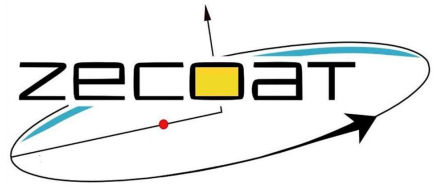
Specular Black Coating For Starshade Razor Edges (second progress update)

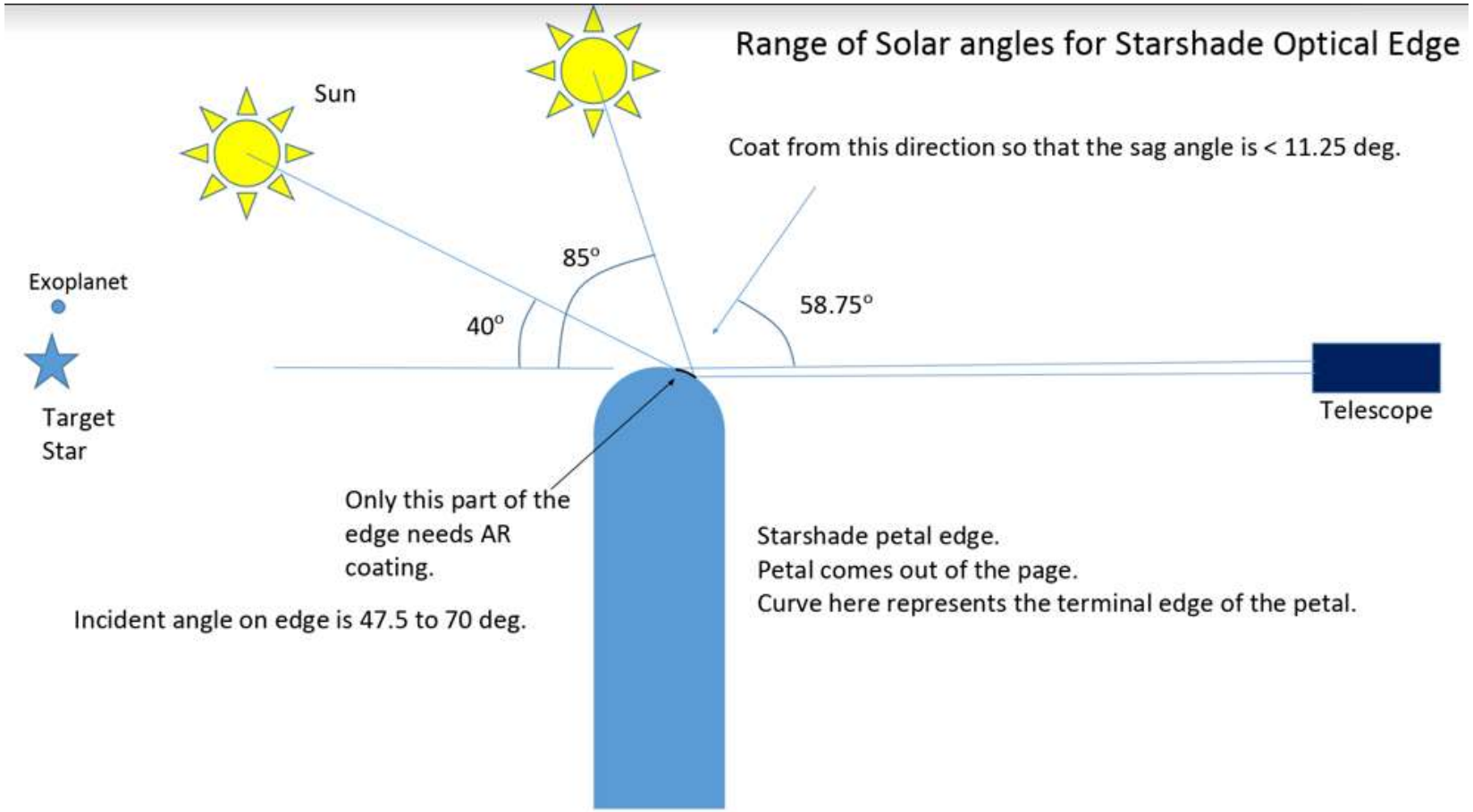
February 6th, 2019 – SIP Boulder, Colorado

