

# CURRENT GPS CONSTELLATION

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# GPS SV CONSTELLATION STATUS

- 26 HEALTHY SVs
  - 5 BLOCK IIs
  - 19 BLOCK IIAs
  - 3 BLOCK IIRs
- 6 ORBIT PLANES
  - NOMINALLY 60° APART
  - 4 OR 5 SVs PER PLANE
  - SV PHASING OPTIMIZED FOR COVERAGE
    - SOME WORLD AREAS EMPHASIZED
    - NOT EQUALLY SPACED
- SEE GPS WORLD SHOWCASE *ALMANAC*
- SEE US COAST GUARD WEB PAGE
  - [WWW.NAVCEN.USCG.MIL](http://WWW.NAVCEN.USCG.MIL)



# GPS SV TYPES: PRESENT AND FUTURE

- BLOCK II, IIA
  - ROCKWELL INTERNATIONAL (NOW BOEING)
- BLOCK IIR
  - LOCKHEED MARTIN
- BLOCK IIRM
  - MODIFIED BLOCK IIR
  - ADDS M-CODE AND C/A ON L2
- BLOCK IIF LIGHT (AS OPPOSED TO IIF)
  - BOEING
  - ADDS M-CODE, C/A ON L2 AND L5 SIGNAL
- BLOCK III
  - NEW COMPETITION
  - NO NEW SIGNALS
  - ENHANCED CAPABILITIES (TO BE STUDIED FIRST)



# GPS SV ORBIT PARAMETERS USED BY RTCA FOR ANALYSIS – 24 SVs

CONSTELLATION POSITION	A (KM)	e	i (DEG)	w (DEG)	M (DEG)	W (DEG)
A1	26,559.8	0	55	0	-91.874	-87.153
A2	26,559.8	0	55	0	161.786	-87.153
A3	26,559.8	0	55	0	11.676	-87.153
A4	26,559.8	0	55	0	41.806	-87.153
B1	26,559.8	0	55	0	80.956	-27.153
B2	26,559.8	0	55	0	173.336	-27.153
B3	26,559.8	0	55	0	-155.624	-27.153
B4	26,559.8	0	55	0	-50.024	-27.153
C1	26,559.8	0	55	0	111.876	32.847
C2	26,559.8	0	55	0	11.796	32.847
C3	26,559.8	0	55	0	-20.334	32.847
C4	26,559.8	0	55	0	-118.444	32.847
D1	26,559.8	0	55	0	135.226	92.847
D2	26,559.8	0	55	0	-94.554	92.847
D3	26,559.8	0	55	0	35.156	92.847
D4	26,559.8	0	55	0	167.356	92.847
E1	26,559.8	0	55	0	-162.954	152.847
E2	26,559.8	0	55	0	-57.404	152.847
E3	26,559.8	0	55	0	66.066	152.847
E4	26,559.8	0	55	0	-26.314	152.847
F1	26,559.8	0	55	0	-121.114	-147.153
F2	26,559.8	0	55	0	-14.774	-147.153
F3	26,559.8	0	55	0	105.206	-147.153
F4	26,559.8	0	55	0	135.346	-147.153

