GNSS
Küresel Navigasyon Uydu Sistemleri



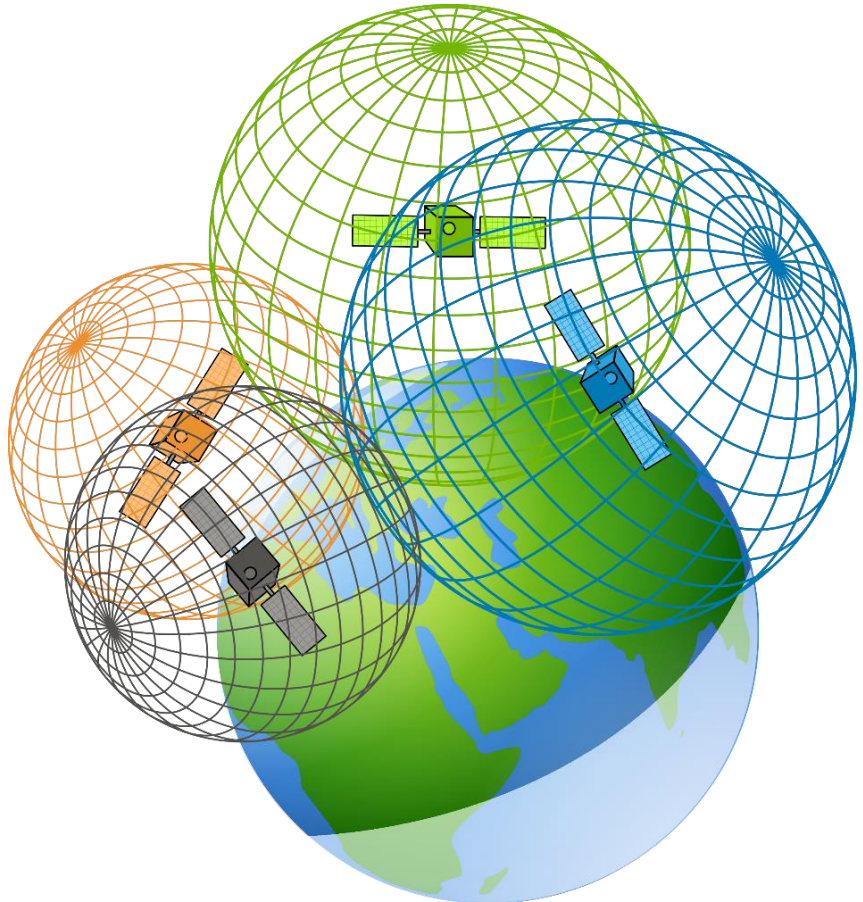
Yrd.Doç.Dr.Serkan AYDIN

Marmara Üniversitesi

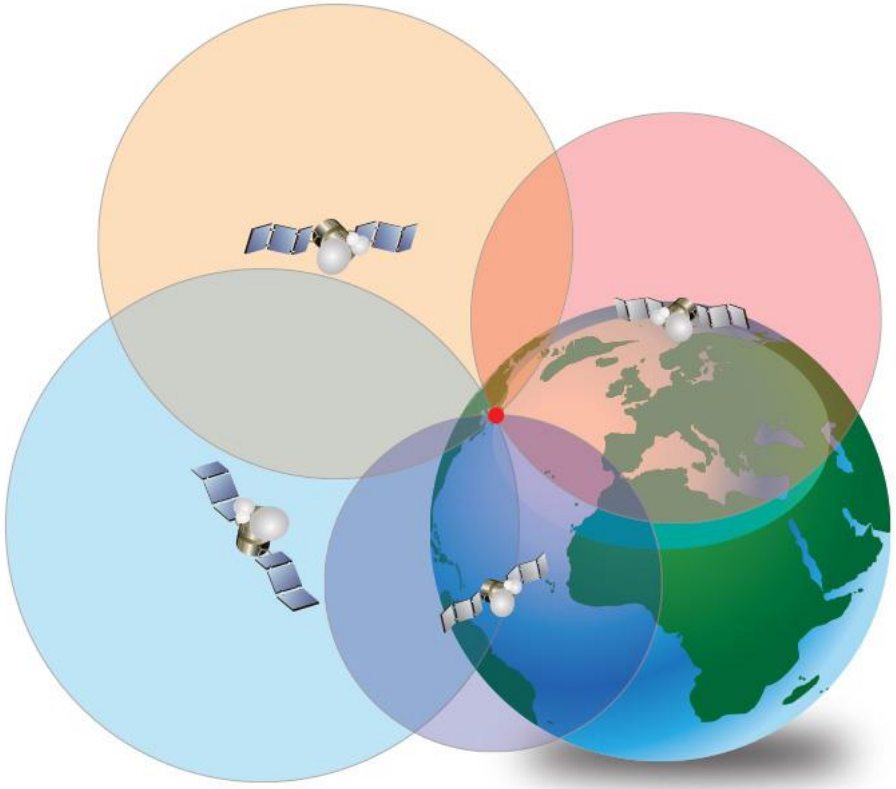
Elektronik Otomasyon Bölümü

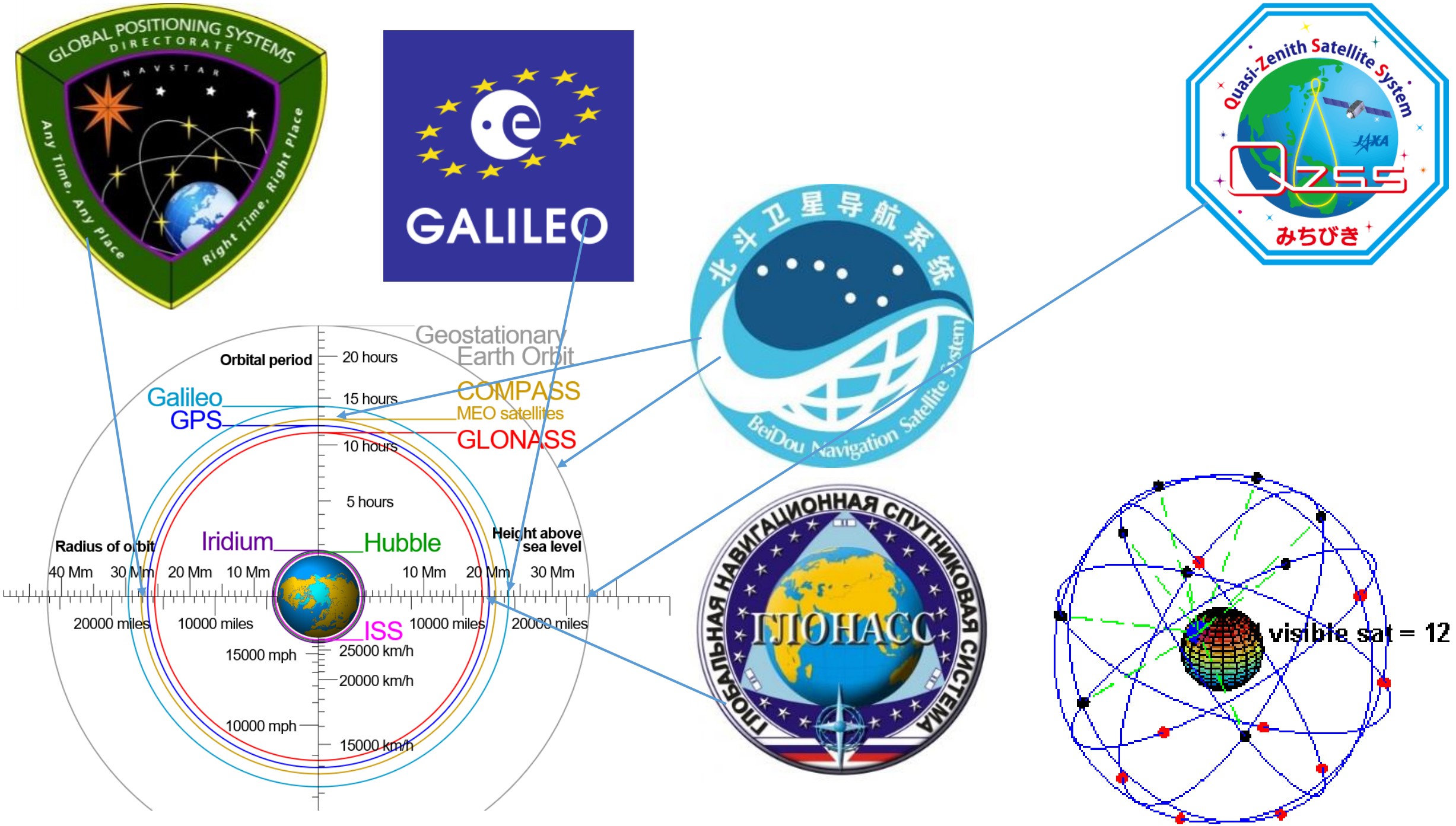
Konum Belirleme: Tüm uydular uzaydaki konum bilgilerin yayınını yapar.

Bu yayını alan alıcı kendi konumunu tirileterasyon tekniği ile hesaplar. Bu hesabın yapılabilmesi için gönderilen sinyalin ne kadar sürede geldiğinin hesaplanması gerekmektedir. Bu süre hesaplanıp ışık hızı ile çarpıldığında yaklaşık uzaklık bulunacaktır. İçersinde hata payıda olan bu hesabın daha doğru ve hassas yapılabilmesi için daha çok uydunun sinyalin hesaplanması gerekir.

