

***NOAA SWPC Use of 3-views to Forecast
CME Arrival
and
A NOAA-Funded JHU/APL L5 Concept***

Douglas Biesecker

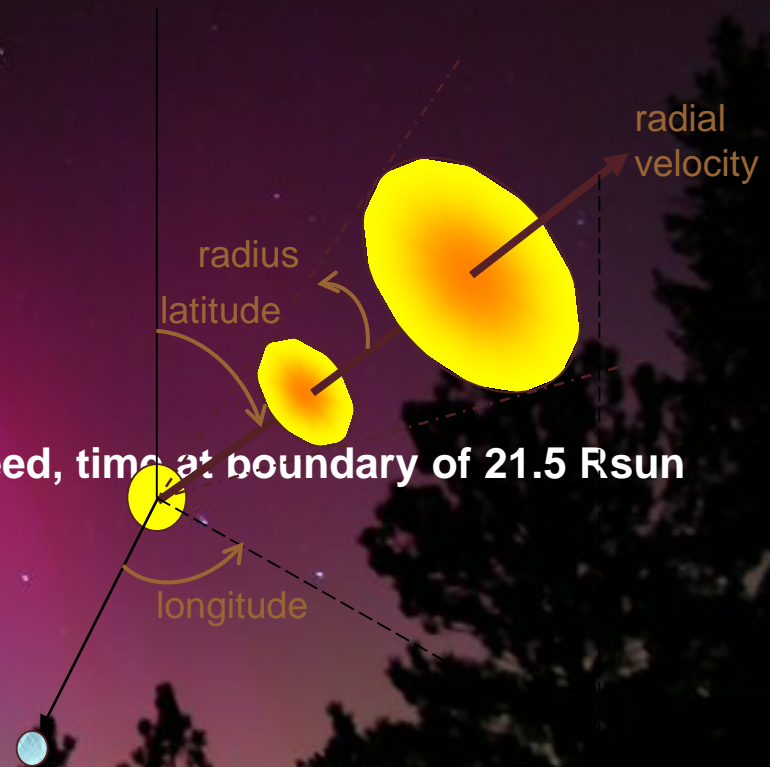
**NOAA/Space Weather Prediction Center
(NOAA/NWS/NCEP/SWPC)**

