ILRS SLR MISSION SUPPORT REQUEST FORM (version: January 2018)

SUBMISSION STATUS:

- [x] New Submission (default)
- [ ] Incremental Submission (accepted only for a follow-on mission; fill-in new information only)

(provide the reference mission and the date approved by the ILRS: ________________________)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: ELSA-d Chaser

Satellite Host Organization: Astroscale

Web Address: astroscale.com

Contact Information:

Primary Technical Contact Information:

Name: David Antal-Wokes

Organization and Position: Astroscale UK - Flight Dynamics Engineer

Address: Building R103, Rutherford Appleton Laboratory, Harwell Didcot OX11 0QX UK

Phone No.: +49 (0)177 276 4958

E-mail Address: d.antalwokes@astroscale.com

Alternate Technical Contact Information:

Name: Jason Forshaw

Organization and Position: Astroscale UK - European R&D Manager

Address: Building R103, Rutherford Appleton Laboratory, Harwell Didcot OX11 0QX UK

Phone No.: T. +44 1235 395359

E-mail Address: j.forshaw@astroscale.com

Primary Science Contact Information:

Name: Kaoru Asaba

Organization and Position: Director, GNC Manager

Address: 1-17-2 Kinshi Sumida-ku, Tokyo, Japan
Phone No.: +81 3 6658 8175
E-mail Address: k.asaba@astroscale.com

Alternate Science Contact Information:
Name: Kohei Fujimoto
Organization and Position: Engineer - Guidance, Navigation, and Control
Address: 1-17-2 Kinshi Sumida-ku, Tokyo, Japan
Phone No.: +81 3 6658 8175
E-mail Address: k.fujimoto@astroscale.com

Mission Specifics:

Scientific or Engineering Objectives of Mission:
(specify)

The ELSA-d mission's goal is to demonstrate end-of-life support and removal of semi-cooperative targets. Semi-cooperative means the target is equipped with a docking plate which allows for a less complex chaser. The idea is to have this docking plate mounted on future spacecraft, including large constellations. This would allow for reliable removal from orbit, even if the spacecraft does not reach it's designed end-of-life.
In order to find the target reliably, precise knowledge of its orbit is required. TLEs are not accurate enough. Astroscale thus promotes equipping future spacecraft with retro-reflectors

Role of Satellite Laser Ranging (SLR) for the Mission:
(specify)

The Satellite Laser Ranging will be used to perform Precise Orbit Determination of both Chaser and Target spacecrafts. This will allow the validation of relative ranging measurements that constitute the core of rendezvous & docking capabilities. It will also be vital for demonstrating the capability to find a semi-cooperative target. In the target search demo phase, SLR data will be used to get the chaser close enough for its proximity sensors to work.
The support of the ILRS network to precise orbit determination would be very welcome.

Anticipated Launch Date: July2020
Expected Mission Duration: 6 months
Required Orbital Accuracy: Centimeter-levelRMS

Anticipated Orbital Parameters:

Altitude (Min & Max for eccentric orbits): Min 500 – Max 600 km km

Inclination: 97.6 degrees degrees

Eccentricity: 0.001

Orbital Period: 95 min

Frequency of Orbital Maneuvers: Continuous during demo; AOCS maint

Mission Timeline:
(example)
Should include when SLR is to start within the mission timeline, such as "on insertion into orbit" or "launch +N" days.

Launch: 22.03.2021 (Start of ILRS tracking: 01.08.2021 (or whenever possible) (Start of first capture demo: end of August (Start of second capture demo: TBD (Start of third capture demo: TBD (Planned end of mission (and end of ILRS tracking): 31.08.2021

SLR support is required from the final term of commissioning (L+4weeks) until Re-orbit

Tracking Requirements:

Tracking Schedule: ☑ horizon-to-horizon ☐ custom (specify: ______________)

Spatial Coverage: ◉ global ILRS network ☐ custom (specify: ______________)

Temporal Coverage: ◉ full-time ☐ custom (specify: ______________)

Normal Point Bin Size (Time Span): 15 seconds

(Choose one from 5, 15, 30, 120 and 300 seconds. Justify if other bin size is required.)
(See the "Bin Size" of other satellites on the ILRS Web site at
http://ilrs.gsfc.nasa.gov/missions/satellite_missions/current_missions/index.html .)