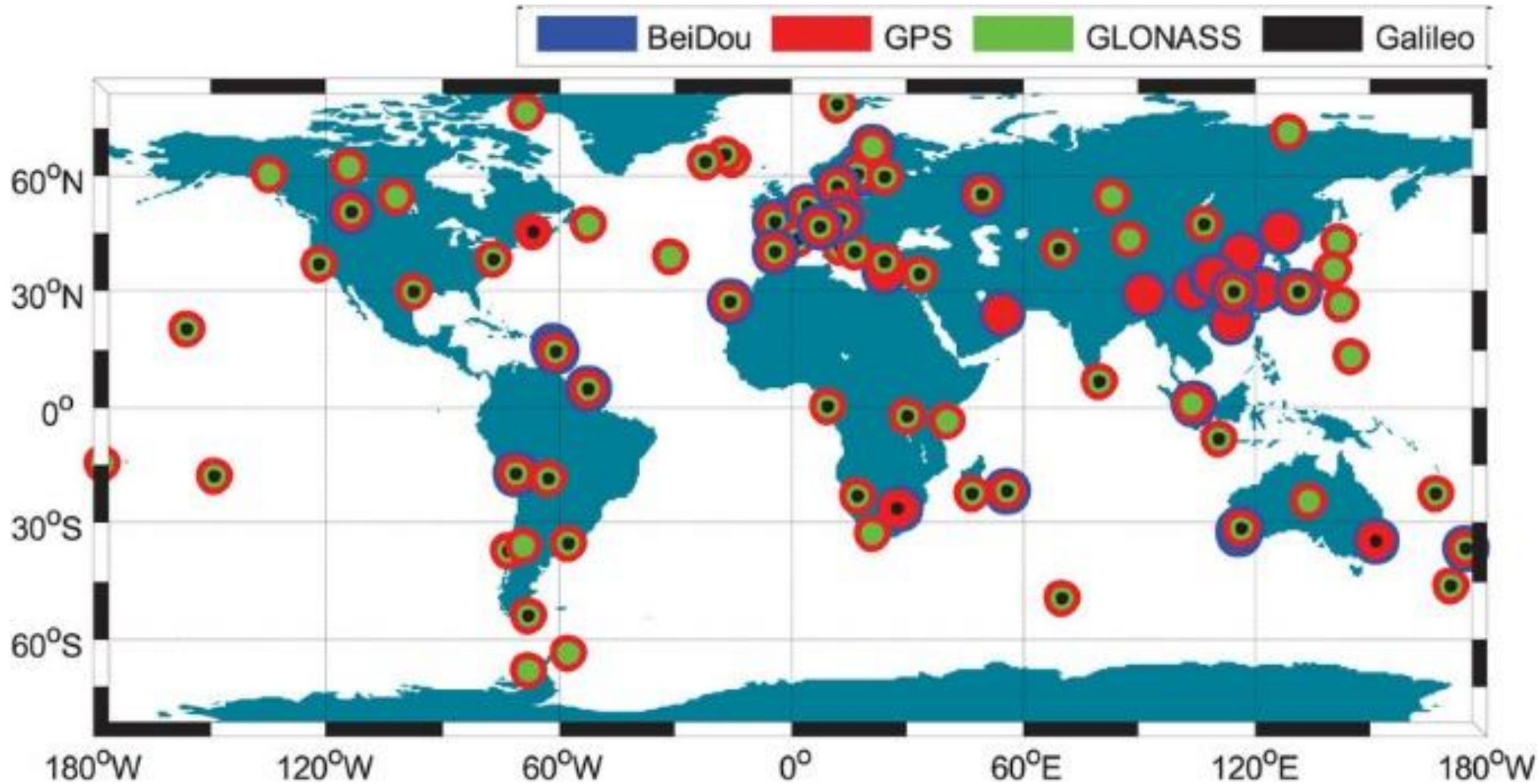


Ne kadar çok uydu o kadar hassa konum belirleme




GLOBAL POSITIONING SYSTEMS DIRECTORATE
NAVSTAR
Any Time, Any Place
Right Time, Right Place
GALILEO
Quasi-Zenith Satellite System
JAXA
QZSS
みちびき
北斗卫星导航系统
BeiDou Navigation Satellite System
ГЛОБАЛЬНАЯ НАВИГАЦИОННАЯ СПУТНИКОВАЯ СИСТЕМА
ГЛОНАСС
Geostationary Earth Orbit
Orbital period
20 hours
15 hours
10 hours
5 hours
Galileo
GPS
COMPASS
MEO satellites
GLONASS
Iridium
Hubble
ISS
Radius of orbit
Height above sea level
40 Mm
30 Mm
20 Mm
10 Mm
10 Mm
20 Mm
30 Mm
20000 miles
10000 miles
10000 miles
20000 miles
15000 mph
25000 km/h
20000 km/h
10000 mph
15000 km/h
visible sat = 12

Kontrol ve Ölçüm Referans Noktaları



Kapsama ve Spektrum

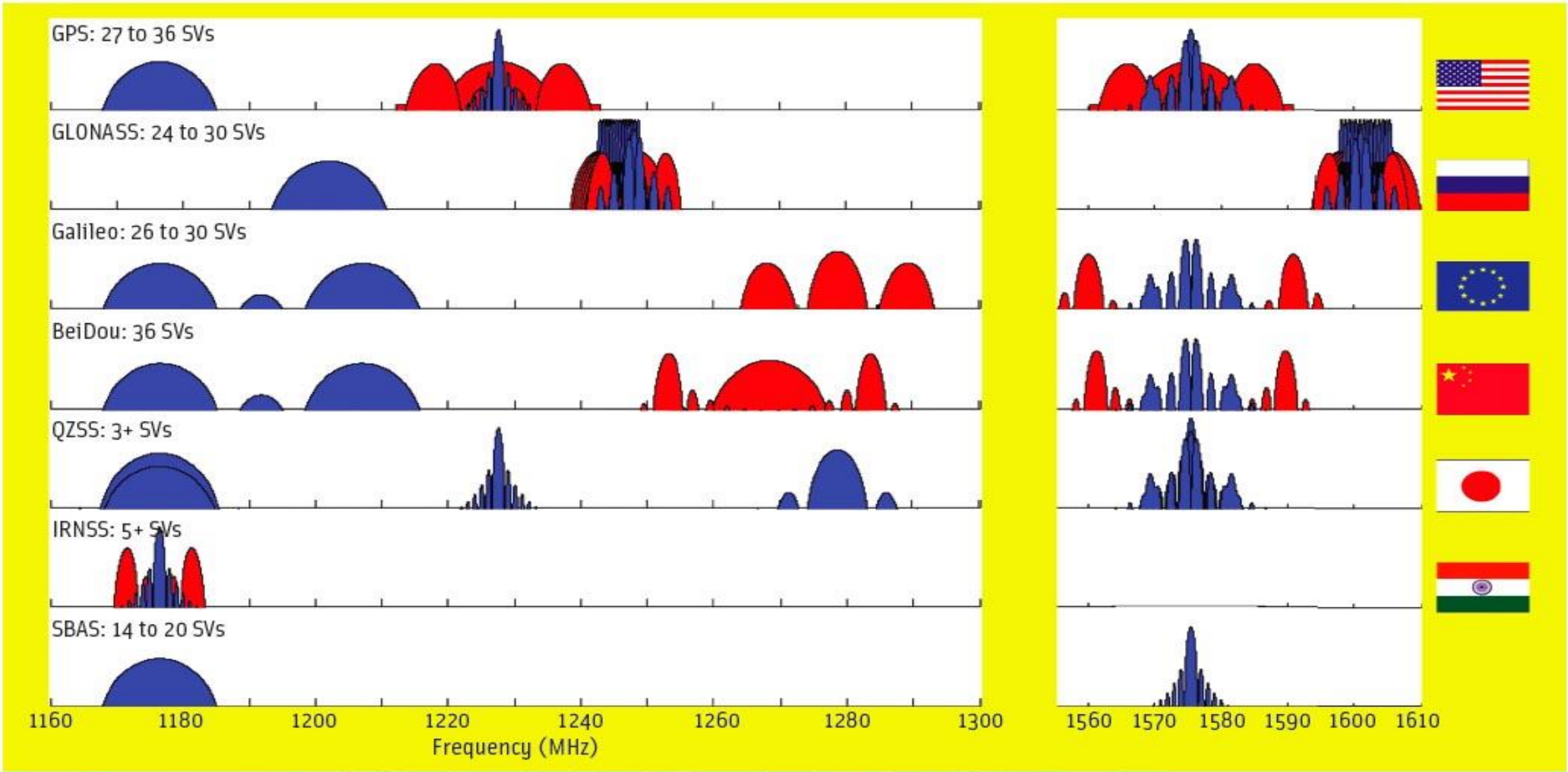
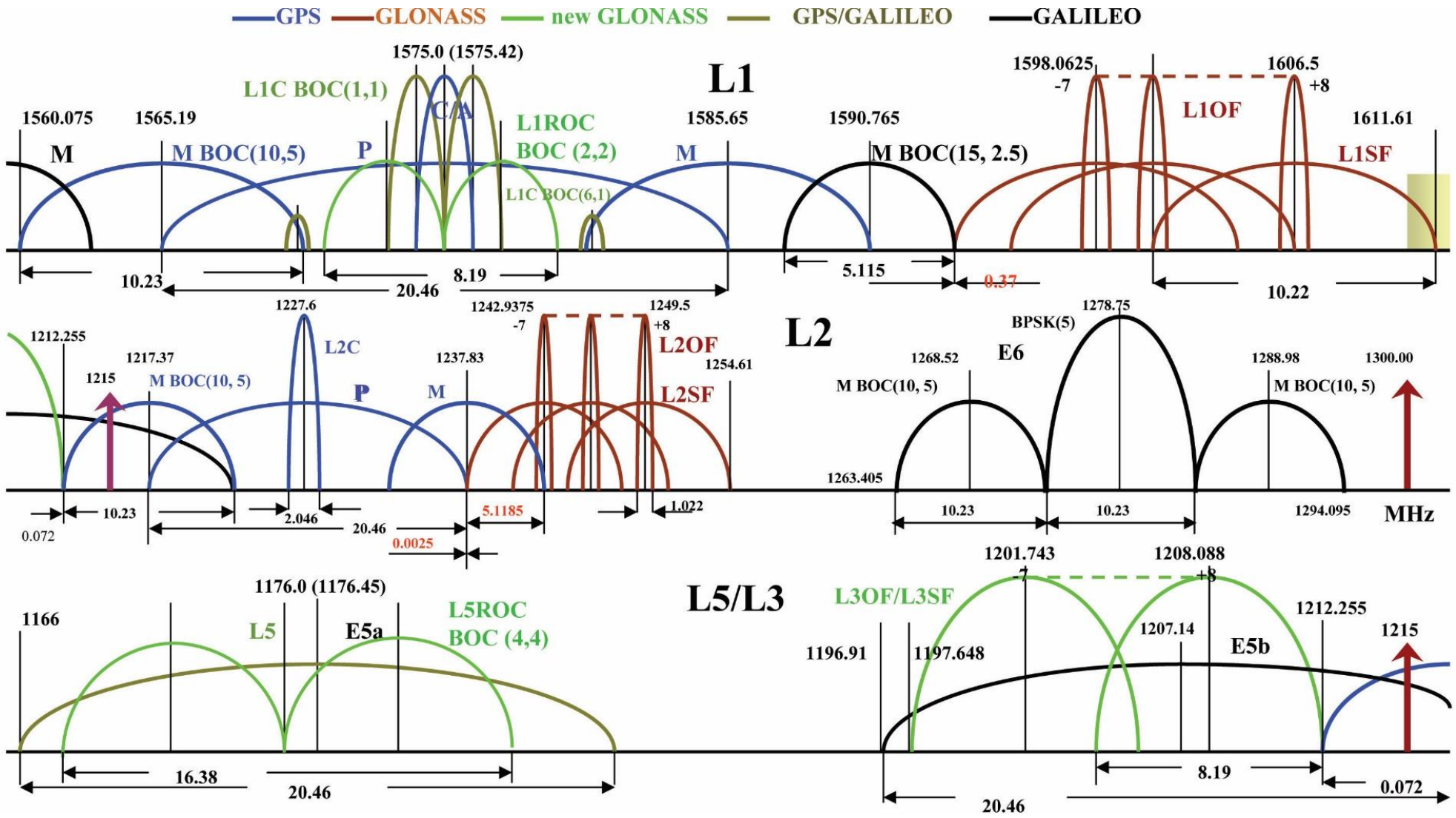
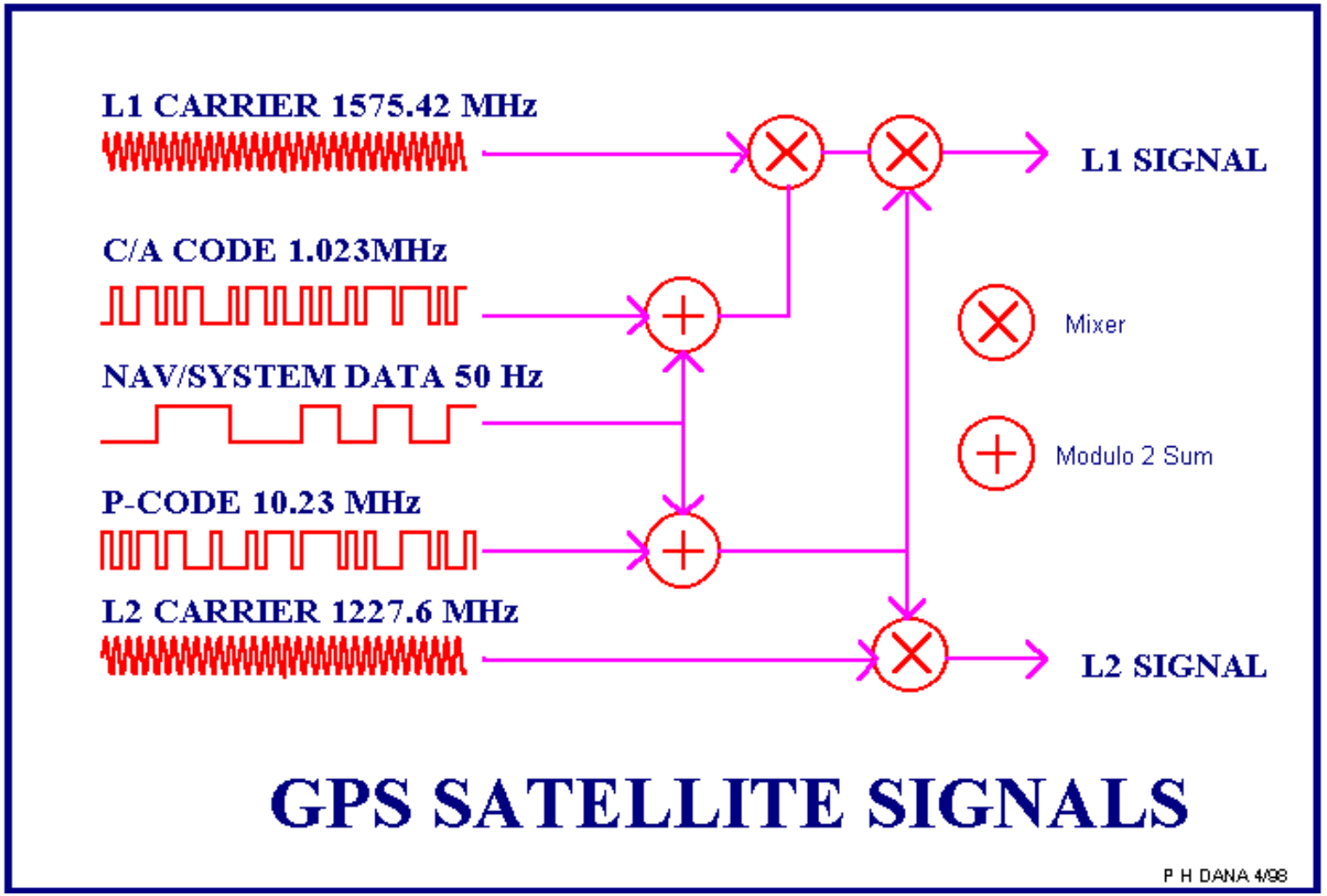


