

# ***Global Positioning System (GPS) Constellation Status***

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# Overview



- Overall GPS Constellation Health/Status
- GPS Constellation Age
- Status of GPS Satellite Subsystems
- U.S. Launch Forecast
- Summary

# Navigation Signal Availability



	A	B	C	D	E	F
1	SVN 39 PRN 09	SVN 22 PRN 22	SVN36 PRN06	SVN 24 PRN 24	SVN 51 PRN 20	SVN 41 PRN 14
2	SVN 25 PRN 25	SVN 30 PRN 30	SVN 33 PRN 03	SVN 46 PRN 11	SVN 21 PRN 21	SVN 26 PRN 26
3	SVN 38 PRN 08	SVN 13 PRN 02	SVN 31 PRN 31	SVN 17 PRN 17	SVN 40 PRN 10	SVN 43 PRN 13
4	SVN 27 PRN 27	SVN 35 PRN 05	SVN 37 PRN 07	SVN 34 PRN 04	SVN 23 PRN 23	SVN 32 PRN 01
5	SVN 19 PRN 19	SVN 44 PRN 28		SVN 15 PRN 15		SVN 29 PRN 29

**MMD:**  $\Pi=9.22$  yrs  
 IIA=10.68yrs  
 IIR=7.84yrs  
 IIF=12.7yrs

**28 Operational Satellites**  
 5- Block IIs  
