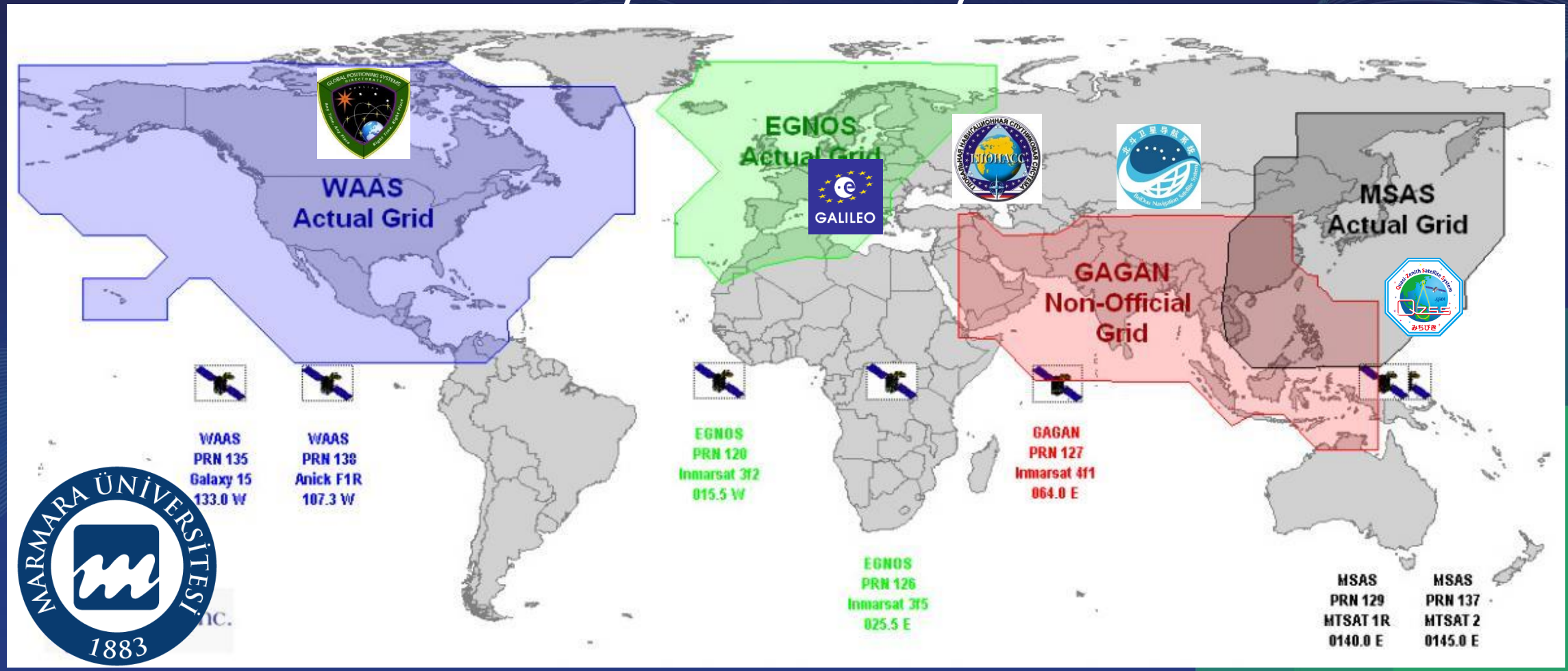
TÜBİTAK

Havacılık ve Uzay



TÜBİTAK SENİNLE !