David A. Sheikh

ZeCoat Corporation

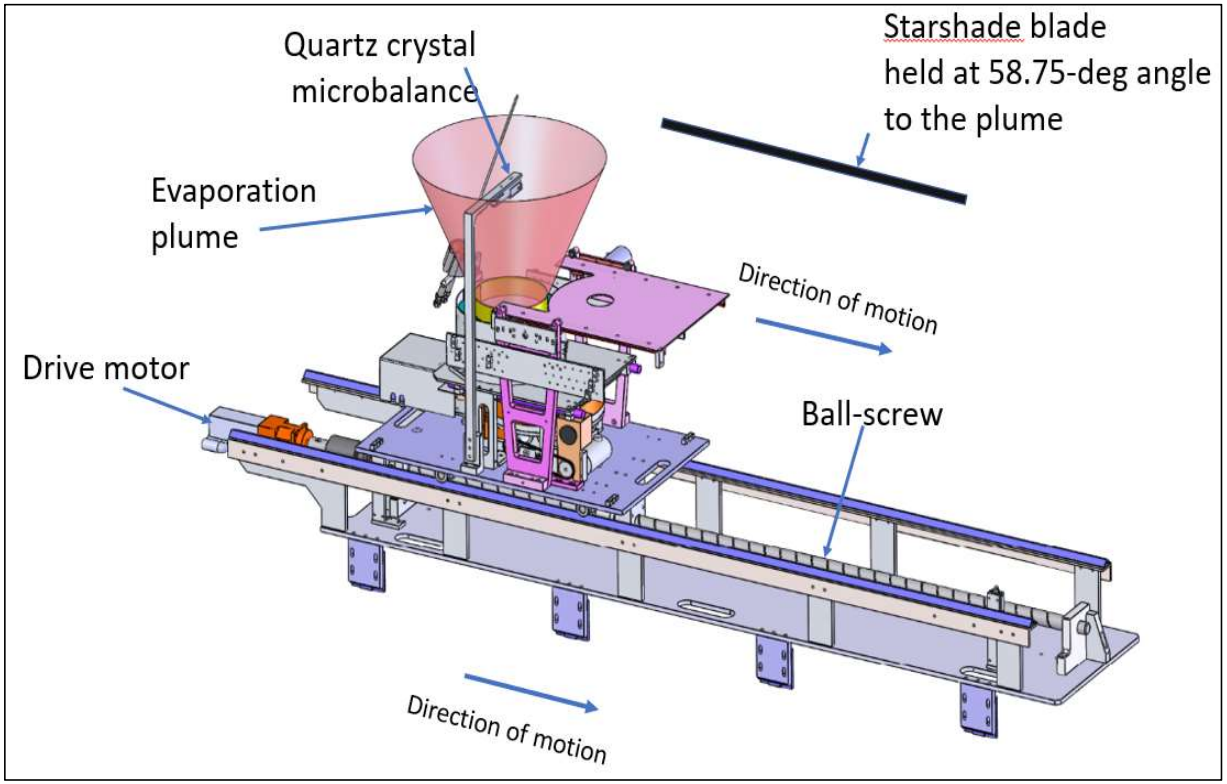
Torrance, California




Range of Solar angles for Starshade Optical Edge
Sun
Coat from this direction so that the sag angle is < 11.25 deg.
85°
58.75°
40°
Exoplanet
Target
Star
Telescope
Only this part of the
edge needs AR
coating.
Incident angle on edge is 47.5 to 70 deg.
Starshade petal edge.
Petal comes out of the page.
Curve here represents the terminal edge of the petal.

