Debris,* NAS A-STD-8719.14A, 25 May 2012, are addressed in this document; sections 9 through 14 are in the domain of the launch provider and are addressed by others.

RECORD OF REVISIONS		
REV	**DESCRIPTION**	**DATE**
0	Original submission	April 2019

The following table summarizes the compliance status of the NOOR-1A and NOOR-1B spacecraft. They are fully compliant with all applicable requirements.

Requirements	**Compliance Assessment**	**Comments**
4.3-1a	Not Applicable	No planned debris release
4.3-1b	Not Applicable	No planned debris release
4.3-2	Not Applicable	No planned debris release
4.4-1	Compliant	Batteries incapable of debris producing failure
4.4-2	Compliant	Batteries incapable of debris producing failure
4.4-3	Not Applicable	No planned breakups
4.4.-4	Not Applicable	No planned breakups
4.5-1	Compliant	

Table 1 Compliance Assessment per Requirement

Section 1: Mission Overview

The overall goal of the NOOR-1 mission, is to test, develop, and demonstrate the efficacy and design of a nano-satellite network, including associated software applications and their ability to exchange encrypted data via crosslinks, relay store-and-forward requests, and reliably communicate with Stara's ground station.

Section 2: Spacecraft Description

The two spacecraft are identical, using an Alba Orbital 3p PocketQube platform. Each has the dimensions 8 x 6.9 x 19 cm stowed, and 44 x 7 x 18.5 cm with the solar panels deployed. The total mass of each is about 0.75 Kg.