FIGURE 1 Prospective satnav signal structures, with open signals in blue and restricted signals in red

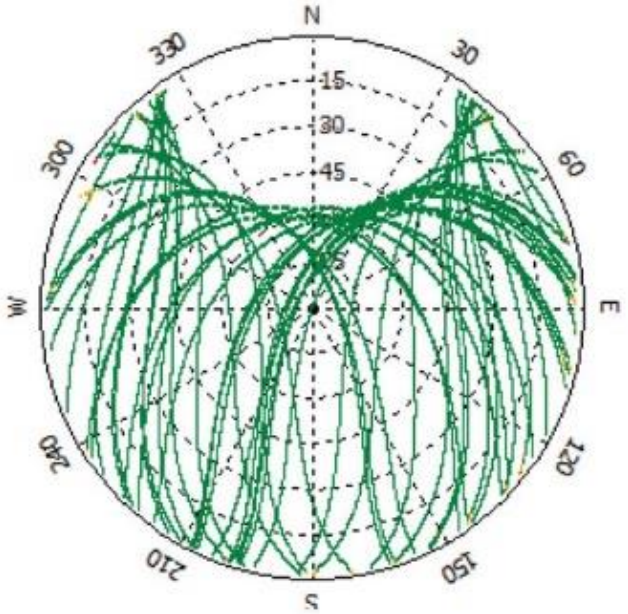
Taşıyıcılar



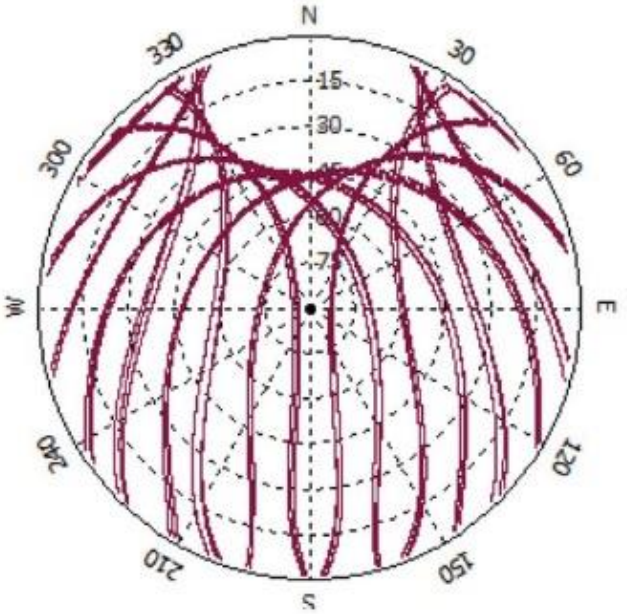
Kod Jenerasyonu



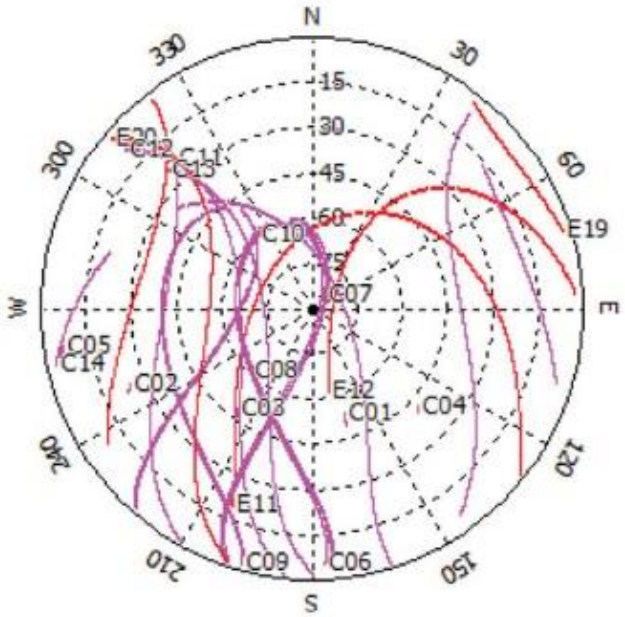
GNSS Uydu İzlemleri



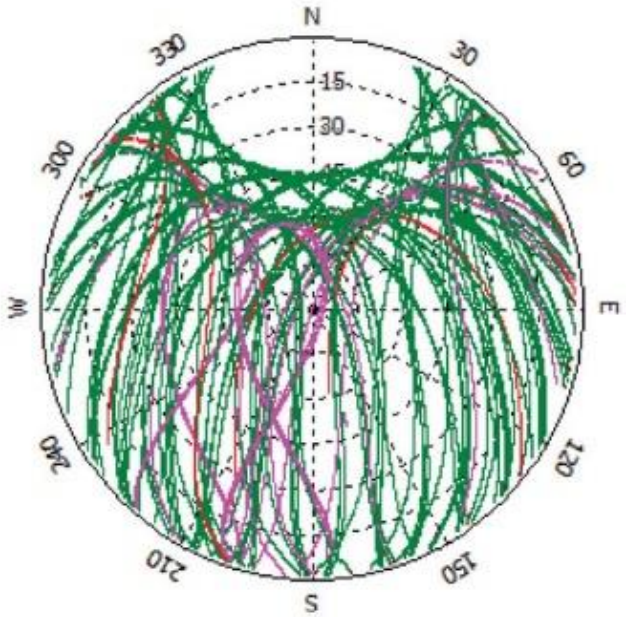
(a) GPS



(b) GLONASS



(c) BeiDou+Galileo

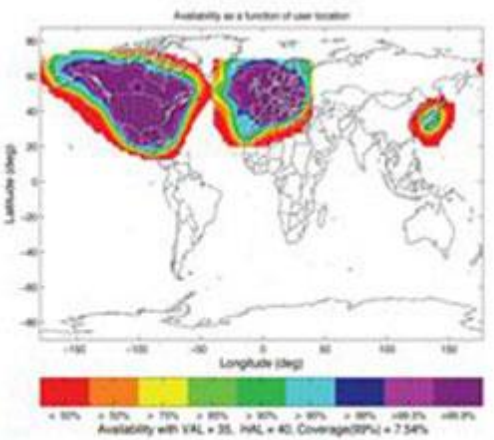


(d) G+R+E+C

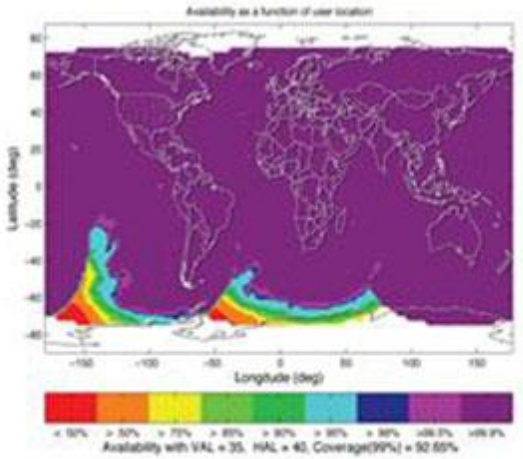
Long term (2020-2025) plan – Global SBAS
Extract of joint presentation SBAS provider IWG23

esa

Current Coverage WAAS-EGNOS-MSAS



Dual Frequency / dual GNSS WAAS-EGNOS-MSAS-SDCM-GAGAN with expanded network of stations in South hemisphere



Beidou NAVİGASYON SİSTEMİ

Isim	NORAD Kimliği	Uluslararası Kod	Lansman tarihi	Periyot [dakika]
Beidou I2 S	40.938	2015-053A	29 Eylül 2015	1435,9
Beidou-3 M2	40749	2015-037B	25 Temmuz 2015	773,3
Beidou-3 M1	40.748	2015-037A	25 Temmuz 2015	773,2
Beidou I1 S	40549	2015-019A	30 Mart 2015	1435,7
Beidou G6	38.953	2012-059A	25 Ekim 2012	1436,1
Beidou M6	38.775	2012-050B	18 Eylül 2012	773,2
Beidou M5	38774	2012-050A	18 Eylül 2012	773,1
Beidou M4	38.251	2012-018B	29 Nisan 2012	773,2
Beidou M3	38250	2012-018A	29 Nisan 2012	773,2
Beidou G5	38091	2012-008A	24 Şubat 2012	1436,1
Beidou IGSO 5	37948	2011-073A	1 Aralık 2011	1436,3
Beidou IGSO 4	37763	2011-038A	26 Temmuz 2011	1436
Beidou IGSO 3	37384	2011-013A	9 Nisan 2011	1436,2
Beidou IGSO 2	37.256	2010-068A	17 Aralık 2010	1435,7
Beidou G4	37210	2010-057A	31 Ekim 2010	1436,1
Beidou IGSO 1	36.828	2010-036A	31 Temmuz 2010	1435,8
Beidou G3	36590	2010-024A	2 Haziran 2010	1436,1
Beidou G1	36287	2010-001A	16 Ocak 2010	1436,2
Beidou G2	34.779	2009-018A	14 Nisan 2009	1435,3
Beidou M1	31.115	2007-011A	13 Nisan 2007	812
Beidou 1D	30323	2007-003A	2 Şubat 2007	1452,3
Beidou 1C	27.813	2003-021A	2003 24 Mayıs	1443,2
Beidou 1B	26.643	2000-082A	20 Aralık 2000	1450,9
Beidou 1	26.599	2000-069A	30 Ekim 2000	1455,9

GALILEO UYDULAR

Isim	NORAD Kimliği	Uluslararası Kod	Lansman tarihi	Periyot [dakika]
GALILEO 10 (206)	40.890	2015-045B	11 Eylül 2015	844,7
Galileo 9 (205)	40889	2015-045A	11 Eylül 2015	844,7
GSAT0204	40545	2015-017B	27 Mart 2015	844,7
GSAT0203	40544	2015-017A	27 Mart 2015	844,7
GALILEO 6 (262)	40129	2014-050B	22 Ağustos 2014	776,2
GALILEO 5 (261)	40128	2014-050A	22 Ağustos 2014	776,2
GALILEO-FM4	38858	2012-055B	12 Ekim 2012	844,7
GALILEO-FM3	38.857	2012-055A	12 Ekim 2012	844,7
GALILEO-FM2	37847	2011-060B	21 Ekim 2011	844,7
GALILEO-PFM	37846	2011-060A	21 Ekim 2011	844,7
GIOVE-B	32781	2008-020A	27 Nisan 2008	870,6
GIOVE-A	28922	2005-051A	28 Aralık 2005	849,9

QZSS UYDULAR

Qzss (QZSS), Japonya' bölgesel zaman transfer sistemi ve Uydu Tabanlı Büyütme

Isim	NORAD Kimliği	Uluslararası Kod	Lansman tarihi	Periyot [dakika]
QZS-1 (MICHIBIKI)	37.158	2010-045A	11 Eylül 2010	1435,9

IRNSS UYDULAR

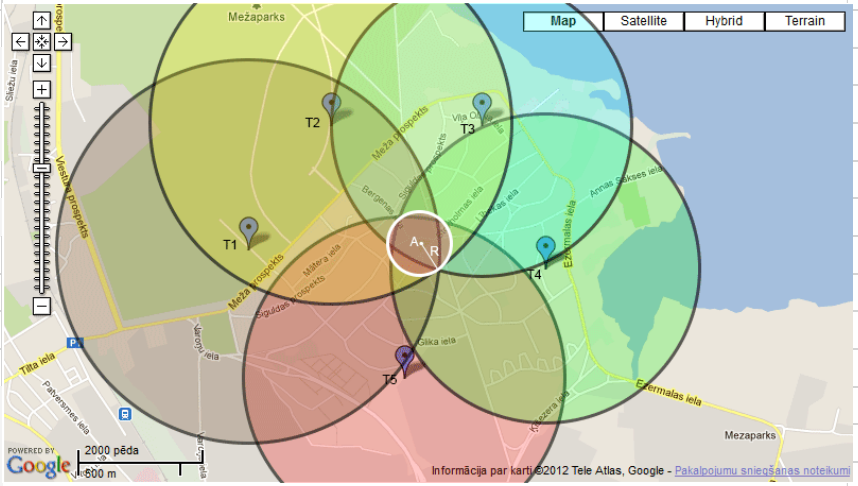
Hint Bölgesel Navigasyon Uydu Sistemi (IRNSS) Hint hükümetinin tam kontrolü altında olacağını Hint Uzay Araştırma Örgütü (USAK) tarafından geliştirilmekte olan özerk bir bölgesel uydu navigasyon sistemidir.

