

SDO EVE Science Data Processing Workshop

Don Woodraska

Agenda

- Introduction/Overview – Resource projections (Don Woodraska)
- Processing Overview – Product content
- Interfaces – DDS, IOC
- Level 0 Products – 0B, 0CS (Chris Jeppesen), 0C, 0D
- *BREAK*
- Level 1 Products
 - MEGS-A, B Products (Don Woodraska)
 - MEGS-A, B Calibration (Rachel Hock)
 - MEGS-P (Tom Woods)
 - ESP (Leonid)
- Additional Calibration Discussion (All)
- *BREAK*
- Level 2 – Spectrum & Lines/Bands(Chris Jeppesen)
- Level 3 (Chris Jeppesen)
- Special products – Mission merged Level 3, low-res, others (Don Woodraska)
- Data Dissemination Discussion (Don Woodraska)

Resource projections – Phase E (post-launch) Budget

- Year 1
 - \$x – addition/replacement of compute nodes
 - \$x – additional disk storage (+\$3k maintenance)
 - \$x – off-site data storage
 - \$x – additional tapes
- Year 2
 - \$x – addition/replacement of compute nodes
 - \$x – additional disk storage
 - \$x – off-site data storage
 - \$x – replace adam001, adam002, & adam003
 - \$x – additional tapes
 - \$x - Maintenance (beyond purchase for cluster2, disk, tape library)
- Year 3
 - \$x – off-site data storage
 - \$x – replace/upgrade eve backup computer
 - \$x – replace cluster #1 (and FC raid1) and maintenance
 - \$x – upgrade tape library drives to newer technology
 - \$x – additional tapes

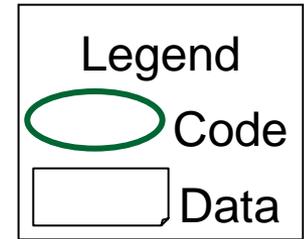
Resource projections – Year 1 needs

- Compute capacity
 - Sufficient capacity exists for the first year, new nodes are not yet needed
- Additional disk
 - Need 27 TB additional storage each year – 135 TB total for 5 year mission
 - Would like to purchase 60 TB+ using funds for nodes
 - Technical
 - 10-ports of 16-port FC switch are in use, new disk would use 2 more
 - Requires a new rack
- Additional tapes
 - 100 more tapes would be about \$x
 - Purchase spare replacement disks to reduce down-time

Processing Levels

Level	Description	Span	Type
0A (TLM)	Unprocessed VCDUs (packets) – files received from DDS	~1 min	binary
0B	Assembled/merged integration separated by channel	~1 min	FITS
0C	Space weather (Ka-band) – all channels available in Latest and Daily files	15 min & 1 day	ASCII
0CS	Space weather (S-band) – <u>lowest latency</u> , only diodes and proxies	Same	ASCII
0D	Daily merged 0B data with duplicates removed	1 day	FITS
1	Fully calibrated science results for each channel (irradiance)	1 hour	FITS
1A	SAM only, event list	1 day	FITS
1B	SAM only, spectrum (cadence is TBD)	Same	FITS
2S	Merged MEGS-A and B level 1 spectra to MEGS-B grid (.02 nm)	1 hour	FITS
2L	Extracted lines and bands, averaged diodes to match spectrum timestamp, proxies (same as 0C)	Same	FITS
3	Daily average spectrum at 0.02 nm	1 day	FITS
3	Daily average 0.1 nm spectrum	1 year	FITS/N etCDF/ SAV
3	Daily average 1 nm spectrum	Mission	