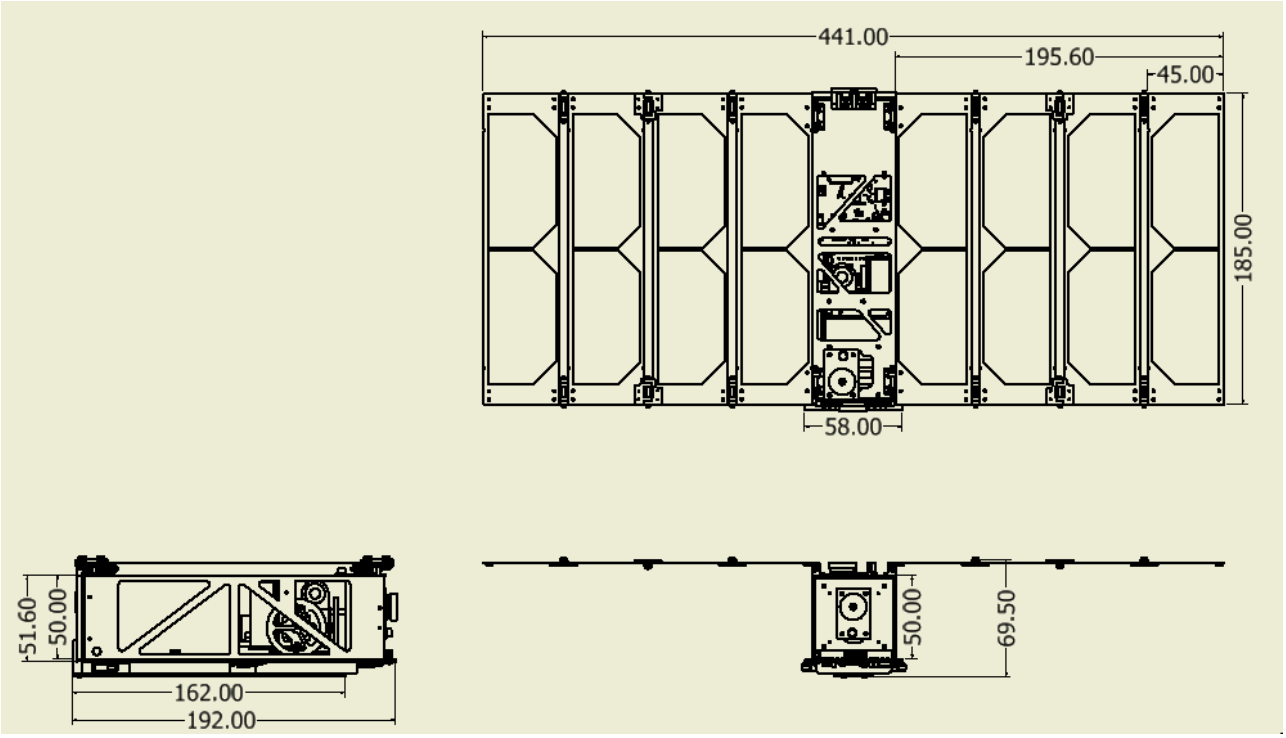


Figure 1: A Noor-1 Unit, Dimension Drawing: Solar Panels Deployed
Dimensions in mm

