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Tethered Satellite System (TSS)

Science Operations Center Display Definition Document

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Revision: ~~Basic~~ Rev A.
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Science Operations Center (SOC)

Display Definition Document

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OVERVIEW

This document provides definitions of data for the Science Operations Center (SOC) displays to be used during the TSS-1 mission. The displays include four Joint Science Displays (JSD) and four Payload Operations Control Center (POCC) displays. The definition includes measurement numbers and algorithms, when available, for each displayed parameter. Attachments provide descriptions of time scales and indicators, unique algorithms, display formats and Calibrated Ancillary System (CAS) parameters. Where parameters are unresolved, the information in question is underlined. In these cases, further input is required from cognizant PIs, PEDs, et. al. Also, where information is undefined, "TBD" is stated.

An effort was made to retain the numbering system used by MMAG/SwRI for each display item. For instance, the extended tether of POCC display I was item 53 in their documentation and remains item 53 herein. These number assignments are shown on the MMAG/SwRI display formats, enclosed as the first eight pages of Attachment D (the second eight pages are MSFC/SvT display formats). Where MMAG/SwRI failed to identify an item, the existing numbering system was extended. As an example, two satellite thrusters were not identified on POCC I; therefore, the thrusters were assigned the next unused numbers, 54 and 55, by SvT.

ISD I

- Item 1, Satellite Potential, is SRD No. K06A5212A. The limits are ±5000 volts
- Item 2, Bias Current, is SRD No. K06A5210A. The limits are ±9 microamps
- Item 3, dC-E, is SRD No. K06A5220A. The limits are 0 – 25 volts
- Item 4, Ion Flux, is SRD No. K06A5218A. The limits are ±110 NANOamps
- Item 5, B_X, is SRD No. L03A008S, in units of nT.
- Item 6, B_Y, is SRD No. L03A012S, in units of nT.
- Item 7, B_Z, is SRD No. L03A016S, in units of nT.
- Item 8, is deleted.
- Item 9, is deleted.
- Item 10, is deleted.

- Item 11, RETE E Field, will show one of 3 components (E_X is default) of the E-field, selectable by the operator. The display is comprised of 13 different horizontal spectrostrips (or bands) each corresponding to a different frequency. Within a given spectrostrip, there are 16 channels which will need to be averaged to determine what the signal strength is (color coded in units of $(mV)^2/Hz$). See RETE IDFS for the AC waveform data locations. The vertical scale should be "Freq", from 0.16 KHz to 12 MHz. The color bar scale is logarithmic from 0.1 to 1000 $(mV)^2/Hz$
- Item 12, RETE B Field, is the same as item 11 above except that it is the B Field data, color coded to units of $(mV)^2/Hz$. Also, only 2 components, B_X and B_Z, are available.
- Item 13, RETE Langmuir Probe, is SRD No.'s K06A5214A and K06A5216A.
- Item 14, Satellite Thrusters On/Off, is SRD No.'s A02J002D, A03J002D, A04J002D, A05J002D, A06J002D, A07J002D, A09J002D, A09J004D.

  The algorithm is:

  If any measurements indicate "OPEN", then the display should indicate On;

  Else display should indicate Off.
- Item 15, Orbiter Thrusters On/Off, is CAS measurements V79X2601X thru V79X2644X. The algorithm is:

  If any thrusters are "On", then the display should indicate on;

  else display should indicate off.
- Item 16, FPEG On/Off, is SRD No. N03V011D.

The Y-axis scale is from -5 to +15 Volts. The color bar scale is LINEAR between $\pm 10^{-5}$ amps

JSD_I (cont'd)

- Item 17, EGA1 On/Off, is defined in the SRD as M00C007S.
  The algorithm is:
  If EGA1 filament current > 65 Amps, then display should indicate EGA1 On;
  Else display should indicate EGA1 Off.
- Item 18, EGA2 On/Off, is defined in the SRD as M00C008S.
  The algorithm is:
  If EGA2 filament current > 65 Amps, then display should indicate EGA2 On;
  Else display should indicate EGA2 Off.
- Item 19a, Water, will show color for "ON" if either CAS No.'s V62X0465E or V62X0538E is high.
- Item 19b, FES, will show color for "ON" if FES is on. See Attachment E for FES "ON" definition.
- Item 20, DIFP Defl Voltage, is ROPE logical instrument RPDP, Sensor 0. Vetical scale is in VDC from -100 to +100, [redacted] The color bar is in Amps, from [redacted] 5x10^{-11} to 5x10^{-6}.
- Item 21, DIFP Retarding Voltage, is [redacted] of ROPE logical instrument RPDP, [redacted] SENSOR 2 [redacted] VERTICAL SCALE IS IN VDC, from 0. to +100. THE COLOR BAR IS IN AMPS, FROM 5X10-11 TO 5 X10-6.
- Item 22, SPES-1 Ions, is ROPE logical instrument RPIB, Sensor 0. The color bar scale will be logrithmic with units of Diff E Flux. The range will be from [redacted] to 10. 10^{-3}
- Item 23, SPES-2 Electrons, is ROPE logical instrument RPEB, Sensor 1. The color bar scale will be logrithmic with units of Diff E Flux. The range will be from [redacted] to 100. 10^{-2}
- Item 24, SPES-3 Electrons, is ROPE logical instrument RPEA, Sensor 0. The color bar scale will be logrithmic with units of Diff E Flux. The range will be from [redacted] to 10. 10^{-3}
- Item 25, Time, is [redacted] defined in attachment A.
- Item 26, Lat, is defined in Attachment I.
- Item 27, Lon, is defined in Attachment I.
- Item 28, MET, is CAS measurement V75W3514D. See Attachment A.
- [redacted]
- Item 29, YEAR/DAY/HR:MIN:SS:SSS, is defined in Attachment A.

ISD II

For items 1 thru 4, there are 2 Heads which are selectable by the operator, either Head A or Head B. It is envisioned that one display will have Head A and a similar display will have Head B. The PIT crew will select which display to use on a frequency basis of approximately every LOS. Also, display all vertical scales as log scales from 10eV to 10KeV. Color scales should be in counts/sec from 0 to 2E6.

- Item 1, SPREE Ions from Zone 4, use SRD No.'s R00U428S thru R00U459S if Head A; if Head B, use SRD No.'s R01U202S thru R01U233S.
- Item 2, SPREE Ion Summed Spectra, use SRD No.'s R00U002S thru R00U033S if Head A; if Head B use SRD No.'s R00U036S thru R00U067S.
- Item 3, SPREE Electrons from Zone 4 use SRD No.'s R00U396S thru R00U427S; if Head B use SRD No.'s R01U170S thru R01U201S.
- Item 4, SPREE Electron Summed Spectra, use SRD No.'s R00U075S thru R00U106S, R00U139S thru R00U170S, R00U204S thru R00U235S, R00U268S thru R00U299S, R00U332S thru R00U363S, R00U396S thru R00U427S, R00U460S thru R00U491S, R00U524S thru R00U555S, R00U588S thru R00U619S, R00U652S thru R00U683S, R00U849S thru R00U880S, R00U913S thru R00U944S, R00U977S thru R01U008S, R01U041S thru R01U073S, R01U106S thru R01U137S, R01U170S thru R01U201S, R01U234S thru R01U265S, R01U298S thru R01U329S, R01U362S thru R01U393S, R01U426S thru R01U457S.

If ESA A selected, use:

If ESA B selected, use: SRD No.'s

- Item 5, SETS CCP I use SRD No. N04C001S if SRD No. N04J003D is low. If SRD No. N04J003D is high, use SRD No. N04C003S. Left side vertical scale should be ±100 mA/m^2.
- Item 6, SETS CCP Q, use SRD No. N04V005S if SRD No. N04J002S is low. If SRD No. N04J002S is high, display N04V008S; right side vertical scale should be from +1000 VDC to -4000 VDC.
- Items 7-12, Satellite Thrusters On/Off thru Flash Evaporators On/Off, are described under JSD I.
- Item 13, Tether Length, is SRD No D01H022S. The spectrostrip will be color coded from green for 0 km to red for 20 km).
- Item 14, TSS Mode is deleted.
- Item 15, Pressure, is SRD No. M00P003S.
- Item 16a, Anode Leakg 1, is SRD measurement No. M00C005S.

JSD II (cont'd)

- Item 16b, Anode Leakg 2, is SRD measurement No. M00C006S.
- Item 17, SPREE Potential, is SRD No. R00U069S. The spectrostrip will be color coded [redacted] from green for 0V. to red for 3LV
- Items 18 and 19, Pitch Angle Spectrostrip and FPEG Spectrostrip, are deleted.

[For items 20 thru 22, the right side vertical scale should be 0 to 0.75A.]

- Item 20, DCORE Tether I, is two plotted parameters: SRD No.'s M00C003S, (EGA1) M00C004S (EGA2).
- Item 21, SETS Tether I, is SRD No. N02C003S.
- Item 22, SA Tether I, is SRD No. I03C002S.

[For items 23 and 24, the [redacted] vertical scale should be from +100 VDC to -5000 VDC.]

- Item 23, DCORE Tether V, use algorithm for "D Volt" in SRD, DDCU Page 1.
- Item 24, SETS Tether V, is same as "S VOLT" on DDCS page 1.
- Item 25, DV Tether V, is deleted.
- Item 26, SETS SRPA, is either N05V009S(IPHI) or N05V010S(IPLO), selectable by the operator. Note that each byte (IPHI or IPLO) has 2 settings as well for a total of 4 separate configurations. The voltage is determined via interpolation between the following SRD No.'s: N05V006S, N05J003S, N05J004S and N05J005S (IPSWP1, IPSWP2, IPSWP3, and IPSWP4). Color bar is from -80 dB to 0 dB, sweep voltage scale is from -2.0 V to +15 V.
- Item 27, SETS Langmuir Probe, is SRD No. N05V011S (shown as color coding). The voltage is determined via interpolation between successive samples of SRD No. N05V008S. Range is -2.0 to +10.0 VDC (vertical axis), -80 to 0 dB (color bar).
- Item 28, Time, is defined under JSD I.
- Item 29, Lat, is defined under JSD I.
- Item 30, Lon, is defined under JSD I.
- Item 31, MET, is defined under JSD I.
- Item 32, YR/DAY, is defined under JSD I.

JSD III

For items 1 and 2, the right side vertical scale should be +60 to -20 millig.

- Item 1, A_Z, is SRD No. I01A006S.
- Item 2, A_X and A_Y, A_X is SRD No. I01A002S and A_Y is I01A004S.

For items 3 thru 5, the right side vertical scale should be ± 2.4 deg/s.

- Item 3, Gyro X, is SRD No. B01R002A.
- Item 4, Gyro Y, is SRD No. B01R004A.
- Item 5, Gyro Z and Gyro skew, is SRD No. B01R006A, and B01R008A.
- Item 6, Tensiometer, consists of 3 measurements. SRD No. D01G001A (fine) should have a vertical scale on the right side of 0-9N. SRD No.'s D01G002A (coarse) and D01H029S (blended) should have a vertical scale on the left side of 0-60N .
- Item 7, Tether L, is SRD No. D01H022S. Scale is 0-22 km.
- Item 8, Tether L-DOT, is SRD No. D01H024S. Scale is ± 2 m/s.
- Item 9, Satellite Thrusters, will be an ON/OFF spectrostrip using the measurements and algorithm described under JSD I.
- Item 10, Orbiter Thrusters, will be an ON/OFF spectrostrip using the measurements and algorithm described under JSD I.
- Item 11, Range, is CAS No. V74U2623J. Vertical scale should be on the right side from 0 to 22 km.
- Items 12 and 13 are defined in attachment D. Vertical scale should be on the left side from 0 to 360 deg.
- Item 14, Predicted Tether Voltage, is deleted.
- Item 15, Measured Tether Voltage, will be two plotted parameters - "D Volt" and "S Volt" defined in the SRD's DDCU Page 1 description. Vertical scale is from +100 VDC to -5000 VDC.
- Item 16, MET, is defined under JSD I.
- Item 17, YR/DAY, is defined under JSD I.
- Item 18, Time, is defined under JSD I.
- Item 19, Lat, is defined under JSD I.
- Item 20, Lon, is defined under JSD I.

JSD IV

- Items 1-4, Ions from Zone 4 thru Electron Summed Spectra, are identified in JSD I, Items 1 through 4.
- Item 5, SETS CCP I, is described under JSD II.
- Item 6, SETS CCP Q, is described under JSD II.
- Items 7-12, Satellite Thrusters On/Off thru Flash Evaporators On/Off, were defined under JSD I.
- Items 13-18, Tether Length Spectrostrip thru Pitch Angle Spectrostrip, were defined under JSD II.
- Item 19, FPEG Spectrostrip, is deleted.
- Item 20, Orbiter Pitch Angle, is deleted.
- Item 21, Orbiter RAM Angle, is expressed in AZ and COEL. It is defined in Attachment J. It is expressed in degrees, from 0 to 360.
- Item 22, AMAG, is 3 line plots of the 3 magnetic field components, in the Orbiter coordinate system (x-axis out the tail, z-axis up out of the cargo bay). The units are (nT), from -60,000 to +60,000. The three components should be plotted as follows:
  - (+) B_X = N07U002S
  - (-) B_Y = N07U003S
  - (+) B_Z = N07U001S
- Item 23, Pressure, is deleted.
- Item 24, SETS RPA, is described under JSD II.
- Item 25, SETS Langmuir Probe, is described under JSD II.
- Item 26, Time, is defined under JSD I.
- Item 27, Lat, is defined under JSD I.
- Item 28, Lon, is defined under JSD I.
- Item 29, MET, is defined under JSD I.
- Item 30, YR/DAY, is defined under JSD I.

POCC I

- Item 1, B_{AZ}, is defined in SRD, DDCU Pg 1 as "B AZ".
- Item 2, B_{COEL}, is defined in SRD, DDCU Pg 1 as "B COEL".
- Item 3, V_x, is CAS measurement V95L0190C.
- Item 4, V_y, is CAS measurement V95L0191C.
- Item 5, V_z, is CAS measurement V95L0192C.
- Items 6 and 7, Tether Az and COEL, are defined in Attachment D.
- Item 8, DRB, is SRD measurements Y03U009S (DRBA) and Y03U018S (DRBD).
- Item 9, $\dot{L}$, is SRD No. D01H024S and is FMD data type, as defined in ECR EL53-0522 (displayed units are m/sec).
- Item 10, L, is SRD No. D01H022S and is FMD data type, as defined in ECR EL53-0522 (displayed units are km).
- Item 11, SA, is SRD No. I03C002S.
- Item 12, TCM, is SRD No. N02C003S.
- Item 13, DV, is the same as the "D Volt" algorithm from SRD DDCU page 1.
- Item 14, TVMDC, is the same as "S Volt" on DDCS, page 1.
- Item 15, FPEG, is SRD No. N03V011D. It is displayed as "ON" or "OFF".
- Item 16, EGA, is SRD No.'s M00C007S, M00C008S. Algorithm is:
  If EGA1 filament current or EGA2 filament current > 65 amps, then display should indicate EGA is "ON"; else indicate "OFF".
- Item 17, RAM Coel, is defined in Attachment J.
- Item 18,RAM AZ, is defined in Attachment J.
- Item 19, FES, is defined in attachment E.
- Item 20, DUMP, is CAS measurements V62X0538E and V62X0465E. A dump is indicated as "ON" if either valve is open; else indicated as "OFF".
- Item 21, DMT, is deleted.
- Item 22, MET, is CAS measurement V75W3514D.
- Item 23, GMT, is CAS measurement V75W3504D.

For items 24-29 and 54-55, See attachment F.

- Item 24, Out-of-Plane Left Valve, is SRD No. A07J002D.
  Algorithm is:
  If valve is "OPEN", indicate thruster is on; else indicate thruster is off.
  The plume icon is displayed for [redacted] 10 seconds to ensure visibility.