- EPOCH ON JULY 1, 1993 @ 00:00
- REFERED TO AS MARTINEZ CONSTELLATION



# CURRENT GPS SV ORBIT PARAMETERS (HEALTHY SVs AS OF 8/11)

SLOT/PRN/TYPE	A (KM)	e	i (DEG)	w+M (DEG)	W (DEG)
A1/09/IIA	26,559.7	0.0106	54.105	-2.801	-155.188
A2/25/IIA	26,561.1	0.0083	53.693	-112.891	-157.472
A3/08/IIA	26,559.8	0.0076	54.905	99.724	-152.471
A4/27/IIA	26,557.6	0.0143	53.948	123.858	-156.232
A5/19/II	26,559.6	0.0060	53.178	152.773	-158.669
B1/22/IIA	26,558.9	0.0132	53.459	169.904	-97.338
B2/30/IIA	26,559.1	0.0054	54.065	-101.639	-95.181
B3/02/II	26,559.9	0.0204	53.479	30.935	-98.128
B4/05/IIA	26,559.3	0.0022	53.652	-70.253	-96.999
C1/06/IIA	26,559.9	0.0070	54.309	-164.624	-33.717
C2/03/IIA	26,559.9	0.0012	53.875	102.475	-36.116
C3/31/IIA	26,560.5	0.0096	54.380	68.656	-35.459
C4/07/IIA	26,558.9	0.0115	54.412	-34.770	-35.483
D1/24/IIA	26,559.3	0.0090	56.514	-137.785	27.923
D2/11/IIR	26,559.4	0.0024	52.973	-2.671	23.911
D3/17/II	26,560.2	0.0122	56.381	124.812	31.919
D4/04/IIA	26,558.5	0.0052	55.942	-110.073	27.193
D5/15/II	26,555.0	0.0077	56.287	52.841	29.667
E1/20/IIR	26,560.5	0.0025	54.918	-78.277	85.978
E2/21/II	26,559.9	0.0164	55.850	23.564	86.194
E3/10/IIA	26,559.8	0.0041	55.877	157.522	85.850
E4/23/IIA	26,559.3	0.0090	56.028	61.846	88.552
F1/29/IIA	26,560.7	0.0076	55.082	-26.626	144.538
F2/26/IIA	26,558.8	0.0123	55.268	69.449	146.170
F4/01/IIA	26,560.0	0.0050	55.100	-142.604	147.147
F5/13/IIR	26,541.8	0.0023	55.336	151.364	145.853

- Week No. 51 @  $t_{0a} = 61140$ , 26 SVs



# GPS COVERAGE



# GEOMETRIC DILUTION OF PRECISION (GDOP)

- GDOP PROVIDES A MEASURE OF GEOMETRY EFFECTS ON NAVIGATION SOLUTION, INCLUDING TIME

$$- \sigma_{PT} = GDOP \cdot \sigma_{PR} = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2 + c^2 \sigma_T^2}$$

--  $\sigma_{PR}$  = UNCORRELATED RMS ERROR IN PR; THE SAME FOR ALL PRs

$$- GDOP = \sqrt{\text{trace}[\mathbf{H}^T \mathbf{H}]^{-1}}$$

-- i TH ROW OF  $\mathbf{H} = \mathbf{h}_i = [1_{xi} \quad 1_{yi} \quad 1_{zi} \quad -c]$

--  $\mathbf{H}$  MUST HAVE  $N > 4$  ROWS

-- TRACE INDICATES THE SUM OF DIAGONAL ELEMENTS

- PDOP (POSITION) IS COMPUTED BY IGNORING THE 4TH DIAGONAL ELEMENT IN THE TRACE



# HORIZONTAL, VERTICAL AND TIME DILUTION OF PRECISION

- TIME DILUTION OF PRECISION (TDOP) IS THE SQUARE ROOT OF THE 4TH DIAGONAL ELEMENT
- TO COMPUTE HDOP (AND VDOP), A TRANSFORMATION IS REQUIRED
  - TRANSFORM FROM X, Y, Z TO LOCAL TANGENT PLANE (LTP)
    - DEFINES A NEW **H** MATRIX WITH NEW UNIT VECTORS
  - PROCEED WITH THE SAME COMPUTATIONS
    - SELECT APPROPRIATE DIAGONAL ELEMENTS FOR THE TRACE