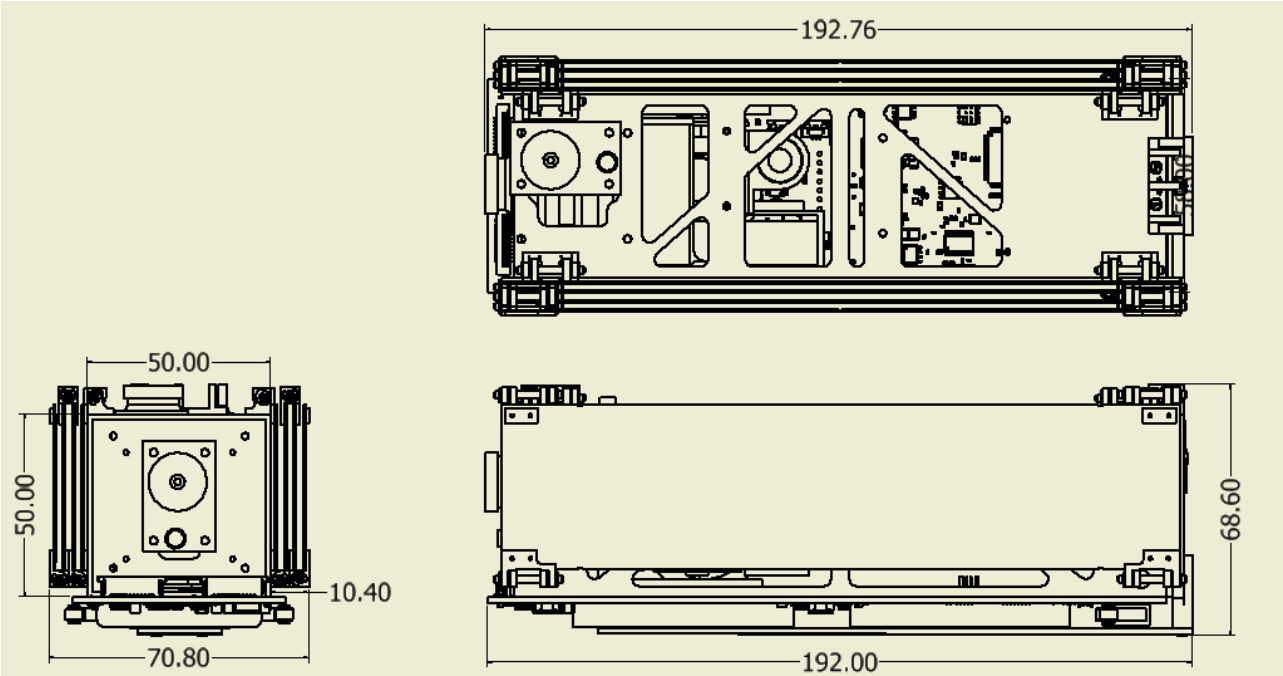


Figure 2: A Noor-1 Unit, Dimension Drawing: Solar Panels Stowed
Dimensions in mm

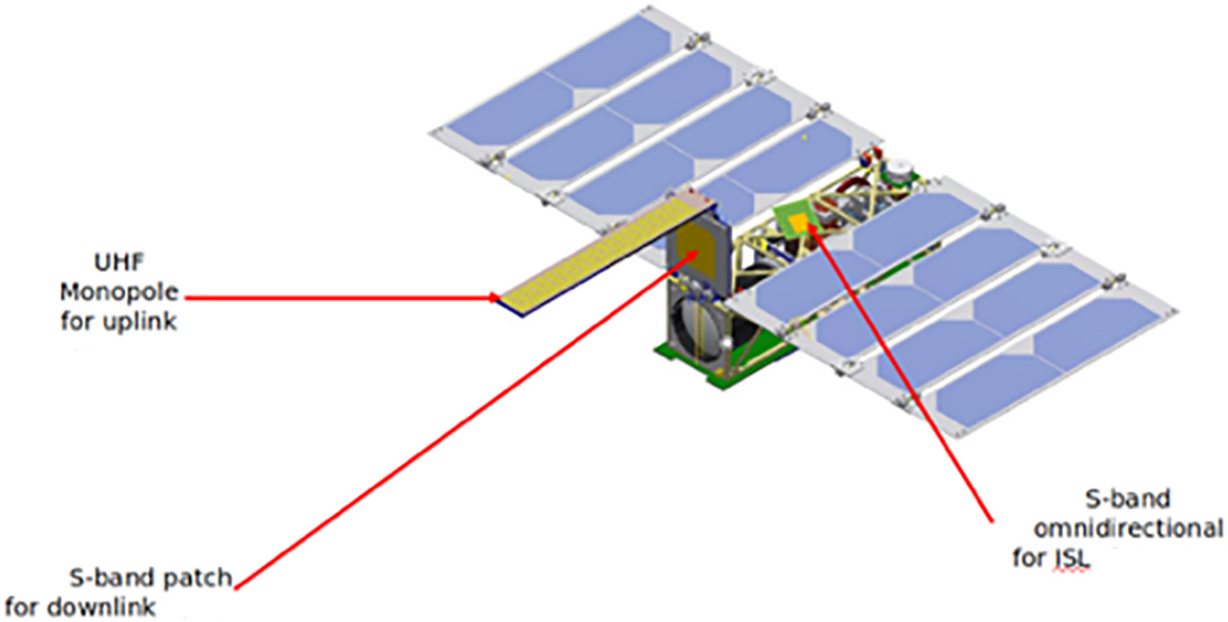


Figure 3: A Noor-1 Unit, Perspective Drawing: Solar Panels and Patch Antenna Deployed

Hazards

There are no pressure vessels, hazardous, or exotic materials.

Batteries

There are 2 batteries per spacecraft. The batteries are Lithium Polymer batteries manufactured from RS-components under RS stock number 125-1266. Their characteristics are: 2000 mAh, 3.7 V, Catalog Number-SR674361P

Battery circuit protection module: This battery has a fuel gauge module which is used for monitoring the state of charge of the battery via the fuel gauge IC (DS2756E+T&R). This IC monitors voltage, temperature, currents and current accumulation and alerts the on-board computer when accumulated current or temperature exceeds programmable limits. No other protection module is present.

This battery complies with the specifications published by RS Components. Electrostatic discharge sensitive devices have been handled and packed under conditions that meet the administrative and technical requirements of the ANSI/ESD S20.20:2014 and BS EN 61340-5-1:2007 Electrostatic Control Standards. Additionally, according to the "ST/SG/AC.10/11/Rev.6/ 2015, UN Model Regulations Part 3 - 38.3 Lithium Batteries**"** standard, provided by the manufacturer, these batteries have passed Vibe, Shock and Thermal Ambient testing.

The batteries have been subjected to a qualification and acceptance test as suggested by the NASA standard JSC-20793D (https://standards.nasa.gov/standard/jsc/jsc-20793). The batteries were:

- Subjected to functional baseline tests (capacity & load check, mass, visual inspection)
- Vibed and shocked
- Subjected to another functional baseline test
- Subjected to multiple charge and discharge cycles before thermal vacuum exposure
- Exposed to a thermal vacuum under extreme temperature conditions
- Subjected to functional baseline tests and a visual inspection to ensure no expansion of the batteries occurred.

The EPS is a direct energy transfer system, using a solar array producing approximately 19W of orbit average power to charge the battery system. The solar arrays utilize standard AzurSpace photovoltaic cells.