 18 -Block IIAs  
 5- Block IIRs

As of 28 November 2000

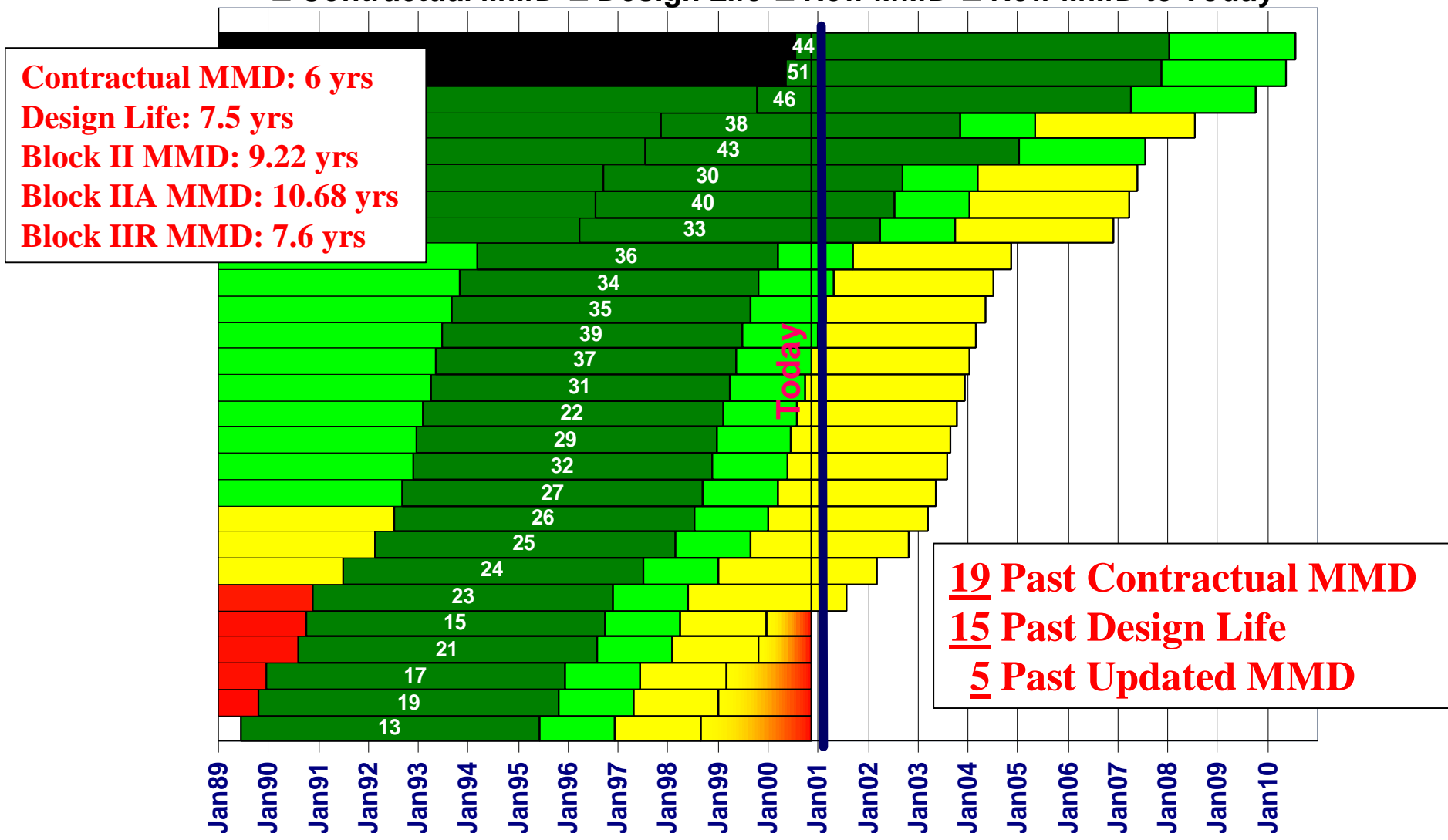
30 November 2000

# Constellation Status

Launch through MMD

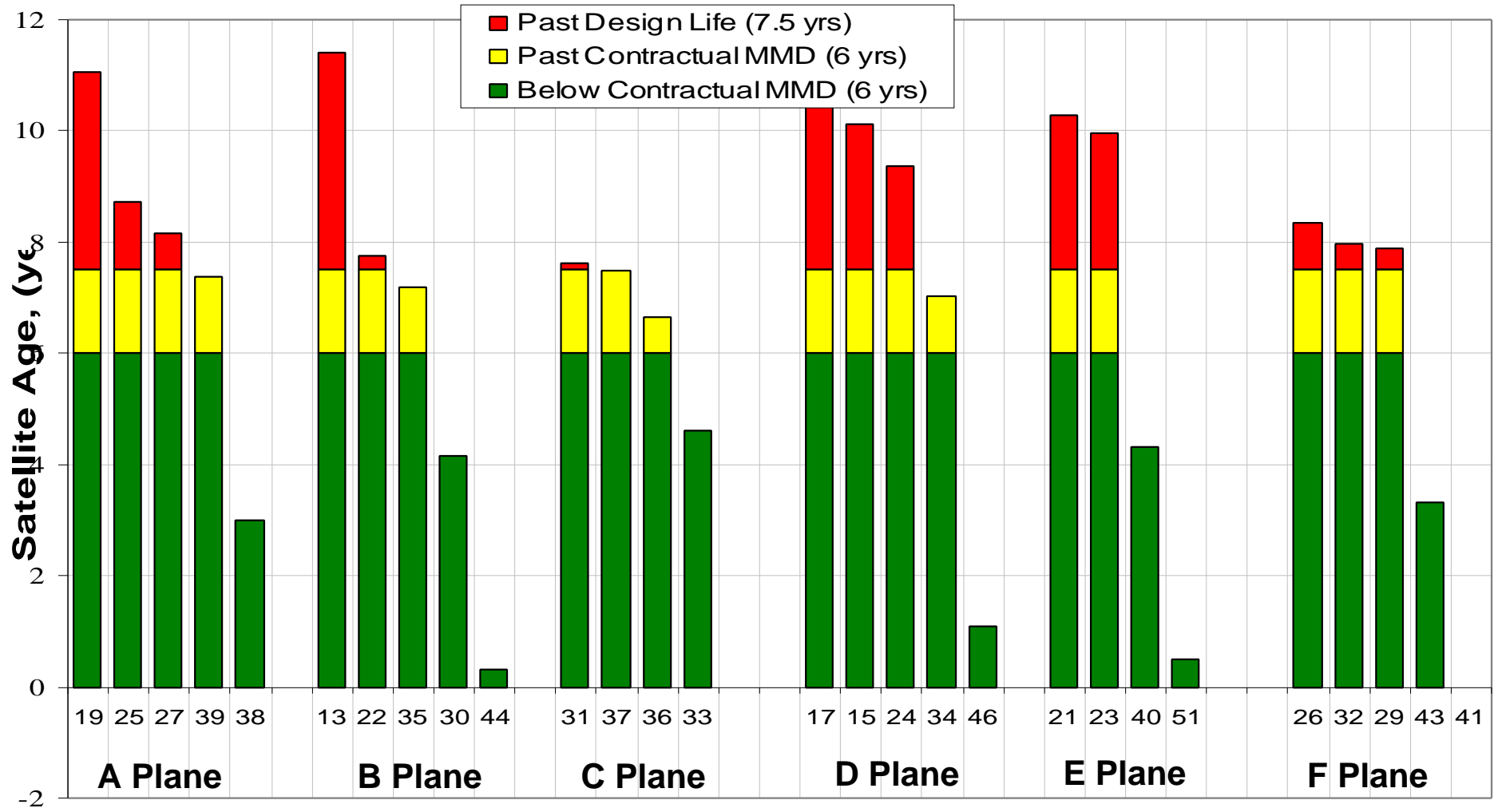


■ Contractual MMD ■ Design Life ■ New MMD ■ New MMD to Today



# Constellation Status

## Age by Plane





# Constellation Status

## Subsystem Assessment



	A	B	C	D	E	F
1	SVN 39 [Green]	SVN 22 [Yellow]	SVN 36 [Green]	SVN 24 [Yellow]	SVN 51 [Green]	SVN 41 [Green]
2	SVN 25 [Yellow]	SVN 30 [Yellow]	SVN 33 [Green]	SVN 46 [Green]	SVN 21 [Yellow]	SVN 26 [Yellow]
3	SVN 38 [Green]	SVN 13 [Yellow]	SVN 31 [Yellow]	SVN 17 [Green]	SVN 40 [Yellow]	SVN 43 [Green]
4	SVN 27 [Yellow]	SVN 35 [Green]	SVN 37 [Yellow]	SVN 34 [Green]	SVN 23 [Yellow]	SVN 32 [Yellow]
5	SVN 19 [Yellow]	SVN 44 [Green]	[White]	SVN 15 [Yellow]	[White]	SVN 29 [Yellow]