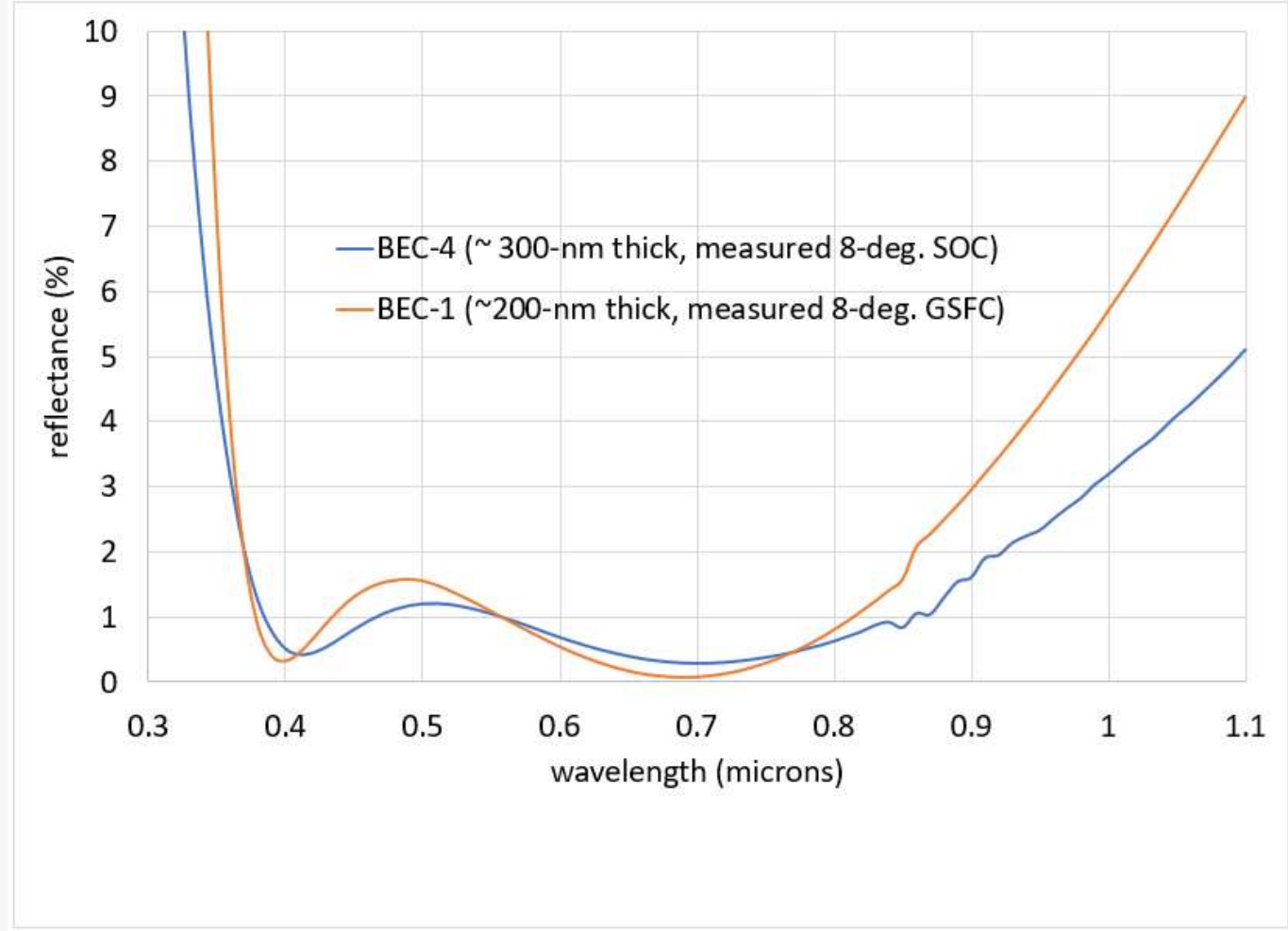
Starshade blade

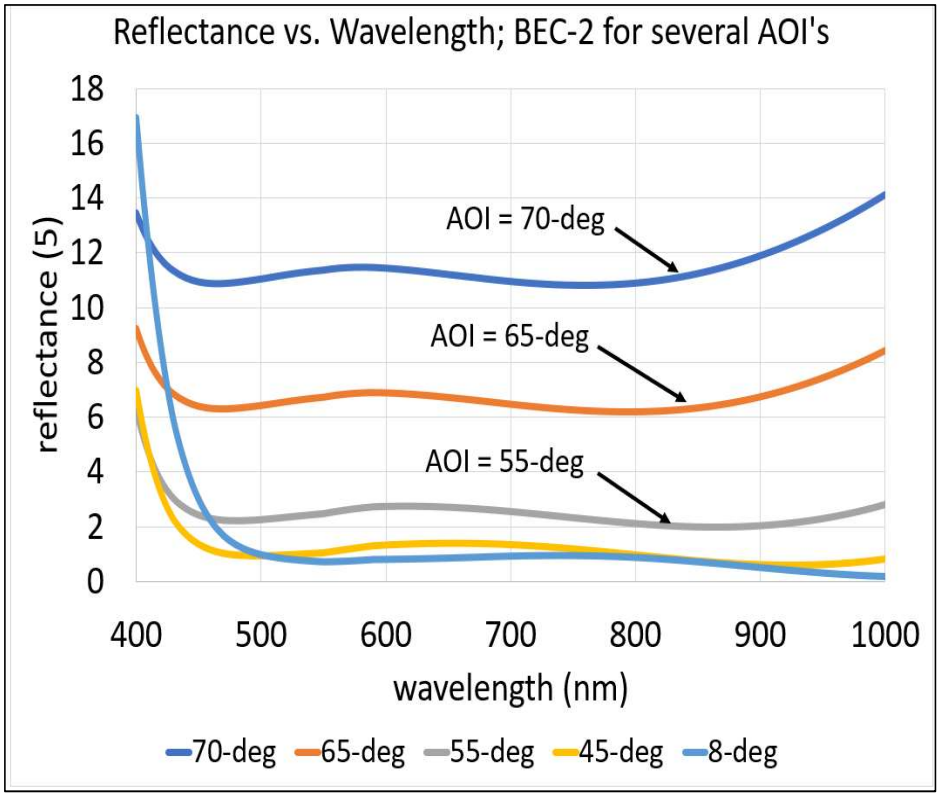
ZeCoat's 2.4-meter coating chamber with integrated motion-controlled evaporation system