Section 3: Assessment of Spacecraft Debris Released during Normal Operations

The assessment of spacecraft debris requires the identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material.

Section 3 requires rationale/necessity for release of each object, time of release of each object, relative to launch time, release velocity of each object with respect to spacecraft, expected orbital parameters (apogee, perigee, and inclination) of each object after release, calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO), and an assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2.

No releases are planned, therefore this section is not applicable.

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

There are NO plans for designed spacecraft breakups, explosions, or intentional collisions.

The probability of battery explosion is very low, and, due to the very small mass of the satellite the effect of an explosion on the far-term LEO environment is negligible, per HQ OSMA Policy Memo/Email to 8719.14: CubeSat Battery Non-Passivation, Suzanne Aleman to Justin Treptow, 10, March 2014

The batteries meet Reg. 56450 (4.4-2), per this reference, by virtue of the HQ OSMA policy regarding battery disconnect stating "CubeSats [3U or smaller] as a satellite class need not disconnect their batteries if flown in LEO with orbital lifetimes less than 25 years."

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4 shows that the satellite pair is compliant.

Section 5: Assessment of Spacecraft Potential for On Orbit Collisions

Calculation of spacecraft probability of collision with space objects larger than 10 cm in diameter during the orbital lifetime of the spacecraft takes into account both the mean cross sectional area (MCSA) and orbital lifetime.

See Appendix for DAS Analysis Input Data and Output Results. This shows that the probability of an on orbit collision with debris or meteoroids greater than 10 cm in diameter is "less than 0.00000". This was calculated for both fully deployed and fully stowed configurations. This satisfies the 0.001 maximum probability requirement 4.5-l.

The spacecraft have no capability nor have plans for end-of- mission disposal, therefore requirement 4.5-2 is not applicable.

Assessment of spacecraft compliance with Requirements 4.5-1 shows it to be compliant.

Requirement 4.5-2 is not applicable to this mission.

Section 6: Assessment of Spacecraft Postmission Disposal Plans and Procedures

The spacecraft all will naturally decay from orbit within 25 years after end of the mission, satisfying requirement 4.6- 1.

Planning for spacecraft maneuvers to accomplish post-mission disposal is not applicable. Disposal is achieved via passive atmospheric reentry.

Summary of DAS 2.1.1 Orbital Lifetime Calculations:

DAS inputs are: 385 km circular orbit, with an inclination of 98° at deployment no earlier than June 15, 2019.

From the DAS output data and the following figure from DAS, in the nominal operation case, the lifetime of the spacecraft is estimated to be approximately six months until demise.