POCC I (cont'd)

- Item 25, Out-of-Plane Right Valve Status, is SRD No. A06J002D.
  Algorithm is:
  If valve is "OPEN", then indicate thruster is on; Else indicate thruster is off.
  The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 26, Yaw 1 Valve Status, is SRD No. A09J002D.
  Algorithm is:
  If valve is "OPEN", then indicate thruster is on; else indicate thruster is off.
  The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 27, Yaw 2 Valve Status, is SRD No. A09J004D.
  Algorithm is:
  If valve is "OPEN", then indicate thruster is on; else indicate thruster is off.
  The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 28, In-line 1 Valve Status, is SRD No. A02J002D.
  Algorithm is:
  If valve is "OPEN", then indicate thruster is on; else indicate thruster is off.
  The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 29, In-line 2 Valve Status, is SRD No. A03J002D.
  Algorithm is:
  If valve is "OPEN", then indicate thruster is on; else indicate thruster is off.
  The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 30, Fore Starboard Lateral Thrusters, is CAS measurement No.'s V79X2606X, V79X2613X, V79X2616X. A large plume is displayed if 2606 or 2613 is fired; small plume if 2616 is fired. The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 31, Fore Port Lateral Thrusters, is CAS measurement No.'s V79X2602X, V79X2610X, V79X2615X. A large plume is displayed if 2602 or 2610 is fired; small plume if 2615 is fired. The plume icon is displayed for at least 10 seconds to ensure visibility.

POCC_I (cont'd)

- Item 32, Aft Starboard Lateral Thrusters, is CAS measurement No.'s V79X2632X, V79X2634X, V79X2638X, V79X2640X, V79X2643X. A large plume is displayed if 2632, 2634, 2638, or 2640 is fired; small plume if 2643 is fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 33, Aft Port Lateral Thrusters, is CAS measurement No.'s V79X2618X, V79X2620X, V79X2624X, V79X2626X, V79X2630X. A large plume is displayed if 2618, 2620, 2624, or 2626 is fired; small plume if 2630 is fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 34, Fore Port Upward Thrusters, is CAS measurement No.'s V79X2603X, V79X2607X, V79X2611X. A large plume is displayed if any of these thrusters are fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 35, Fore Port Downward Thrusters, is CAS measurement No.'s V79X2604X, V79X2612X. A large plume is displayed if either of these thrusters is fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 36, Aft Port Upward Thrusters, is CAS measurement No.'s V79X2619X, V79X2621X, V79X2627X. A large plume is displayed if any of these thrusters are fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 37, Aft Port Downward Thrusters, is CAS measurement No.'s V79X2622X, V79X2625X, V79X2628X, V79X2629X. A large plume is displayed if 2622, 2625, or 2628 is fired; small plume if 2629 is fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 38, Aft Starboard Upward Thrusters, is CAS measurement No.'s V79X2633X, V79X2635X, V79X2642X. A large plume is displayed if any of these thrusters are fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.
- Item 39, Aft Starboard Downward Thrusters, is CAS measurement No.'s V79X2636X, V79X2639X, V79X2641X, V79X2644X. A large plume is displayed if 2636, 2639, or 2641 is fired; small plume if 2644 is fired. The plume icon is displayed for ~~at least~~ 10 seconds to ensure visibility.

POCC I (cont'd)

- Item 40, Fore Starboard Upward Thrusters, is CAS measurement No.'s V79X2603X, V79X2607X, V79X2611X. A large plume is displayed if any of these thrusters are fired. The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 41, Fore Starboard Downward Thrusters, is CAS measurement No.s V79X2608X, V79X2614X. A large plume is displayed if either of these thrusters is fired. The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 42, DMS, is SRD No.'s M00X011D, M00X012D. Algorithm is:
  If either DMS is CLOSED, then indicate circuit is "CLSD"; else indicate circuit is "OPEN".
- Item 43, V, is SRD No. R00U069S.
- Item 44, P, is SRD No. M00P003S.
- Item 45, Accelom, is SRDNo. I01J008D.
- Item 46, ω, is SRD No.'s Q07H006S or Q07H012S; display larger value. It is converted from rad/s to rpm.
- Items 47 thru 52 are deleted.
- Item 53, Tether Projection, is (reference POCC I, Items 6 and 7).
- Item 54, In-plane Front Valve Status, is SRD No. A05J002D. Algorithm is:
  If valve is "OPEN", then indicate thruster is on; else indicate thruster is off.
  Show icon for 10 sec.
- Item 55, In-plane Rear Valve Status, is SRD No. A04J002D. Algorithm is:
  If valve is "OPEN", then indicate thruster is on; else indicate thruster is off.
  Show icon for 10 sec.
- Item 56, Aft Port Rearward Thrusters, is CAS measurement No.'s V79X2617X and V79X2623X. A large plume is displayed if either of these thrusters is fired. The plume icon is displayed for at least 10 seconds to ensure visibility.
- Item 57, Aft Starboard Rearward Thrusters, is CAS measurement No.'s V79X2631X and V79X2637X. A large plume is displayed if either of these thrusters is fired. The plume icon is displayed for at least 10 seconds to ensure visibility.

POCC I (cont'd)

- Item 58, Fore Starboard Foreward Thrusters, is CAS measurement No.'s V79X2601X, V79X2605X, V79X2609X. A large plume is displayed if any of these thrusters are fired. The plume icon is displayed for [redacted] 10 seconds to ensure visibility.
- Item 59, Fore Port Foreward Thrusters, is CAS measurement No.'s V79X2601X, V79X2605X, V79X2609X. A large plume is displayed if any of these thrusters are fired. The plume icon is displayed for [redacted] 10 seconds to ensure visibility.
- Item 60, Pitch Rate, is defined in Attachment K.
- Item 61, Yaw Rate, is defined in Attachment K.
- Item 62, Roll Rate, is defined in Attachment K.

POCC II

- Item 1a, MET, is CAS measurement V75W3514D.
- Item 1b, Orbit No., is computed based upon MET. The algorithm is INT((MET/90)+1).
- Item 1, TEMAG, is SRD No. L01J002D. The graphic is a colored status block.
- Item 2, RETE, is SRD No. K01J002D. The graphic is a colored status block.
- Item 3, ROPE, is SRD No. J01J006D. The graphic is a colored status block.
- Item 4, SCORE, is SRD No. I03E002D. The graphic is a colored status block.
- Item 5, SPREE, is SRD No. R02U703S. The graphic is a colored status block.
- Item 6, SRPA/LP, is SRD No. N01J007D. The graphic is a separate block, colored for status.
- Item 7, LP, is deleted.
- Item 8, CCP, is SRD No. N01J009D. The graphic is a separate block, colored for status.
- Item 9, DV On/Off, is deleted.
- Item 10, DVG, is SRD No. M00X005D.
- Item 11, Tether Length, is SRD No. D01H022S.
- Item 12, Tether Voltage, is same as "S VOLT" on DDCS page 1.
- Item 13, Orbiter Pitch Angle, is defined in Attachment H.
- Item 14, Orbiter Yaw Angle, is defined in Attachment H.
- Item 15, Day/Night, is deleted.
- Item 16 is omitted.
- Item 17, acpb, is SRD measurement Y03U009S. It is an alphanumeric entry of the AC DRB extension or retraction. The DRB is also shown graphically [redacted] position.
- Item 18, dcbp, is SRD measurement Y03U018S. It is an alphanumeric entry of the DC DRB extension or retraction. The DRB is also shown graphically [redacted] position.

POCC II (cont'd)

- Item 19, spin indicator, is SRD No.'s Q07H006S and Q07H012S. If either is ≥ 0.1RPM, show CW arrow. If either is ≤ -0.1 RPM, show CCW arrow. Else remove arrow.
- Item 20, DMS1, is SRD No. M00X011D. Algorithm is:
  If DMS Switch 1 Status = "CLOSE", switch is closed; else switch is open.
- Item 21, DMS2, is SRD No. M00X012D. Algorithm is
  If DMS Switch 2 Status = "CLOSE", switch is closed; else switch is open.
- Item 22, TCM On/Off, is deleted.
- Item 23, CMS, is SRD No. N02J005D and N02J007D. If either is low, show open. Else show closed.
- Item 24, MMS, is SRD No. N02J009D. If it is low show open, else closed.
- Item 25, SHT, is SRD No. N02J010D and N02J008D. If either is low, show open. Else show closed.
- Item 26, R1, is SRD No. N02J003D. It is displayed as an opened/closed switch. Algorithm is:
  If R1 Relay = "LOW", switch is open; else switch is closed.
- Item 27, R2, is SRD No. N02J002D. It is displayed as an opened/closed switch. Algorithm is:
  If R2 Relay = "LOW", switch is open; else switch is closed.
- Item 28, R3, is SRD No. N02J001D. It is displayed as an opened/closed switch. Algorithm is:
  If R3 Relay = "LOW", switch is open; else switch is closed.
- Item 29, PROT, is SRD No. N02J006D. It is displayed as an opened/closed switch. Algorithm is:
  If PROT Relay = "LOW", switch is open; else switch is closed.
- Item 30, CPROT, is a static symbol.
- Item 31, R1A TEMP, is SRD No. N02T004S.
- Item 32, R1B TEMP, is SRD No. N02T007S.
- Item 33, N.NNN A, is SRD No. N02C003S.
- Item 34, +/- NNNN V (Left side), is the same as "S Volt" on DDCS page 1.

POCC II (cont'd)

- Item 35, CEGHS Power, is SRD No. M00X032D.
  If it is high, display blank character (open circuit) and display "OFF". Else display line character (closed circuit) and display "ON".
- Item 36, CEGHS1, is SRD No. M00X006D. It is displayed as an opened/closed switch. Algorithm is:
  If CEGHS Switch 1 = "HIGH", switch is open; else switch is closed.
- Item 37, CEGHS2, is SRD No. M00X007D. It is displayed as an opened/closed switch. Algorithm is:
  If CEGHS Switch 2 = "HIGH", switch is open; else switch is closed.
- Item 38, DV HV, is SRD No. M00X010D. It is displayed as an opened/closed switch. Algorithm is:
  If DV HV Switch = "HIGH", switch is open; else switch is closed.
- Item 39, EM1 XXX, is SRD No. M00C007S. Algorithm is:
  If EGA1 Filament Current > 65 Amps, then EM1 = "ON"; else EM1 = "OFF".
- Item 40, EM2 XXX, is SRD No. M00C008S. Algorithm is:
  If EGA2 Filament Current > 65 Amps, then EM2 = "ON"; else EM2 = "OFF".
- Item 41, +/- NNNN V (right side), is same as "D Volt" on DDCU Page 1 in SRD.
- Item 42, FPEG AAAA, is SRD No. N03V011D. It is displayed as "ON" or "OFF".
- Item 43, Orbiter Cur N.NNN A, is same as "Orbiter Cur" on DDCU Pg 1 in SRD.
- Item 44, satellite thruster indicator, is SRD No.'s A02J002D, A03J002D, A04J002D, A05J002D, A06J002D, A07J002D, A09J002D, A09J004D. Algorithm is:
  If any thrusters are "ON", then plume icon is displayed; else no icon is displayed. The plume is displayed for [redacted] 10 seconds to ensure visibility.
- Item 45, orbiter thruster indicator, is CAS No.'s V79X2601X thru V79X2644X. Algorithm is:
  If any thrusters are "ON", then plume icon is displayed; else no icon is displayed. The plume is displayed for [redacted] 10 seconds to ensure visibility.

POCC III

- Item 1, MET, is CAS measurement V75W3514D.
- Item 2, Orbit No., is computed based on MET. The algorithm is INT ((MET/90)+1).
- Item 3, Orbiter Thrusters, is CAS measurements V79X2601X thru V79X2644X.

  Algorithm is:

  If any thrusters are "On", then display should indicate on; else display should indicate off.

  The bar is highlighted for [illegible] 10 seconds to ensure visibility.
- Item 4, Flash Evaporators On/Off, is defined in attachment E.

  If any flash evaporators are ON, then display should indicate On;

  Else display should indicate Off.

  The bar is displayed for [illegible] 10 seconds to ensure visibility.
- Item 5, Dumps, is CAS measurement V62X0538E and V62X0465E.

  Algorithm is:

  If any dumps occur, then display should indicate on; else display should indicate off.

  The bar is displayed for [illegible] 10 seconds to ensure visibility.
- Item 6, LOS, is deleted.
- Item 7, Night, is deleted.
- Item 8, Sat In-line thrusters, is SRD No.'s A02J002D, A03J002D.

  Algorithm is:

  If either thruster valve is "OPEN", then display should indicate on; else display should indicate off.

  The bar is displayed for [illegible] 10 seconds to ensure visibility.
- Item 9a, Spin Thrusters, is SRD No.'s A09J002D, A09J004D.

  Algorithm is:

  If either thruster valves are "OPEN", then display should indicate on; else display should indicate off.

  The bar is displayed for [illegible] 10 seconds to ensure visibility.

POCC III (cont'd)

- Item 9b, Canted Thrusters, is SRD No.'s A04J002D, A05J002D, A06J002D, A07J002D.
  Algorithm is:
  If any thruster valve is "OPEN", then display should indicate on; else display should indicate off.
  The bar is displayed for at least 10 seconds to ensure visibility.
- Item 10, S/C Spin Mode, is SRD No.'s Q07H006S and Q07H012S.
  If either is $\geq$ 0.1 RPM or $\leq$ -0.1 RPM, show spin.
- Item 11, Brake On, is [redacted] deleted.
- Item 12, Switches: CMS, is same as item 23 on POCC II.
  MMS, is SRD No. N02J009D. If it is low, show blank (open); if high, show shaded (closed).
  DV-HV, is SRD No. M00X010D. If it is high, show blank (open); if low, show shaded (closed).
- Item 13, SETS: Shunt, is SRD No.'s N02J010D and N02J008D. If either is low, show open. Else, show closed.
  R1, is SRD No. N02J003D. If low, switch is open. Else show closed.
  R2, is SRD No. N02J002D. If low, switch is open. Else show closed.
  R3, is SRD No. N02J001D. If low, switch is open. Else show closed.
- Item 14, FPEG Gun, is SRD No. N03V011D. If low, gun is off; if high, gun is on.
- Item 15, DCORE EGA1, is same as item 17 on JSD I.
  DCORE EGA2, is same as item 18 on JSD I.
- Item 16, Tether Current, is a line plot with vertical scale in log form from 1 to .001 amps, using the sum of SRD No.'s M00C003S and M00C004S.

POCC III (cont'd)

- Item 17, Tether Voltage line plot is the same as "S VOLT" on DDCS page 1. Vertical scale is +100 VDC to -5000 VDC.
- Item 18, MET, is CAS No. V75W3514D.

GENERAL: A scroll bar should operate as in the JSD's. Data should be overwritten as in the JSD's. There should be a backround set of vertical lines tied to the timescale tick marks.

POCC IV

- Item 1, MET, is CAS measurement V75W3514D.
- Item 2, Orbit No., is computed based on MET. The algorithm is INT((MET/90)+1).
- Item 3, Attitude: Roll is defined in Attachment H.
- Item 4, Attitude: Pitch is defined in Attachment H.
- Item 5, Attitude: Yaw is defined in Attachment H.
- Item 6, Roll Rate, is defined in Attachment K.
- Item 7, Pitch Rate, is defined in Attachment K.
- Item 8, Yaw Rate, is defined in Attachment K.
- Item 9, RAM AZ, see POCC I, item 18.
- Item 10, RAM COEL, see POCC I, item 17.
- Item 11, B-Field AZ, is described in SRD, DDCU Pg 1, as "B AZ".
- Item 12, B-Field COEL, is described in SRD, DDCU Pg 1, as "B COEL".
- Item 13, B-Field Mag, is SRD No.'s N07U001S (B_x), N07U002S (B_y), N07U003S (B_z).