**With slides from Larry Zanetti
(JHU/APL)**

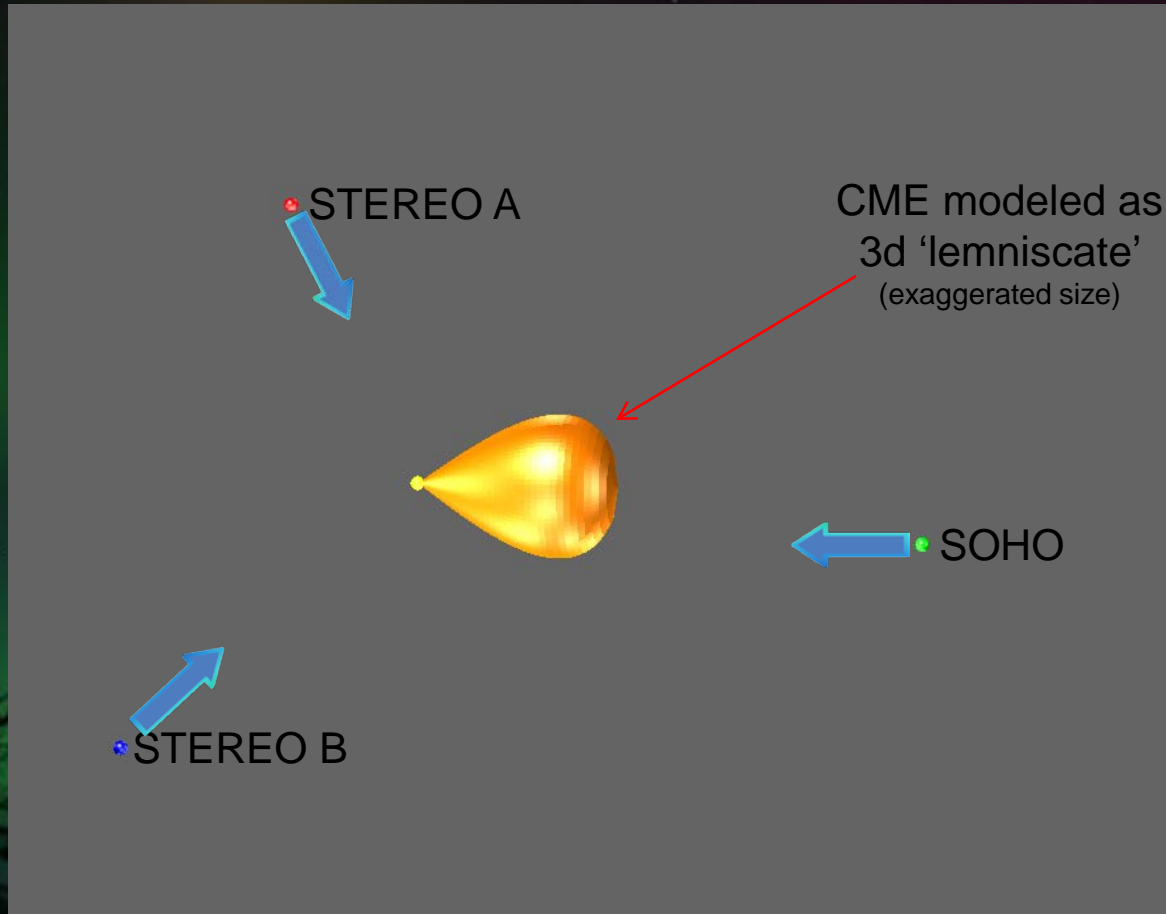


Driving WSA-Enlil to Forecast CME's

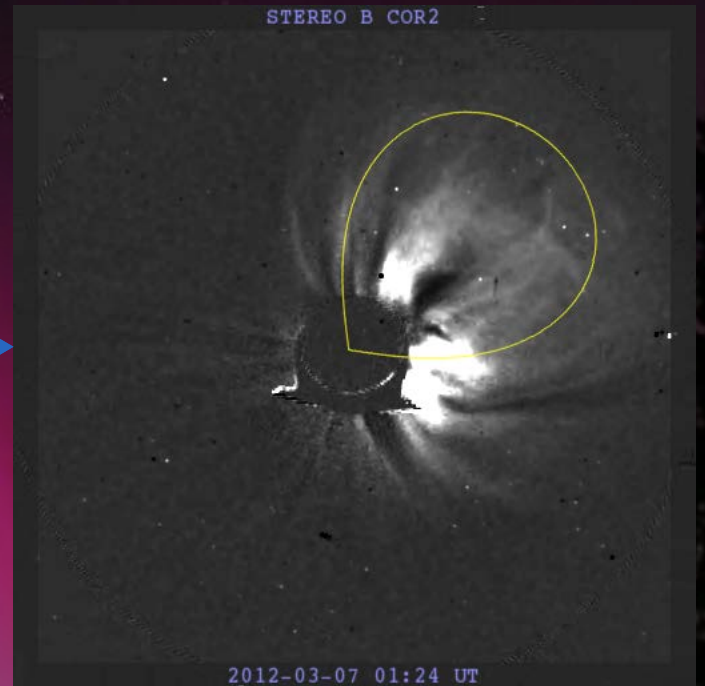
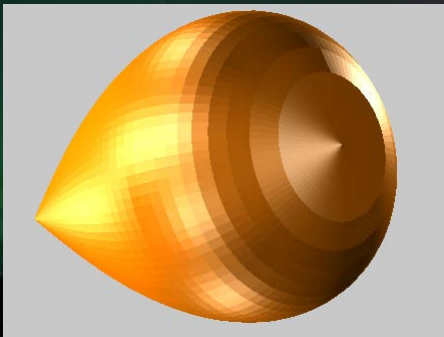
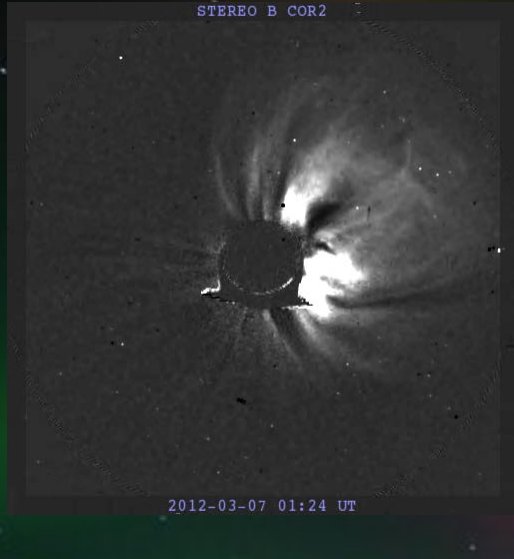
- Solar Cycle 23 – accepted errors in forecasting CME arrival time $\sim \pm 12-15$ hours.
- SWPC has reduced this to $\sim \pm 7$ hours
 - WSA-Enlil
 - STEREO
- WSA-Enlil driven by inputs
 - WSA-Enlil requires CME
 - Direction (lat/lon), width (half-angle), speed, time at boundary of 21.5 R_{sun}
 - CME Analysis Tool (CAT)
 - aka swpc_cat in solarsoft