Prediction Center: Astroscale UK - Harwell

Prediction Technical Contact Information:

Name: David Antal-Wokes

Organization and Position: Astroscale - Flight Dynamics Engineer

Address: Building R103, Rutherford Appleton Laboratory, Harwell Didcot OX11 0Q

Phone No.: +49 (0)177 276 4958

E-mail Address: d.antalwokes@astroscale.com

Priority of SLR for POD: ☐ Primary ☐ Secondary ◉ Backup

Other Sources of POD:

☒ GNSS ☐ DORIS ☒ Accelerometer ☐ other (specify: ______________)

Other comments on mission information:

(specify) (list backup prediction centers and references/links to non-SLR techniques if available)

SECTION II: TRACKING RESTRICTIONS:

Several types of tracking restrictions have been required during some satellite missions. See *http://ilrs.gsfc.nasa.gov/satellite_missions/restricted.html* for a complete discussion.

1) Elevation restrictions: Certain satellites have a risk of possible damage when ranged near the zenith. Therefore a mission may want to set an elevation (in degrees) above which a station may not range to the satellite.
2) Go/No-go restrictions: There are situations when on-board detectors on certain satellites are vulnerable to damaged by intense laser irradiation. These situations could include safe hold position or maneuvers. A small ASCII file is kept on a computer controlled by the satellite's mission which includes various information and the literal "go" or "nogo" to indicate whether it is safe to range to the spacecraft. Stations access this file by ftp every 5-15 minutes (as specified by the mission) and do not range when the flag file is set to "nogo" or when the internet connection prevents reading the file.
3) Segment restrictions: Certain satellites can allow ranging only during certain parts of the pass as seen from the ground. These missions provide station-dependent files with lists of start and stop times for ranging during each pass.
4) Power limits: There are certain missions for which the laser transmit power must always be restricted to prevent detector damage. This requires setting laser power and beam divergence at the ranging station before and after each pass. While the above restrictions are controlled by software, this restriction is often controlled manually.

Many ILRS stations support some or all of these tracking restrictions. You may wish to work through the ILRS with the stations to test their compliance with your restrictions or to encourage additional stations that are critical to your mission to implement them.

The following information gives the ILRS a better idea of the mission's restrictions. Be aware that once predictions are provided to the stations, there is no guarantee that forgotten restrictions can be immediately enforced.

Are there any science instruments, detectors, or other instruments on the spacecraft that can be damaged or confused by excessive radiation, particularly in any one of these wavelengths (532nm, 1064nn, 846nm, or 432nm)?

☒ No ☐ Yes (specify the instrument or detector in question, providing the wavelength bands and modes of sensitivity.)

Are there times when the LRA (Laser Retroreflector Array) will not be accessible from the ground?

☒ No ☐ Yes (specify: ______________________________

(If so, go/nogo or segmentation files might be used to avoid ranging an LRA that is not accessible.)

→ Skip the next questions and go directly to SECTION III if you answered "No" to both of the above questions.

Is there a need for an elevation tracking restriction?

☒ No ☐ Yes (What elevation (minimum to maximum in degrees)? _________ degrees)

Is there a need for a go/no-go tracking restriction?

☒ No ☐ Yes (Explain the reason(s) ____)

Is there a need for a pass segmentation restriction?

☒ No ☐ Yes (Explain the reason(s) ____)

Is there a need for a laser power restriction?

☒ No

☐ Yes (Under what circumstances? ____)

(What is the maximum permitted power level **at** the satellite (nJ/cm^2)? ___________)

(Is manual control of laser transmit power acceptable? ☐ Yes ☐ No)

For ILRS stations to range to satellites with restrictions, the mission sponsor must agree to the following statement:

"The mission sponsor agrees not to make any claims against the station or station contractors or subcontractors, or their respective employees for any damage arising from these ranging activities, whether such damage is caused by negligence or otherwise, except in the case of willful misconduct."