  Algorithm is:

  $(B_x^2 + B_y^2 + B_z^2)^{1/2}$
- Item 14, Thrusters, is CAS measurement No.'s V79X2601X thru V79X2644X.

  Algorithm is:

  If any thrusters are on, then display should indicate "On"; else display should indicate "Off".

  The indication is displayed for [redacted] 10 seconds [redacted] or until the next ON state change.
- Item 15, Flash Evaporators On/Off, is defined in Attachment E. The algorithm is:

  If any flash evaporators are ON, then display should indicate On;

  Else display should indicate Off.

  The indication is displayed for [redacted] 10 seconds [redacted] or until the next ON state change.

POCC IV (cont'd)

- Item 16, Dumps ID, is CAS measurement No.'s V62X0465E, V62X0538E.
  Algorithm is: else
  If V62X0465E is "OPEN", then indicate "Supply"; if V62X0538E is "OPEN", then indicate "WASTE". If any dumps are executed, then display should indicate "On" next to ID, else display should indicate "Off".
  Indications are displayed for ~~at least~~ 10 seconds ~~minimum visibility~~. or until the next ON state change.
- Item 17, LOS/AOS, is deleted.
- Item 18, Day/Night, is deleted.
- Item 19, Latitude, is defined in Attachment I. The units are degrees.
- Item 20, Longitude, is defined in Attachment I. The units are degrees.
- Item 21, Radar Rng., is CAS measurement No.'s V74V2623J.
- Items 22 and 23, Radar Az and Radar COEL, are defined in Attachment D.
- Item 24, DMS, is SRD No.'s M00X011D and M00X012D.
  Algorithm is:
  If DMS1 or DMS2 is closed, then indicate "CLSD", else indicate "OPEN".
- Item 25, SETS Switch Mode, is defined in attachment C. Use "R1", "R2", "R3", or "Shunt". If more than one, list all.
- Item 26, SETS Mode, is SRD No. N01U001S.
- Item 27, SETS Dur., is SRD No.'s N01U005S, N01U006S.
- Item 28, DCORE Mode, is the parameter "DCORE" in the SRD, DDCU Page 1.
- Item 29, DCORE Dur., is the parameter "TM REM" in the SRD, DDCU Page 1.
- Item 30, Sat: I, is SRD No. I03C002S.
- Item 31, DCORE: I, is simple addition of SRD No.'s M00C003S and M00C004S.
- Item 32, DCORE: V, is same as "D VOLT" from SRD DDCS PAGE 1.
- Item 33, Tether Vs, is deleted.
- Item 34, SETS I, is SRD No. N02C003S .
- Item 35, SETS V, is same as "S VOLT" from SRD DDCS PAGE 1.
- Item 36, SPREE Pot., is SRD No. R00U069S.
- Item 37, CHG PRB, is SRD No. N04V005S.
- Item 38, Pressure, is SRD No. M00P003S.

POCC IV (cont'd)

- Item 39, B_{AZ}, is deleted.
- Item 40, B_{COEL}, is deleted.
- Item 41, B_M, is deleted.
- Item 42, Spin Rt., is SRD No. Q07H006S or Q07H012S, whichever is larger.
- Item 43, Spin Dir., is derived from the sign of SRD No. Q07H006S or Q07H012S.
  Algorithm is:
  If Rate $\geq$ 0.1 RPM, then display should indicate "CW"; else if $\leq$ -0.1 RPM, indicate "CCW"; else indicate " ".
- Item 44, IL Thruster ID, is SRD No.'s A02J002D, A03J002D.
  Algorithm is:
  If valve 1 is "OPEN", then indicate "In-line 1"; else if valve 2 is "OPEN", indicate "In-line 2"; else indicate " ".
  The indication is displayed for at least 10 seconds or until the next ON state change.
- Item 45, Thruster duration, is deleted.
- Item 46, Canted Thruster ID, is SRD No.'s A04J002D, A05J002D, A06J002D, A07J002D.
  Algorithm is:
  If in-plane rear valve is "OPEN", display "In Pl. Rear";
  Else if in-plane front valve is "OPEN", display "In Pl. Front";
  Else if out-of-plane right valve is "OPEN", display "Out Pl. Right";
  Else if out-of-plane left valve is "OPEN", display "Out Pl. Left";
  Else display " ".
  The indication is displayed for at least 10 seconds or until the Next ON state change.
- Item 47, Thruster Dur., is deleted.
- Item 48, Yaw Thruster ID, is SRD No.'s A09J002D, A09J004D.
  Algorithm is:
  If Yaw1 Valve is "OPEN", then indicate "Yaw1"; Else if Yaw2 Valve is "OPEN", then indicate "Yaw2"; Else indicate " ".
  The indication is displayed for at least 10 seconds or until the Next ON state change.
- Item 49, Thruster Dur., is deleted.
- Item 50, Power P/L, is SRD No. Q04U042S.
- Item 51, Power Tot., is SRD No. Q04U040S.
- Item 52, DRB Ext., is SRD measurements Y03U009S (DRBA) and Y03U018S (DRBD).

POCC IV (cont'd)

- Item 53, SCORE I, is SRD No. I03C002S.
- Item 54, ACCEL Z, is SRD No. I01A006S.
- Item 55, ACCEL X, is SRD No. I01A002S (a_x), ACCEL Y, is I01A004S (a_y).
- Item 56, Tether L, is SRD No. D01H022S.
- Item 57, Tether L, is SRD No. D01H024S.
- Item 58, Tether Tension, is SRD No. D01H029S.
- Item 59, Sun Ang. AZ, is deleted.
- Item 60, Sun Ang. COEL, is deleted.

DARKEN DOT ABOVE L

ATTACHMENT A

All_ISDs

white

- A scrolling time bar is displayed on each panel to accommodate the various experiment update rates.
- As the scroll bar reaches the right side (end) of the graph, the bar returns to the left side (beginning). It then begins overwriting the old data, including individual tick mark values. The old data therefore provide a history display until overwritten.
- Time scale is identical across all panels on display page.
- Time axis values and units are annotated only on the lower panels.
- Tick marks are displayed across the top and bottom of all panels.
- Minimum of 5 equally spaced tick marks per time axis (including left and right borders of each panel).
- The number and distribution of tick marks is automatically set according to the user-selected time scale.
- On the lower panels, tick marks are annotated with time, latitude, and longitude. Time ~~values range from 00 to 60 (minutes or seconds).~~ Latitude values range from -90 (90 degrees south of equator) to +90 (90 degrees north of equator). Longitude values range from -179 (179 degrees west of prime meridian) to 180 (180 degrees from prime meridian).
- The display of current MET, from the CAS downlink, is placed in the upper right corner of the display and shown as ~~HHHMMSS~~. HH ranges from 00 to 23; MM and SS from 00 to 59. DAY/HH:MM:SS.
- MET is updated based upon the CAS IDFS period.
- ~~Year and day are displayed in upper left area of display.~~

The GMT time displayed in the upper left corner of the display represents the time of the left-hand margin of the graphed data. This will be fixed while the scroll bar is marching from left to right. When the scroll bar wraps back to the left, this time will be updated. The display units are year/day/hrs:min:sec:milliseconds.

↳ is displayed in 2 units, the smaller of which represents the fastest changing unit. For example, if the plot units

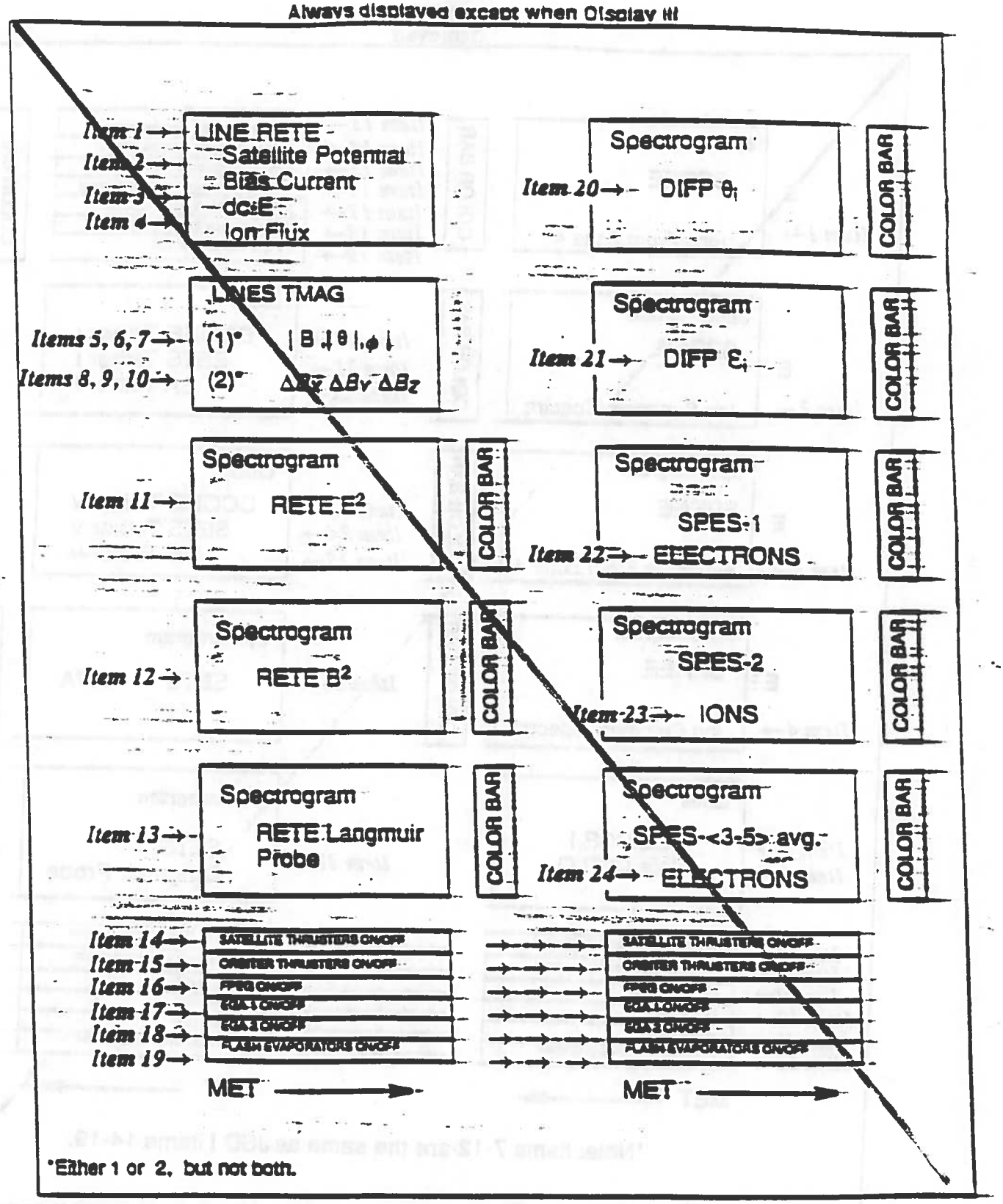
ATTACHMENT B

~~Original "Requirements" from~~
~~SOC Requirements Document~~
~~SOC-DR-01~~

- DELETED

JSD 1

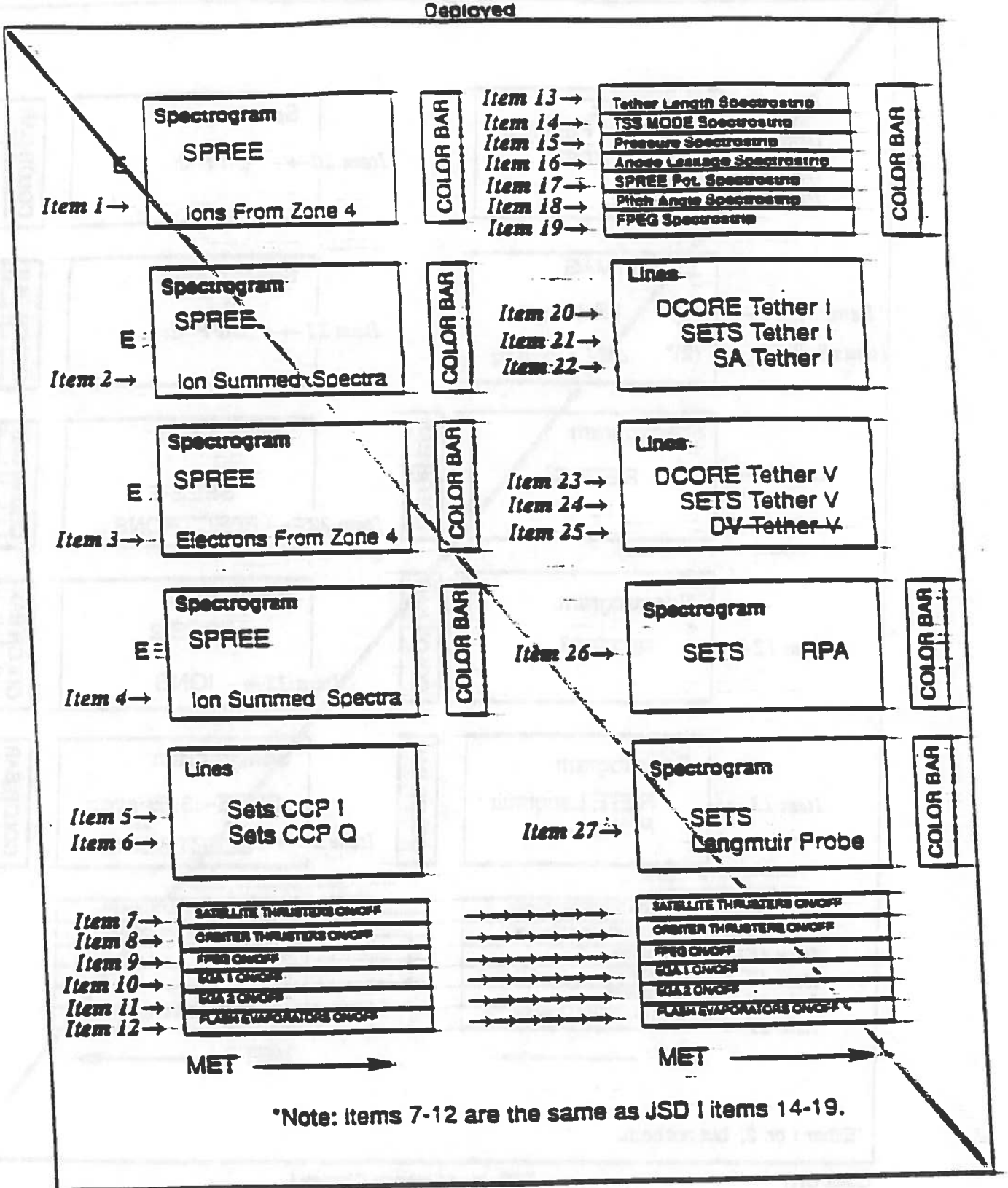
Always displayed except when Display III



*Either 1 or 2, but not both.