### LEGEND

SVN
[Green]
[Yellow]

BUS

NAV

### Bottom Line

16 out of 28 vehicles are yellow  
 9 vehicles are yellow due to bus failures  
 12 vehicles are yellow due to nav failures  
 >57% of constellation is degraded



# Constellation Status

## Attitude Control System



	A	B	C	D	E	F
1	SVN 39 [ ][ ][ ][ ]	SVN 22 [ ][ ][ ][ ]	SVN 36 [ ][ ][ ][ ]	SVN 24 [ ][ ][ ][ ]	SVN 51 [ ][ ][ ][ ]	SVN 41 [ ][ ][ ][ ]
2	SVN 25 [ ][ ][ ][ ]	SVN 30 [ ][ ][ ][ ]	SVN 33 [ ][ ][ ][ ]	SVN 46 [ ][ ][ ][ ]	SVN 21 [ ][ ][ ][ ]	SVN 26 [ ][ ][ ][ ]
3	SVN 38 [ ][ ][ ][ ]	SVN 13 [ ][ ][ ][ ]	SVN 31 [ ][ ][ ][ ]	SVN 17 [ ][ ][ ][ ]	SVN 40 [ ][ ][ ][ ]	SVN 43 [ ][ ][ ][ ]
4	SVN 27 [ ][ ][ ][ ]	SVN 35 [ ][ ][ ][ ]	SVN 37 [ ][ ][ ][ ]	SVN 34 [ ][ ][ ][ ]	SVN 23 [ ][ ][ ][ ]	SVN 32 [ ][ ][ ][ ]
5	SVN 19 [ ][ ][ ][ ]	SVN 44 [ ][ ][ ][ ]	[ ][ ][ ][ ]	SVN 15 [ ][ ][ ][ ]	[ ][ ][ ][ ]	SVN 29 [ ][ ][ ][ ]

### LEGEND

BLK II/IA	BLK IIR
[ ][ ][ ][ ]	[ ][ ][ ][ ]
WHEELS DCEA CSCD SENSORS	WHEELS SPU SENSORS

### Bottom Line

8 vehicles with degraded attitude control  
3 Wheel, 2 Sensor, and 2 DCEA Failures



# Constellation Status

## Reaction Wheels



	A	B	C	D	E	F
1	SVN 39 [Green][Green][Green]	SVN 22 [Green][Green][Green]	SVN 36 [Green][Green][Green]	SVN 24 [Yellow][Red][Grey]	SVN 51 [Green][Green][Green]	SVN 41 [Green][Green][Green]
2	SVN 25 [Green][Green][Green]	SVN 30 [Green][Green][Green]	SVN 33 [Green][Green][Green]	SVN 46 [Green][Green][Green]	SVN 21 [Grey][Grey][Grey]	SVN 26 [Green][Green][Green]
3	SVN 38 [Green][Green][Green]	SVN 13 [Grey][Grey][Grey]	SVN 31 [Green][Green][Green]	SVN 17 [Grey][Grey][Grey]	SVN 40 [Green][Green][Green]	SVN 43 [Green][Green][Green]
4	SVN 27 [Green][Green][Green]	SVN 35 [Green][Green][Green]	SVN 37 [Green][Green][Green]	SVN 34 [Green][Green][Green]	SVN 23 [Grey][Grey][Grey]	SVN 32 [Green][Green][Green]
5	SVN 19 [Grey][Grey][Red]	SVN 44 [Green][Green][Green]	[White][White][White]	SVN 15 [Yellow][Red][Grey]	[White][White][White]	SVN 29 [Green][Green][Green]

### LEGEND



WHEEL 1  
WHEEL 2  
WHEEL 3  
WHEEL 4



LOW-LUBE DESIGN

### Bottom Line

**43% of low lube vehicles with at least one failed reaction wheel**





# Constellation Status

## Electrical Power System



	A	B	C	D	E	F
1	SVN 39 [ ] [ ] [ ]	SVN 22 [ ] [ ] [ ]	SVN 36 [ ] [ ] [ ]	SVN 24 [ ] [ ] [ ]	SVN 51 [ ] [ ] [ ]	SVN 41 [ ] [ ] [ ]
2	SVN 25 [ ] [ ] [ ]	SVN 30 [ ] [ ] [ ]	SVN 33 [ ] [ ] [ ]	SVN 46 [ ] [ ] [ ]	SVN 21 [ ] [ ] [ ]	SVN 26 [ ] [ ] [ ]
3	SVN 38 [ ] [ ] [ ]	SVN 13 [ ] [ ] [ ]	SVN 31 [ ] [ ] [ ]	SVN 17 [ ] [ ] [ ]	SVN 40 [ ] [ ] [ ]	SVN 43 [ ] [ ] [ ]
4	SVN 27 [ ] [ ] [ ]	SVN 35 [ ] [ ] [ ]	SVN 37 [ ] [ ] [ ]	SVN 34 [ ] [ ] [ ]	SVN 23 [ ] [ ] [ ]	SVN 32 [ ] [ ] [ ]
5	SVN 19 [ ] [ ] [ ]	SVN 44 [ ] [ ] [ ]	[ ] [ ] [ ] [ ] [ ] [ ]	SVN 15 [ ] [ ] [ ]	[ ] [ ] [ ] [ ] [ ] [ ]	SVN 29 [ ] [ ] [ ]