Tablo sıralanabilir. Sıralama azalan / artan için başlığındaki tıklayınız.

Isim	NORAD Kimliği	Uluslararası Kod	Lansman tarihi	Periyot [dakika]
IRNSS 1D	40547	2015-018A	28 Mart 2015	1436,1
IRNSS 1C	40.269	2014-061A	15 Ekim 2014	1436,1
IRNSS 1B	39.635	2014-017A	4 Nisan 2014	1436,2
IRNSS-1A	39.199	2013-034A	1 Temmuz 2013	1436

GPS OPERASYONEL UYDULAR

SIRA	Name Isim	NORAD ID NORAD Kimliği	Int'l Code Uluslararası Kod	Launch date Lansman tarihi	Period Periyot [minutes] [dakika]	PRN PRN
1	NAVSTAR 66 (USA 232) NAVSTAR 66 (ABD 232)	37753 37.753	2011-036A 2011-036A	July 16, 2011 16 Temmuz 2011	718 718	1 1
2	NAVSTAR 38 (USA 126) NAVSTAR 38 (ABD 126)	23953 23.953	1996-041A 1996-041A	July 16, 1996 16 Temmuz 1996	718 718	10 10
3	NAVSTAR 46 (USA 145) NAVSTAR 46 (ABD 145)	25933 25.933	1999-055A 1999-055A	October 7, 1999 7 Ekim 1999	718 718	11 11
4	NAVSTAR 59 (USA 192) NAVSTAR 59 (ABD 192)	29601 29.601	2006-052A 2006-052A	November 17, 2006 17 Kasım 2006	717.9 717,9	12 12
5	NAVSTAR 43 (USA 132) NAVSTAR 43 (ABD 132)	24876 24876	1997-035A 1997-035A	July 23, 1997 23 Temmuz 1997	718 718	13 13
6	NAVSTAR 49 (USA 154) NAVSTAR 49 (ABD 154)	26605 26605	2000-071A 2000-071A	November 10, 2000 10 Kasım 2000	718 718	14 14
7	NAVSTAR 60 (USA 196) NAVSTAR 60 (ABD 196)	32260 32260	2007-047A 2007-047A	October 17, 2007 17 Ekim 2007	718 718	15 15
8	NAVSTAR 51 (USA 166) NAVSTAR 51 (ABD 166)	27663 27.663	2003-005A 2003-005A	January 29, 2003 29 Ocak 2003	718 718	16 16
9	NAVSTAR 57 (USA 183) NAVSTAR 57 (ABD 183)	28874 28.874	2005-038A 2005-038A	September 26, 2005 26 Evlül 2005	717.9 717,9	17 17
10	NAVSTAR 50 (USA 156) NAVSTAR 50 (ABD 156)	26690 26690	2001-004A 2001-004A	January 30, 2001 30 Ocak 2001	718 718	18 18
11	NAVSTAR 54 (USA 177) NAVSTAR 54 (ABD 177)	28190 28.190	2004-009A 2004-009A	March 20, 2004 20 Mart 2004	718.6 718,6	19 19
12	NAVSTAR 56 (USA 180) NAVSTAR 56 (ABD 180)	28474 28.474	2004-045A 2004-045A	November 6, 2004 6 Kasım 2004	718 718	2 2
13	NAVSTAR 47 (USA 150) NAVSTAR 47 (ABD 150)	26360 26.360	2000-025A 2000-025A	May 11, 2000 2000 11 Mavıs	718 718	20 20
14	NAVSTAR 52 (USA 168) NAVSTAR 52 (ABD 168)	27704 27.704	2003-010A 2003-010A	March 31, 2003 31 Mart 2003	718 718	21 21
15	NAVSTAR 53 (USA 175) NAVSTAR 53 (ABD 175)	28129 28129	2003-058A 2003-058A	December 21, 2003 21 Aralık 2003	718 718	22 22
16	NAVSTAR 55 (USA 178) NAVSTAR 55 (ABD 178)	28361 28.361	2004-023A 2004-023A	June 23, 2004 23 Haziran 2004	718 718	23 23
17	NAVSTAR 67 (USA 239) NAVSTAR 67 (ABD 239)	38833 38.833	2012-053A 2012-053A	October 4, 2012 4 Ekim 2012	718 718	24 24
18	NAVSTAR 65 (USA 213) NAVSTAR 65 (ABD 213)	36585 36585	2010-022A 2010-022A	May 28, 2010 2010 28 Mavıs	717.9 717,9	25 25
19	NAVSTAR 26 (USA 83) NAVSTAR 26 (ABD 83)	22014 22014	1992-039A 1992-039A	July 7, 1992 7 Temmuz 1992	766.3 766,3	26 26
20	NAVSTAR 68 (USA 242) NAVSTAR 68 (ABD 242)	39166 39.166	2013-023A 2013-023A	May 15, 2013 2013 15 Mavıs	718 718	27 27
21	NAVSTAR 48 (USA 151) NAVSTAR 48 (ABD 151)	26407 26407	2000-040A 2000-040A	July 16, 2000 16 Temmuz 2000	718 718	28 28
22	NAVSTAR 61 (USA 199) NAVSTAR 61 (ABD 199)	32384 32384	2007-062A 2007-062A	December 20, 2007 20 Aralık 2007	718 718	29 29
23	NAVSTAR 69 (USA 248) NAVSTAR 69 (ABD 248)	39533 39533	2014-008A 2014-008A	February 21, 2014 21 Subat 2014	718 718	30 30
24	NAVSTAR 58 (USA 190) NAVSTAR 58 (ABD 190)	29486 29.486	2006-042A 2006-042A	September 25, 2006 25 Evlül 2006	718 718	31 31
25	NAVSTAR 22 (USA 66) NAVSTAR 22 (ABD 66)	20959 20.959	1990-103A 1990-103A	November 26, 1990 26 Kasım 1990	718 718	32 32
26	NAVSTAR 35 (USA 96) NAVSTAR 35 (ABD 96)	22877 22877	1993-068A 1993-068A	October 26, 1993 26 Ekim 1993	718 718	4 4
27	NAVSTAR 64 (USA 206) NAVSTAR 64 (ABD 206)	35752 35752	2009-043A 2009-043A	August 17, 2009 17 Ağustos 2009	718 718	5 5
28	NAVSTAR 70 (USA 251) NAVSTAR 70 (ABD 251)	39741 39.741	2014-026A 2014-026A	May 17, 2014 2014 17 Mavıs	717.9 717,9	6 6
29	NAVSTAR 62 (USA 201) NAVSTAR 62 (ABD 201)	32711 32.711	2008-012A 2008-012A	March 15, 2008 15 Mart 2008	718 718	7 7
30	NAVSTAR 44 (USA 135) NAVSTAR 44 (ABD 135)	25030 25030	1997-067A 1997-067A	November 6, 1997 6 Kasım 1997	718 718	8 8
31	NAVSTAR 71 (USA 256) NAVSTAR 71 (ABD 256)	40105 40105	2014-045A 2014-045A	August 2, 2014 2 Ağustos 2014	718 718	9 9
	NAVSTAR 27 (USA 84) NAVSTAR 27 (ABD 84)	22108 22108	1992-058A 1992-058A	September 9, 1992 9 Evlül 1992	718 718	N/A N / A
	NAVSTAR 10 (USA 5) NAVSTAR 10 (ABD 5)	15271 15271	1984-097A 1984-097A	September 8, 1984 8 Evlül 1984	747.6 747,6	N/A N / A
	NAVSTAR 39 (USA 128) NAVSTAR 39 (ABD 128)	24320 24320	1996-056A 1996-056A	September 12, 1996 12 Evlül 1996	772.1 772,1	N/A N / A