Please provide signature to express agreement to above statement:

Signature: ____

Date: ___________________________

Name (print): David Antal-Wokes,TimFlohrer

Organization and Position: AstroscaleFlightDynamicsEngineer,ESASeniorSpaceDebrisMonitor

Other comments on tracking restrictions:
(specify)

SECTION III: RETROREFLECTOR ARRAY INFORMATION:

A prerequisite for accurate reduction of laser range observations is a complete set of pre-launch parameters that define the characteristics and location of the LRA on the satellite. The set of parameters should include a general description of the array, including references to any ground-tests that may have been carried out, array manufacturer and whether the array type has been used in previous satellite missions. So the following information is requested:

Retroreflector Primary Contact Information:

Name: Takashi Araki (temporary)

Organization and Position: Astroscale Japan: Mechanical Engineer

Address: 1-17-2 Kinshi Sumida-ku, Tokyo, Japan

Phone No.: +81 3 6658 8175

E-mail Address: t.araki@astroscale.com

Array type:

☐ Single reflector ☐ Spherical ◉ Hemispherical/Pyramid ☐ Planar

☐ other (specify: ______________________)

Attach a diagram or photograph of the satellite that shows the position of the LRA, at the end of this document.

☒ Attached

Attach a diagram or photograph of the whole LRA at the end of this document.

◉ Attached ☐ Same as above, Not attached (acceptable only for a cannonball satellite)

Array manufacturer:

Astroscale Japan

Link (URL and/or reference) to any ground-tests that were carried out on the array:

____

____

Has the LRA design and/or type of cubes been used previously?

◉ No ☐ Yes (List the mission(s): ______________________)

For accurate orbital analysis it is essential that full information is available in order that the 3-dimensional position of the satellite center of mass may be referred to the location in space at which the laser range measurements are made. To achieve this, the 3-D location of the LRA phase center must be specified in a satellite-body-fixed reference frame with respect to the satellite's mass center. In practice this means that the following parameters must be available at 1 mm accuracy or better.

Define the satellite-body-fixed XYZ coordinates (i.e. origin and axes) on the spacecraft:
(specify) (add a diagram in the attachment)

Origin:centerofsidewithlaunchadapter
+X-axis:towardsthespacecraftcentreandthedockingplatewithtargetspacecraft (+Y-axis:
towardsthesidewithsolarpanel1 (+Z-axis:towardsthesidewithcornercubearray1

Relate the satellite-body-fixed XYZ coordinates to a Celestial/Terrestrial/Solar Reference Frame including the attitude control policy:
(specify) (add a diagram in the attachment)

Thereisnofixedattitudecontrolpolicy.Thisiscompensatedbyomnidirectionalcoveragebyretroreflectors.

The 3-D location of the satellite's mass center in satellite-body-fixed XYZ coordinates is:

☐ Always fixed at (0, 0, 0)
☒ Always fixed at (+568.8+/-6, +0.91+/-5 , +6.36+/-5) in mm
☐ Time-varying by approximately (__________) mm during the mission lifetime.
Will a time-variable table of the mass center location be available on the web?
☒ No ☐ Yes (URL: ____________________)

The 3-D location (or time-variable range) of the phase center of the LRA in the satellite-body-fixed XYZ coordinates:

(Inattachme, ________, ________) in mm

The following information on the corner cubes must also be supplied.

The XYZ coordinates referred to in the following are given in:

☒ Satellite-body-fixed system (same as above)
☐ LRA-fixed system (specify below)
(specify the origin and orientation) (add a diagram in the attachment)

List the position (XYZ) of the center of the front face of each corner cube, and the orientation (two angles or normal vector) and the clocking (horizontal rotation) angle of each corner cube. Note that the angles should be clearly defined.

- [x] Attached at the end of this document
- [ ] Listed here (acceptable for small number (10 or fewer) of corner cubes)

(specify) (add a diagram in the attachment)

Is the corner cube recessed in its container (i.e. can the container obscure a part of the corner cube)?