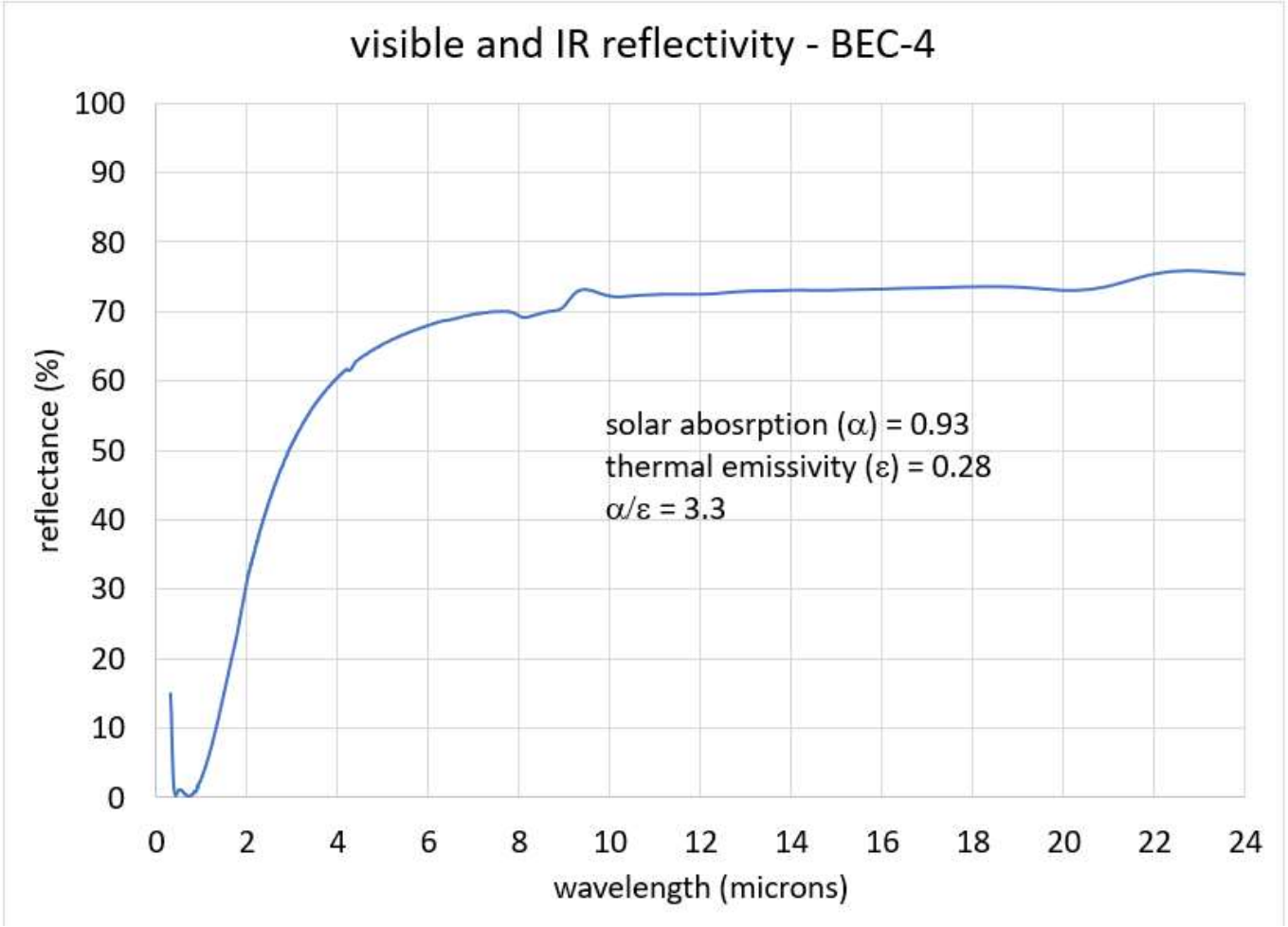

Quartz crystal microbalance
Starshade blade held at 58.75-deg angle to the plume
Evaporation plume
Direction of motion
Drive motor
Ball-screw
Direction of motion

	Performance Metrics - Starshade Edge	
	JPL stated goals	ZeCoat expected performance
wavelength range	425-nm to 1000-nm	425-nm to 1000-nm
reflectance	< 5% 47.5 deg to 70 deg.	R<2% 0-45deg
		R<5% 0-62-deg