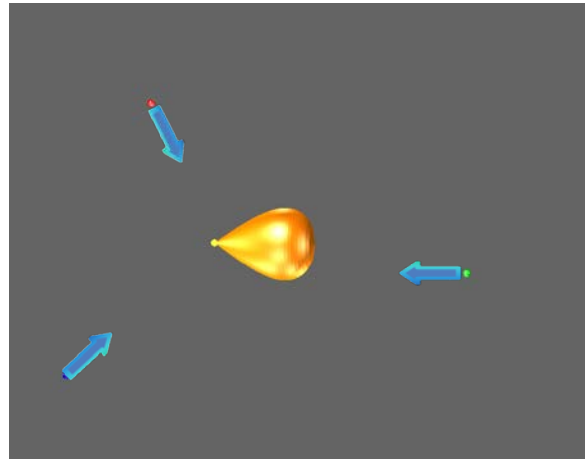
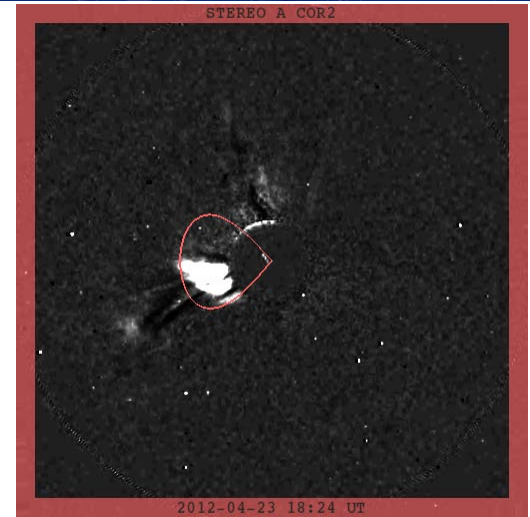
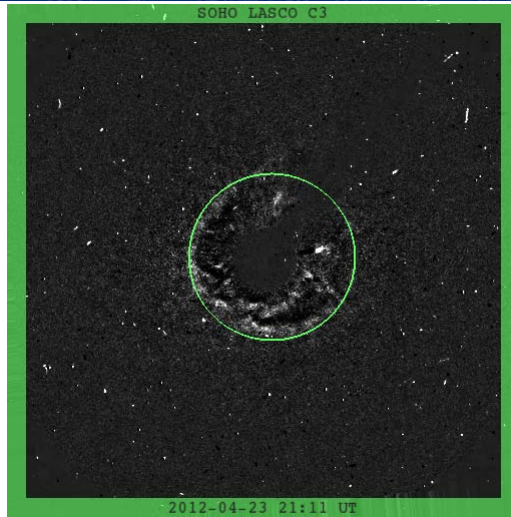
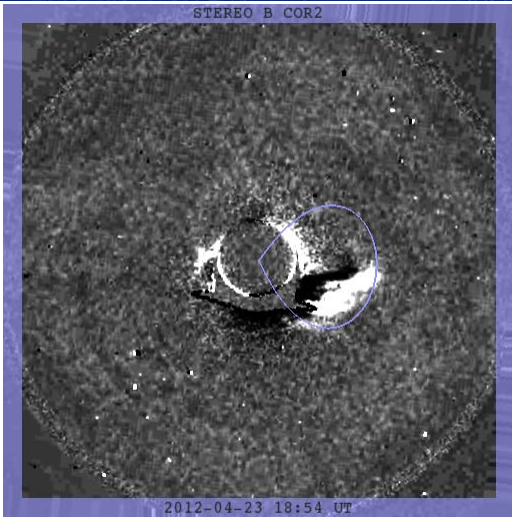
3D Graphics modeling



Overlay 3D model on coronagraph image



'3 view'



CME Analysis Tool (CAT)