[x] No [ ] Yes (specify below)

(specify) (add a diagram)

The size of each corner cube: Diameter (12.7) mm Height (10.16) mm

The material from which the cubes are manufactured (e.g. quartz):

Fused Silica

The refractive index of the cube material

= 85% at 400-700nm for wavelength λ = 0.532 micron

= See attached data sheet as a function of wavelength λ (micron):

The group refractive index of the cube material, as a function of wavelength λ (micron):

= 85% at 400-700nm for wavelength λ = 0.532 micron

= See attached data sheet as a function of wavelength λ (micron):

Dihedral angle offset(s) and manufacturing tolerance (in arcseconds):
5 arcseconds

Radius of curvature of front surfaces of cubes:

☒ Not applied ☐ Yes (specify: ______________________________)

Flatness of cubes' surfaces:
λ/10

Back-face coating:

☐ Uncoated ☒ Coated (specify the material: aluminum)

Other comments on LRA:

(specify) (add a reference to a study of the optical response simulation/measurement if available) (add a diagram if applicable)

The laser retroreflector works with infrared e.g. 1064nm. The fused Silica CCRs that are employed can be used for both visible light (VIS) and near-infrared (NIR).

SECTION IV: MISSION CONCURRENCE

The ILRS is a voluntary organization that operates under the auspices of the International Association of Geodesy (IAG). The ILRS adheres to the IAG policy to make all acquired laser ranging data and derived products publicly available. We request that the mission website, as well as mission publications, reference the scientific work derived from ILRS data and derived products, **acknowledge** the role of the ILRS. This acknowledgment is crucial for the continued support from the funding agencies of the ILRS participating organizations.

As an authorized representative of the ELSA-d mission, I hereby request and authorize the ILRS to track the satellite described in this document.

Name (print): David Antal-Wokes,TimFlohrer

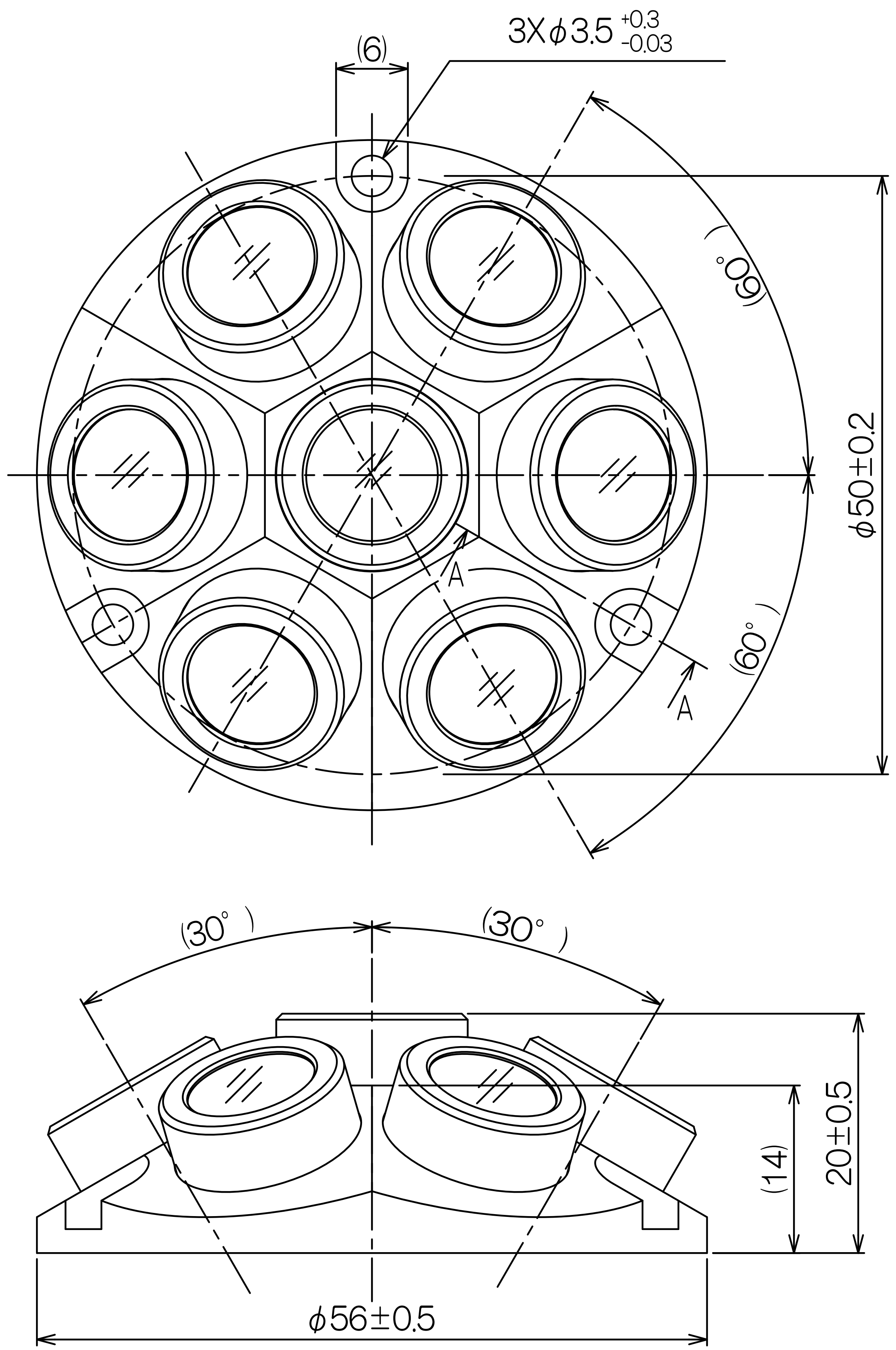
Organization and Position: AstroscaleFlightDynamicsEngineer,ESASeniorSpaceDebrisMonitori