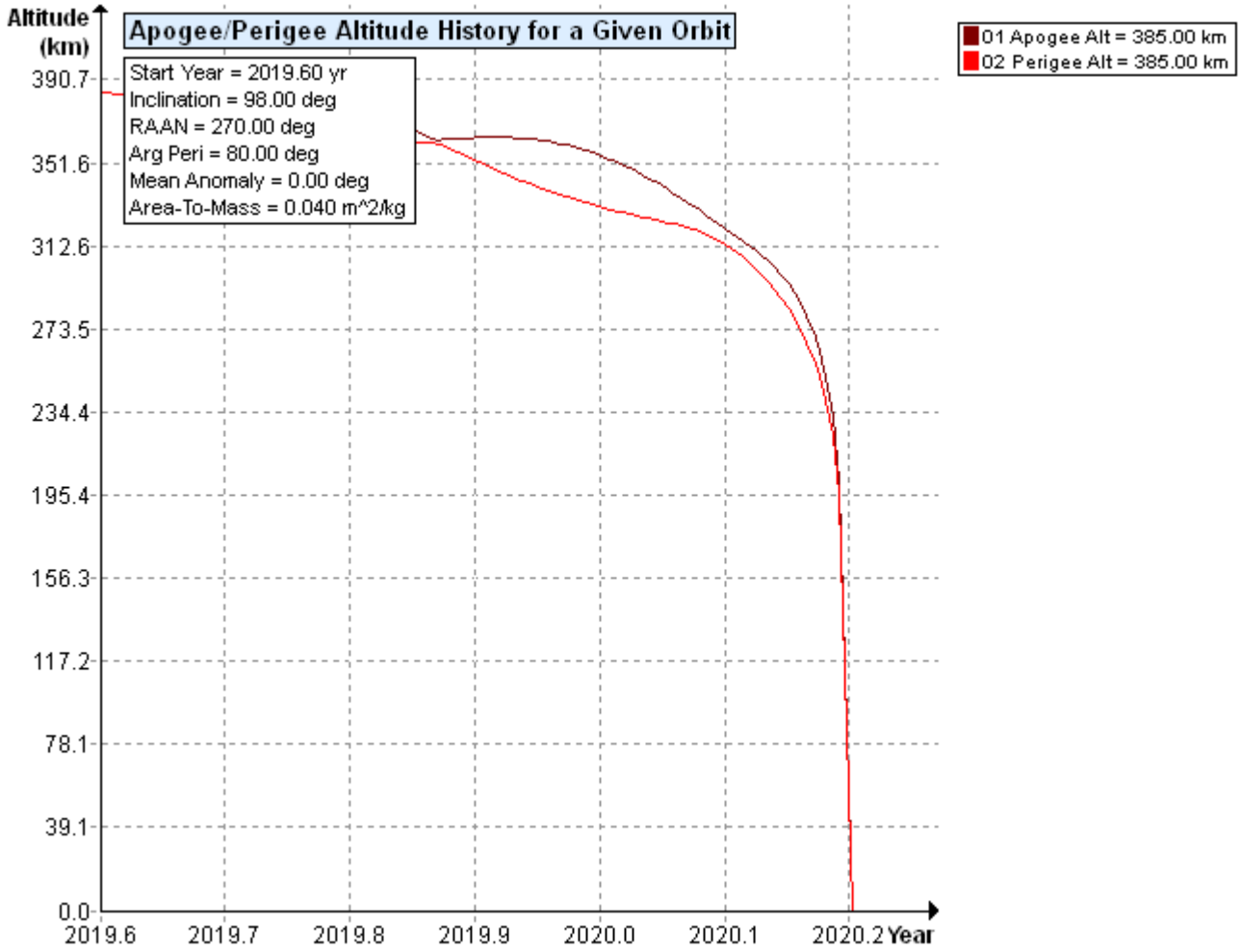


Figure 4 Altitude vs. Time For Noor-1 Spacecraft. Deployed

Similarly, in the case of non-deployment, the orbit lifetime is shown to be 1.1 years, in Figure 5.