GNSS
Küresel Seyrüsefer Uydu Sistemleri



Dr.Öğr.Üyesi Serkan AYDIN Elektronik ve Otomasyon Bölümü
Marmara Üniversitesi

TÜBİTAK

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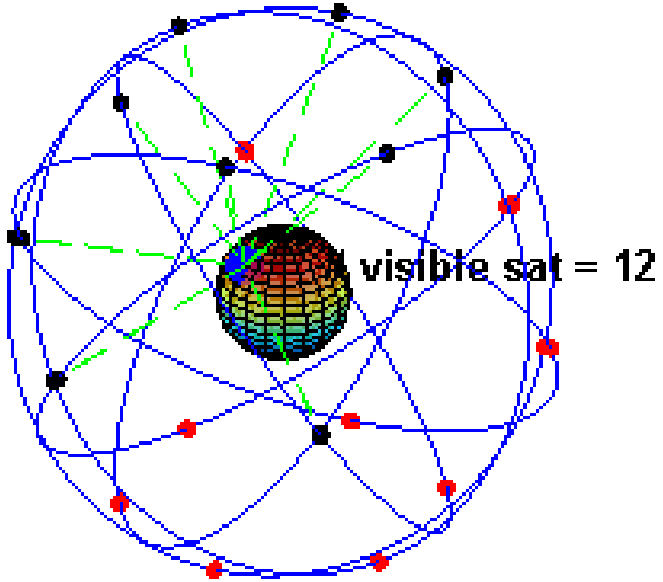
TÜBİTAK SENİNLE !

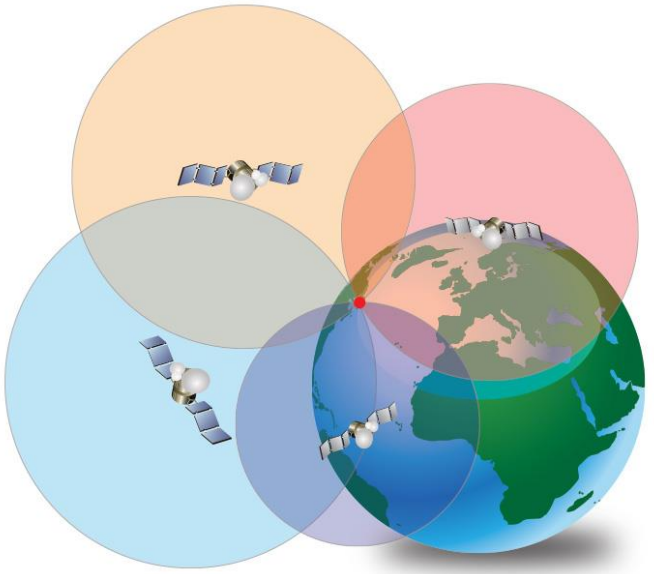
Konum Belirleme:

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. İçerisinde hata payı da olan bu hesabın daha doğru ve hassas yapılabilmesi için daha çok uydunun sinyalin hesaplanması gerekir.



Ne kadar çok güvenilir uydu o kadar hassas konum belirleme!