**LEGEND**

SVN
[ ] [ ] [ ]

ARRAYS  
BATTERIES  
SENSORS

**Bottom Line**  
**3 vehicles with degraded EPS capabilities**



# Constellation Status

Telemetry, Tracking & Commanding System



	A	B	C	D	E	F
1	SVN 39 [ ][ ]	SVN 22 [ ][ ]	SVN 36 [ ][ ]	SVN 24 [ ][ ]	SVN 51 [ ][ ]	SVN 41 [ ][ ]
2	SVN 25 [ ][ ]	SVN 30 [ ][ ]	SVN 33 [ ][ ]	SVN 46 [ ][ ]	SVN 21 [ ][ ]	SVN 26 [ ][ ]
3	SVN 38 [ ][ ]	SVN 13 [ ][ ]	SVN 31 [ ][ ]	SVN 17 [ ][ ]	SVN 40 [ ][ ]	SVN 43 [ ][ ]
4	SVN 27 [ ][ ]	SVN 35 [ ][ ]	SVN 37 [ ][ ]	SVN 34 [ ][ ]	SVN 23 [ ][ ]	SVN 32 [ ][ ]
5	SVN 19 [ ][ ]	SVN 44 [ ][ ]	[ ][ ] [ ][ ]	SVN 15 [ ][ ]	[ ][ ] [ ][ ]	SVN 29 [ ][ ]

LEGEND



UPLINK  
DOWNLINK  
LOCKOUT



SUSCEPTIBLE TO AUX LOCKOUT

Bottom Line

3 vehicles with degraded TT&C capabilities



# Constellation Status

## Navigation Payload



	A	B	C	D	E	F
1	SVN 39 [Green]	SVN 22 [Yellow]	SVN 36 [Green]	SVN 24 [Yellow]	SVN 51 [Green]	SVN 41 [Green]
2	SVN 25 [Yellow]	SVN 30 [Yellow]	SVN 33 [Green]	SVN 46 [Green]	SVN 21 [Yellow]	SVN 26 [Yellow]
3	SVN 38 [Green]	SVN 13 [Yellow]	SVN 31 [Yellow]	SVN 17 [Green]	SVN 40 [Yellow]	SVN 43 [Green]
4	SVN 27 [Yellow]	SVN 35 [Green]	SVN 37 [Green]	SVN 34 [Green]	SVN 23 [Green]	SVN 32 [Yellow]
5	SVN 19 [Yellow]	SVN 44 [Green]	[White]	SVN 15 [Green]	[White]	SVN 29 [Green]