		R< 11% @70-deg
thermal cycle	TBD	10 cycles; -85C to + 150C
humidity	TBD	80C/80%RH, 48-hrs
adhesion	TBD	tape adhesion MIL PRF13830B
abrasion	TBD	moderate abrasion MIL PRF13830B
cleanability	TBD	alcohol, acetone, First Contact
space radiation	TBD	GEO, 5-years (protons, electrons, UV)

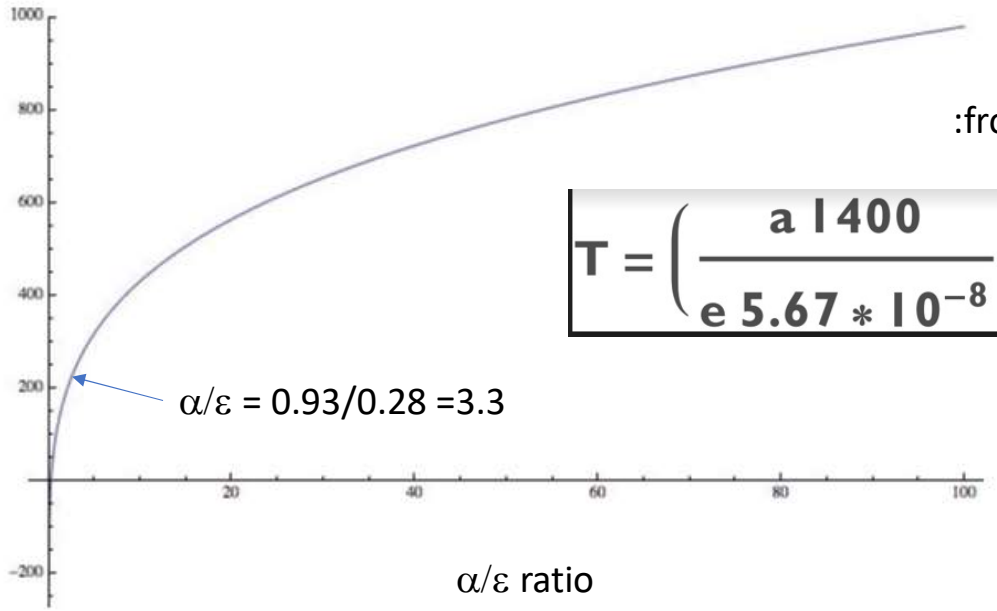
Measured reflectance for first two delivered coating designs deposited on edges