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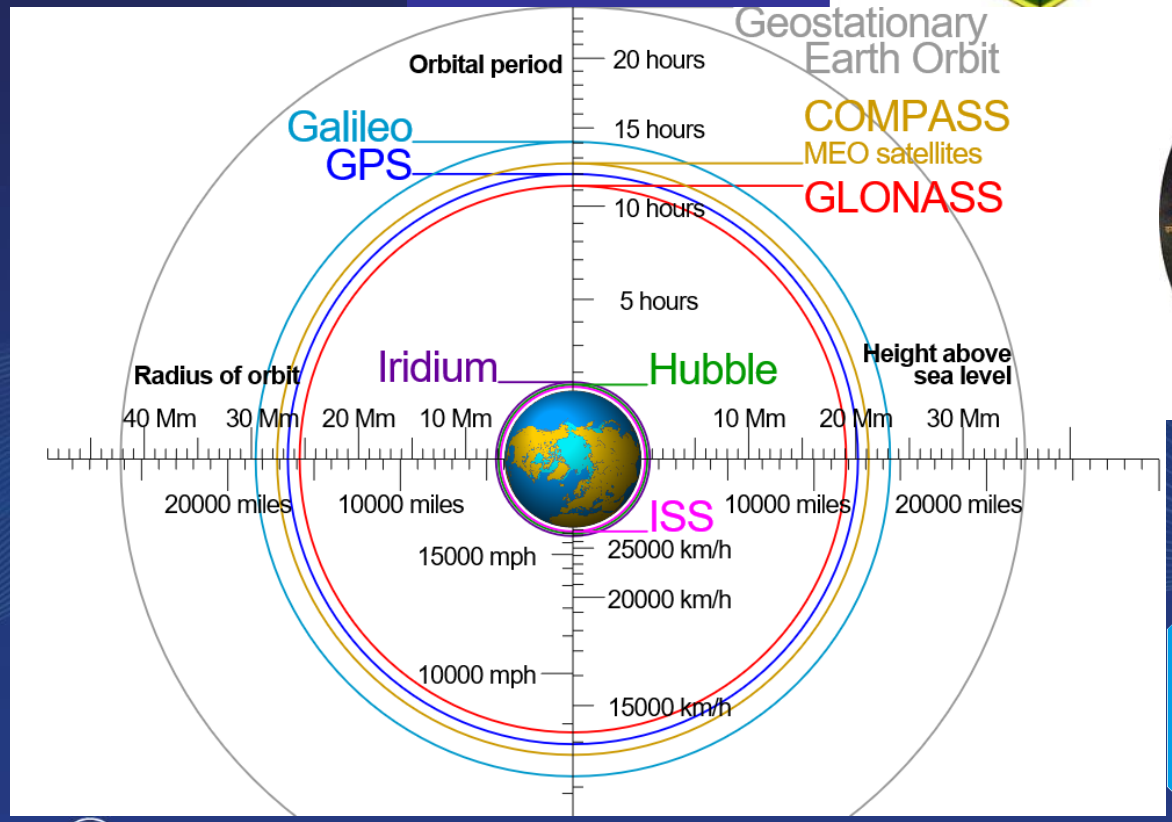
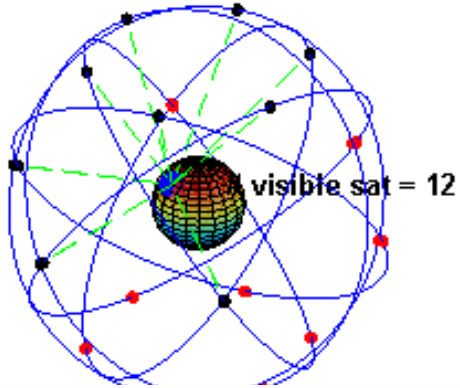
BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE !

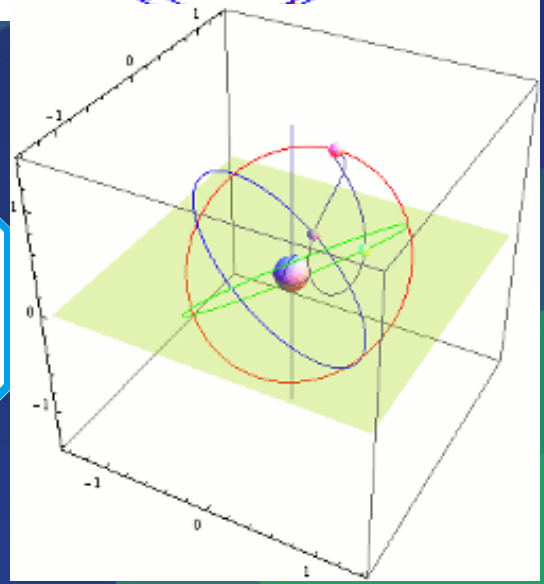
GALILEO











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BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE !

Yapay Zekayla Yazışma

GNSS alıcısı olan bir cep telefonunun GNSS (ilk kullanım ifadesi GPS) uydusundan sinyali alırken tasvir eder misin? Yalnız şeffaflaştırma yaparak modülü kapalı kutunun içende ilüstre etmeni istiyorum

ChatGPT:

Elbette, sana bir illüstrasyon hazırlayabilirim. Anladığım kadarıyla aşağıdaki özellikleri taşıyan bir görüntü istiyorsun:

•**GPS uydusundan gelen sinyal**: Uzaydan telefona doğru bir yol izleyen sinyal dalgaları.

•**Telefonun GNSS modülü görünmeli**: Ancak telefonun içi **şeffaflaştırılarak** gösterilecek, yani cihazın içi dıştan görünür hâle getirilecek.