Science Product Subsystem Overview



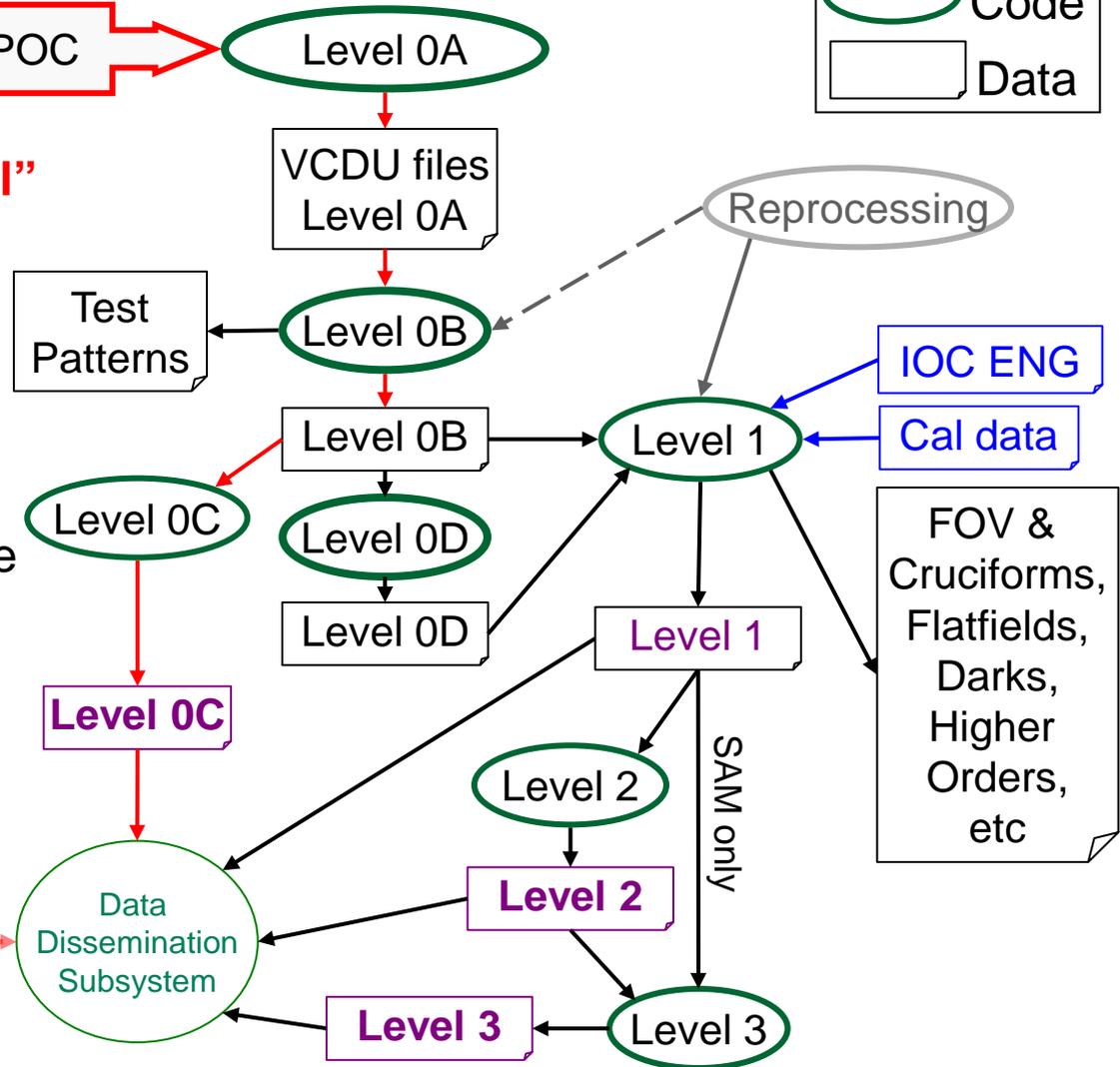
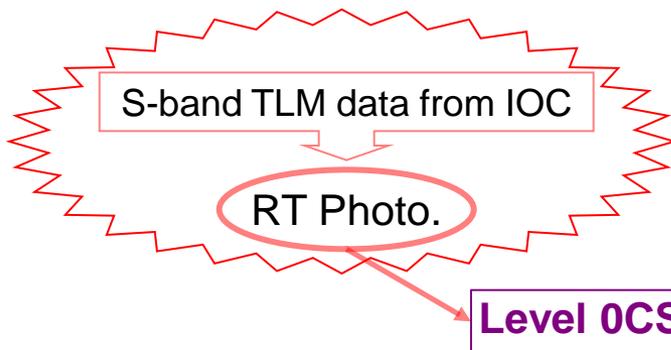
Level 0A to 0C are “time-critical” space weather data flow