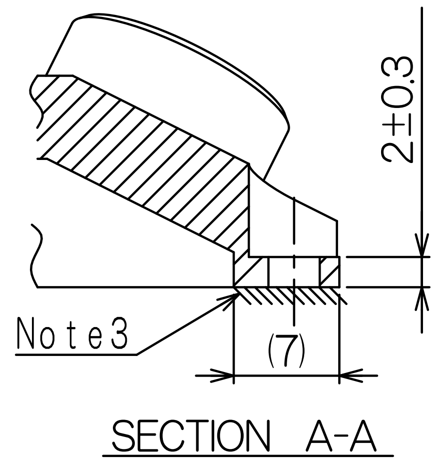
Signature: ______________________________

Date: ______________

Send form to: ILRS Central Bureau
c/o Carey Noll
NASA GSFC
Code 61A
Greenbelt, MD 20771
USA
301-614-6542 (Voice)
301-614-6015 (Fax)
Carey.Noll@nasa.gov

SECTION V: ATTACHMENT(S)





Note1. Numerical values with ( ) are reference dimensions.
2. Weight: about 70g
3. Contact surface: Chemical treatment
4. Aluminum parts have anodized treatment surfaces except contact surfaces.

Rev.	Description	Appr.
1	2018.04.05	

—	—	
Material	Surface treatment	
Torelance	JIS B 0419 -mK	
	scale 2:1	
Drawn	Checked	Appr.