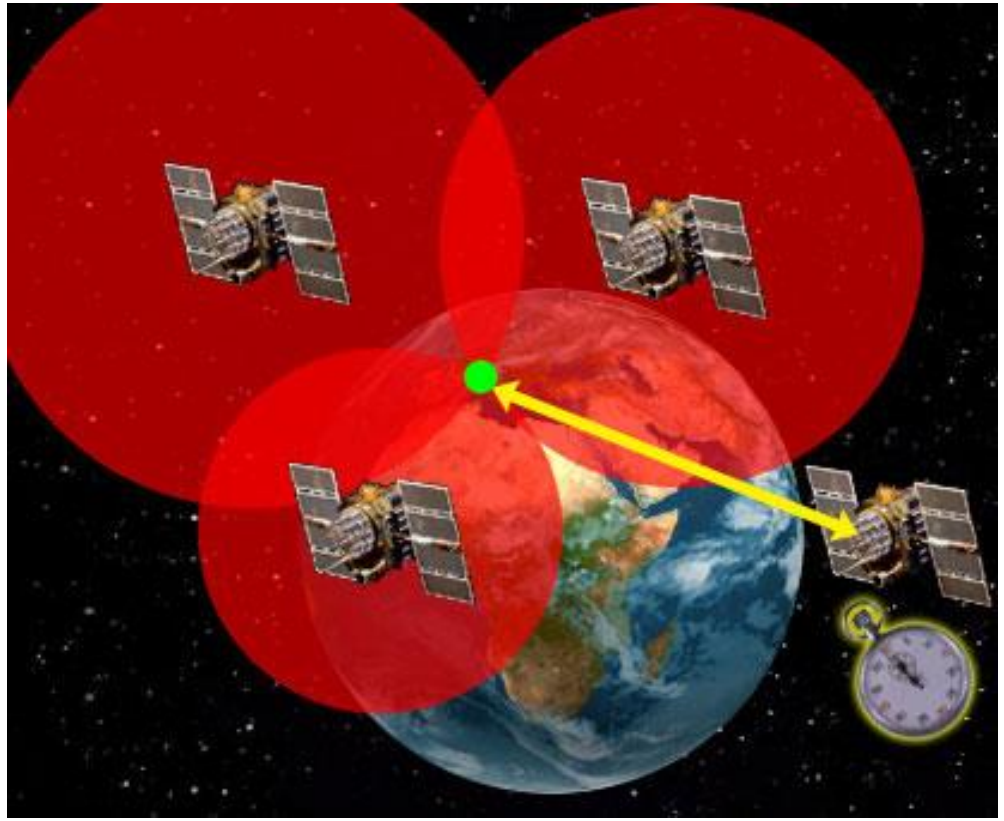
GLONASS OPERASYONEL UYDULAR

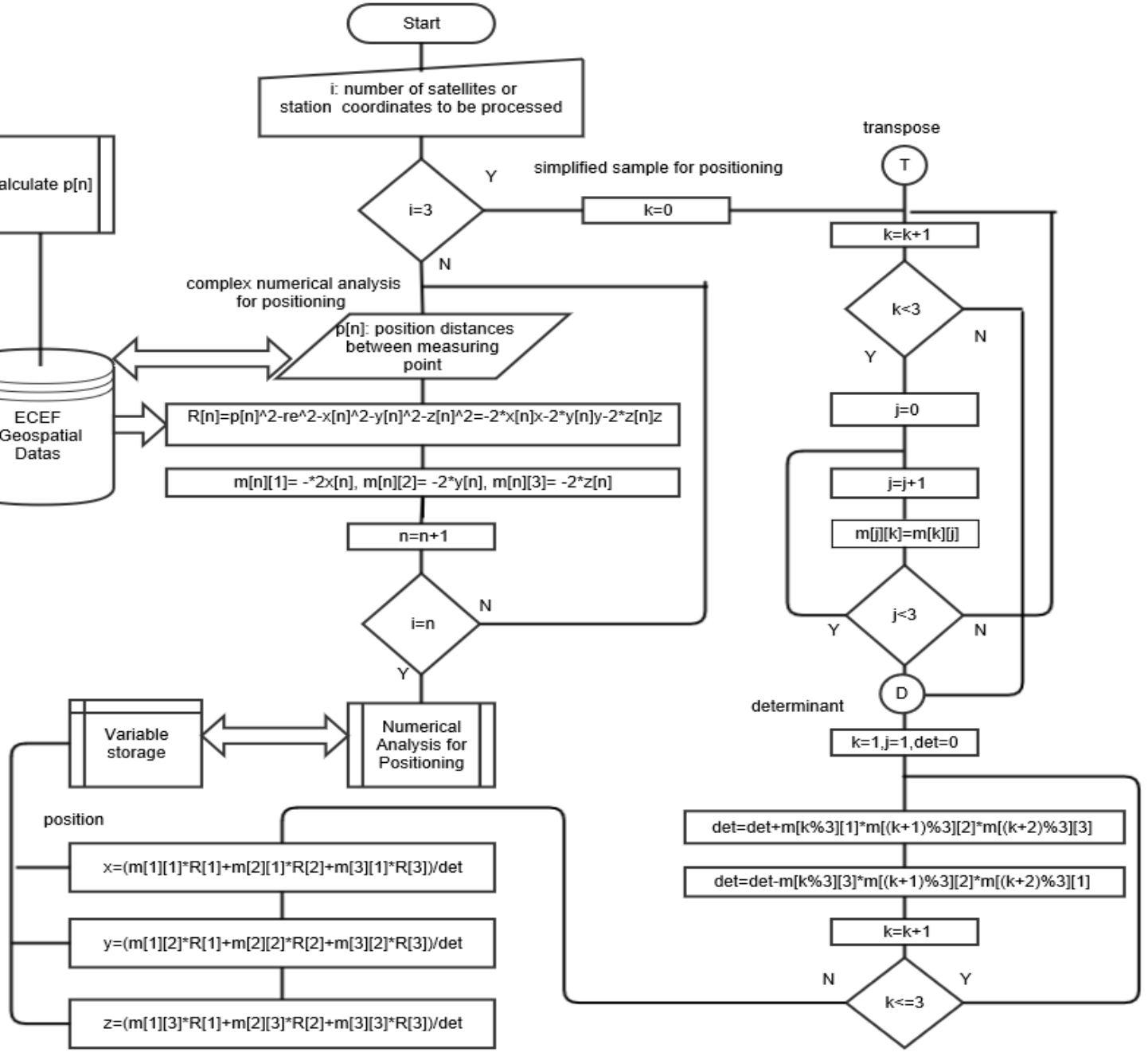
SIRA	Name Isim	NORAD ID NORAD Kimliği	Int'l Code Uluslararası Kod	Launch date Lansman tarihi	Period Periyot [minutes] [dakika]	SV SV
1	COSMOS 2471 (GLONASS) 2471	37372 37.372	2011-009A 2011-009A	February 26, 2011 26 Subat	675.7 675,7	701 701
2	COSMOS 2404 (GLONASS) 2404	28112 28112	2003-056A 2003-056A	December 10, 2003 10 Aralık	675.8 675,8	701 701
3	COSMOS 2411 (GLONASS) 2411	28509 28.509	2004-053B 2004-053B	December 26, 2004 26 Aralık	675.7 675,7	712 712
4	COSMOS 2419 (GLONASS) 2419	28915 28915	2005-050A 2005-050A	December 25, 2005 25 Aralık	675.7 675,7	714 714
5	COSMOS 2424 (GLONASS) 2424	29672 29672	2006-062C 2006-062C	December 25, 2006 25 Aralık	675.7 675,7	715 715
6	COSMOS 2425 (GLONASS) 2425	29670 29670	2006-062A 2006-062A	December 25, 2006 25 Aralık	675.7 675,7	716 716
7	COSMOS 2426 (GLONASS) 2426	29671 29671	2006-062B 2006-062B	December 25, 2006 25 Aralık	675.7 675,7	717 717
8	COSMOS 2432 (GLONASS) 2432	32276 32.276	2007-052B 2007-052B	October 26, 2007 26 Ekim	675.7 675,7	719 719
9	COSMOS 2433 (GLONASS) 2433	32275 32.275	2007-052A 2007-052A	October 26, 2007 26 Ekim	675.7 675,7	720 720
10	COSMOS 2434 (GLONASS) 2434	32393 32.393	2007-065A 2007-065A	December 25, 2007 25 Aralık	675.7 675,7	721 721
11	COSMOS 2435 (GLONASS) 2435	32394 32.394	2007-065B 2007-065B	December 25, 2007 25 Aralık	675.7 675,7	722 722
12	COSMOS 2436 (GLONASS) 2436	32395 32.395	2007-065C 2007-065C	December 25, 2007 25 Aralık	675.7 675,7	723 723
13	COSMOS 2442 (GLONASS) 2442	33378 33378	2008-046A 2008-046A	September 25, 2008 25 Evlül	675.7 675,7	724 724
14	COSMOS 2443 (GLONASS) 2443	33379 33.379	2008-046B 2008-046B	September 25, 2008 25 Evlül	675.7 675,7	725 725
15	COSMOS 2444 (GLONASS) 2444	33380 33.380	2008-046C 2008-046C	September 25, 2008 25 Evlül	675.7 675,7	726 726
16	COSMOS 2447 (GLONASS) 2447	33466 33.466	2008-067A 2008-067A	December 25, 2008 25 Aralık	675.7 675,7	727 727
17	COSMOS 2448 (GLONASS) 2448	33468 33.468	2008-067C 2008-067C	December 25, 2008 25 Aralık	675.7 675,7	728 728
18	COSMOS 2449 (GLONASS) 2449	33467 33.467	2008-067B 2008-067B	December 25, 2008 25 Aralık	675.7 675,7	729 729
19	COSMOS 2456 (GLONASS) 2456	36111 36111	2009-070A 2009-070A	December 14, 2009 14 Aralık	675.7 675,7	730 730
20	COSMOS 2459 (GLONASS) 2459	36400 36400	2010-007A 2010-007A	March 1, 2010 1 Mart 2010	675.7 675,7	731 731
21	COSMOS 2460 (GLONASS) 2460	36402 36402	2010-007C 2010-007C	March 1, 2010 1 Mart 2010	675.7 675,7	732 732
22	COSMOS 2457 (GLONASS) 2457	36112 36112	2009-070B 2009-070B	December 14, 2009 14 Aralık	675.7 675,7	733 733
23	COSMOS 2458 (GLONASS) 2458	36113 36113	2009-070C 2009-070C	December 14, 2009 14 Aralık	675.7 675,7	734 734
24	COSMOS 2461 (GLONASS) 2461	36401 36401	2010-007B 2010-007B	March 1, 2010 1 Mart 2010	675.7 675,7	735 735
25	COSMOS 2464 (GLONASS) 2464	37139 37139	2010-041C 2010-041C	September 2, 2010 2 Evlül	675.7 675,7	736 736
26	COSMOS 2465 (GLONASS) 2465	37138 37138	2010-041B 2010-041B	September 2, 2010 2 Evlül	675.7 675,7	737 737
27	COSMOS 2466 (GLONASS) 2466	37137 37.137	2010-041A 2010-041A	September 2, 2010 2 Evlül	675.7 675,7	738 738
28	COSMOS 2474 (GLONASS) 2474	37829 37.829	2011-055A 2011-055A	October 2, 2011 2 Ekim	675.7 675,7	742 742
29	COSMOS 2475 (GLONASS) 2475	37869 37.869	2011-064C 2011-064C	November 4, 2011 4 Kasım	675.7 675,7	743 743
30	COSMOS 2476 (GLONASS) 2476	37867 37.867	2011-064A 2011-064A	November 4, 2011 4 Kasım	675.7 675,7	744 744
31	COSMOS 2477 (GLONASS) 2477	37868 37868	2011-064B 2011-064B	November 4, 2011 4 Kasım	675.7 675,7	745 745
32	COSMOS 2478 (GLONASS) 2478	37938 37938	2011-071A 2011-071A	November 28, 2011 28 Kasım	675.8 675,8	746 746
33	COSMOS 2485 (GLONASS) 2485	39155 39155	2013-019A 2013-019A	April 26, 2013 26 Nisan 2013	675.7 675,7	747 747
34	COSMOS 2494 (GLONASS) 2494	39620 39.620	2014-012A 2014-012A	March 23, 2014 23 Mart 2014	675.7 675,7	754 754

GLONASS Constellation Status at 09.12.2015 based on both the almanac analysis and navigation messages received at 07:00 09.12.15 (UTC) in IAC PNT TsNIImash

Orb. slot	Orb. pl.	RF chnl	# GC	Launched	Operation begins	Operation ends	Life-time (months)	Satellite health status		Comments
								In almanac	In ephemeris (UTC)	
1	1	01	730	14.12.09	30.01.10		71.9	+	+ 07:16 09.12.15	In operation
2	1	-4	747	26.04.13	04.07.13		31.5	+	+ 07:16 09.12.15	In operation
3	1	05	744	04.11.11	08.12.11		49.2	+	+ 07:16 09.12.15	In operation
4	1	06	742	02.10.11	25.10.11		50.3	+	+ 07:16 09.12.15	In operation
5	1	01	734	14.12.09	10.01.10		71.9	+	+ 07:16 09.12.15	In operation
6	1	-4	733	14.12.09	24.01.10		71.9	+	+ 07:16 09.12.15	In operation
7	1	05	745	04.11.11	18.12.11		49.2	+	+ 07:16 09.12.15	In operation
8	1	06	743	04.11.11	20.09.12		49.2	+	+ 07:16 09.12.15	In operation
9	2	-2	736	02.09.10	04.10.10		63.3	+	+ 07:16 09.12.15	In operation
10	2	-7	717	25.12.06	03.04.07		107.5	+	+ 07:16 09.12.15	In operation
11	2	00	723	25.12.07	22.01.08		95.5	+	+ 07:16 09.12.15	In operation
12	2	-1	737	02.09.10	12.10.10		63.3	+	+ 07:16 09.12.15	In operation
13	2	-2	721	25.12.07	08.02.08		95.5	+	+ 07:16 09.12.15	In operation
14	2	-7	715	25.12.06	03.04.07		107.5	+	+ 07:16 09.12.15	In operation
15	2	00	716	25.12.06	12.10.07		107.5	+	+ 07:16 09.12.15	In operation
16	2	-1	738	02.09.10	11.10.10		63.3	+	+ 07:16 09.12.15	In operation
17	3	-6	714	25.12.05	31.08.06	17.10.15	119.5	-		Under check by the SPC
18	3	-3	754	24.03.14	14.04.14		20.5	+	+ 07:16 09.12.15	In operation
19	3	03	720	26.10.07	25.11.07		97.5	+	+ 07:16 09.12.15	In operation
20	3	02	719	26.10.07	27.11.07		97.5	+	+ 07:16 09.12.15	In operation
21	3	04	755	14.06.14	03.08.14		17.9	+	+ 07:16 09.12.15	In operation
22	3	-3	731	02.03.10	28.03.10		69.3	+	+ 07:16 09.12.15	In operation
23	3	03	732	02.03.10	28.03.10		69.3	+	+ 07:16 09.12.15	In operation
24	3	02	735	02.03.10	28.03.10		69.3	+	+ 07:16 09.12.15	In operation
09	2	07	702	01.12.14			12.3			Flight Tests
20	3	-5	701	26.02.11			57.4			Flight Tests
21	3		725	25.09.08	05.11.08	02.08.14	86.5			Under check by the SPC
17	3		746	28.11.11	23.12.11	13.04.15	48.4			Under check by the SPC