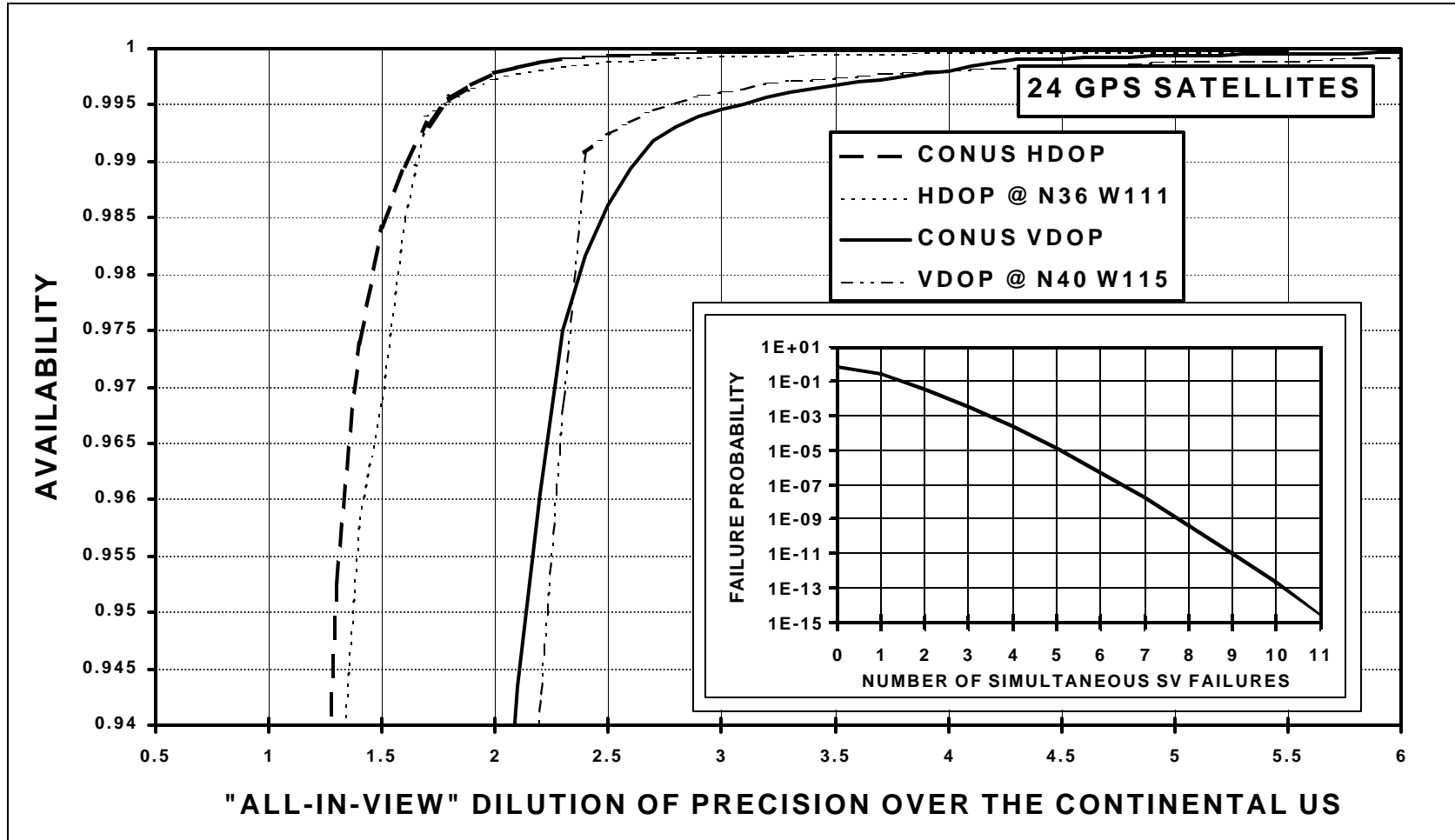


# AVAILABILITY

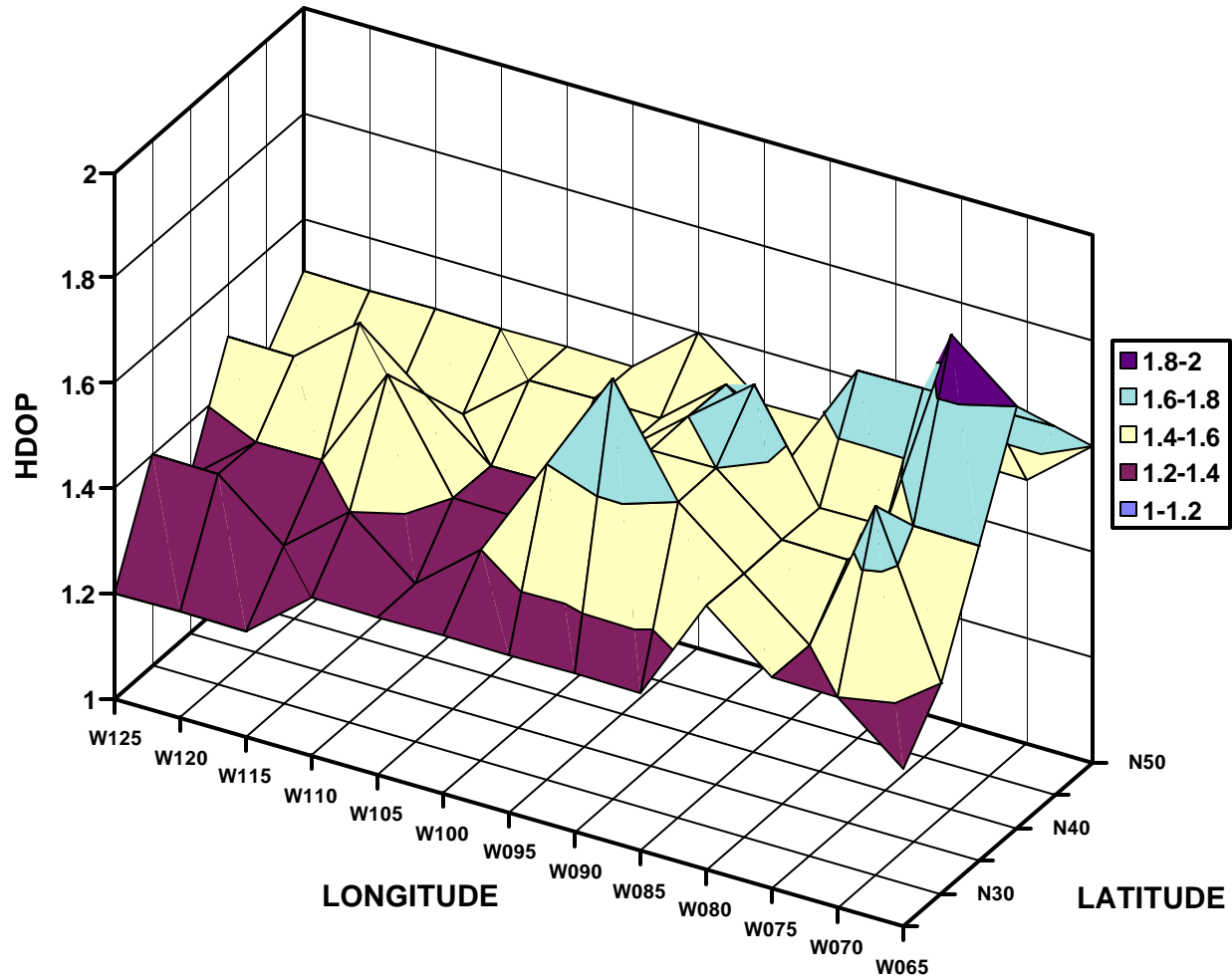
- AVAILABILITY COMES IN MANY FORMS
  - AVAILABILITY OF DOP
  - AVAILABILITY OF ACCURACY
    - USE SQUARE-ROOT OF COVARIANCE INSTEAD OF DOP
  - AVAILABILITY OF INTEGRITY
    - USES PROTECTION LIMITS
  - AVAILABILITY OF CONTINUITY
    - BASED UPON EXPOSURE TIME
- AVAILABILITY IS BASED UPON SV FAILURE RATES AND RESTORATION TIME
  - DoD IS IN PROCESS OF UPDATING THESE NUMBERS
    - NEXT VERSION OF SPS SPECIFICATION
- A MATHEMATICAL CHALLENGE AS WELL



# EXAMPLE OF AVAILABILITY OF DOP



# GPS 98% HDOP OVER CONUS



# GPS 98% VDOP OVER CONUS