Name
LASER REFLECTOR

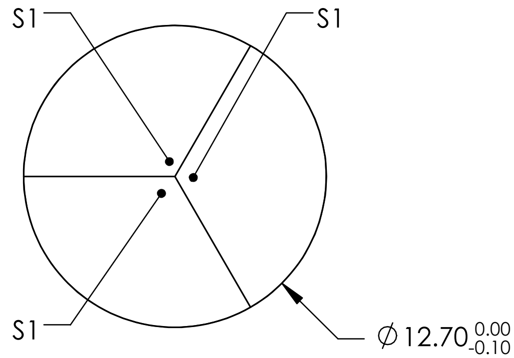
Dwg. No. AX180110 SHT. 1/1 REV. 1

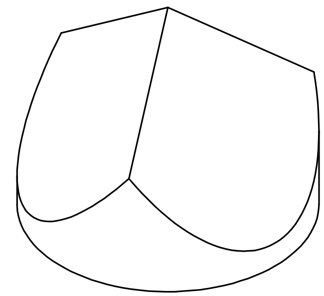
Fig.2 MICD of laser reflector

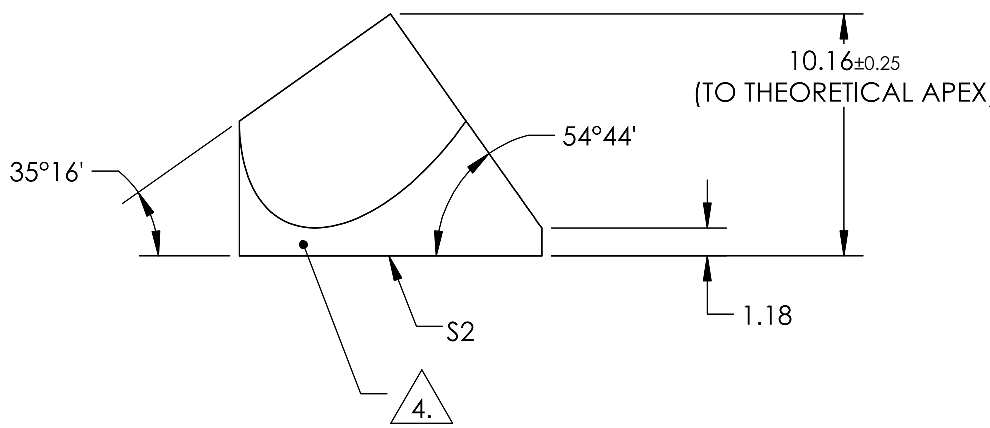
NOTES:

1. SUBSTRATE : FUSED SILICA
2. BLACK OVERPAINT IS 30-60 μm THICK
3. COATING (APPLY ACROSS COATING APERTURE)
   S1: PROTECTED ALUMINUM
   R(avg) >85% @ 400 - 700nm W/BLACK OVERPAINT