Hesaplama




Start
i: number of satellites or station coordinates to be processed
calculate p[n]
i=3
Y
N
simplified sample for positioning
k=0
transpose
T
k=k+1
k<3
Y
N
complex numerical analysis for positioning
p[n]: position distances between measuring point
ECEF Geospatial Datas
R[n]=p[n]^2-re^2-x[n]^2-y[n]^2-z[n]^2=-2*x[n]x-2*y[n]y-2*z[n]z
m[n][1]= -*2x[n], m[n][2]= -2*y[n], m[n][3]= -2*z[n]
n=n+1
i=n
N
Y
j=0
j=j+1
m[j][k]=m[k][j]
j<3
Y
N
D
determinant
k=1,j=1,det=0
Variable storage
Numerical Analysis for Positioning
position
x=(m[1][1]*R[1]+m[2][1]*R[2]+m[3][1]*R[3])/det
y=(m[1][2]*R[1]+m[2][2]*R[2]+m[3][2]*R[3])/det
z=(m[1][3]*R[1]+m[2][3]*R[2]+m[3][3]*R[3])/det
det=det+m[k%3][1]*m[(k+1)%3][2]*m[(k+2)%3][3]
det=det-m[k%3][3]*m[(k+1)%3][2]*m[(k+2)%3][1]
k=k+1
N
Y
k<=3

Saat Farkı

GPS ERROR SOURCES

ERROR SOURCE	TYPICAL RANGE ERROR	DGPS (CODE) RANGE ERROR <100 KM REF-REMOTE
SV CLOCK	1 M	
SV EPHEMERIS	1 M	
SELECTIVE AVAILABILITY	10 M	
TROPOSPHERE	1 M	
IONOSPHERE	10 M	
PSEUDO-RANGE NOISE	1 M	1 M
RECEIVER NOISE	1 M	1 M
MULTIPATH	0.5 M	0.5 M
RMS ERROR	15 M	1.6 M
ERROR * PDOP=4	60 M	6 M

PDOP=Position Dilution of Precision (3-D) 4.0 is typical

GPS Pseudorange Navigation Example - Peter H. Dana - 4/24/96

Satellite (SV) coordinates in ECEF XYZ from Ephemeris Parameters and SV Time

$SVx_0 := 15524471.175$ $SVy_0 := -16649826.222$ $SVz_0 := 13512272.387$ SV 15

$SVx_1 := -2304058.534$ $SVy_1 := -23287906.465$ $SVz_1 := 11917038.105$ SV 27

$SVx_2 := 16680243.357$ $SVy_2 := -3069625.561$ $SVz_2 := 20378551.047$ SV 31

$SVx_3 := -14799931.395$ $SVy_3 := -21425358.24$ $SVz_3 := 6069947.224$ SV 7

Satellite Pseudoranges in meters (from C/A code epochs in milliseconds)

$P_0 := 89491.971$ $P_1 := 133930.500$ $P_2 := 283098.754$ $P_3 := 205961.742$ Range + Receiver Clock Bias

Receiver Position Estimate in ECEF XYZ

$Rx := -730000$ $Ry := -5440000$ $Rz := 3230000$

For Each of 4 SVs $i := 0..3$

Ranges from Receiver Position Estimate to SVs (R) and Array of Observed - Predicted Ranges

$$R_i := \sqrt{(SVx_i - Rx)^2 + (SVy_i - Ry)^2 + (SVz_i - Rz)^2} \qquad L_i := \mathrm{mod}\left[\left(R_i\right), 299792.458\right] - P_i$$

Compute Directional Derivatives for XYZ and Time

$$Dx_i := \frac{SVx_i - Rx}{R_i} \qquad Dy_i := \frac{SVy_i - Ry}{R_i} \qquad Dz_i := \frac{SVz_i - Rz}{R_i} \qquad Dt_i := -1$$

Solve for Correction to Receiver Position Estimate

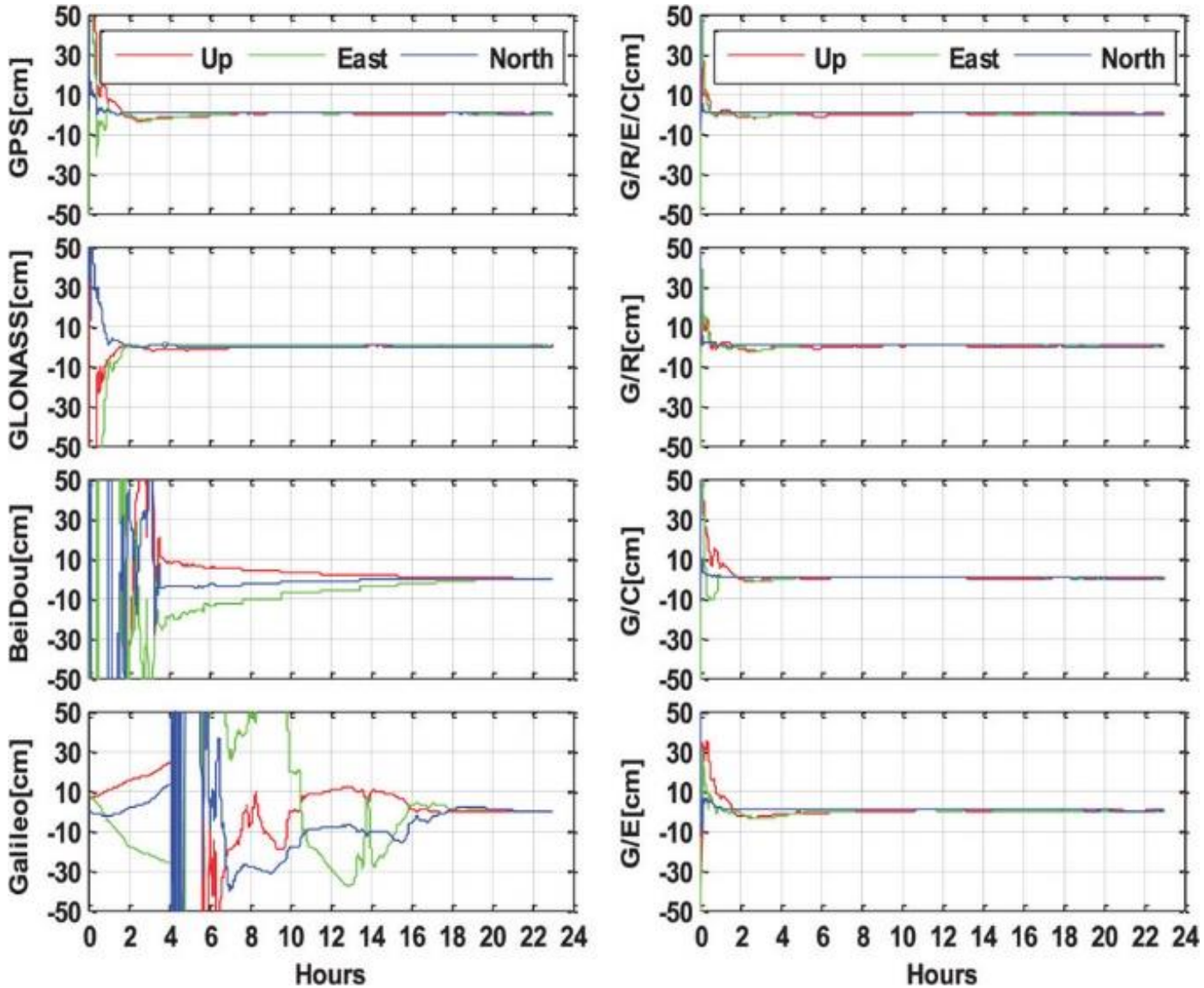
$$A := \begin{bmatrix} Dx_0 & Dy_0 & Dz_0 & Dt_0 \\ Dx_1 & Dy_1 & Dz_1 & Dt_1 \\ Dx_2 & Dy_2 & Dz_2 & Dt_2 \\ Dx_3 & Dy_3 & Dz_3 & Dt_3 \end{bmatrix} \qquad dR := \left(A^T \cdot A\right)^{-1} \cdot A^T \cdot L \qquad dR = \begin{bmatrix} -3186.496 \\ -3791.932 \\ 1193.286 \\ 12345.997 \end{bmatrix}$$

Apply Corrections to Receiver XYZ and Compute Receiver Clock Bias Estimate

$Rx := Rx + dR_0$ $Ry := Ry + dR_1$ $Rz := Rz + dR_2$ $Time := dR_3$

$Rx = -733186.496$ $Ry = -5443791.932$ $Rz = 3231193.286$ $Time = 12345.997$

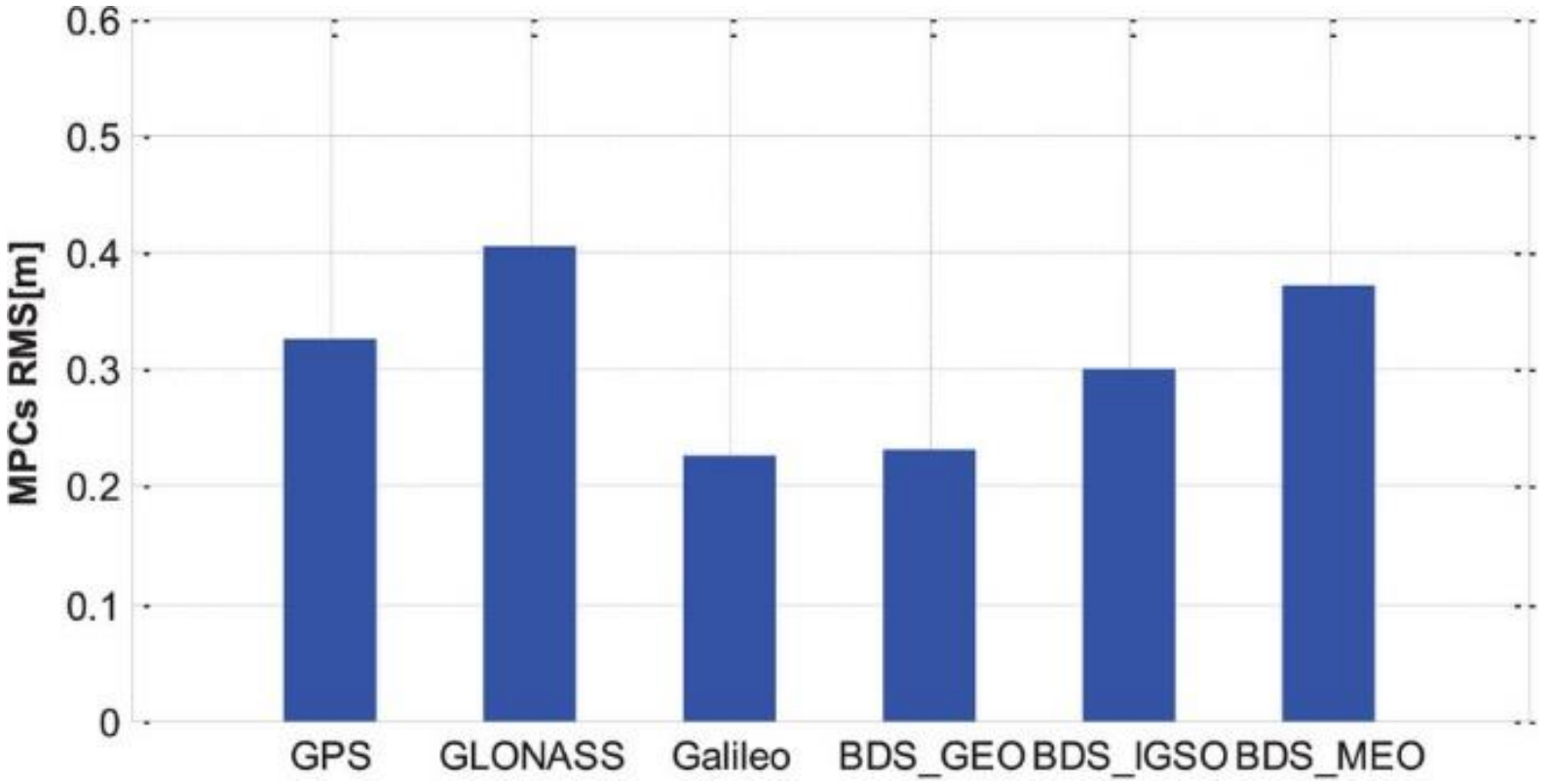
Sabit Nokta Ölçümleri



Standart Sapma

Table 2 | The RMS values of kinematic PPP solutions of single- , and four-system modes in north, east and up components (MGEX and BETN networks from September 1 to December 9 in 2013)