Levels 1-3 are not near-RT
Public Products

Primary are 0C, 0CS, 2, & 3

Level 0A, 0B, 0D complete

Most of 0CS, 1, 2, & 3 complete



Science Product Availability

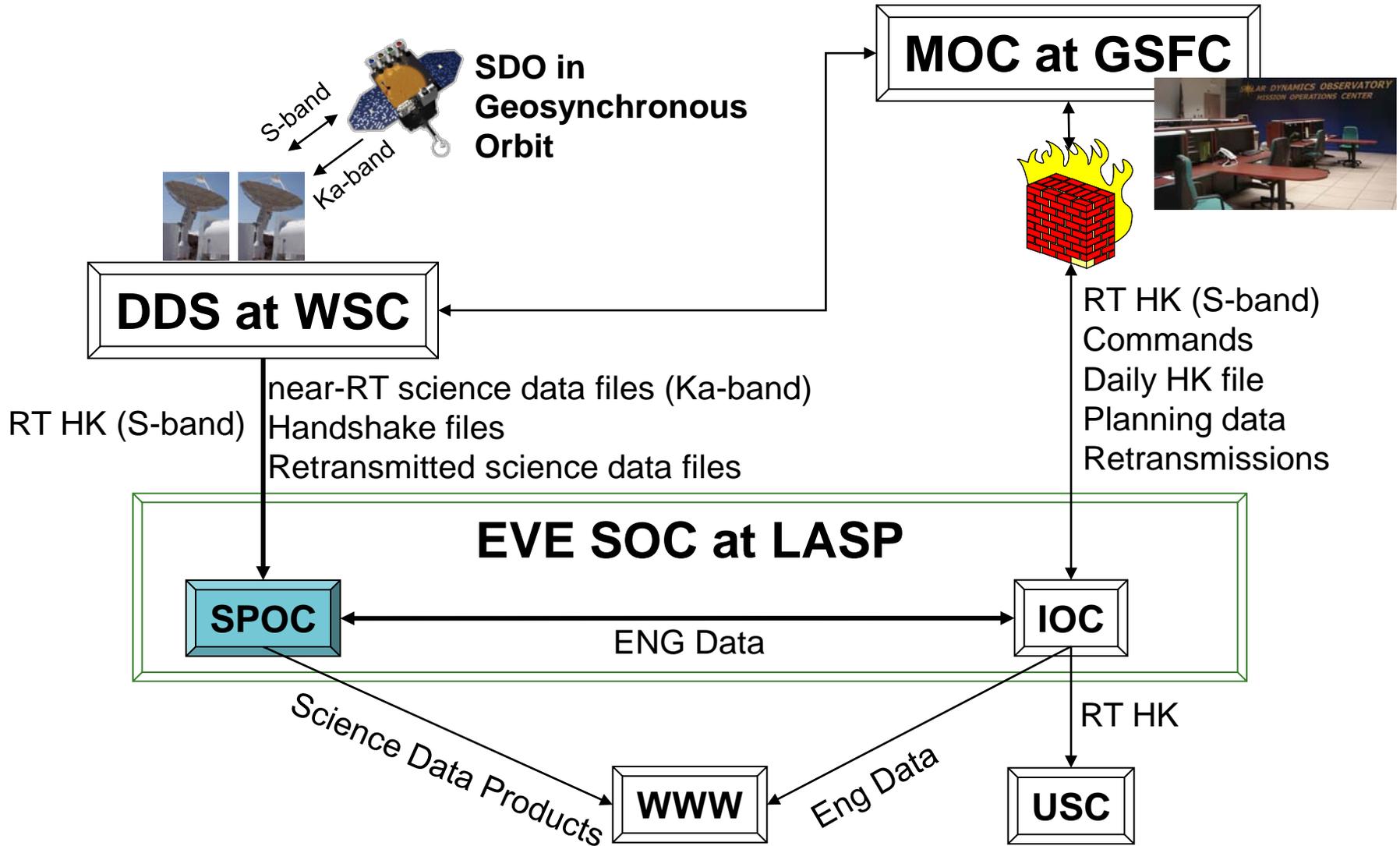
- Post-commissioning validation period ~ 6 months
 - Analysis of in-flight calibrations
 - Track relative changes between channels
 - ESP, MEGS-A/B overlap, similar emission behavior
 - Suborbital rocket flight
 - Provides absolute calibration
 - Post-flight NIST-SURF recalibration
- Normal product generation – publishing products to the web site
 - S-band latency is seconds
 - Photometer file combining ESP & MEGS-P
 - A single 4 Hz sample every 10-seconds for all photometer bands
 - Ka-band latency is > 3 minutes and < 15 minutes
 - Level 0C is expected to be available after ~ 6 minutes
 - Routine products available after 14 UT for the previous day.
 - Completed ASDP packets available
 - Best products available after 30 day routine reprocessing

Internal Data Access & Organization

- Primary access server
 - Login tox
 - NFS mounts are possible for desktops
 - x will be retired
 - Over 5 years old
- 2 primary disk volumes
 - /x
 - All processed data (no TLM)
 - /xx