•GNSS modülü de kutu içinde olacak ama o kutunun içi de şeffaf olacak, değil mi?

Şunu netleştireyim:

•GNSS modülü küçük bir kutu içinde mi olacak, yani özel bir donanım birimi gibi mi göstermek istersin?

•Yoksa telefonun içindeki GNSS çipinin yeri belirgin şekilde mi görünsün?

•Ayrıca tasarım daha teknik (mühendislik çizimi gibi) mi olsun, yoksa daha gerçekçi ve görsel olarak şık bir 3D görüntü mü tercih edersin?

Birkaç saniyede sana örnek oluşturabilirim ama önce stil ve detayları netleştirelim :)

Şunu dedin:

telefonun içinde olacak belirgin bir şekilde görünsün. 2 tane tercih göster netleştirilecek 2. ve 3 seçenek için



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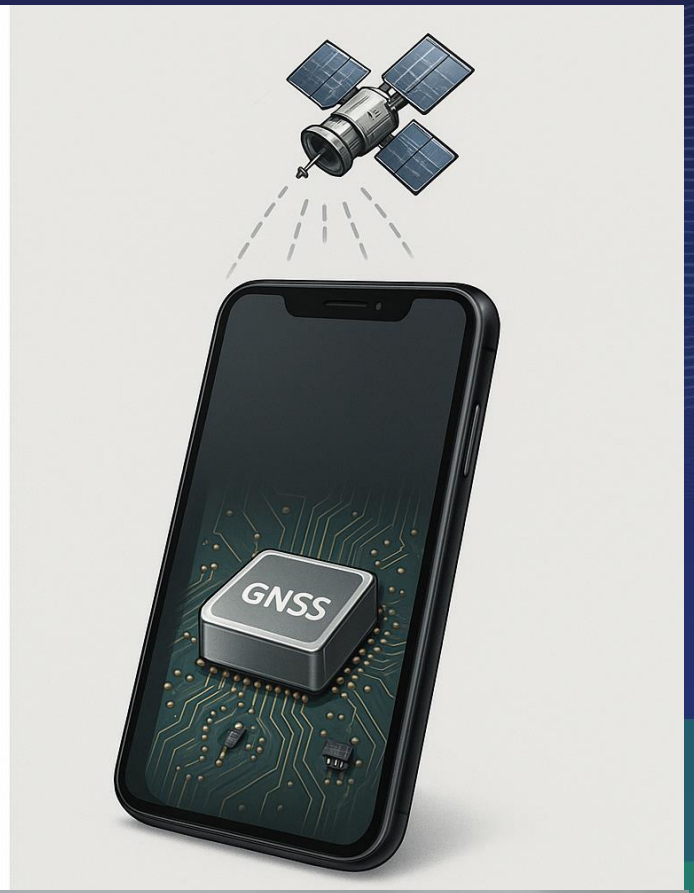
TÜBİTAK SENİNLE !

Yapay Zekanın Çizdiği Şekil

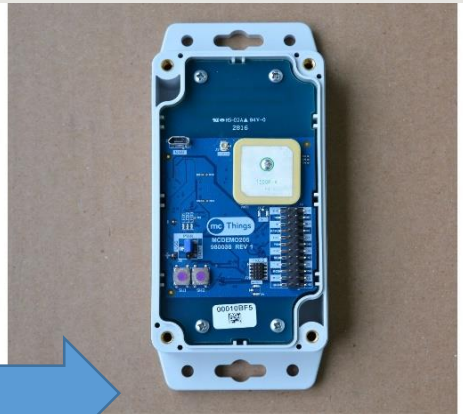
Daha çok uydudan sinyal alması gerekiyor