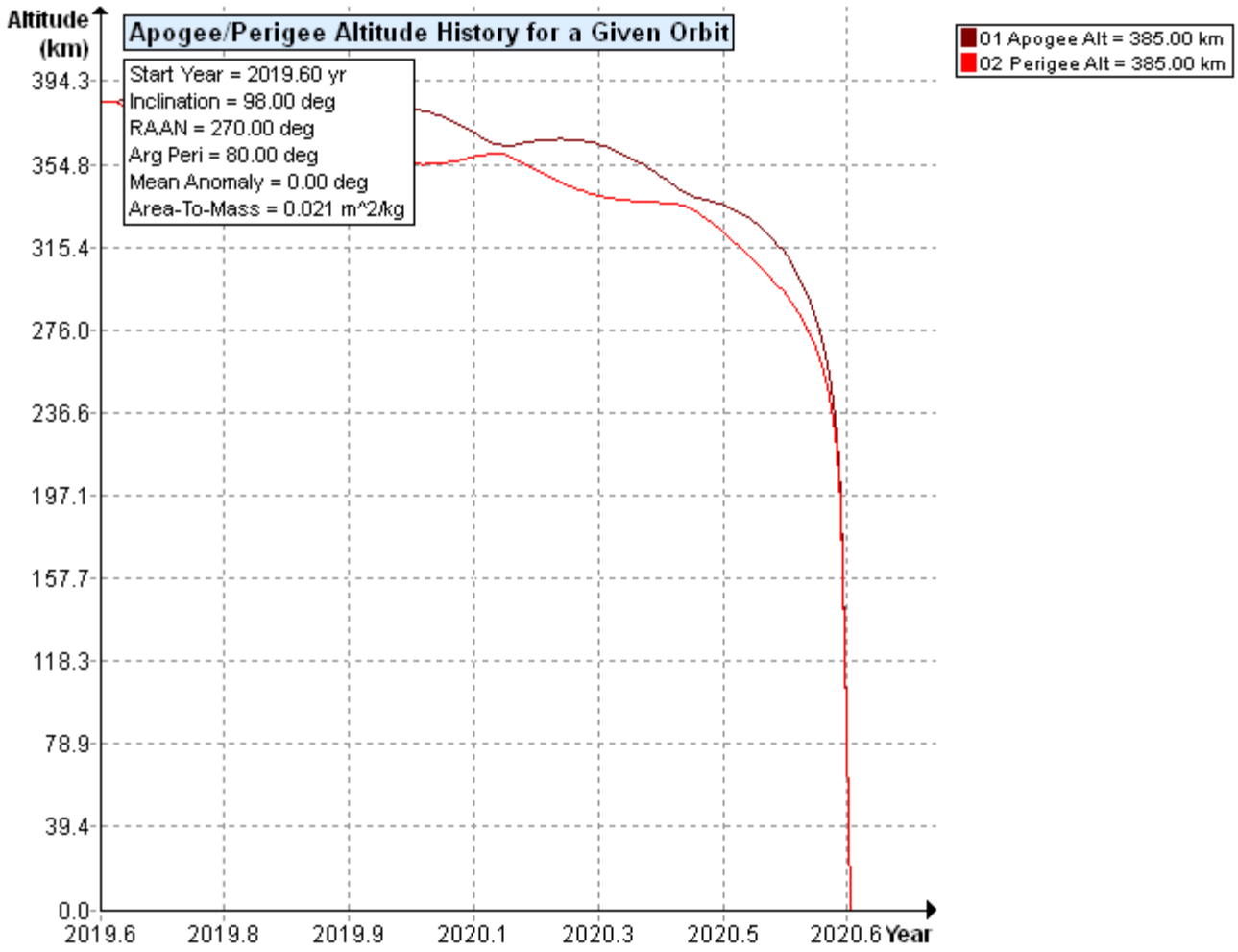


Figure 5 Altitude vs. Time For Noor-1 Spacecraft. Stowed Configuration

The assessment of the spacecraft illustrates it is compliant with Requirements 4.6-1 through 4.6-5.

Section 7: Assessment of Spacecraft Reentry Hazards

A detailed assessment of the components of the spacecraft was performed using DAS 2.1.1, to verify Requirement 4.7-1. See Appendix for a complete log of DAS inputs and outputs. The analysis provides a bounding analysis for characterizing the survivability of a component during re-entry. It is conservative in that when it shows terminal energy of a component surviving reentry, it is does not consider any loss material from ablation or charring. Both of these may for some materials decrease the mass and dimensions of the re-entering components, reducing the risk below that calculated.

All components demise upon reentry and all spacecraft comply with the less than 1:10,000 probability of Human Casualty Requirement 4.7-1.

The satellites thus are in compliance with Requirement 4.7-1 of NASA-STD-8719.14A.

Section 8: Assessment for Tether Missions

No tethers are used. Requirement 4.8-1 is satisfied.

Section 9 through 14:

ODAR sections 9 through 14 pertain to the launch vehicle, and are not covered here.