Sensitive information has been removed

EVE-SOC Interface Overview

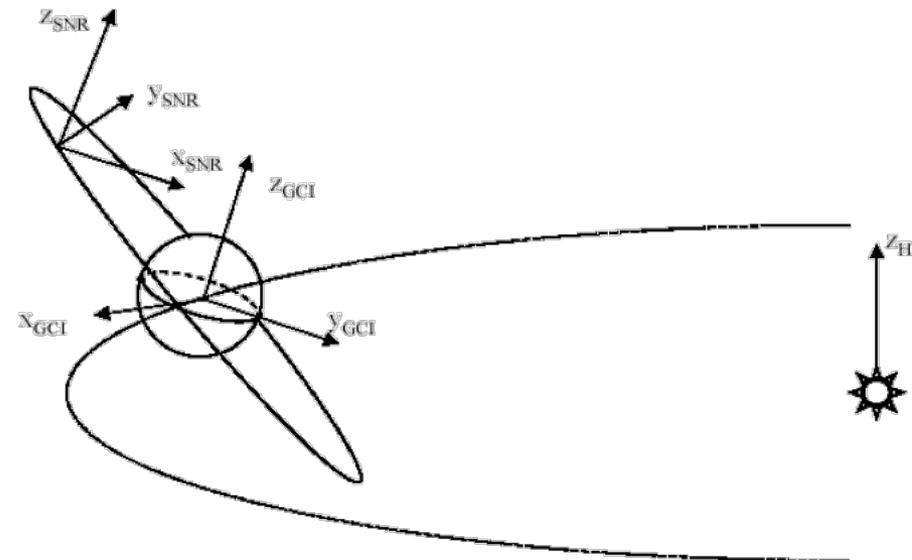
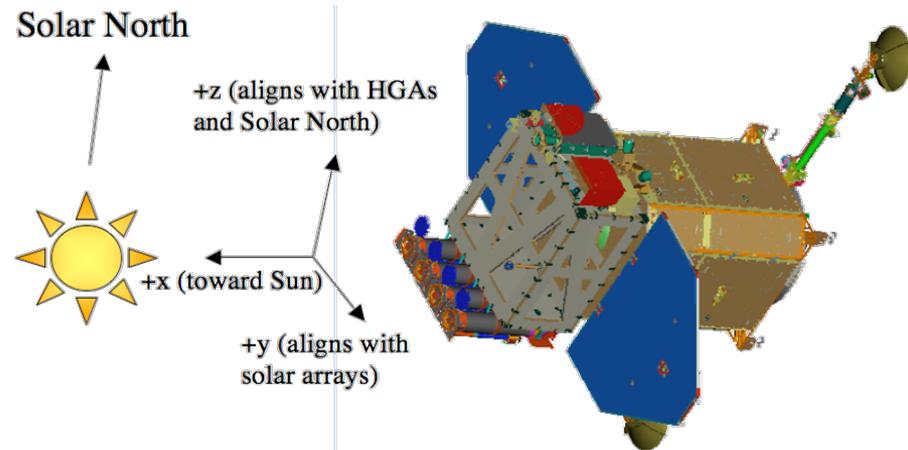


Interfaces

- DDS – DS3 (45 Mbps) WAN
 - Ka-band science data - directed to interface computer x1 (x2)
 - ~3-minute lag for real-time full science data
 - Retransmission of science data
 - 50 MB files pushed to EVE cluster for processing
 - S-band housekeeping data - directed to x (engineering)
 - ~1 second latency for health and safety
 - x connects to evedp via TCP socket (OCS)
 - One 4 Hz diode sample per 10 seconds from the slow packet
- IOC
 - Pushes new ASDP and ENG data files to evefs1 prior to 1400 UT
 - One FITS file per day (3 HDUs, binary tables)
 - Location: .../data/eng/YYYY
 - HDU #1: ASDP table
 - HDU #2: Eng data from side A (TAI, Bus voltage, dec_htr_current)
 - HDU #3: Eng data from side B

Orientation

- The SDO orientation is shown in the figure (464-ACS-ICD-0067 rev F)
 - Solar North Reference (SNR)
 - +x is S/C to sun direction
 - +z along solar north pole
 - +y completes the right-hand system
 - ESP X = SNR Pitch angle
 - EXP Y = SNR Negative Yaw angle
- SNR is rotated wrt SURF frame
 - Axis same, names differ
 - SURF z is along the beam
 - SNR minus x
 - SURF x is left-right
 - SNR minus y
 - SURF y is up-down
 - SNR minus z
 - EVE is usually rotated +/- 45 degrees in the SURF tank
 - Rotation is about SURF z or SNR x which is a roll