Color CRT — TSS-Joint Science Display I

JSD II*
Deployed

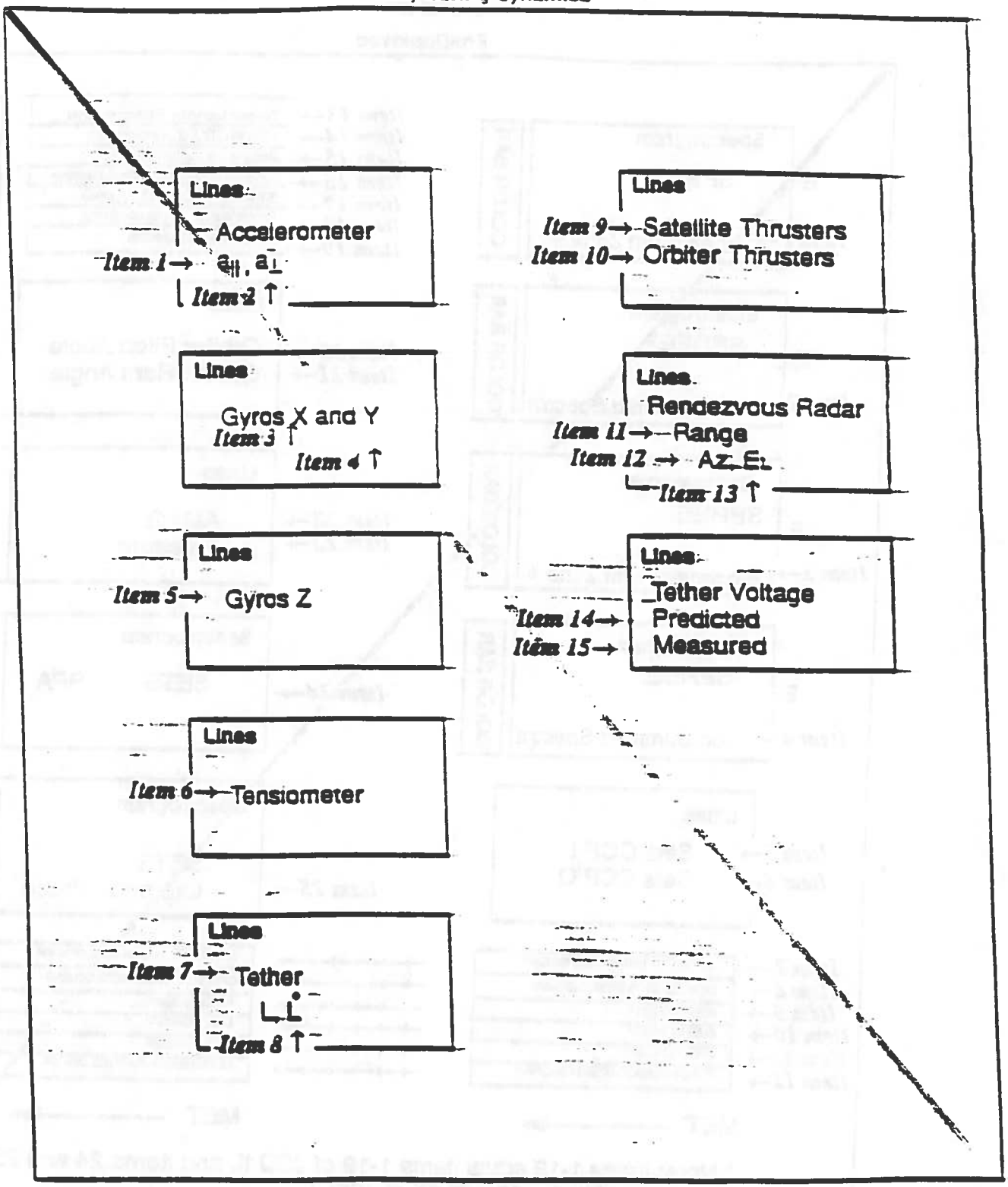


*Note: Items 7-12 are the same as JSD I items 14-19.