CAT (CME Analysis Tool)

STEREO B COR2
2011-08-02 06:39 UT

STEREO A COR2
2011-08-02 06:39 UT

12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12

START / END TIMES
Start [Y M D H M]: 2011 8 1 12
End [Y M D H M]: 2011 8 2 12 0
Buttons: +12h, +24h, Load Images

ANIMATION CONTROLS
L C R
Play
Speed
Altern8

IMAGE ADJUST
L C R
Stretch Bottom
Stretch Top
Gamma Correction
image saturation value
Reset
Copy to L Copy to R

CME CONTROLS
Latitude
Longitude
Angular Width (2 omega)
Radial Distance (delta)
Transparency
CME Parameters
 θ : 8.5
 ϕ : 26.2
 2ω : 108.0
 δ : 3.7
Transparency
 Bernoulli

CME LEADING EDGE vs TIME PLOT
Graph showing CME leading edge position vs time (06 to 09). Y-axis ranges from 0 to 15.

ENLIL PARAMETERS
T 2011-08-02 10:44
Lat 9
Lon 26
Cone 54
Vel 827
Buttons: Calculate Velocity, Export Analysis, Reset Analysis

CME Analysis Tool (CAT)

CAT (CME Analysis Tool)

STEREO B COR2
2011-08-02 07:39 UT

SOHO LASCO C3
2011-08-02 07:42 UT

STEREO A COR2
2011-08-02 07:39 UT

12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11 12

START / END TIMES

Start [Y M D H M]
2011 8 1 12

End [Y M D H M] +12h +24h
2011 8 2 12 0

Load Images

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CME LEADING EDGE vs TIME PLOT

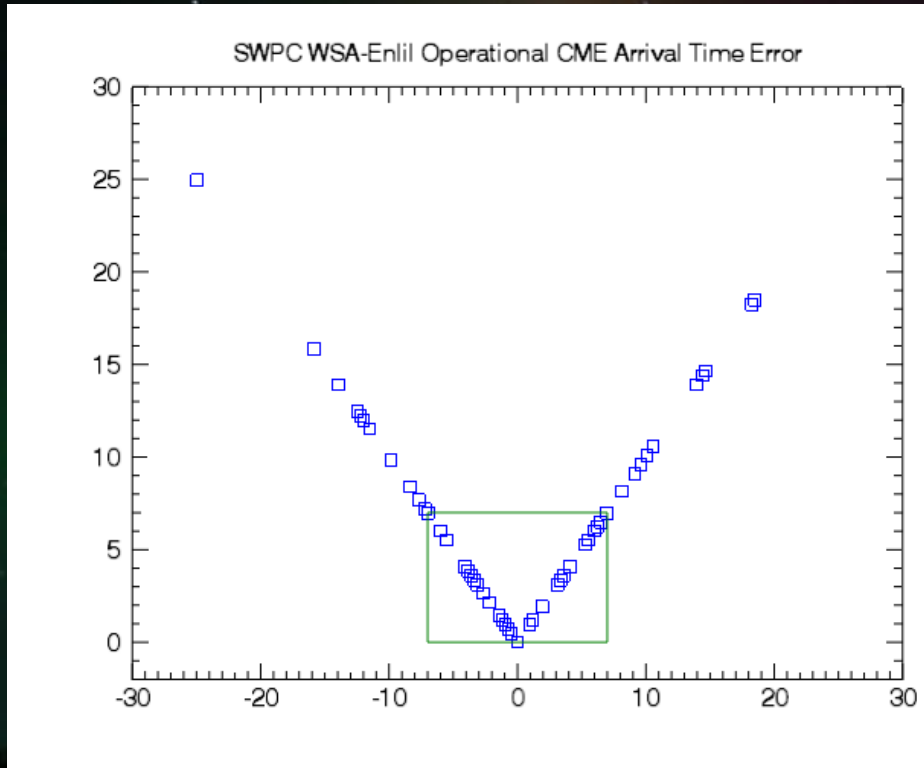
Time (UT)	Radial Distance
06:30	4
07:00	5
07:30	7
08:00	8
08:30	10
08:45	13

ENLIL PARAMETERS

T 2011-08-02 10:44
Lat 9
Lon 26
Cone 54
Vel 827

Calculate Velocity
Export Analysis
Reset Analysis

WSA-Enlil Performance 2011-2014



AVERAGE	6:39 hh:mm
RMS	8:31
2011 AVERAGE	7:06
2011 RMS	8:25
2012 AVERAGE	7:53
2012 RMS	10:21
2013 AVERAGE	4:57
2013 RMS	6:11
2014 AVERAGE	5:07
2014 RMS	6:13

Significant improvement on Solar Cycle 23

But how much is due to 2+ views?