Reflectance vs. Wavelength; BEC-2 for several AOI's
reflectance (5)
18
16
14
12
10
8
6
4
2
0
AOI = 70-deg
AOI = 65-deg
AOI = 55-deg
400
500
600
700
800
900
1000
wavelength (nm)
70-deg
65-deg
55-deg
45-deg
8-deg


visible and IR reflectivity - BEC-4
reflectance (%)
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
wavelength (microns)
solar abosrption (α) = 0.93
thermal emissivity (ε) = 0.28
α/ε = 3.3

Edge temperature determined by α/ε ratio



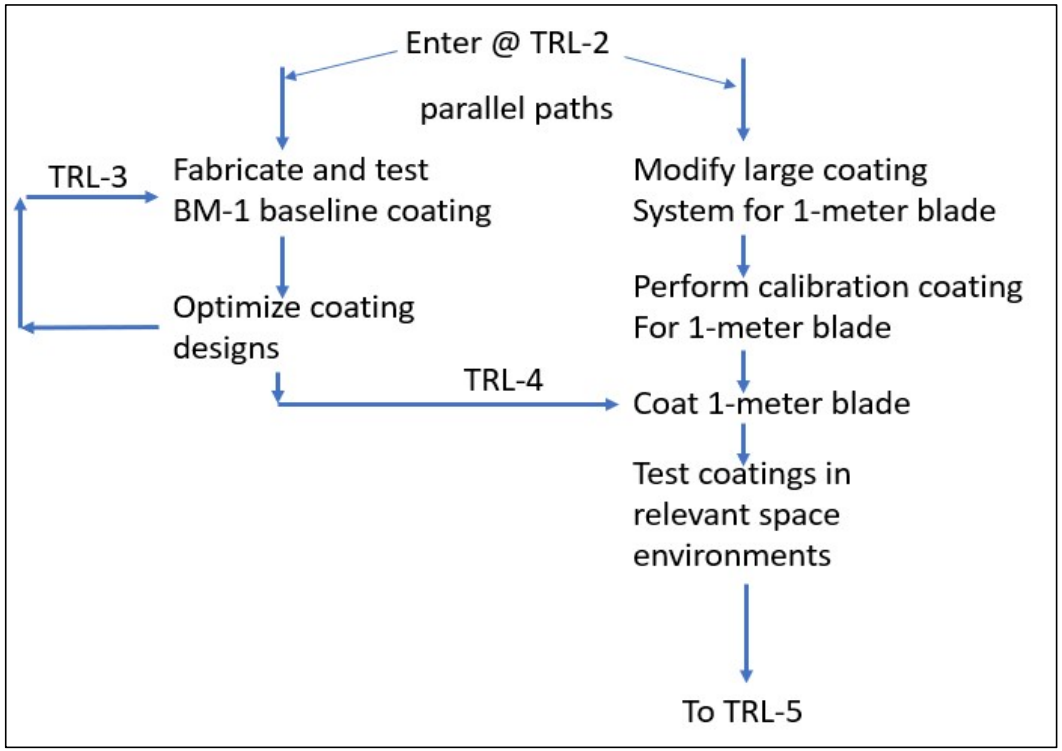
:from Stefan Boltzmann equations

$$T = \left(\frac{a\ 1400}{e\ 5.67 * 10^{-8}}\right)^{1/4} = \left(\frac{a}{e}\right)^{1/4} \left(\frac{1400}{5.67 * 10^{-8}}\right)^{1/4}$$

Temperature on edge in sunlight ~ 200C
Note: preliminary ZeCoat calculation, JPL to verify

STATUS TASKS

Complete	**1. Apply BEC-1 and BEC-2 coatings to customer-supplied amorphous sample blades and measure scatter and collect micrographs at JPL**
Half complete (February)	**2. Determine optical constants n,k for the amorphous metal substrate and for select coating materials, and optimize black interference coating designs for high AOI**
Complete	**3. Scale coating process with linear motion to coat 1-meter piece and perform calibration single-layer coating runs with linear motion system.**
March	**4. Make and test optimized designs on small amorphous blade sample.**
April	**5. Coat 1-meter full-size starshade blade**
April	**6. Environmental testing**


Enter @ TRL-2
parallel paths
TRL-3
Fabricate and test
BM-1 baseline coating
Optimize coating
designs
TRL-4
Modify large coating
System for 1-meter blade
Perform calibration coating
For 1-meter blade
Coat 1-meter blade
Test coatings in
relevant space
environments
To TRL-5

QUESTIONS?