### LEGEND

BLK II/IIA	BLK IIR
CLOCKS	CLOCKS
FSDU	FSU
NDU	MDU
L-BAND	L-BAND

### Bottom Line

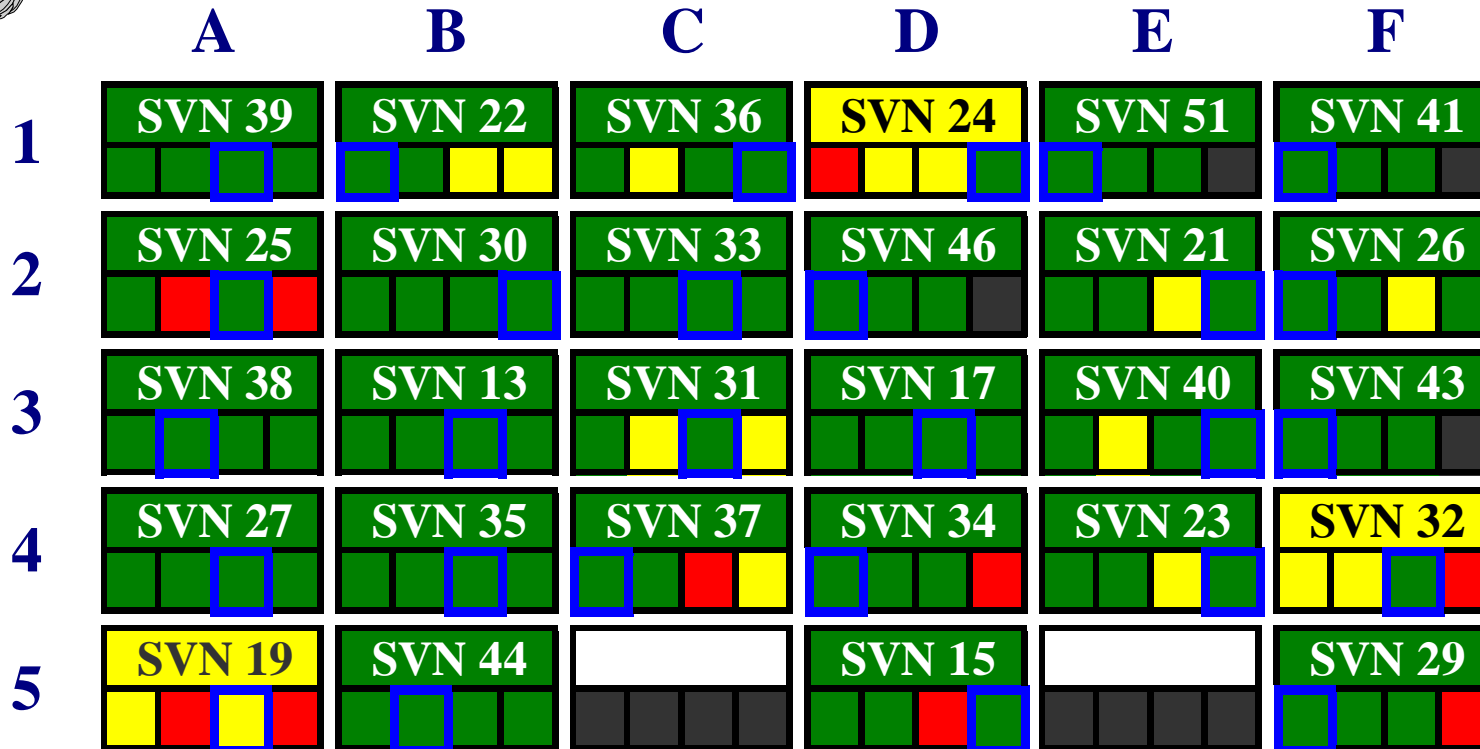
12 vehicles with degraded Nav payload capabilities

3 vehicles single string in two Nav payload subsystems

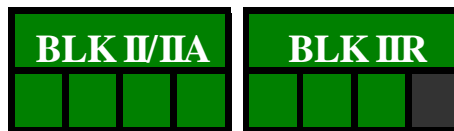


# Constellation Status

Clocks



**LEGEND**



Operational Clock

RB 1 RB 2 CS 3 CS 4 RB 1 RB 2 RB 3

Bottom Line

SVNs 19, 24, 32,--on last clock

# Constellation Status

## Bottom Line



- 19 SVs past contractual mean mission duration (6 years)
- 15 SVs past design life (7.5 years)
- 5 SVs past updated mean mission duration (II--9.22, IIA--10.68, IIR--7.84)
- 12 SVs one component away from navigation mission failure
- 9 SVs one component away from bus failure
- No practical method to predict what component/SV will fail next



# *U.S. Launch Forecast for GPS*

## Programmed Launches:

- FY 01: 3 IIR (9 Nov, 30 Jan, 11 Jun)
- FY 02: 1 IIR (Oct)
- FY 03: 4 IIR Modified
- FY 04: 4 IIR Modified
- FY 05: 2 IIR Modified,
- FY 06: 2 IIR Modified, 1 IIF

# Summary



- GPS is an aging Constellation
- GPS Constellation produces a Healthy Navigation Signal
  - 28 Operational Satellites
- Scheduled launched and upgrades will improve performance
  - Continue to support world-wide users
  - Moving towards meeting future requirements