Color CRT

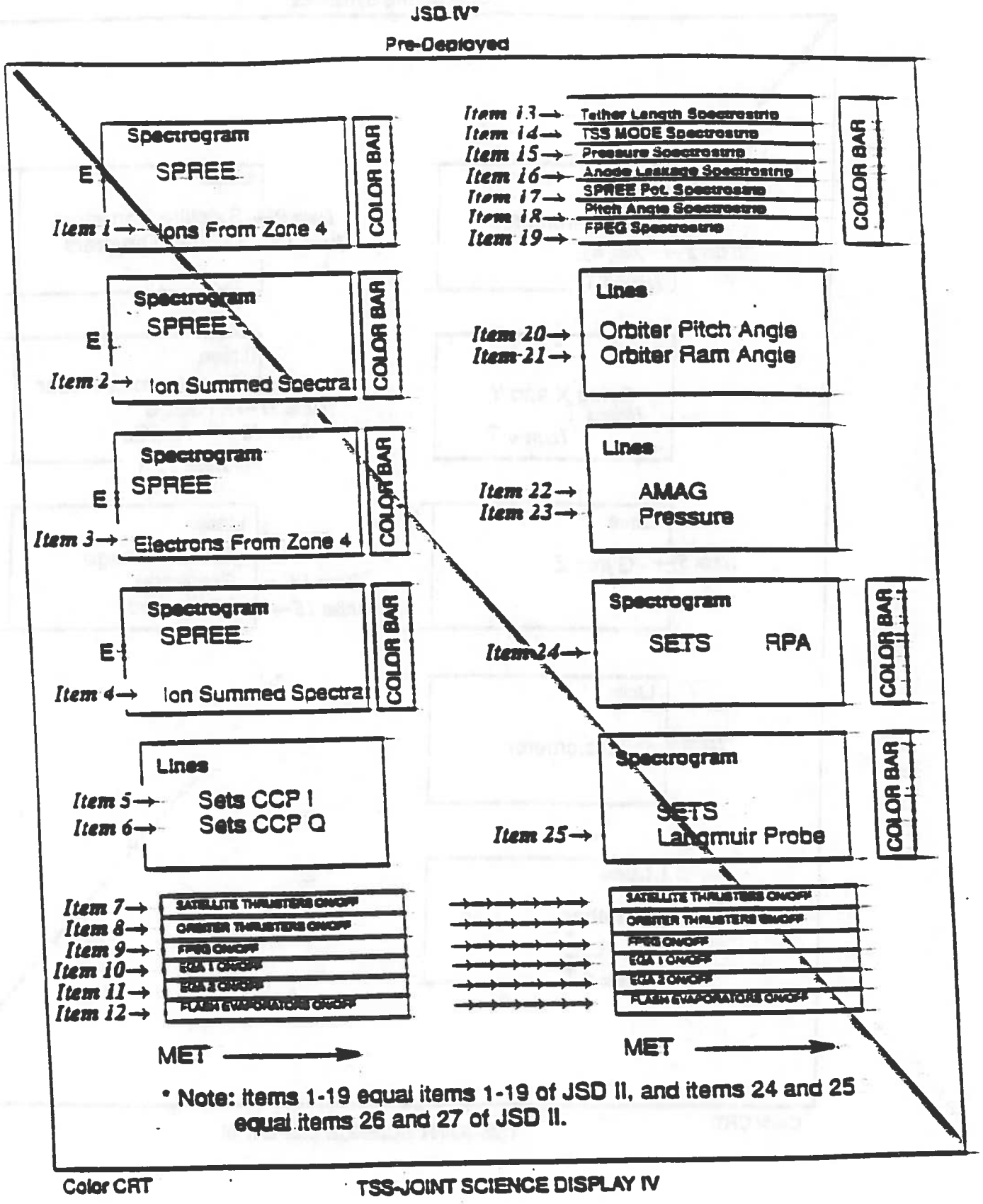
TSS-Joint Science Display II

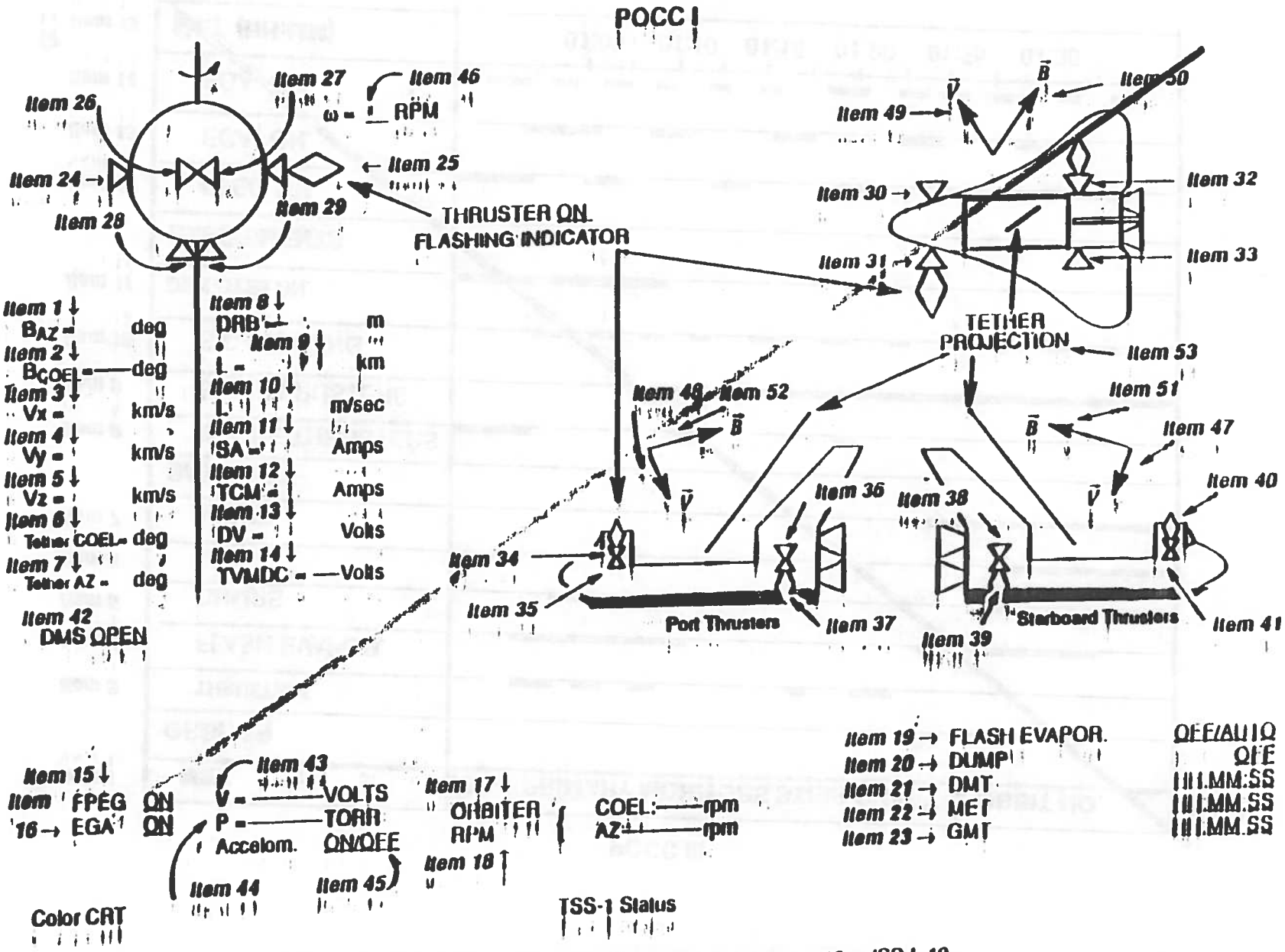
JSD III
Only during dynamics



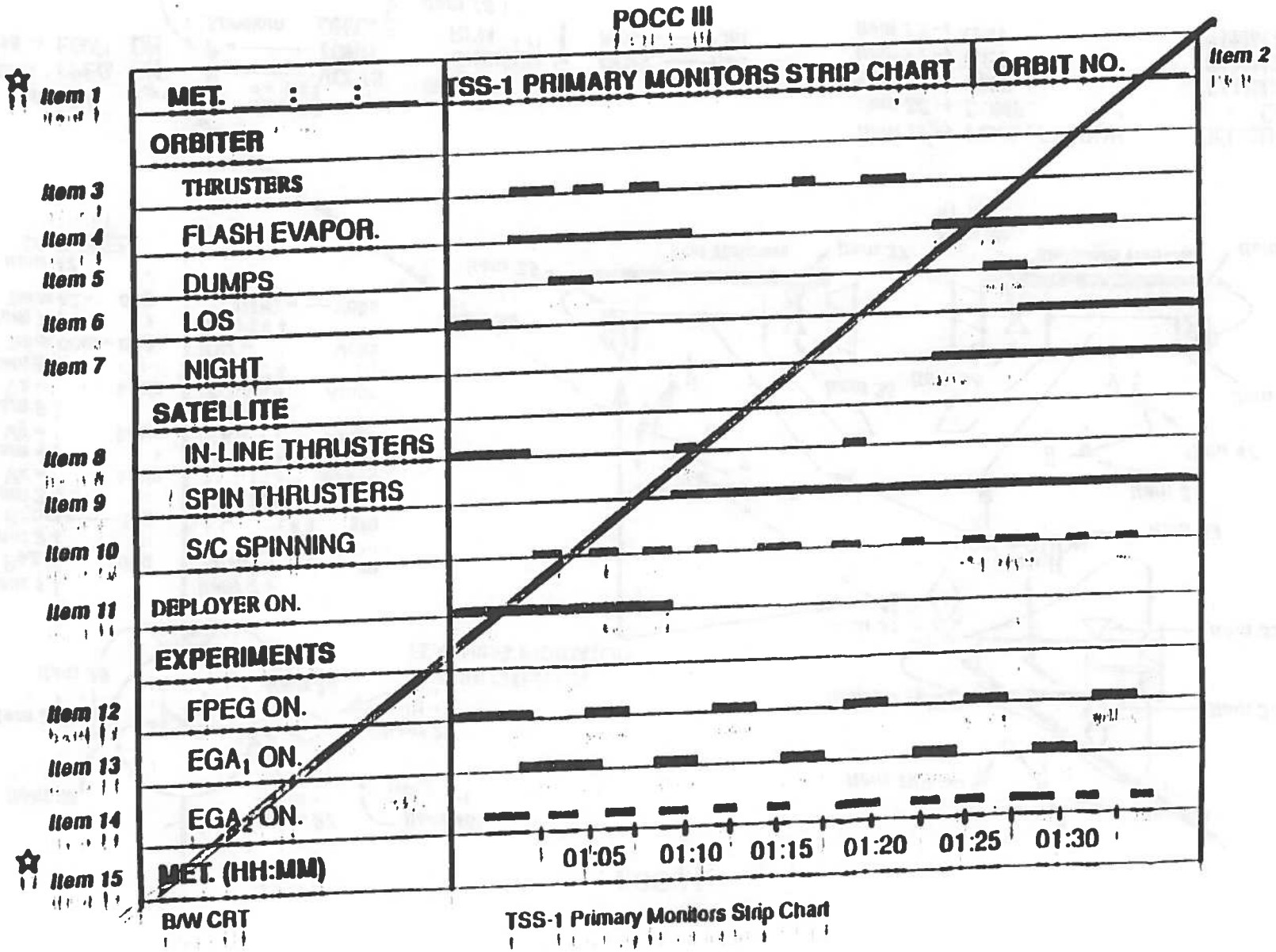
Color CRT

TSS-JOINT SCIENCE DISPLAY III

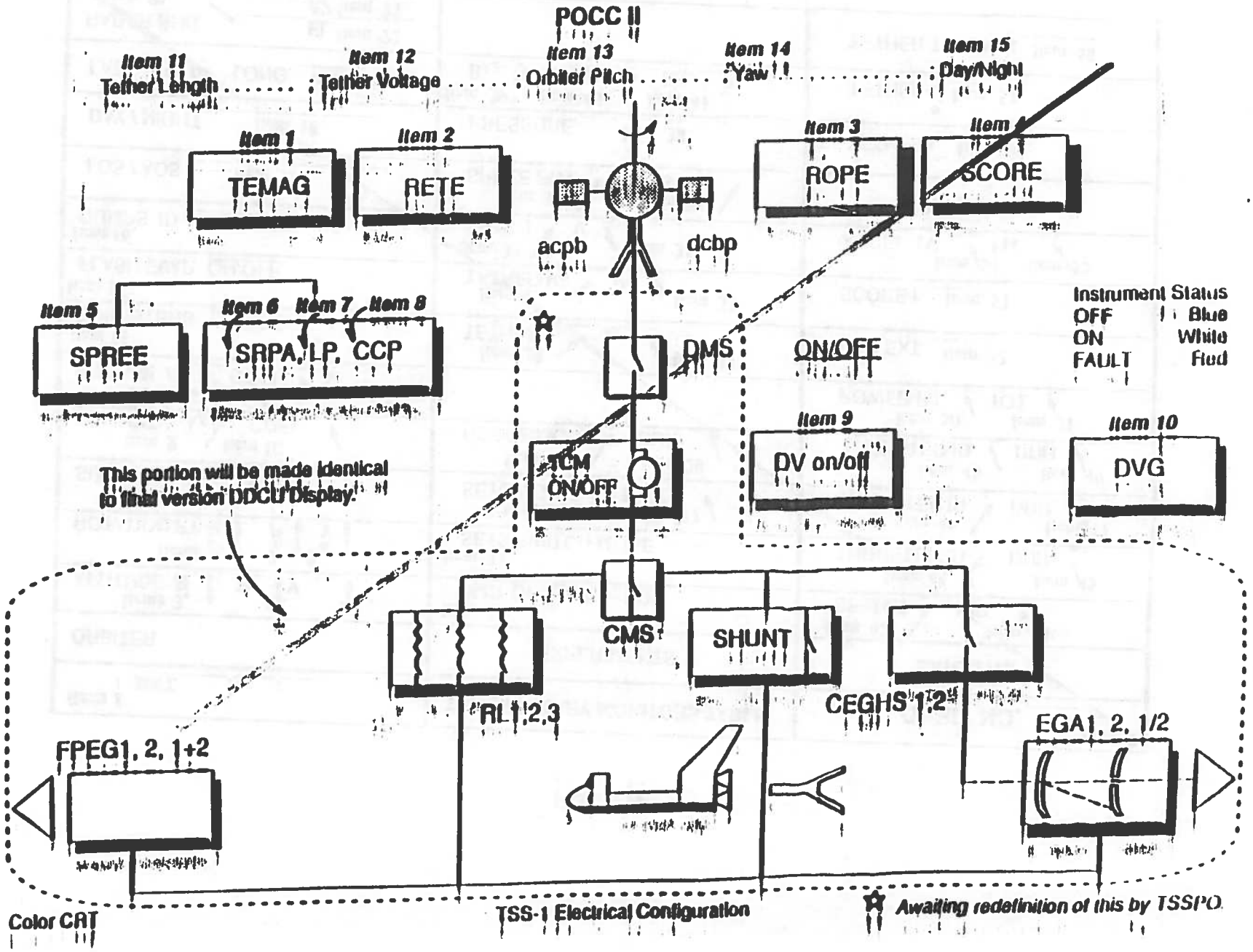

JSD IV*
Pre-Deployed
Spectrogram
E
SPREE
Item 1→ Ions From Zone 4
COLOR BAR
Spectrogram
E
SPREE
Item 2→ Ion Summed Spectra
COLOR BAR
Spectrogram
E
SPREE
Item 3→ Electrons From Zone 4
COLOR BAR
Spectrogram
E
SPREE
Item 4→ Ion Summed Spectra
COLOR BAR
Lines
Item 5→ Sets CCP I
Item 6→ Sets CCP Q
Item 7→ SATELLITE THRUSTERS ON/OFF
Item 8→ ORBITER THRUSTERS ON/OFF
Item 9→ FPEG ON/OFF
Item 10→ EGA 1 ON/OFF
Item 11→ EGA 2 ON/OFF
Item 12→ PLASMA EVAPORATORS ON/OFF
MET
Item 13→ Tether Length Spectrostrip
Item 14→ TSS MODE Spectrostrip
Item 15→ Pressure Spectrostrip
Item 16→ Anode Leakage Spectrostrip
Item 17→ SPREE Pot. Spectrostrip
Item 18→ Pitch Angle Spectrostrip
Item 19→ FPEG Spectrostrip
COLOR BAR
Lines
Item 20→ Orbiter Pitch Angle
Item 21→ Orbiter Ram Angle
Lines
Item 22→ AMAG
Item 23→ Pressure
Spectrogram
Item 24→ SETS RPA
COLOR BAR
Spectrogram
Item 25→ SETS Langmuir Probe
COLOR BAR
SATELLITE THRUSTERS ON/OFF
ORBITER THRUSTERS ON/OFF
FPEG ON/OFF
EGA 1 ON/OFF
EGA 2 ON/OFF
PLASMA EVAPORATORS ON/OFF
MET
* Note: Items 1-19 equal items 1-19 of JSD II, and items 24 and 25 equal items 26 and 27 of JSD II.
Color CRT
TSS-JOINT SCIENCE DISPLAY IV



NOTE: Item 15 = JSD I, 16; Items 9 & 10 = JSD II, 7 & 8; Item 19 = JSD I, 19.



☆ Item 1 – Item 15; Items 3, 4, 8, 9, 12, 13, 14 – JSD I, Items 15, 19, 14, 14, 16, 17, 18


POCC II
Item 11
Tether Length
Item 12
Tether Voltage
Item 13
Orbiter Pitch
Item 14
Yaw
Item 15
Day/Night
Item 1
TEMAG
Item 2
RETE
Item 3
ROPE
Item 4
SCORE
acpb
dcbp
Item 5
SPREE
Item 6
Item 7
Item 8
SRPA, LP, CCP
DMS
ON/OFF
Instrument Status
OFF Blue
ON White
FAULT Red
Item 9
DV on/off
Item 10
DVG
TCM
ON/OFF
This portion will be made identical to final version DDCU Display.
CMS
SHUNT
RL 1,2,3
CEGHS 1,2
EGA1, 2, 1/2
FPEG1, 2, 1+2
Color CRT
TSS-1 Electrical Configuration
Awaiting redefinition of this by TSSPO

POCC IV

Item 1 MET. ___:___:___	TSS-1 PRIMARY MONITORS TABLE	ORBIT NO. ___ Item 2
ORBITER	EXPERIMENTS	SATELLITE
Items 3, 4, 5 ATTITUDE: R ___ P ___ Y ___	Item 24 DMS OPEN/CLOSED	Item 42 SPIN RT. ___ Item 43 DIR. ___
Items 6, 7, 8 ROTATION PT: R ___ P ___ Y ___	Item 25 SETS SWITCH MODE. ___	Item 44 THRUSTER ID ___ Item 45 DUR. ___
SUN ANG.: Az ___ COEL ___	Item 26 SETS MODE ___ Item 27 DUR. ___	Item 46 THRUSTER ID ___ Item 47 DUR. ___
Item 9 VELOCITY: Az ___ Item 10 COEL ___	Item 28 DCORE MODE ___ Item 29 DUR. ___	Item 48 THRUSTER ID ___ Item 49 DUR. ___
Items 11, 12, 13 B-FIELD: Az ___ COEL ___ M ___		Item 50 POWER P/L ___ Item 51 TOT. ___
Item 14 THRUSTERS. ON/OFF	Item 30 TETHER I_D ___ Item 31 I_S ___	DRB EXT. Item 52
Item 15 FLASH EVAP. ON/OFF	Item 32 TETHER V_D ___ Item 33 V_S ___	SCORE I. ___ Item 53
Item 16 DUMPS. ID ___ ON/OFF	Item 34 SETS I ___ Item 35 V ___	Item 54 ACCEL. LV ___ Item 55 III ___
LOS / AOS ___ Item 17 ___	Item 36 SPREE POT. ___ Item 37 SETS POT. ___	DEPLOYER
DAY / NIGHT ___ Item 18 ___	PRESSURE. ___ Item 38 ___	TETHER L ___ Item 56
LAT. ___ Item 19 LONG. ___ Item 20	Item 39 B_{AZ} ___ Item 40 B_{COEL} ___ Item 41 B_M ___	TETHER L ___ Item 57
RADAR HNG. ___ EL Item 22 Item 21 ___ AZ Item 23		TETHER TENSION ___ Item 58
B/W CRT		

TSS-1 Primary Monitors Table

Items 11, 12, 16, 17, 23, 24, 25, 40, 58, 59, 60 = JSD IV; Items 21, 22 = JSD I, 15, 19; JSD III, 15, 12, 11; JSD IV, 24 JSD III; 6, 7, 8; POCC III & IV highly redundant.

ATTACHMENT C

TCVM RESISTORS:

SHUNT - SRD NO.'S N02J010D AND N02J008D (BOTH MUST BE HIGH)
R1 - SRD NO. N02J003D
R2 - SRD NO. N02J002D
R3 - SRD NO. N02J001D

ALGORITHM

IF SHUNT IS "ON", THEN SPECTROSTRIP SHOULD BE GREEN;
ELSE IF R1 IS "ON", THEN YELLOW;
ELSE IF R2 IS "ON", THEN ORANGE;
ELSE IF R3 IS "ON", THEN RED;
ELSE BLACK (NO RESISTOR RELAYS ENABLED).

ATTACHMENT D

Tether (or Radar) Az, COEL Determination

FIRST:

θ = V74H2618J

ϕ = V74H2619J

IF $\theta \geq 1°$,

THEN: $AZ = 90° + \text{Tan}^{-1} (\sin\phi/\sin\theta)$

IF $|\theta| < 1°$,

THEN: Az = 0° if ϕ is negative

Az = 180° if ϕ is positive

IF $\theta \leq -1°$,

THEN: $Az = 270° - \tan^{-1} [(\sin\phi/(-\sin\theta)]$

$$COEL = +\left(\theta^2 + \phi^2\right)^{1/2}$$

NOTE: "Az" is measured as the angle between the Orbiter tail and the projection of the end vector on the Orbiter X-Y plane. 0° is out the Orbiter tail; the angle is defined as positive as a clockwise (toward the left wing) motion from the tail. Range (0-360°).

"Coel" is measured as the angle between the Orbiter Z axis (pointing up out of the cargo bay) and the end vector, 0° is straight up. Range (0-180°).

ATTACHMENT E
FES OPERATIONS

To determine if FES is enabled, one of four discretes must be high:

V63S1600E: Flash Evap Cntlr Pri A - GPC
V63S1610E: Flash Evap Cntlr Pri A - ON
V63S1650E: Flash Evap Cntlr Pri B - GPC
V63S1660E: Flash Evap Cntlr Pri B - ON

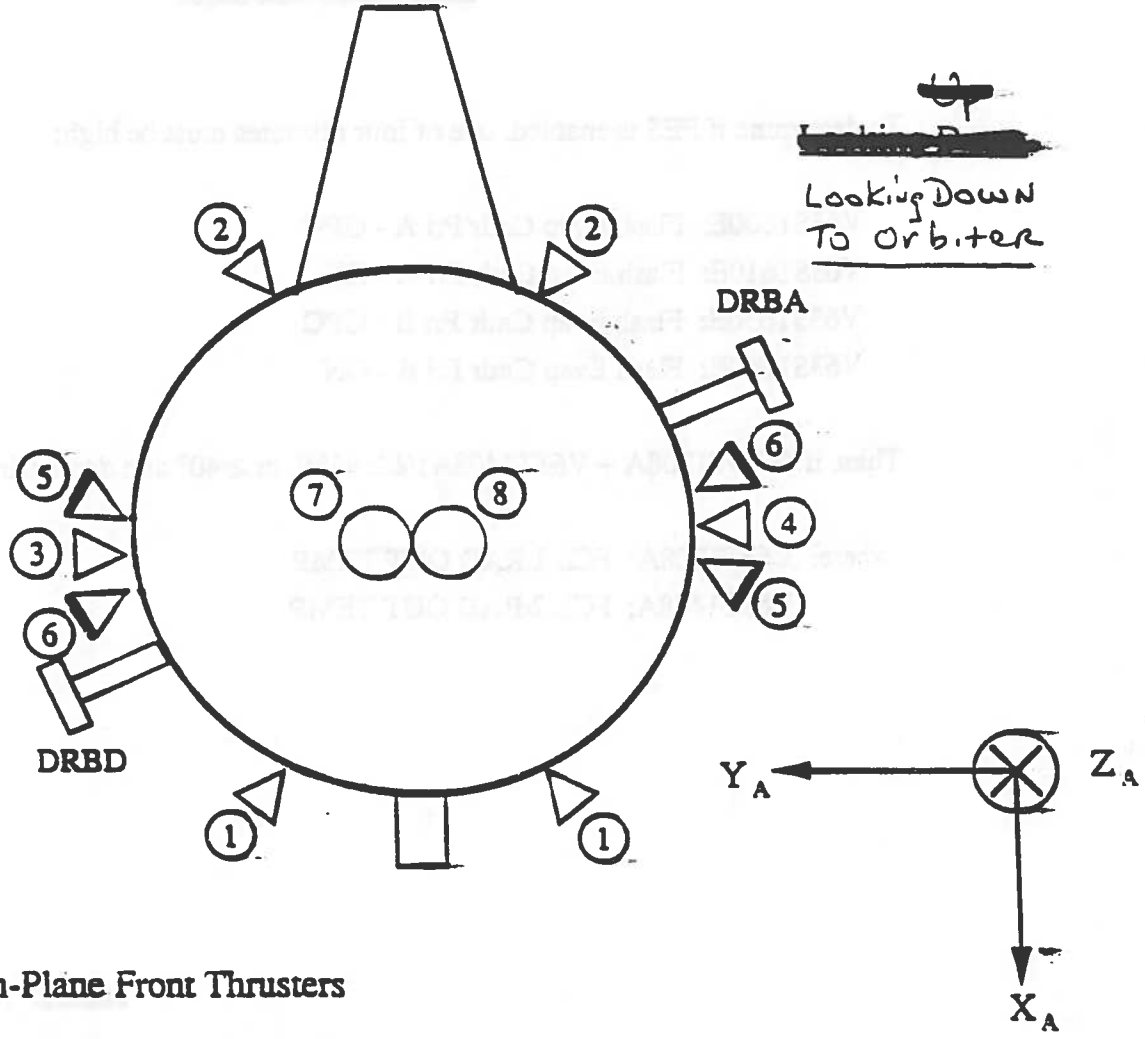
Then, if (V63T1208A + V63TT408A)/2 ≥ 41°F, or ≥ 40° and decreasing, FES is "ON".