   0.3 J/cm² @ 532nm & 1064nm, 10ns

   S2: UNCOATED
4. (△) FINE GRIND SURFACE
5. ROHS COMPLIANT







FOR INFORMATION ONLY:
DO NOT MANUFACTURE
PARTS TO THIS DRAWING

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE
DIMENSIONS ARE FOR REFERENCE ONLY

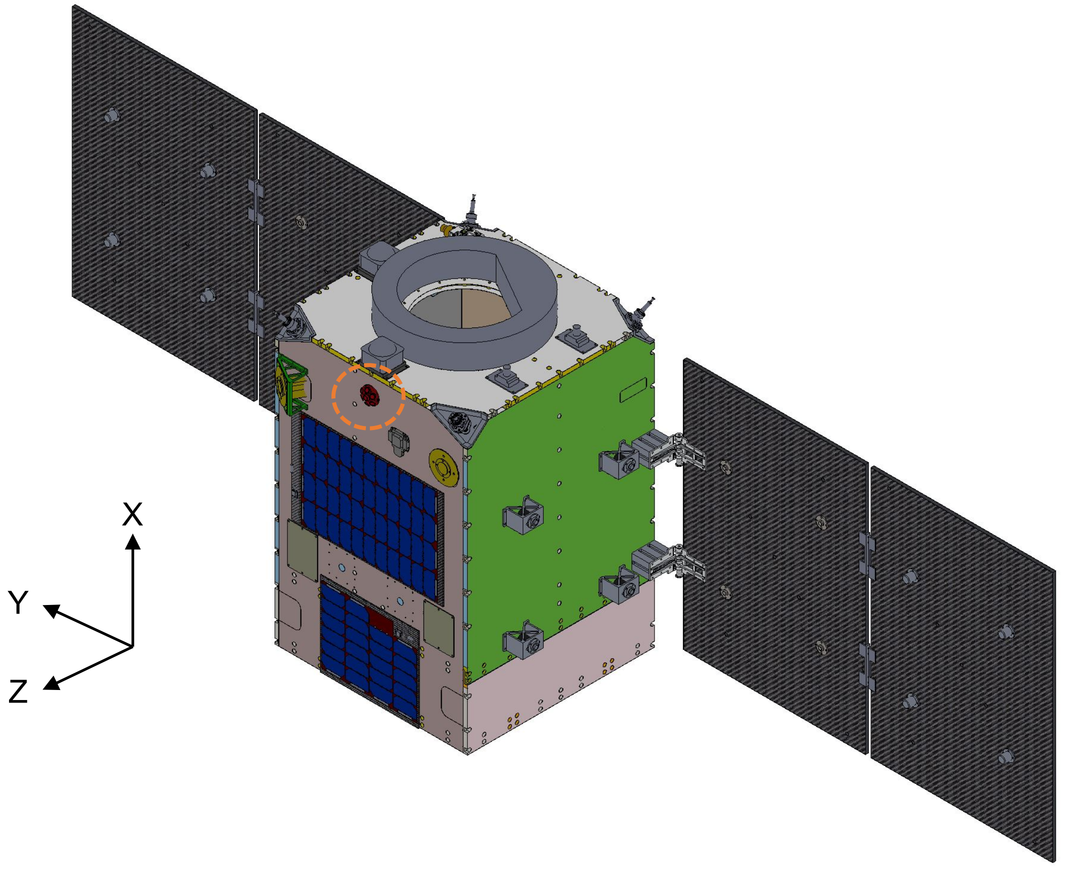
REV A	S1 & S2
SURFACE FLATNESS	λ/10
SURFACE QUALITY	20-10
WAVELENGTH RANGE	400 - 700 nm
ANGLE TOL. (arcsec)	5
BEVEL	PROTECTED AS NEEDED