System	E(cm)	N(cm)	U(cm)
G	1.4	1.2	4.4
R	2.9	1.8	5.9
C	1.3	1.3	5.4
G/R/E/C	0.9	0.9	3.1



TechEmail.com - Free Ema | Geomaterials - Scientific R | Türksat Uydu Haberleşme | Iyngsat - Google'da Ara | Precise GNSS Satellite Co | IGS -- International GNSS
www.navipedia.net/index.php/Precise_GNSS_Satellite_Coordinates_Computation

Precise GNSS Satellite Coordinates Computation

fundamentals	
Title	Precise GNSS Satellite Coordinates Computation
Author(s)	J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares, Technical University of Catalonia, Spain.
Level	Intermediate
Year of Publication	2011

Precise orbits and clocks for GPS and GLONASS satellites can be found at the International GNSS Service (IGS) web server (http://igscb.jpl.nasa.gov) [footnotes 1].

These products are in the public domain and free of charge for all users. They are available in ASCII files, providing *precise orbits & clock files* with a sample rate of 15 minutes, as well as *precise clock files* with 5 minutes and 30 seconds sample rate in SP3 format.

Table 1 summarizes the different products available, their accuracy, latency and sampling rate. It must be pointed out that IGS has adopted the International Terrestrial Reference System (ITRS) as its reference system. Thence, IGS products are referred to this system.

Products (delay)	Broadcast (Real-Time)	Ultra-Rapid Predicted (Real-Time)	Ultra-Rapid Observed (3-9 h)	Rapid (17-41 h)	Final (12-18 d)
Orbit GPS (sampling)	~100 cm (~2 h)	~5 cm (15 min)	~3 cm (15 min)	~2.5cm (15 min)	~ 2.5 cm (15 min)
GLONASS (sampling)					~5 cm (15 min)
Clock GPS (sampling)	~5 ns (daily)	~3 ns (15 min)	~150 ps (15 min)	~75 ps (5 min)	~75 ps (30 sec)
GLONASS (sampling)					~ TBD (15 min)

Table 1: IGS orbits and clocks products: RMS accuracy, latency and sampling (source: http://igscb.jpl.nasa.gov/components/prods.html, 2009).

Some centres provide also GPS satellite clocks with 5 seconds sampling rate, like files obtained from the CDDIS site [footnotes 2]. Please bear in mind that orbits and clock files must be consistent (i.e., they must come from the same centre). Therefore, CODE clocks must be used with CODE orbits, and not with JPL nor EMR products, for instance.

The ANTenna EXchange format (ANTEX) files, along with other additional useful information on IGS antennas [footnotes 3].

The satellite coordinates between epochs can be computed by polynomial interpolation. A 10 order polynomial is enough for a centimetre level of accuracy with 15 minutes data. Clocks with sampling rate of 30 seconds or higher can be interpolated with a 1 order polynomial with few centimetres of accuracy. Clocks with lower sampling rate should not be interpolated, because clocks perform as random walk processes.

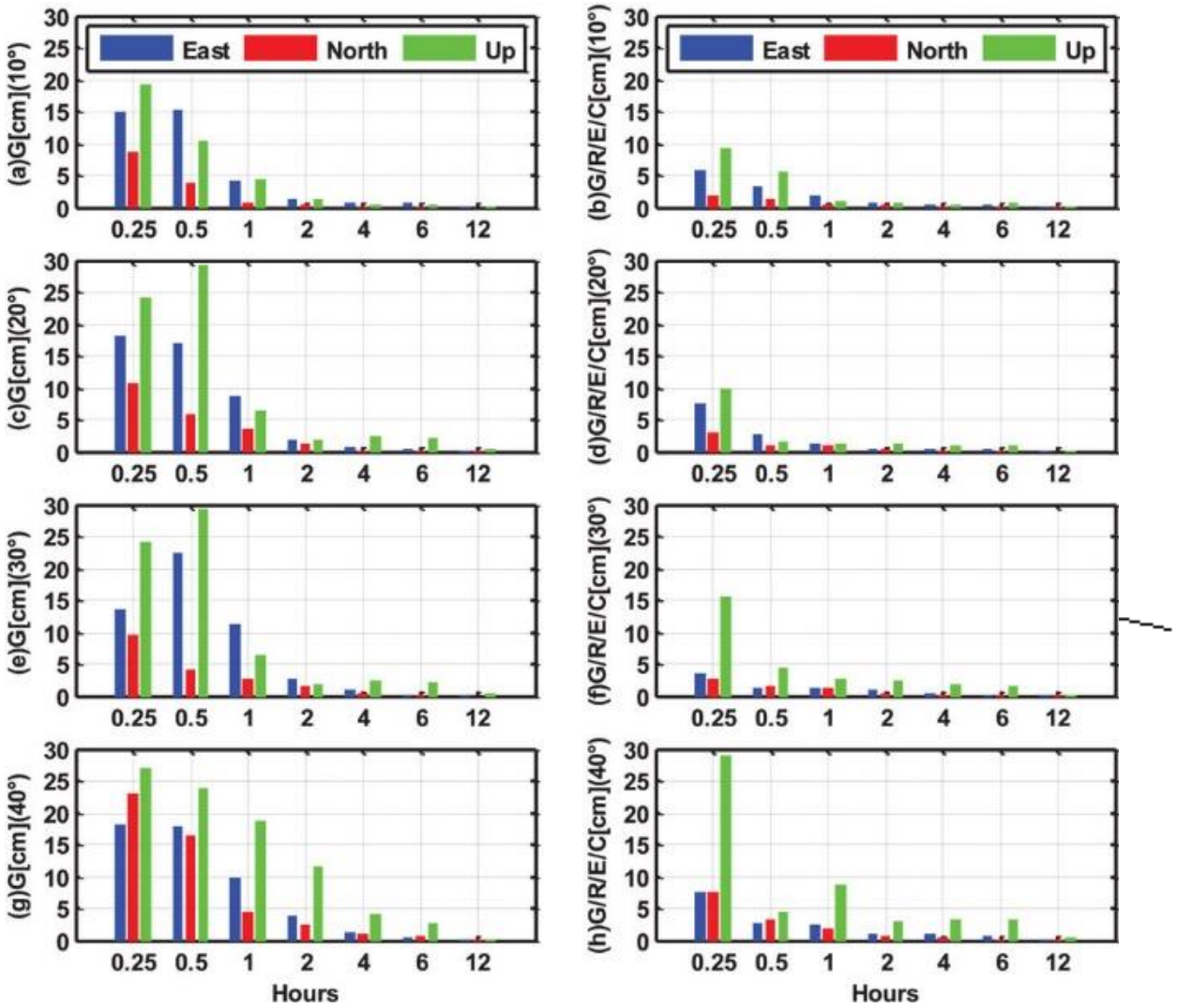
As an example of polynomial interpolation, the Lagrange method is presented as follows:

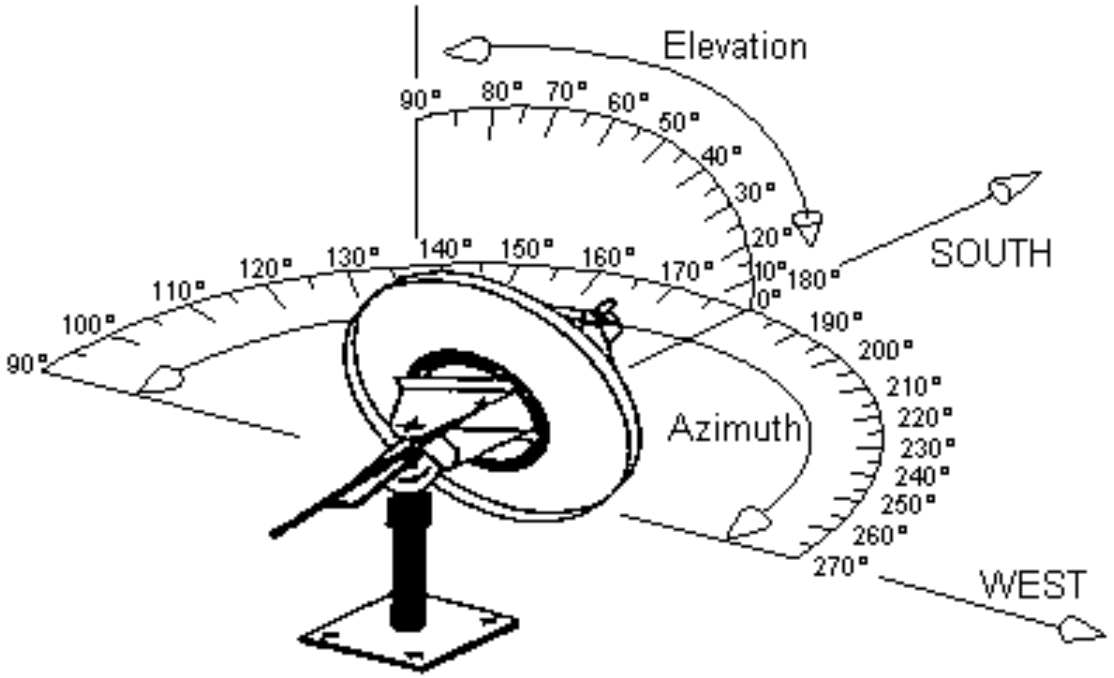
Given a table of values (x_i, y_i). $i = 1, \ldots, n$. the interpolated value $y \simeq P_n(x)$ at a given x can be computed as:

$$\begin{aligned} P_n(x) &= \sum_{i=1}^{n} y_i \frac{\prod_{j\neq i}(x-x_j)}{\prod_{j\neq i}(x_i-x_j)} = \\ &= y_1 \frac{x-x_2}{(x_1-x_2)} \cdots \frac{x-x_n}{(x_1-x_n)} + \cdots \\ &+ y_i \frac{x-x_1}{(x_i-x_1)} \cdots \frac{x-x_{i-1}}{(x_i-x_{i-1})} \frac{x-x_{i+1}}{(x_i-x_{i+1})} \cdots \frac{x-x_n}{(x_i-x_n)} + \cdots \\ &+ y_n \frac{x-x_1}{(x_n-x_1)} \cdots \frac{x-x_{n-1}}{(x_n-x_{n-1})} \end{aligned} \quad (1)$$