where: V63T1208A: FCL 1 RAD OUT TEMP
V63T1408A: FCL 2 RAD OUT TEMP

Source: Kathy Messersmith

ATTACHMENT F

Satellite Thruster Positions

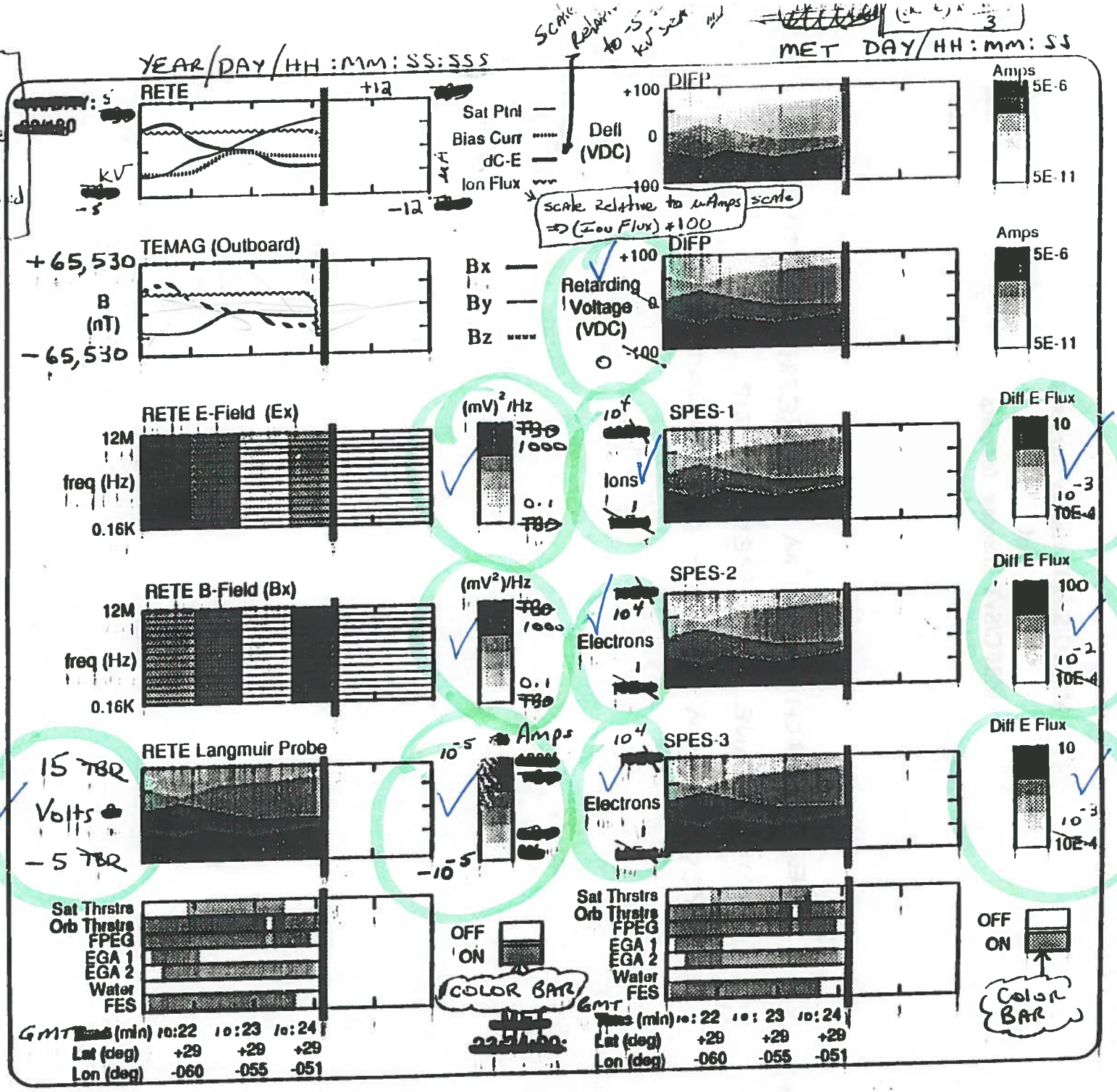


1. In-Plane Front Thrusters
2. In-Plane Rear Thrusters
3. Out-of-Plane Right Thruster
4. Out-of-Plane Left Thruster
5. Yaw 2 Thrusters
6. Yaw 1 Thrusters
7. In-Line 1 Thruster
8. In-Line 2 Thruster

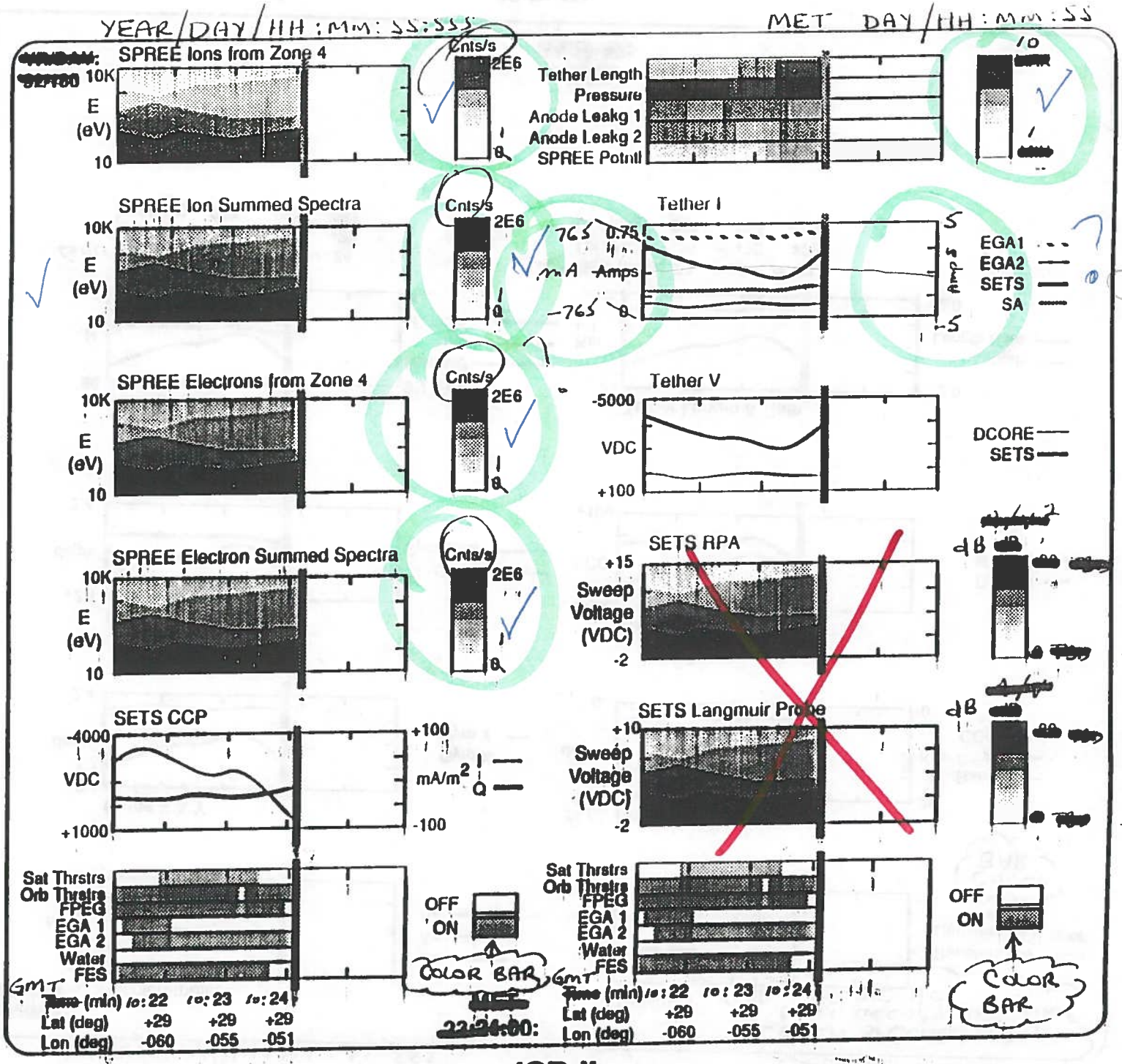
ATTACHMENT G

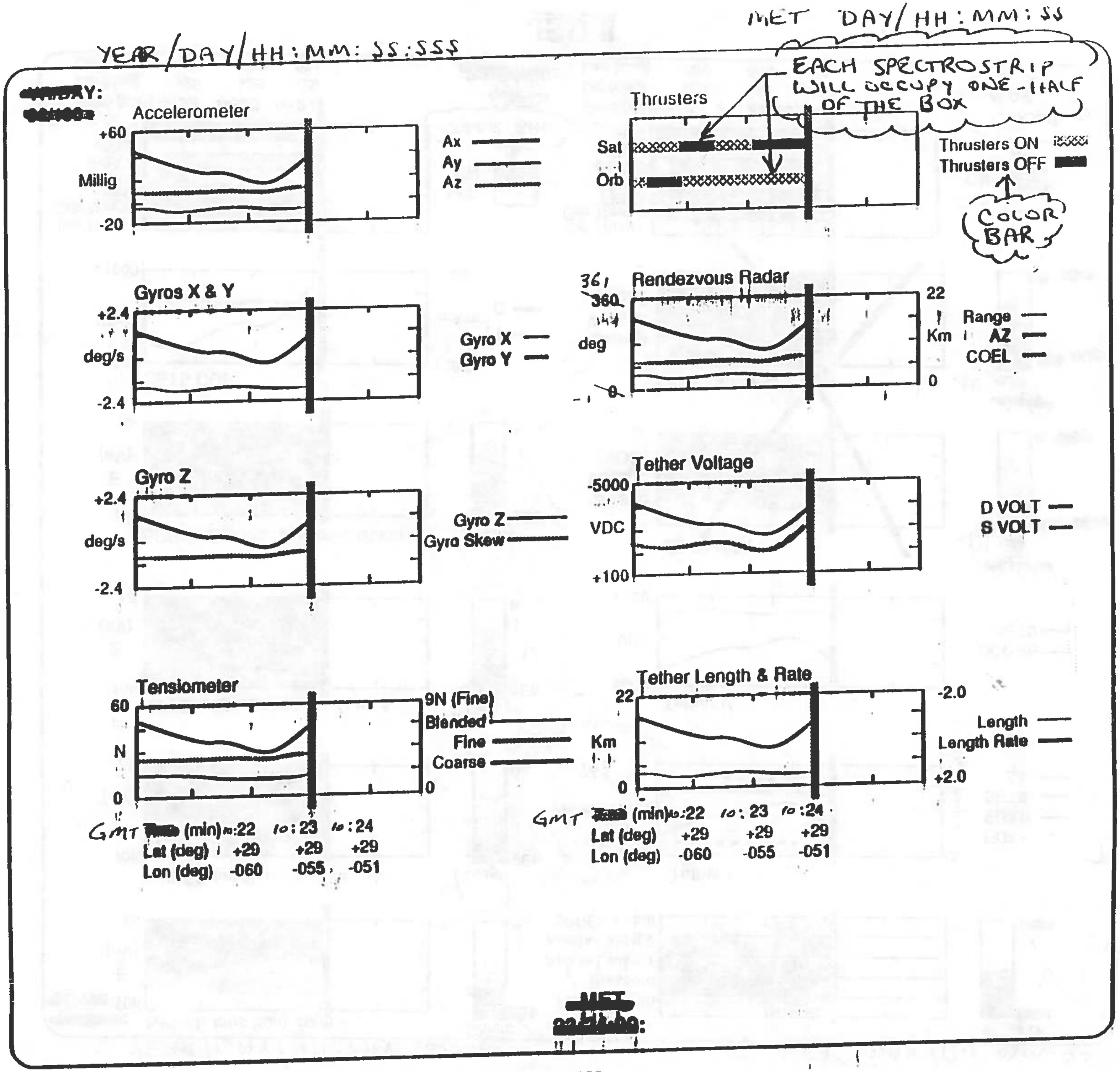
MMAG/SwRI display formats
and
MSFC/SvT display formats

SEE ATTACHMENT M FOR REPRESENTATIVE SAMPLE LINE PLOT, SPECTROSTRIP, AND SPECTROGRAM FORMAT AND ANNOTATION


YEAR/DAY/HH:MM:SS:SSS
MET DAY/HH:MM:SS
RETE
+12
-12
KV
Sat Ptnl
Bias Curr
dC-E
Ion Flux
DIFP
+100
0
-100
Defl (VDC)
Amps
5E-6
5E-11
scale relative to uAmps scale
TEMAG (Outboard)
+65,530
B (nT)
-65,530
Bx
By
Bz
Retarding Voltage (VDC)
RETE E-Field (Ex)
12M
freq (Hz)
0.16K
(mV)²/Hz
1000
0.1
SPES-1
Ions
Diff E Flux
10
10⁻³
10E-4
RETE B-Field (Bx)
SPES-2
Electrons
10⁻²
RETE Langmuir Probe
15 TBR
Volts
-5 TBR
Amps
10⁻⁵
-10⁻⁵
SPES-3
Sat Thrstrs
Orb Thrstrs
FPEG
EGA 1
EGA 2
Water
FES
OFF
ON
COLOR BAR
GMT
Time (min)
Lat (deg)
Lon (deg)
10:22
10:23
10:24
+29
-060
-055
-051

JSD

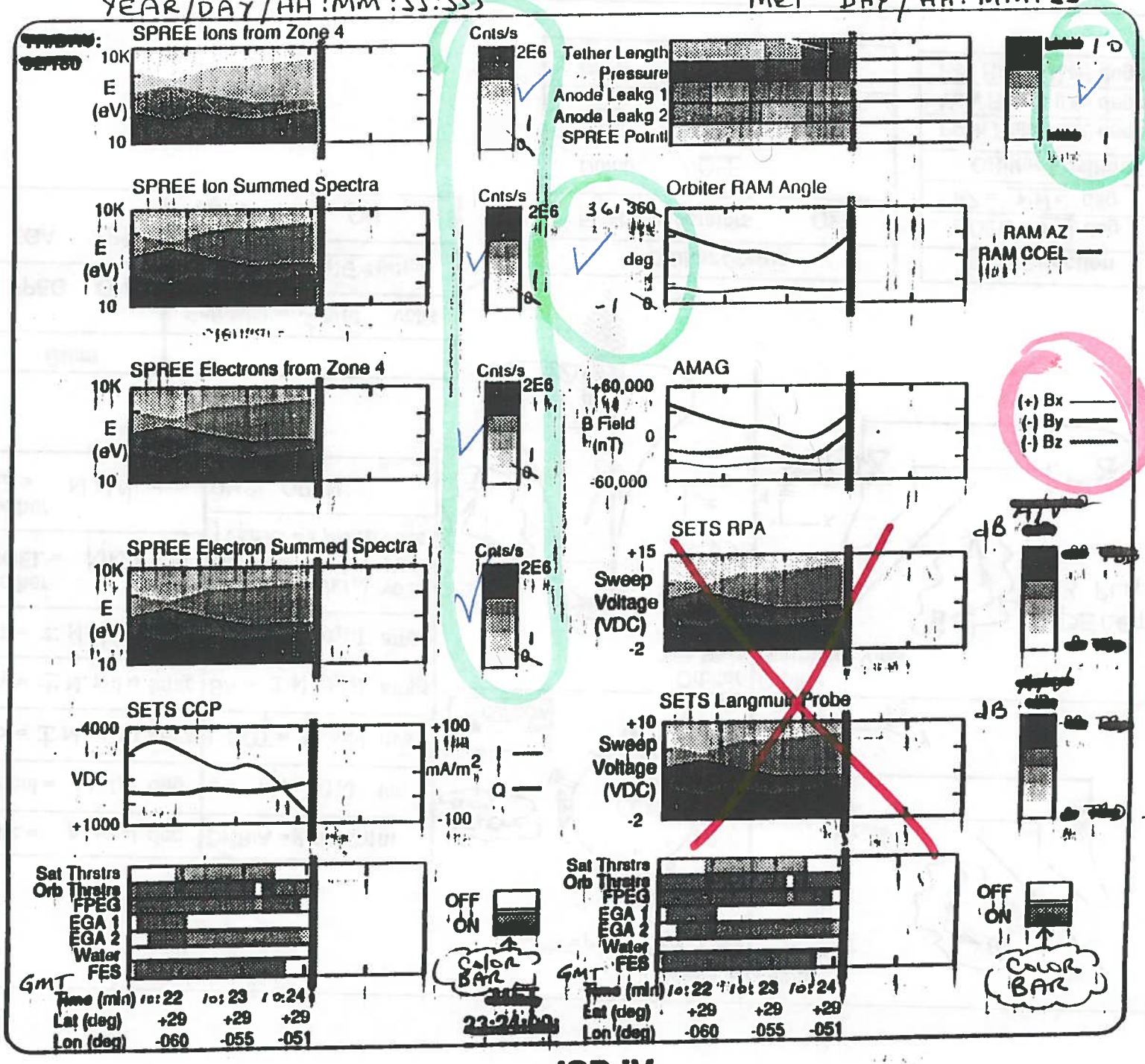

YEAR/DAY/HH:MM:SS:SSS
MET DAY/HH:MM:SS
SPREE Ions from Zone 4
10K
E
(eV)
10
Cnts/s
2E6
0
Tether Length
Pressure
Anode Leakg 1
Anode Leakg 2
SPREE Potntl
10
SPREE Ion Summed Spectra
Tether I
765
0.75
mA
Amps
-765
5
0
-5
EGA1
EGA2
SETS
SA
0-765 mA
± 0.6 amps
± 5 amps
SPREE Electrons from Zone 4
Tether V
-5000
VDC
+100
DCORE
SETS
SPREE Electron Summed Spectra
SETS RPA
+15
Sweep
Voltage
(VDC)
-2
dB
0
-80
SETS CCP
-4000
VDC
+1000
+100
mA/m2
I
Q
-100
SETS Langmuir Probe
+10
Sweep
Voltage
(VDC)
-2
Sat Thrstrs
Orb Thrstrs
FPEG
EGA 1
EGA 2
Water
FES
OFF
ON
COLOR BAR
GMT
Time (min)
Lat (deg)
Lon (deg)
10:22
10:23
10:24
+29
+29
+29
-060
-055
-051
?. Change to REAL Units
JSD II