Data Processing Timing and Version Numbering

- Space weather (S and Ka)
 - Seconds latency and < 15 minutes
- Routine processing
 - At 14 UT, the previous days routine processing begins (Level 1-3)
 - Completed L0 data files from the MOC unavailable until this time.
- Routine reprocessing
 - After 30 days, processing is repeated
 - Holes are filled, we have all the data we will ever get
 - Calibration/degradation corrections can be interpolated, higher quality products
- New Version release reprocessing
 - When significant changes are made to the calibration corrections, or processing algorithms that impact the quality of the data, a new processing version number is created.
 - Requires **regenerating the entire mission**
 - The majority of compute time is spent doing this.
 - Version Plan is subject to change
 - Version 1 is the pre-flight, testing version
 - Version 2 will be released on launch day
 - Version 3 is expected after the first rocket calibration is applied (L+4 months)
 - Version 4 is expected after the 2nd or 3rd rocket calibration is applied (L+12 months)
 - Other versions...

Science Data Discovery

- Two complimentary databases
 - LISIRD for daily averages (contains multiple missions, tools)
 - EVE Custom: 1-minute data with links to data product files
 - Daily insertion of calibrated data, NOT space weather
 - Database can support search capability for finding files based on:
 - Time range, possibly flare flags, quality flags
 - **Need community input on what is desired**
 - Support automated external queries
 - Database and appropriate tools can provide interactive browse capability
 - Event discovery, time scaling (pan / zoom)
 - Flares, anything else?
 - Tables contain selected bands/lines, all 1-min avg.
 - Bands: ESP, MEGS-P bands, MA1, MA2, SAM, MB bands, bg estimates, AIA bands, GOES-R/13 bands, Q_{EUV} , SEM 304 band
 - Lines
 - Integrated over fixed range, includes background
- Are movies of spectra useful?

Data File Details

- All data products are either ASCII or FITS
- Reader software
 - ASCII files are readable by any text reader
 - Some may have very long lines, where each line pertains to one date/time
 - FITS standard readers
 - FV (FITS View) is a graphical tool for opening/editing FITS files
 - <http://heasarc.gsfc.nasa.gov/ftools/fv/>
 - IDL software packages are available from several sources (like SolarSoft)
 - EVE processing uses high-level mrdfits.pro/mwrfits.pro available from the GSFC IDL Astronomy Library (we also use the low-level cfitsio library)
 - <http://idlastro.gsfc.nasa.gov/fitsio.html>
 - Header keywords are sparsely used
 - **Any requests for header keywords?**
 - Rather than treating metadata (like time, date, resolver, etc) as ASCII strings that need to be extracted from the header, it is included with the data and treated like data
 - Limitations of FITS
 - No convention for nested structures, so all internal structures are only 1 level or “flat”
 - Level 1-3 files are all FITS
 - Files contain an empty primary HDU (for compatibility), and a binary table
 - A row in the table corresponds to a time
 - Columns are data fields (scalars or arrays, no pointers, no objects, no structures)
 - Each row pertains to one date/time
 - **Fixed length? 8639-8641 variable number of integrations depending on clock drift, power cycles, Ka-comm switches, etc.**

Summary

- EVE SPOC contains sufficient hardware redundancy to produce products under most common failure scenarios
- EVE science processing will create files with several latencies
 - Availability ranges from seconds to 30+ days
- File formats are ASCII and FITS
 - Many standard readers exist for FITS, we use mrdfits.pro and fv
- Level 2 maintains the instrument spectral resolution
 - Time cadence is maintained for CCD data
- Online accessible database (2)
 - One for daily average data (LISIRD)
 - One for 1-minute samples of bands and lines

Extracted Lines

Wavelength (nm)	Log T	Ion
9.39	6.81	Fe XVIII
13.12	5.57	Fe VIII
13.29	6.97-7.16	Fe XX Fe XXIII
17.11	5.81	Fe IX
17.72	5.99	Fe X
18.04	6.07	Fe XI
19.51	6.13	Fe XII
20.20	6.19	Fe XIII
21.13	6.27	Fe XIV
25.63	4.75	He II
28.42	6.30	Fe XV
30.38	4.70	He II
33.54	6.43	Fe XVI
36.08	6.43	Fe XVI
36.81	5.99	Mg IX

Wavelength (nm)	Log T	Ion
46.52	5.71	Ne VII
49.94	6.29	Si XII
52.58	4.92	O III
55.44	5.19	O IV
58.43	4.16	He I
59.96	4.92	O III
62.49	6.05	Mg X
62.97	5.37	O V
71.85	4.48	O II
77.04	5.81	Ne VIII
79.02	5.19	O IV
97.25	3.84	H I
97.70	4.84	C III
102.57	3.84	H I
103.19	5.47	O VI

Fe series:
VIII-XVI,
XVIII, XX

O series:
II-VI