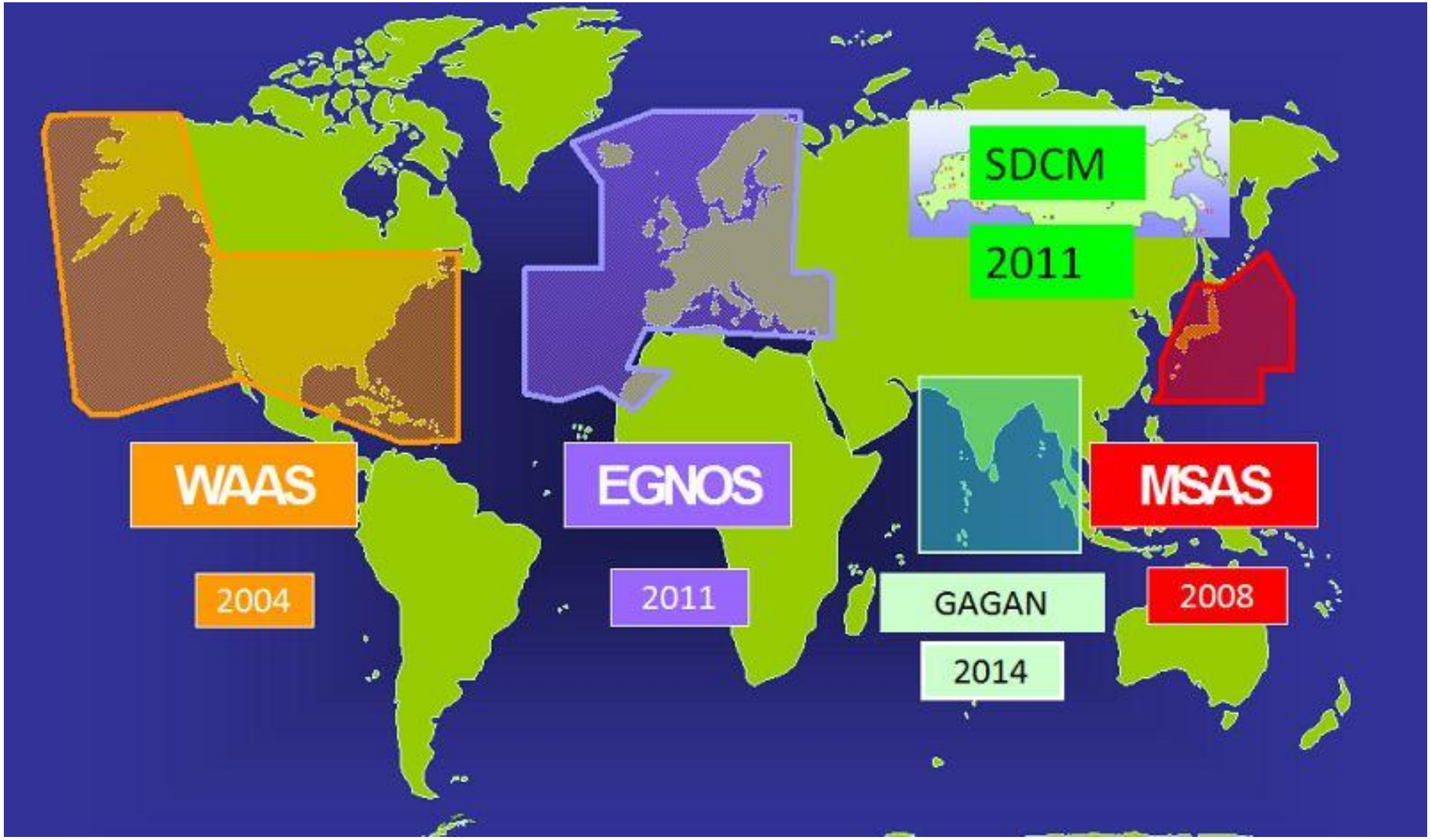
TUR 10:50 04.12.2015

Elevasyon Açısına Bağlı Zayıflama





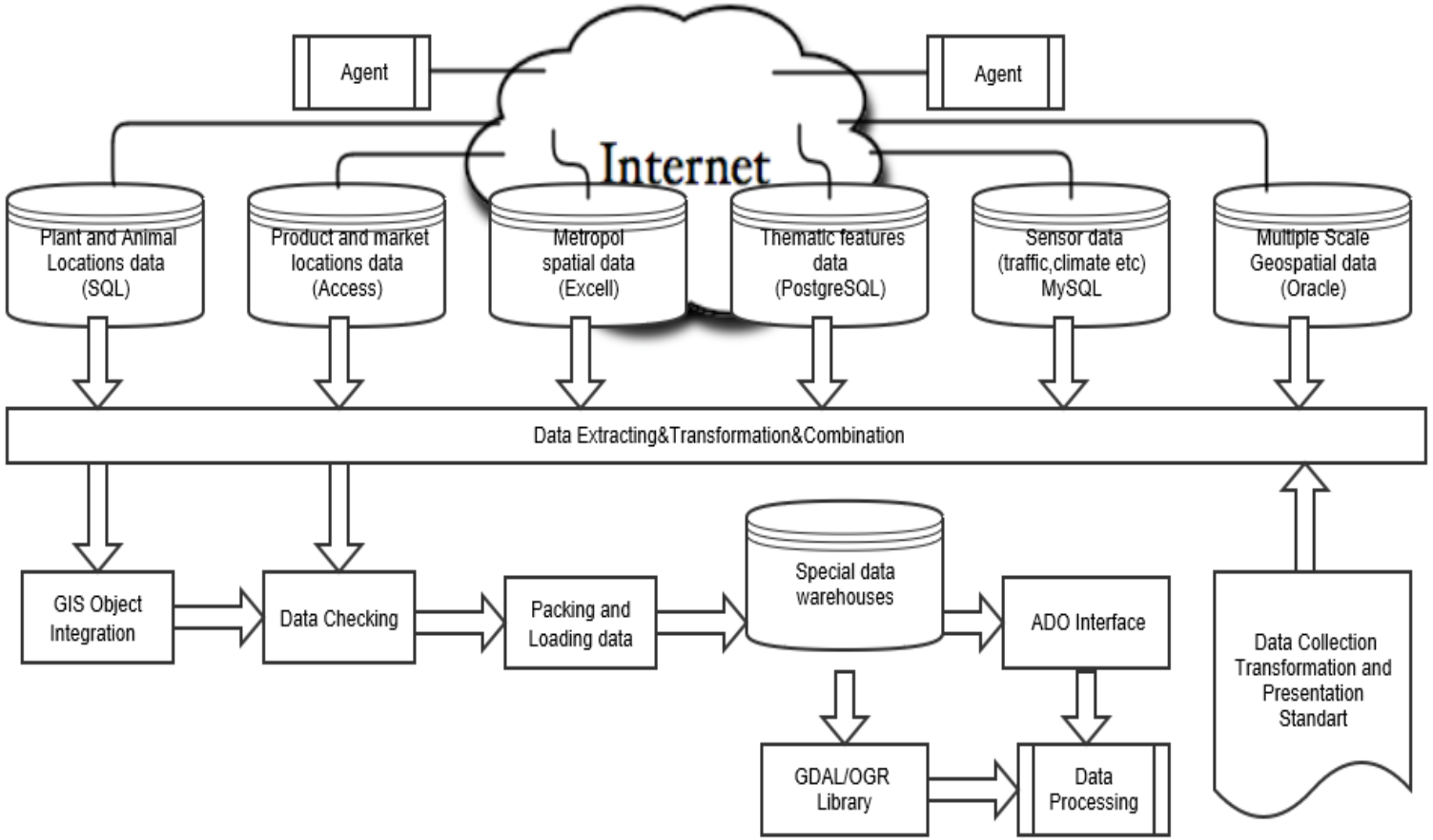
Takviye –Geosenkron Uydu Destekli Sistemler-SBAS’s

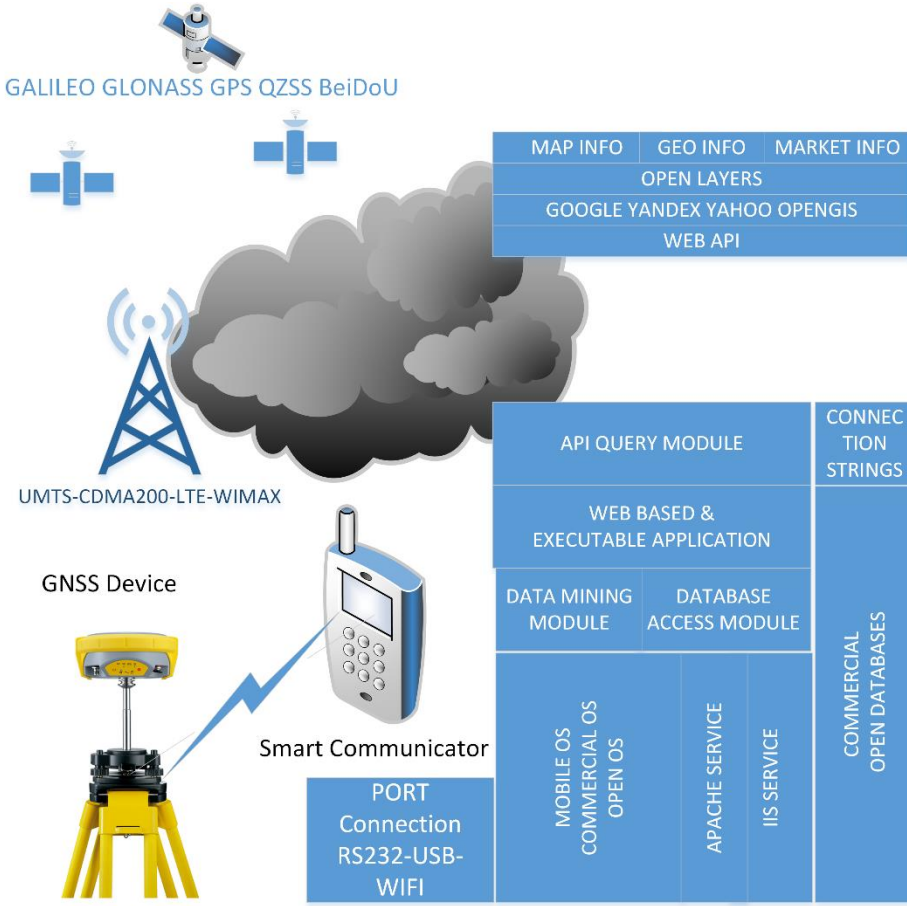


Hava Araçlarında Yakıt Tasarrufu



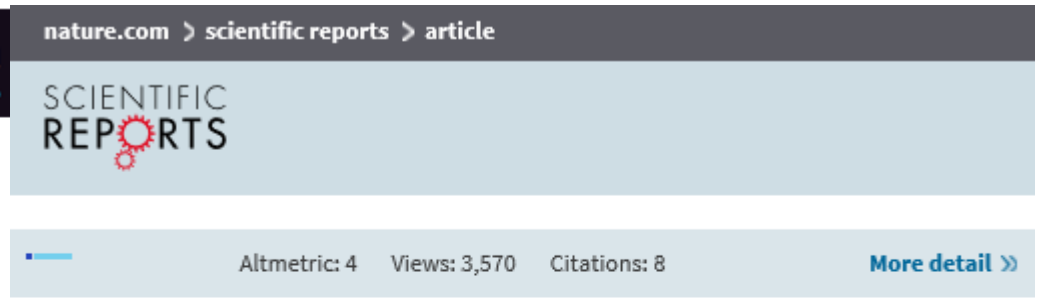
GNSS Uygulamaları



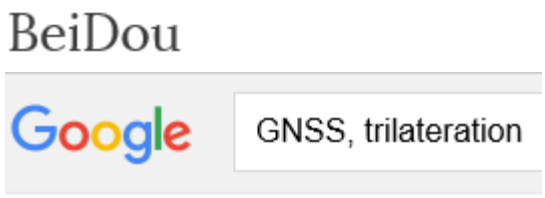


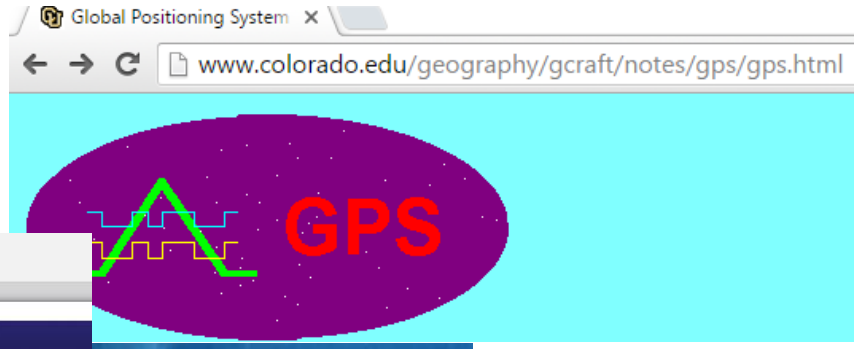
Referanslar















TEŞEKKÜRLER