YEAR/DAY/HH:MM:SS:SSS
MET DAY/HH:MM:SS
EACH SPECTROSTRIP WILL OCCUPY ONE-HALF OF THE BOX
Accelerometer
+60
Millig
-20
Ax
Ay
Az
Thrusters
Sat
Orb
Thrusters ON
Thrusters OFF
COLOR BAR
Gyros X & Y
+2.4
deg/s
-2.4
Gyro X
Gyro Y
Rendezvous Radar
361
360
deg
0
22
Km
0
Range
AZ
COEL
Gyro Z
+2.4
deg/s
-2.4
Gyro Z
Gyro Skew
Tether Voltage
-5000
VDC
+100
D VOLT
S VOLT
Tensiometer
60
N
0
9N (Fine)
Blended
Fine
Coarse
0
GMT (min) 10:22 10:23 10:24
Lat (deg) +29 +29 +29
Lon (deg) -060 -055 -051
Tether Length & Rate
22
Km
0
-2.0
+2.0
Length
Length Rate
GMT (min) 10:22 10:23 10:24
Lat (deg) +29 +29 +29
Lon (deg) -060 -055 -051

JSD III

YEAR/DAY/HH:MM:SS:SSS

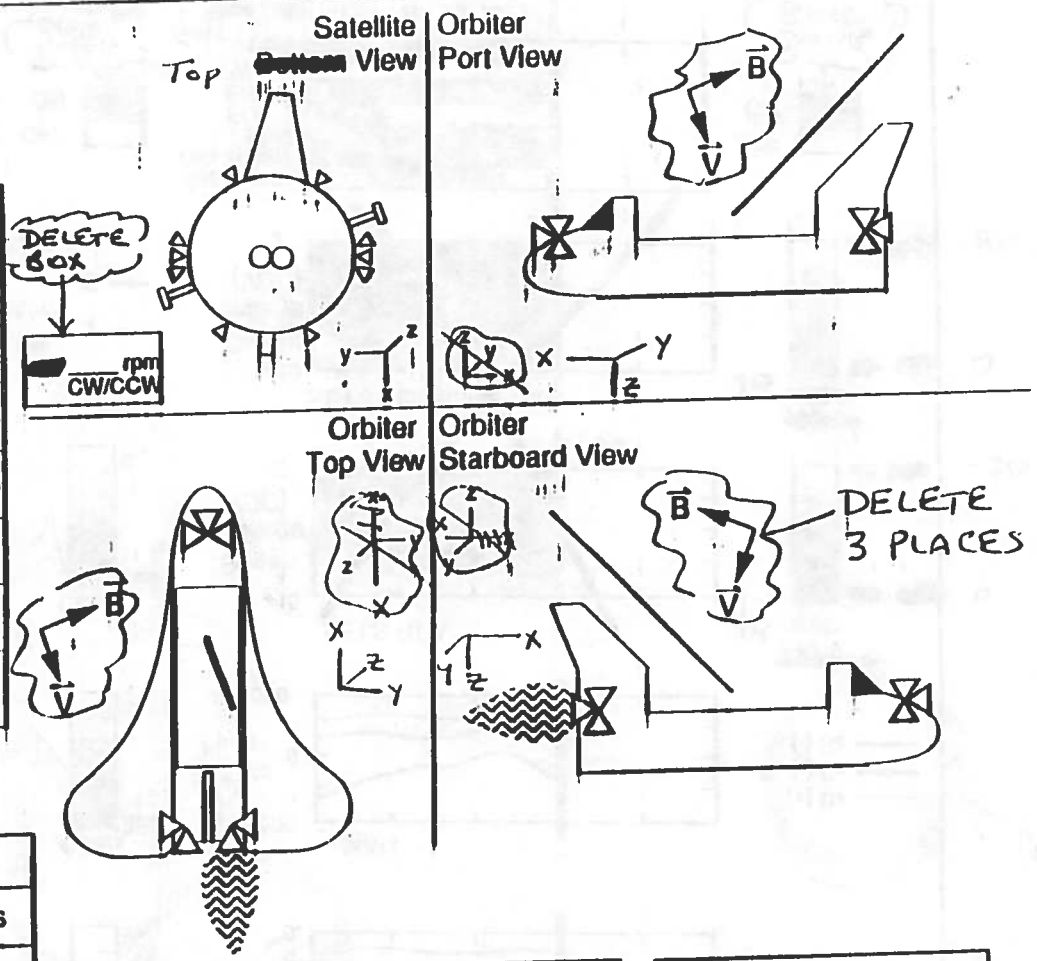
MET DAY/HH:MM:SS



according to test

.ISD IV

Baz = NNN deg	DRB:A = N.NB = N.N m
Bcoel = NNN deg	L = NN.NN km
Vx = ± N.NNN km/s	L-DOT = N.NN m/s
Vy = ± N.NNN km/s	SA = ± N.NNN amps
Vz = ± N.NNN km/s	TCM = ± .NNN amps
Tether COEL = NNN deg	DV = ± NNNN volts
	TVMDC = ± NNNN volts
Tether AZ = NNN deg	DMS OPEN



Guns	
FPEG ON	Potential = ± NN volts
EGA ON	Pressure = N.NE ± NN torr
	Accelerometer ON

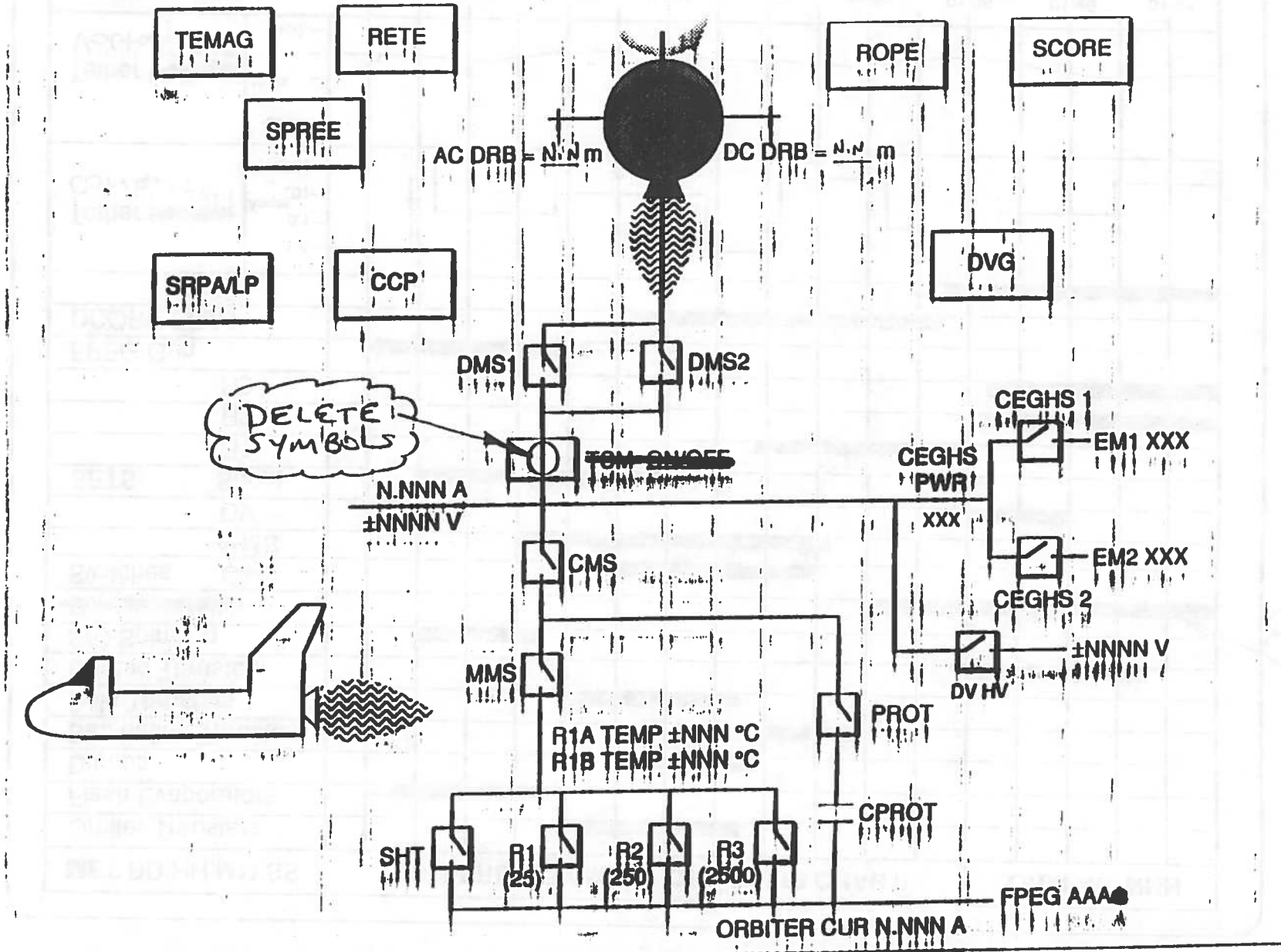
Orbiter Status	
Flash Evaporators	OFF
Dump	OFF
MET	DD:HH:MM:SS
GMT	DD:HH:MM:SS

RAM Direction
COEL = NNN deg
AZ = NNN deg
Orbiter Position
Pitch Rate = N.NN deg/s
Yaw Rate = N.NN deg/s
Roll Rate = N.NN deg/s

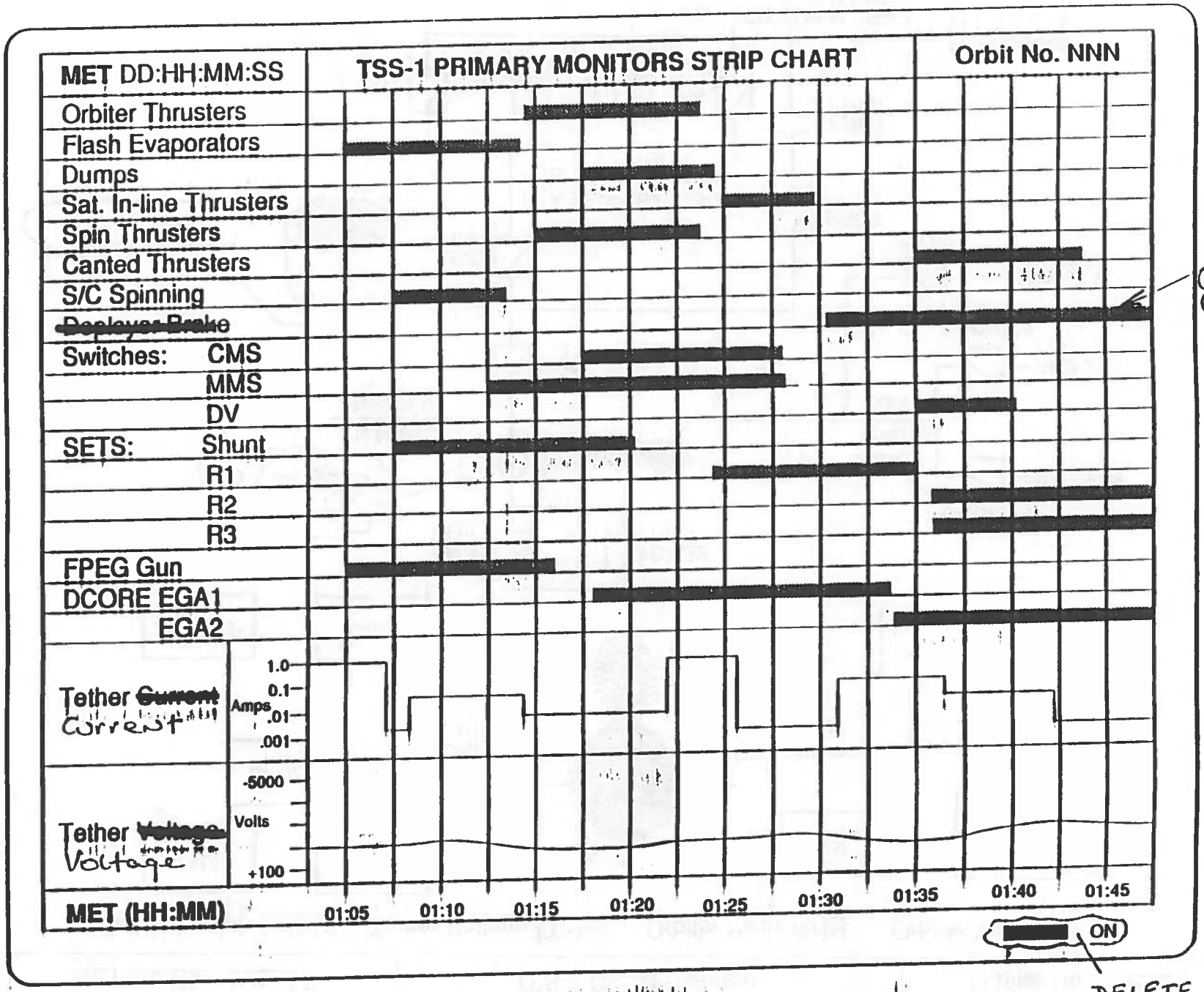
POCC

MET DD:HH:MM:SS | TSS-1 Circuit Diagram | Orbit No. NNN

Tether Length NNNNN Tether Voltage ±NNNN Orbiter Pitch NNN Orbiter Yaw NNN



POCC II


MET DD:HH:MM:SS
TSS-1 PRIMARY MONITORS STRIP CHART
Orbit No. NNN
Orbiter Thrusters
Flash Evaporators
Dumps
Sat. In-line Thrusters
Spin Thrusters
Canted Thrusters
S/C Spinning
~~Deployer Brake~~
Switches: CMS
MMS
DV
SETS: Shunt
R1
R2
R3
FPEG Gun
DCORE EGA1
EGA2
Tether ~~Current~~ Current
1.0
0.1
Amps
.01
.001
Tether ~~Voltage~~ Voltage
-5000
Volts
+100
MET (HH:MM)
01:05
01:10
01:15
01:20
01:25
01:30
01:35
01:40
01:45
DELETE BAR
ON
DELETE

POCC III

MET DD:HH:MM:SS	TSS-1 PRIMARY MONITORS TABLE	Orbit No. NNN
Orbiter	**Experiments**	**Satellite**
Attitude: R NNN P NNN Y NNN	DMS OPEN	Spin: Rate ±N.N Direction ____
LVLH RATE: R N.NN P N.NN Y N.NN	SETS Sw[redacted] ____	IL Thruster: ID ____
[redacted] Angle: AZ NNN COEL NNN	SETS: Mode ____ [redacted]	Canted Thruster: ID ____
B-Field: AZ NNN COEL NNN [redacted]	DCORE: Mode ____ [redacted]	Yaw Thruster: ID ____
Thrusters ON	SAT: I ±N.NNN	Power: P/L NNNN TOT NNNN
Flash Evaporators ON	DCORE: I NNNN V ±NNNN	DRBA [redacted] N.N DRBD [redacted] N.N
Dumps: ID ____ ON	SETS: I ±N.NNN V ±NNNN	SCORE I ±N.NNN
Lat. ±NN Long. ±NNN	SPREE Pot ±NN Chg Prb ±NNNN	Accel: X±NN.N Y±NN.N Z±NN.N
Radar Range NNNNN	Pressure ±N.N	**Deployer**
Radar COEL NNN [redacted] AZ NNN	SETS : Duration NNNNN	Tether L NNNNN
B-Field : MAG NNNNN	DCORE : Duration N.NNENN	Tether (L) ±N.NN
		Tether Tension NN

L-Dot

POCC IV

ATTACHMENT H

Pitch, Yaw and Roll LVLH Values

The following computations can be used to calculate the Orbiter pitch, yaw, and roll attitudes in the Local Vertical Local Horizontal (LVLH) reference frame, using the following downlisted data: 1) LVLH RELQUAT [Q]M50_LVLH, 2) body-to-inertial quaternion [Q]BDY_M50.