Appendix

04 11 2019; 13:39:40PM Activity Log Started
04 11 2019; 13:42:30PM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2019.000000 (yr)
Perigee Altitude = 385.000000 (km)
Apogee Altitude = 385.000000 (km)
Inclination = 98.000000 (deg)
RAAN = 270.000000 (deg)
Argument of Perigee = 80.000000 (deg)
Area-To-Mass Ratio = 0.039816 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 0.553046 (yr)
Time Spent in LEO during Lifetime = 0.553046 (yr)
Last year of Propagation = 2019 (yr)
Returned Error Message: Object reentered
04 11 2019; 13:46:04PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 385.000000 (km)
Apogee Altitude = 385.000000 (km)
Inclination = 98.000000 (deg)
RAAN = 270.000000 (deg)
Argument of Perigee = 80.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.039816 (m^2/kg)
Start Year = 2019.600000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot
04 11 2019; 13:48:02PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Start Year = 2019.000000 (yr)
Perigee Altitude = 385.000000 (km)
Apogee Altitude = 385.000000 (km)
Inclination = 98.000000 (deg)
RAAN = 270.000000 (deg)
Argument of Perigee = 80.000000 (deg)
Area-To-Mass Ratio = 0.020995 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 1.100616 (yr)
Time Spent in LEO during Lifetime = 1.100616 (yr)

Last year of Propagation = 2020 (yr)
Returned Error Message: Object reentered
04 11 2019; 13:48:49PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 385.000000 (km)
Apogee Altitude = 385.000000 (km)
Inclination = 98.000000 (deg)
RAAN = 270.000000 (deg)
Argument of Perigee = 80.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.020995 (m^2/kg)
Start Year = 2019.600000 (yr)
Integration Time = 1.000000 (yr)

OUTPUT

Plot

04 11 2019; 13:50:22PM Activity Log Started
04 11 2019; 13:51:10PM *********Processing Requirement 4.7-1
Return Status : Passed

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quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 0.754370
Thermal Mass = 0.754370
Diameter/Width = 0.080000
Length = 0.190000
Height = 0.069000

name = Solar panel board module
quantity = 8
parent = 1
materialID = 19
type = Flat Plate
Aero Mass = 0.015730
Thermal Mass = 0.015730
Diameter/Width = 0.045000
Length = 0.185000

name = Solar cell
quantity = 16
parent = 1
materialID = 24
type = Flat Plate
Aero Mass = 0.002600
Thermal Mass = 0.002600

Diameter/Width = 0.040000
Length = 0.080000

name = Back plane
quantity = 1
parent = 1
materialID = 19
type = Flat Plate
Aero Mass = 0.057860
Thermal Mass = 0.057860
Diameter/Width = 0.058000
Length = 0.191000

name = Main structure frame
quantity = 1
parent = 1
materialID = 8
type = Box
Aero Mass = 0.050970
Thermal Mass = 0.050970
Diameter/Width = 0.050000
Length = 0.178000
Height = 0.050000

name = End plate 1
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.002440
Thermal Mass = 0.002440
Diameter/Width = 0.047000
Length = 0.047000

name = End plate 2
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.004960
Thermal Mass = 0.004960
Diameter/Width = 0.047000
Length = 0.047000

name = Lithium ion batteries
quantity = 2
parent = 1
materialID = 5
type = Box
Aero Mass = 0.040000
Thermal Mass = 0.040000
Diameter/Width = 0.050000
Length = 0.054300
Height = 0.006100

name = Radio mounting bracket

quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.007110
Thermal Mass = 0.007110
Diameter/Width = 0.047000
Length = 0.054000

name = Radio assembly rods
quantity = 4
parent = 1
materialID = 54
type = Cylinder
Aero Mass = 0.002000
Thermal Mass = 0.002000
Diameter/Width = 0.002500
Length = 0.080000

name = Patch mounting panel
quantity = 1
parent = 1
materialID = 76
type = Box
Aero Mass = 0.013150
Thermal Mass = 0.013150
Diameter/Width = 0.050000
Length = 0.056000
Height = 0.007000

name = Top shield
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 0.011000
Thermal Mass = 0.011000
Diameter/Width = 0.042000
Length = 0.042000
Height = 0.005000

name = Bottom shield
quantity = 3
parent = 1
materialID = 8
type = Box
Aero Mass = 0.007000
Thermal Mass = 0.007000
Diameter/Width = 0.042000
Length = 0.042000
Height = 0.005000

name = Ipex Cable
quantity = 3
parent = 1
materialID = 64

type = Cylinder
Aero Mass = 0.001620
Thermal Mass = 0.001620
Diameter/Width = 0.002500
Length = 0.180000

name = ISL S-band radio board
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.010430
Thermal Mass = 0.010430
Diameter/Width = 0.042000
Length = 0.042000
Height = 0.016000