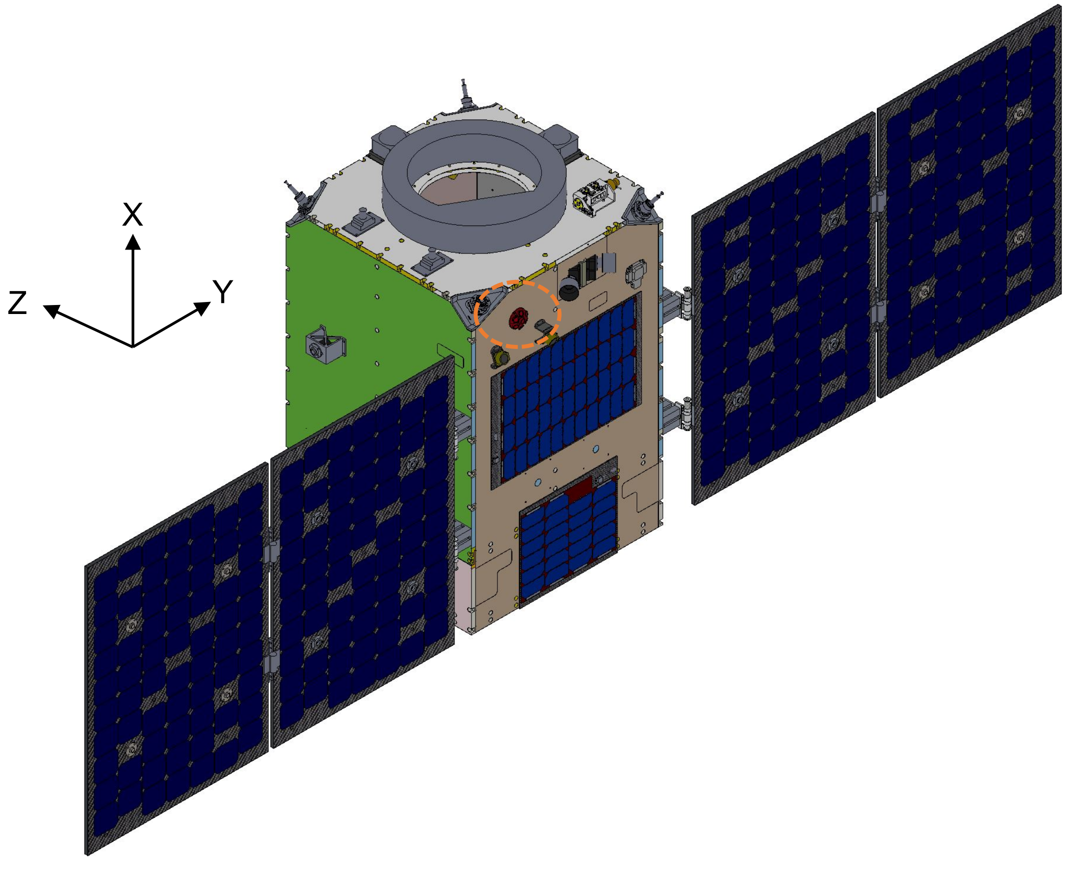
Edmund Optics®

THIRD ANGLE PROJECTION		TITLE	12.7mm ALUMINUM COATED, FUSED SILICA CORNER CUBE	
ALL DIMS IN	mm	DWG NO	49013	SHEET 1 OF 1

12.7mm Aluminum Coated, Fused Silica Corner Cube (Edmund Opt.)		
Stock #49-013		
	Diameter (mm):	12.70 +0.00/-0.10
	Height (mm):	10.16 + 30-60µm w/Black Overpaint
	Coating:	Protected Aluminum (400-2000nm)
	Beam Deviation (arcsec):	5
	Coating Specification:	Entrance: Uncoated Reflective Surfaces: Ravg >85% @ 400 - 700nm w/Black Overpaint
	Height Tolerance (mm):	±0.25
	Image Orientation:	Left-Handed
	Note:	Black Overpaint is 30-60 µm Thick
	Image Orientation:	Left-Handed
	Note:	Black Overpaint is 30-60 µm Thick
	Ray Deviation (°):	180
	Substrate:	Fused Silica
	Surface Flatness:	λ/10
	Surface Quality:	20 - 10
	Type:	Retroreflector
	Typical Energy Density Limit:	Reflective Surfaces: 0.3 J/cm2 @ 532nm & 1064nm, 10ns
	Wavelength Range (nm):	400 - 700
	RoHS:	Compliant

Location of Laser Retroreflectors on ELSA-d Chaser





List the position (XYZ) of the center of the front face of each corner cube, and the orientation (two angles or normal vector) and the clocking (horizontal rotation) angle of each corner cube. Note that the angles should be clearly defined.

Array 1 (phase centre [945.00, 0.00, 320.20])

```
cca1_ca1: position = [945.    0.  340.2] mm, normal vector = [0 0 1]
cca1_ca2: position = [964.4  11.2 334.2] mm, normal vector = [0.433 0.25  0.866]
cca1_ca3: position = [945.   22.4 334.2] mm, normal vector = [0.    0.5   0.866]
cca1_ca4: position = [925.6  11.2 334.2] mm, normal vector = [-0.433  0.25   0.866]
cca1_ca5: position = [925.6 -11.2 334.2] mm, normal vector = [-0.433 -0.25   0.866]
cca1_ca6: position = [945.  -22.4 334.2] mm, normal vector = [-0.    -0.5    0.866]
cca1_ca7: position = [964.4 -11.2 334.2] mm, normal vector = [ 0.433 -0.25   0.866]
```

Array 2 (phase centre [910.00, -172.00, -320.20])

```
cca2_ca1: position = [ 910.  -172.  -340.2] mm, normal vector = [ 0  0 -1]
cca2_ca2: position = [ 929.4 -166.  -329. ] mm, normal vector = [ 0.433 -0.866  0.25 ]
cca2_ca3: position = [ 910.  -166.  -317.8] mm, normal vector = [ 0.    -0.866  0.5  ]
cca2_ca4: position = [ 890.6 -166.  -329. ] mm, normal vector = [-0.433 -0.866  0.25 ]
cca2_ca5: position = [ 890.6 -166.  -351.4] mm, normal vector = [-0.433 -0.866 -0.25 ]
cca2_ca6: position = [ 910.  -166.  -362.6] mm, normal vector = [-0.    -0.866 -0.5  ]
cca2_ca7: position = [ 929.4 -166.  -351.4] mm, normal vector = [ 0.433 -0.866 -0.25 ]
```