## ***Back-Up Slides***



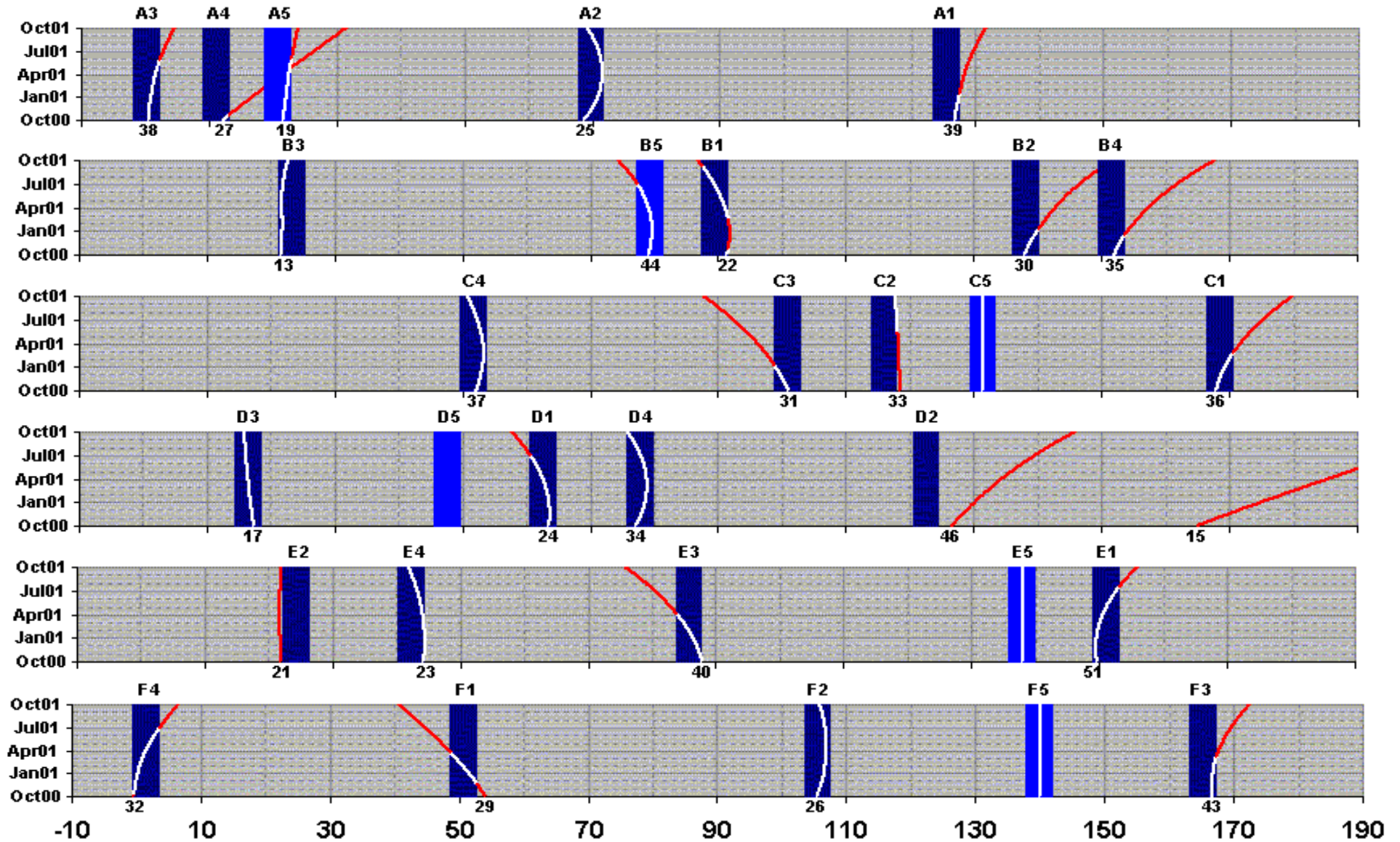


# *Constellation Activity*

- Recent constellation activity (since 18 August 2000)
  - SVN18 (F3) disposed due to DCEA and Wheel failure
  - SVN43 moved from F5 to F3
  - SVN16 (E5) disposed due to clock failures
  - SVN23 (E4) Yaw Sun Sensor (YSS) degradation
  - SVN21 (E2) anomaly
  - SVN24 (D1) last clock activated
  - SVN46 (D2) A2 step 3 completed but anomaly unresolved