name = DL S-band radio board
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.010430
Thermal Mass = 0.010430
Diameter/Width = 0.042000
Length = 0.042000
Height = 0.016000

name = UHF radio board
quantity = 1
parent = 1
materialID = 23
type = Box
Aero Mass = 0.010430
Thermal Mass = 0.010430
Diameter/Width = 0.042000
Length = 0.042000
Height = 0.016000

name = DL S-band patch antenna
quantity = 1
parent = 1
materialID = 19
type = Flat Plate
Aero Mass = 0.008400
Thermal Mass = 0.008400
Diameter/Width = 0.050000
Length = 0.050000

name = ISL S-band omni antenna
quantity = 1
parent = 1
materialID = 19
type = Flat Plate
Aero Mass = 0.004500
Thermal Mass = 0.004500

Diameter/Width = 0.012000
Length = 0.100000

name = UHF omni antenna
quantity = 1
parent = 1
materialID = 19
type = Flat Plate
Aero Mass = 0.009300
Thermal Mass = 0.009300
Diameter/Width = 0.023000
Length = 0.162000

name = ADCS Main Support Frame
quantity = 1
parent = 1
materialID = 5
type = Box
Aero Mass = 0.018340
Thermal Mass = 0.018340
Diameter/Width = 0.046000
Length = 0.047000
Height = 0.040500

name = ADCS Inertia Wheels
quantity = 3
parent = 1
materialID = 14
type = Cylinder
Aero Mass = 0.011610
Thermal Mass = 0.011610
Diameter/Width = 0.007500
Length = 0.035000

name = ADCS BLDC Motor
quantity = 3
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.006900
Thermal Mass = 0.006900
Diameter/Width = 0.019000
Length = 0.008800

name = ADCS Core+wire (40mm 'torquer)
quantity = 2
parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.052000
Thermal Mass = 0.052000
Diameter/Width = 0.014000
Length = 0.040000

name = ADCS Core+wire (50mm 'torquer)
quantity = 1

parent = 1
materialID = 19
type = Cylinder
Aero Mass = 0.066000
Thermal Mass = 0.066000
Diameter/Width = 0.014000
Length = 0.050000

name = ADCS Core Ends
quantity = 6
parent = 1
materialID = 14
type = Cylinder
Aero Mass = 0.001000
Thermal Mass = 0.001000
Diameter/Width = 0.004000
Length = 0.011600

name = ADCS Support Frame (40mm 'torquer)
quantity = 2
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.001100
Thermal Mass = 0.001100
Diameter/Width = 0.017000
Length = 0.040000

name = ADCS Support Frame (50mm 'torquer)
quantity = 1
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.001100
Thermal Mass = 0.001100
Diameter/Width = 0.017000
Length = 0.050000

name = Sun Sensor Cap
quantity = 2
parent = 1
materialID = 8
type = Cylinder
Aero Mass = 0.001000
Thermal Mass = 0.001000
Diameter/Width = 0.006000
Length = 0.016000

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quantity = 2
parent = 1
materialID = 23
type = Flat Plate
Aero Mass = 0.003800
Thermal Mass = 0.003800
Diameter/Width = 0.033000

Length = 0.033000

**********OUTPUT****
Item Number = 1

name = NOOR-1
Demise Altitude = 77.992844
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Impact Kinetic Energy = 0.000000

****
name = Solar panel board module
Demise Altitude = 77.515686
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Solar cell
Demise Altitude = 77.936600
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Back plane
Demise Altitude = 76.632027
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Main structure frame
Demise Altitude = 77.232742
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Impact Kinetic Energy = 0.000000

****
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Demise Altitude = 77.719124
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****
name = End plate 2
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Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
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****
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Debris Casualty Area = 0.000000

Impact Kinetic Energy = 0.000000

****
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Impact Kinetic Energy = 0.000000

****
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****
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****
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****
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Impact Kinetic Energy = 0.000000

****
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Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

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Impact Kinetic Energy = 0.000000

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****

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****

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****

========== End of Requirement 4.7-1 ==========