This computation involves a three step process using the following operations:

1. [Q]BDY_LVLH = [Q]BDY_M50 * [Q]M50_LVLH
2. [Q]LVLH_BDY = Conjugate [Q]BDY_LVLH
3. Extract Pitch, Yaw, and Roll Euler angles from [Q]LVLH_BDY in the P-Y-R sequence.

The following definitions will be used to define the variables in the detailed equations. [Q]M50_LVLH will be defined as [QL]M50_LVLH with elements L1, L2, L3, and L4. [Q]BDY_M50 will be defined as [QI]BDY_M50 with elements I1, I2, I3, and I4. Table 1 illustrates these quaternions and their elements. These are the only input data required to calculate the Orbiter LVLH attitude.

QUATERNION	ELEMENTS	MSID#
[QI]BDY_M50	I1	V90U2240C
	I2	V90U2241C
	I3	V90U2242C
	I4	V90U2243C
[QL]M50_LVLH	L1	V90U2641C
	L2	V90U2642C
	L3	V90U2643C
	L4	V90U2644C

Table 1.

Equations 1 through 4 were derived by combining the calculation of the body-to-LVLH quaternion ([Q]BDY_LVLH) with the conjugation of the same quaternion to produce the LVLH-to-body quaternion ([Q]LVLH_BDY). These calculations were mentioned above as operations 1 and 2. The individual elements of [Q]LVLH_BDY can be calculated using the equations 1 through 4.

EQ 1. $Q1 = (I1*L1) - (I2*L2) - (I3*L3) - (I4*L4)$

EQ 2. $Q2 = -(I1*L2) - (I2*L1) - (I3*L4) + (I4*L3)$

EQ 3. $Q3 = -(I1*L3) + (I2*L4) - (I3*L1) - (I4*L2)$

EQ 4. $Q4 = -(I1*L4) - (I2*L3) + (I3*L2) - (I4*L1)$

Two or more operations must be followed to extract the pitch, yaw, and roll angles from the [Q]LVLH_BDY quaternion. First, the [Q]LVLH_BDY quaternion must be converted into key elements of a direction cosine matrix. This conversion is shown in equations 5 through 9.

EQ 5. $M21 = 2((Q2*Q3) + (Q1*Q4))$

EQ 6. $M11 = Q1^2 + Q2^2 - Q3^2 - Q4^2$

EQ 7. $M31 = 2((Q2*Q4) - (Q1*Q3))$

EQ 8. $M22 = Q1^2 - Q2^2 + Q3^2 - Q4^2$

EQ 9. $M23 = 2((Q3*Q4) - (Q1*Q2))$

Equations 5 through 9 contain all of the information required to determine the LVLH attitude of the Orbiter. These angles can be extracted using equations 10 through 19.

YAW

EQ 10. $YAW = \sin^{-1}(M21)$

EQ11. If Yaw < 0 then $YAW = 360 + YAW$

PITCH

EQ 12. $arg = M11 / (\cos YAW)$

EQ 13. If $|arg| > 1$ then $arg = arg / |arg|$

EQ 14. $PITCH = \cos^{-1} arg$

EQ 15. If $-M31/(\cos YAW) < 0$ then $PITCH = 360 - PITCH$

ROLL

EQ 16. $arg = M22 / (\cos YAW)$

EQ 17. If $|arg| > 1$ then $arg = arg/|arg|$

EQ 18. $ROLL = \cos^{-1} arg$

EQ 19. If $-M23/(\cos YAW) < 0$ then $ROLL = 360 - ROLL$

Equations 1 through 19 can be used to build algorithms that will compute the Orbiter LVLH attitude given the LVLH RELQUAT and the body-to-inertial quaternion.

ATTACHMENT I

Orbiter Lattitude and Longitude

To obtain orbiter Lattitude and Longitude form, the following computation is required:

CAS No. V95H0185C: Shuttle X position = X_I
CAS No. V95H0186C: Shuttle Y position = Y_I
CAS No. V95H0187C: Shuttle Z position = Z_I

First, recognize that the CAS parameters are given with respect to AM50. So, the angle from the vernal equinox to Greenwich Meridian must be calculated (GST). The following 2 Foruran subroutines will compute GST:

JULDAT

This routine computes the Julian Day Number (AJD) from the calender date and Greenwich Mean Time (GMT). Also, computed is the Day of the Year number.

```
SUBROUTINE JULDAT(MON,IDAY,IYEAR,GMT,AJD,DAYNO)
DOUBLE PRECISION AJD,AJX,AJDJAN0,PSF
DIMENSION J(2,12)
DATA J/1,12,1,12,20*0/
IY=IYEAR-J(1,MON)
IM=MON   +J(2,MON)
PSF=0.
IF(IY.LT.0)PSF=.75
AJX=DINT(365.25D0*IY-PSF)+DINT(30.6001D0*(IM+1))+IDAY+1720994.5D0
IF(AJX.GT.2299170.D0)AJX=AJX+2-INT(IY/100)+INT(INT(IY/100)/4)
AJD=AJX+GMT/24.
```

ATTACHMENT I

(cont.)

GST

This routine computes the Greenwich Sidereal Time from the Julian Day Number and the Greenwich Mean Time.

```
FUNCTION GST(AJD,GMT)
IMPLICIT DOUBLE PRECISION (A-H,O-Z)
REAL GMT
DATA C1/.2617993878D+00/C2/1.739935894D+00/C3/628.3319511D+00/
DATA C4/.67559D-5/CJ/2415020.D+0/
TU=(AJD-CJ)/36525.
D=C1*GMT + C2 + C3*TU + C4*TU*TU
GST=PRIN(D)
RETURN
END
```

Next, compute XE, YE, ZE

$$\begin{pmatrix} X_E \\ Y_E \\ Z_E \end{pmatrix} = (GST)_Z \begin{pmatrix} X_I \\ Y_I \\ Z_I \end{pmatrix} = \begin{bmatrix} \cos(GST) & \sin(GST) & 0 \\ -\sin(GST) & \cos(GST) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} X_I \\ Y_I \\ Z_I \end{pmatrix}$$

From here,

Longitude = $\tan^{-1}(Y_E/X_E)$ angle = $\pm 180^\circ$

Latitude = $\sin\text{-}1(Z_E/R)$ angle = $\pm 90^\circ$

where $R = (x^2 + Y^2 + Z^2)^{1/2}$

50
33

ATTACHMENT J

RAM Az and COEL Angles

To obtain the RAM Az and Coel angles, the following equations should be used:

1. $[\vec{V}bar]_{M50}[q\_bod\_M50] = [\vec{V}bar]_{Body}$
2. Unitize $[\vec{V}bar]_{Body}$
3. $Az = \tan^{-1}(-Vbar_{Body\ Y}/-Vbar_{Body\ X})$
4. $Coel = \cos^{-1}(-\vec{V}bar_{Body\ Z})$

The following telemetry inputs are:

$[\vec{V}bar]_{M50}$ =	V95L0190C: X-Comp of Current Shuttle Vel Vctr
	V95L0191C: Y-Comp of Current Shuttle Vel Vctr
	V95L0192C: Z-Comp of Current Shuttle Vel Vctr
[q_bod_M50] =	V90U2240C: M50-To-Measured Body QUAT ELE 1
	V90U2241C: M50-To-Measured Body QUAT ELE 2
	V90U2242C: M50-To-Measured Body QUAT ELE 3
	V90U2243C: M50-To-Measured Body QUAT ELE 4

The quaternion multiplication subroutine is provided on the attached pages.

Note: This lattitude calculation is also refered to as Geocentric Declination. It does not contain nutation (less than 1 arcmin error). It should not be confused with Geodedic Lattitude, which uses the local vertical to compute lattitude. At 45° lattitude, there is about 0.2° difference between the 2; at the equator and at the poles, the 2 are the same.

```
C-- Subroutine QVEC
C*************************************************************************
C       QVEC - This Routine performs the rotational transformation
C              of the input vector VEC_IN by the quaternion QUAT and
C              returns the transformed vector in VEC_OUT.
C
C       Input Variables:
C           Double Precision:
C               vec_in    The input vector to be transformed.
C               quat      The input Quaternion describing the rotation
C                         from the frame of VEC_IN to the destination
C                         frame of VEC_OUT.
C
C       Output Variables:
C           Double Precision:
C               vec_out   The transformed vector.
C
C       Local Variables:
C           Double Precision:
C               temp_dp1  A reoccuring value used in transforming the
C                         input vector.
C               temp_dp2  A reoccuring value used in transforming the
C                         input vector.
C
C       Originally coded by: MPAD
C       Modified by: Craig Vosburgh/DH45 RSOC x30344
C       Documented by: Craig Vosburgh/DH45 RSOC x30344
C*************************************************************************
C>

        subroutine qvec(quat,vec_in,vec_out)

C>
C*************************************************************************
C       Declare them variables.
C*************************************************************************

        doubleprecision
     &          vec_in(3),vec_out(3),quat(4),temp_dp1,temp_dp2

C<
C>
C*************************************************************************
C       Compute the repetative terms.
C*************************************************************************

        temp_dp1 = 2.d0*quat(1)**2-1.d0
        temp_dp2 = 2.d0*(quat(2)*vec_in(1)+quat(3)*vec_in(2) +
     &                   quat(4)*vec_in(3))

C<
C>
C*************************************************************************
C       Transform the Input vector into the destination frame using
C       the supplied Quaternion.
C*************************************************************************

        vec_out(1) = temp_dp1*vec_in(1)+temp_dp2*quat(2) +
     &               2.d0*quat(1)*(quat(3)*vec_in(3)-quat(4)*vec_in(2))
        vec_out(2) = temp_dp1*vec_in(2)+temp_dp2*quat(3) +
```

```
     &                    2.d0*quat(1)*(quat(4)*vec_in(1)-quat(2)*vec_in(3))
          vec_out(3) =    temp_dp1*vec_in(3)+temp_dp2*quat(4) +
     &                    2.d0*quat(1)*(quat(2)*vec_in(2)-quat(3)*vec_in(1))
C<
C<
          return
          end
```

ATTACHMENT K

Pitch, Yaw, and Roll LVLH Rates

The following computations can be used to calculate the Orbiter pitch, yaw, and roll body rates in the Local Vertical Local Horizontal (LVLH) reference frame, compensating for the orbital rate.

This computation involves a four step process using the following operations:

1. Calculate Orbiter-LVLH attitude.
2. Calculate the Orbiter orbital rate.
3. Resolve the orbital rate into body axes.
4. Subtract the orbital body rates from the actual body rates.

Step one will not be addressed in this memo. It is assumed that the Orbiter-LVLH attitude will be calculated via a special computation, and the pitch, yaw, and roll angles will be available for use in this computation.

The following definitions will be used in the equations which make up this special computation.

VARIABLE	VALUE/SOURCE	DEFINITION
U	$1.407646882 \times 10^{16}$ (ft^3/s^2)	Newtonian Gravitational Constant
H	V90H4945C	Orbiter altitude in feet
E	20925672.57 (ft)	Average radius of the Earth in feet
YAW	special computation	Orbiter-LVLH yaw angle
ROLL	special computation	Orbiter-LVLH roll angle
OR	equation 1	Orbital rate in deg/sec
R_{bdy}	V90R2223C	IMU derived body roll rate
P_{bdy}	V90R2224C	IMU derived body pitch rate
Y_{bdy}	V90R2225C	IMU derived body yaw rate
R_{or}	equation 2	Orbital rate resolved into Orbiter roll axis
P_{or}	equation 3	Orbital rate resolved into Orbiter pitch axis

Y_{or}	equation 4	Orbital rate resolved into Orbiter yaw axis
R_{lvlh}	equation 5	Orbiter roll rate in the LVLH reference frame
P_{lvlh}	equation 6	Orbiter pitch rate in the LVLH reference frame
Y_{lvlh}	equation 7	Orbiter yaw rate in the LVLH reference frame

The orbital rate (deg/sec) of the vehicle can be calculated as shown in equation 1.

$$\text{EQ1.} \quad OR = \frac{(U(E+H))^{\frac{1}{2}}}{(E+H)^2} * \frac{180}{pi}$$

If the orbital rate cannot be calculated due to processing time or the value of H is not available, then a default value of .066°/sec can be used (OR = .066°/sec).

Once the orbital rate has been calculated, it must be resolved into Orbiter body axes (deg/sec). This can be done by performing equations 2, 3, and 4.

$$\text{EQ. 2} \quad R_{or} = -OR * (\sin YAW)$$

$$\text{EQ. 3} \quad P_{or} = -OR * (\cos YAW) * (\cos ROLL)$$

$$\text{EQ. 4} \quad Y_{or} = -OR * (-\cos YAW) * (\sin ROLL)$$

Finally, the Orbiter rates in the rotating LVLH reference frame can be calculated by subtracting the orbital rate in body axes from the actual body rates of the vehicle. This process is shown in equations 5, 6, and 7.

$$\text{EQ. 5} \quad R_{lvlh} = R_{bdy} - R_{or}$$

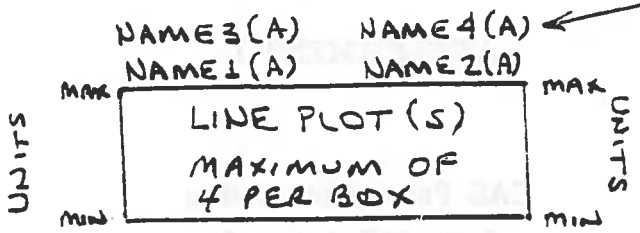
$$\text{EQ. 6} \quad P_{lvlh} = P_{bdy} - P_{or}$$

$$\text{EQ. 7} \quad Y_{lvlh} = Y_{bdy} - Y_{or}$$

ATTACHMENT L

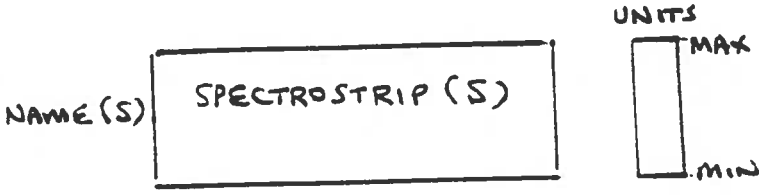
CAS Parameter Listing
from PIP Annex 5

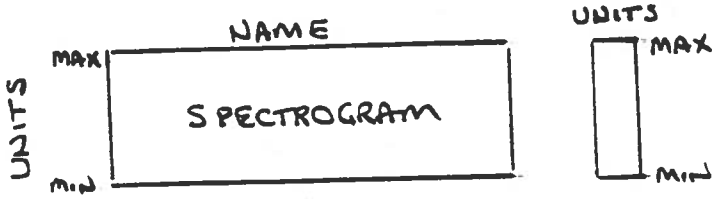
ATTACHMENT M



(A) = (L) LEFT AXIS
(A) = (R) RIGHT AXIS

LINE PLOT AND ASSOCIATED NAME ARE SAME COLOR





FULL SCALE
COLOR BAR
RANGE IS:
RED (MAXIMUM)
YELLOW
GREEN
BLUE
PURPLE (MINIMUM)