# Constellation Status

Satellite Slot Location with 10 October 00 Vectors





# Constellation Status

## Problem Vehicles Summary

### Plane # SV SVN Problems

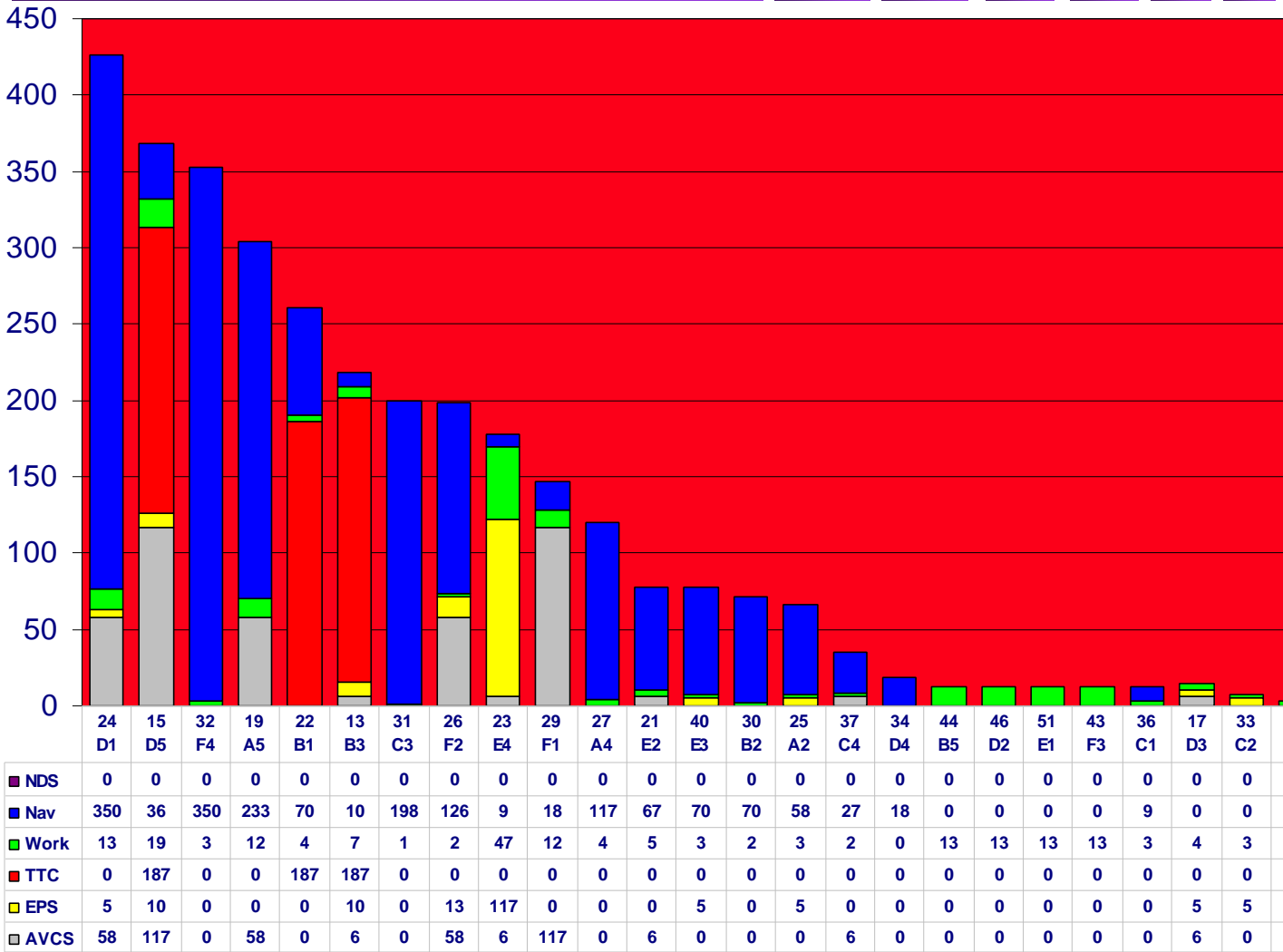
A	5	19	Clocks, Reaction Wheels
		25	NDU
		27	L Band
B	5	13	L Band, EPS, Yaw Sun Sensor, TTC
		22	TTC, FSDU
		30	NDU
C	4	31	NDU, L Band
		37	Control System Command Decoder
D	5	15	Reaction Wheels, Arrays, TTC
		24	Reaction Wheels, L Band, Clocks
E	4	21	L band
		23	Yaw Sun Sensor, Solar Array Drives, Power Level
		40	FSDU
F	4	26	Digital Control Electronics Assembly, L Band
		29	Digital Control Electronics Assembly, L Band
		32	Clocks, L Band

**RED:** lost redundancy in component required for *MISSION*

**BLUE:** lost redundancy in component required for *DISPOSAL*

# Current Disposal Metric

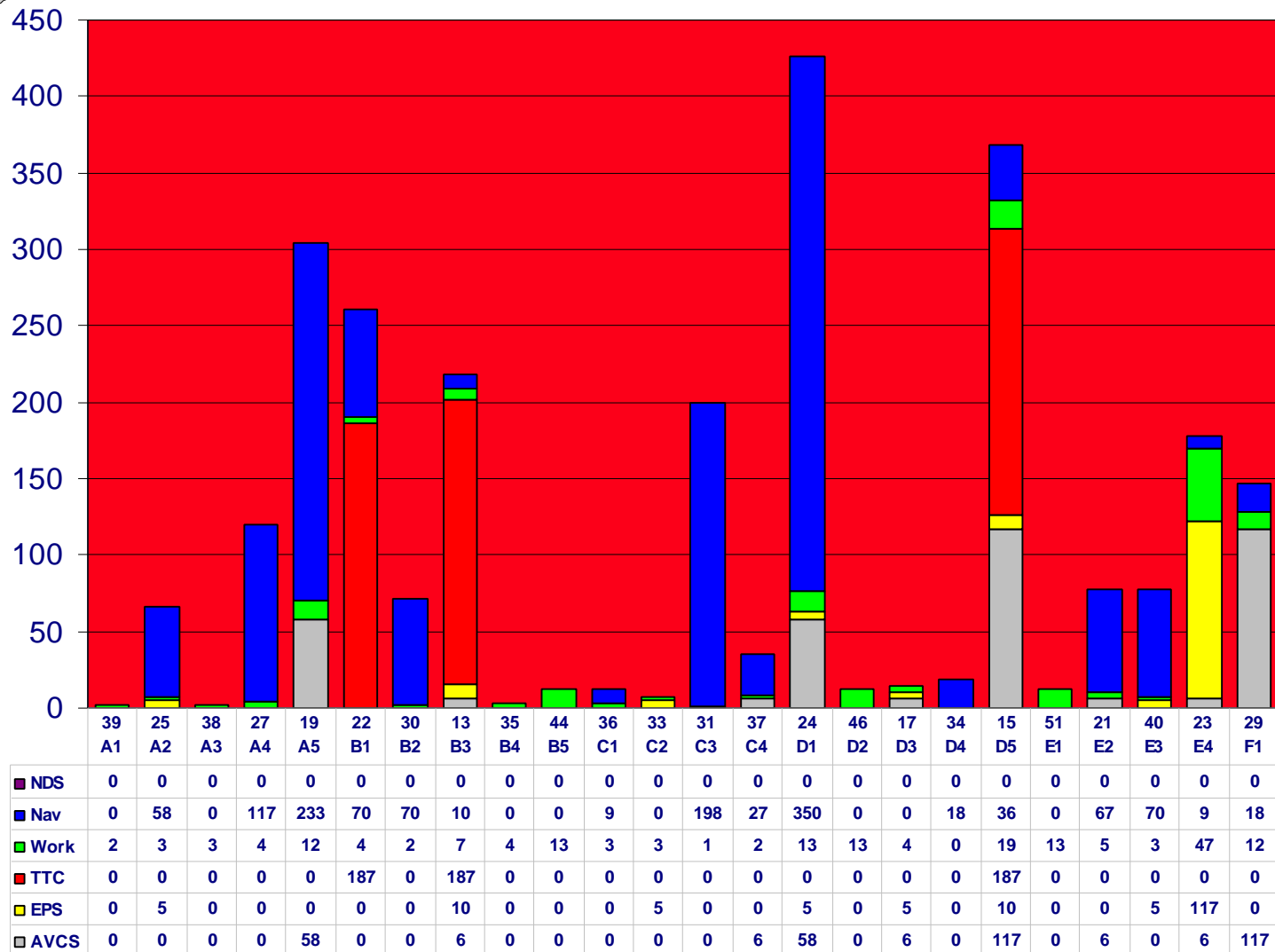
(NDS Ratings not Included)