Need this answer to get NOAA support

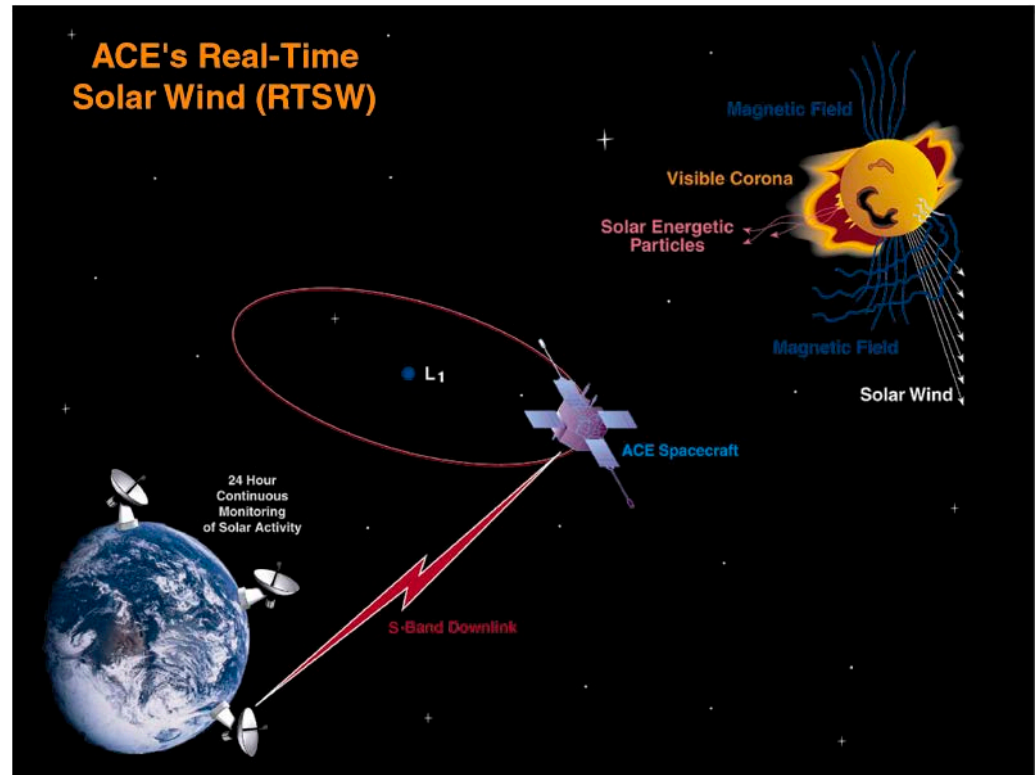
DSCOVR follow-on (NOAA 2020)

- **NOAA has funded many FY14 studies for DSCOVR follow-on**
 - **Planned FY20 launch**
 - **Magnetometer, Thermal Solar Wind Plasma, Low Energy Ions (0.05-1 MeV) and Coronagraph (4-17 R_{sun})**
 - **Government Studies**
 - **2 GSFC studies**
 - **MDL, MMS spares**
 - **1 JHU/APL**
 - **1 Ames/Langley**
 - **Sunjammer derived**
 - **Commercial Service Provider RFI**
- **In FY15 NOAA will choose a path forward for the FY20 launch**
- **The JHU/APL study is being shown here because it includes a STEREO-B like orbit option**

ACE Early Warning for Space Weather

- ACE Real-Time Solar Wind measurements provide early warning capability
- NOAA/AFWA use data to provide operational space weather products to civil operations and warfighters

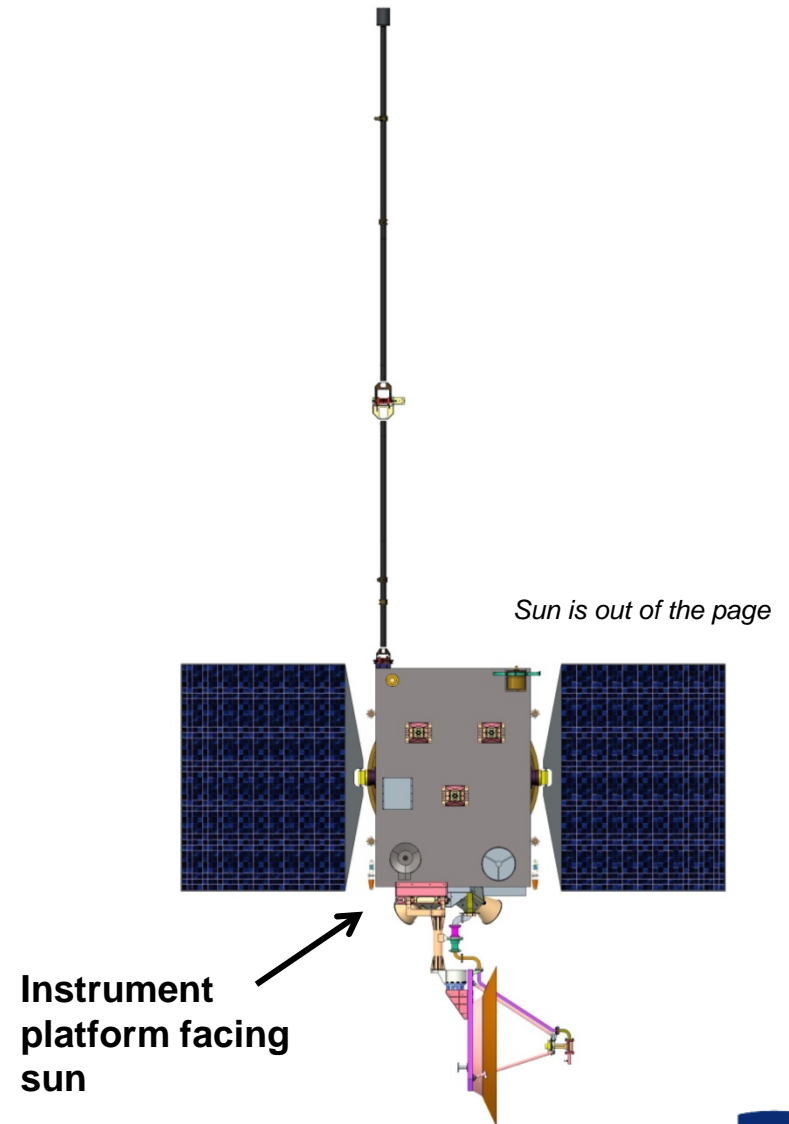
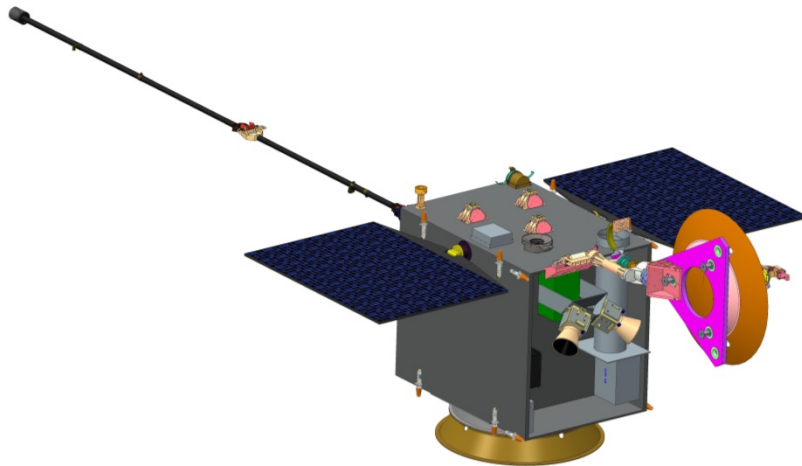
Over the past 16 years, these data have become critical to the user community, in particular the electric power grid, communications and GPS operators; these data have been labeled a “single point failure” in the space weather prediction system.