# Current Disposal Metric by Plane

(NDS Ratings not Included)





# *Special Topics*

- **Special Consideration Satellites**
  - **SVN 19**
  - **SVN 23**
  - **SVN 29**



# SVN 19

## Clock Status

CFS#3 is SVN19's last usable clock

What is the status of CFS#3?

- **CFS #3 - Operational from 11/1/89 - 1/2/92 (2.17 Years)**
  - Deactivated originally due to frequency stepping
  - Reactivated on 9/23/99
- **One Day Stability @ 2.1E-13, Specification = 2.0 E -13**
  - Equates to very marginal clock performance
  - Averaging 2.25 navigation uploads per day
  - Stability will only get worse, **not better**
- **Beam Current = 1.39 nanoamperes**
  - Typically, any beam current less than 2 nA is reason for concern
  - Beam current **will continue to decrease**



# SVN 19

## CFS#3 Prognosis

What can be expected from CFS#3?

- **Optimistically, CFS#3 may live another 2-3 months**
  - **The problem is that its performance will continue to degrade**
- **If CFS #3 does live another 2-3 months:**
  - **Stability will degrade beyond specification**
  - **The number of contingency uploads needed will increase**
  - *It may be very difficult, if not impossible, to maintain SVN19's accuracy within the current accepted tolerance*
- **Anticipated loss drove SVN 44's orbital location**

**Bottom Line: The future performance of SVN 19's CFS is very uncertain and any performance expectations beyond a few months are extremely unwarranted**





## **SVN 23 Status**

- **9.9 years on-orbit**
  - **Past contractual MMD (6 years) and design life (7.5 years)**
  - **0.3 years short of updated Block IIA MMD (10.22 years)**
- **September loss of yaw led to discovery of sensor degradation**
  - **This eliminates scissoring as an option**
  - **Minimum of four critical supports per day for remainder of on orbit life**
- **Eclipse season from 3 Nov 2000 through 16 Dec 2000**
  - **Expect positive power balance problems**
  - **Battery reconditioning impossible due to orbital geometry**
  - **Ability to make it through this eclipse season without disabling secondary payloads is unpredictable**
  - **Workload increases to > 6 critical supports per day during eclipse**

**Bottom Line: SVN 23 continued operations is dependent on disabling part of the secondary payload.**



## **SVN 29 Status**

- **SVN29 nodal position can not be controlled**
- **Vehicle will occupy F1 node from 1 Dec 2000 to 2 April 2001**
- **Following the 2 April exit, SVN29 will not be in a primary node until it reaches the F4 slot (SVN32) in Nov 2003**
- **SVN29 time on orbit = 7.9 years**
- **Options for attempting a delta V**
  - **Following nodal exit in 2001**
  - **As required by failures of other vehicles in the plane (SVN32 or SVN26)**
  - **Following a failure of SVN29**

**Recommendation: Delay decision until a time closer to nodal exit to gain better picture of entire constellation status**

# *Current Transition Plan*



- Upgrade Dedicated Monitor Stations and Ground Antennas with New Digital Receivers and Computers
- Replace Existing Master Control Station Mainframe Computer With a Distributed Architecture
- Add Accuracy Improvement Initiative, Air Force Satellite Control Network Interface with MCS
- Build Fully Mission Capable Alternate Master Control Station (AMCS) at Vandenberg Tracking Station
- Add IIF Command and Control Functionality

**2-Step Plan: Replace Existing Mainframe With Distributed Architecture Then Add Block IIF Functionality**