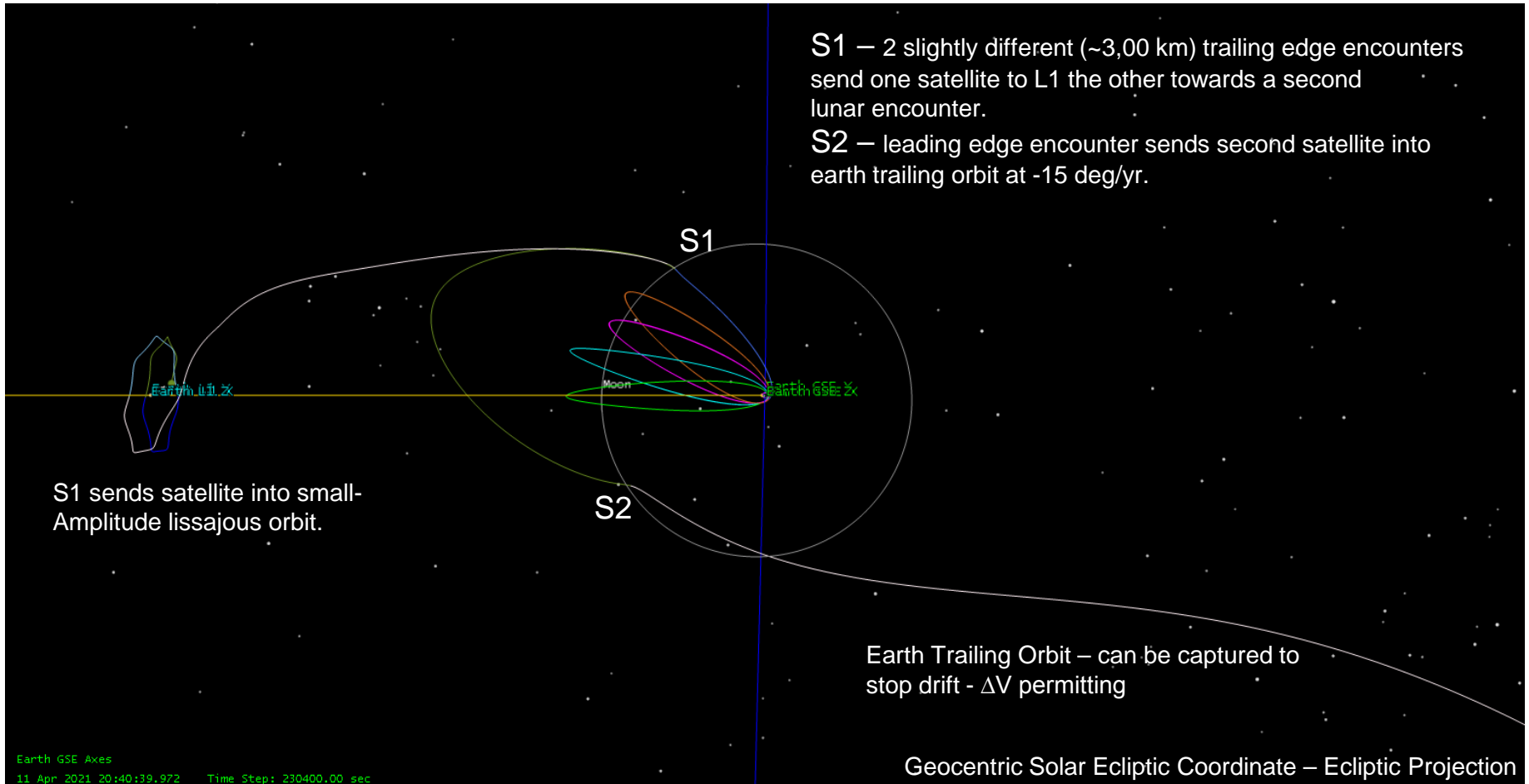
ACE Satellite Reaches End of Life in 2022 and DSCOVR (Launch 2015) Reaches End of Life in 2020. NOAA Tasked APL to Study Follow On for Potential Small Satellite Solution.

Spacecraft Summary (3-axis, in-situ, coronagraph)

- Spacecraft mass
 - 270 kg CBE
- Athena IIc capability for single
- Antares capability for double
 - Two S/C with a 10% adapter plate
 - 590kg (48% margin)



Trajectory Design – Gravity Assist (STEREO)



Lunar gravity assist is gateway to L1 and heliocentric orbit.

Conclusions

ACE Satellite End of Life Expected in 2022

DSCOVR

- Launch 2015
- Lifetime 5 years

Follow On (SUM Study) Initiated to Develop Long Term Solution

- NOAA Sponsored Study
- JHU/APL Study Lead
- Two Study Options were point designed (L1 and L1 plus Off-Angle)

Small Satellite Solutions Identified that Address Key NOAA Upstream Monitoring Requirements

Sun - Solar Wind Monitoring System; substantial cost savings for duplicate build (L1 plus Off-Angle)