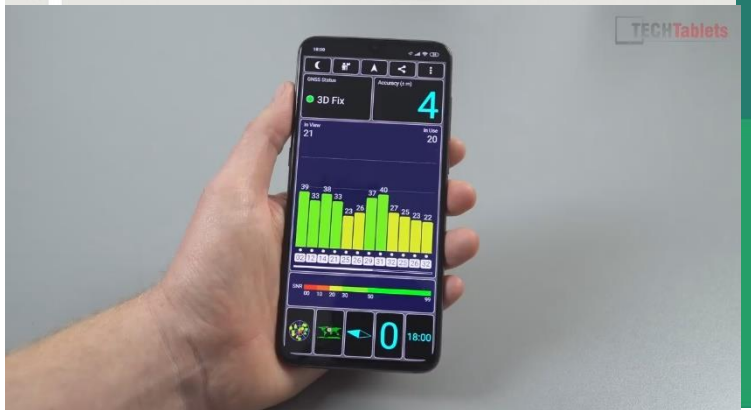






Normalde Olan





BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE!

Yapay Zekanın Çizdiği Şekil







Normalde Olan

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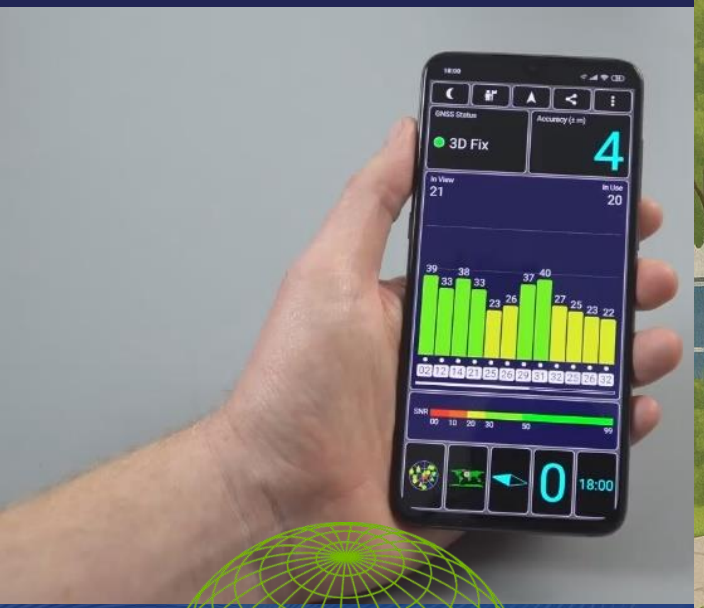
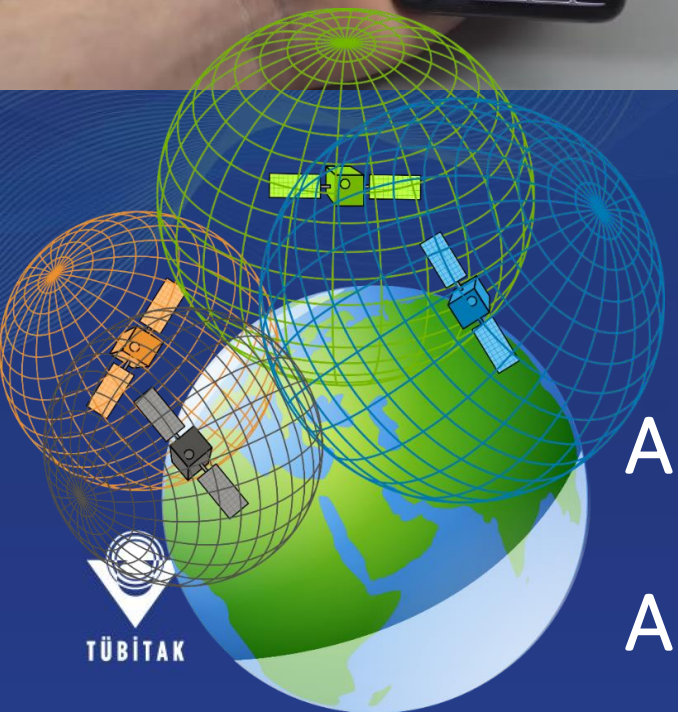
TÜBİTAK SENİNLE !

Saha Etkinliği Sinyal Kanallarındaki Sayıların Toplamı En Yüksek Kimin?







Android Marketteki Programın Adı GPS Test

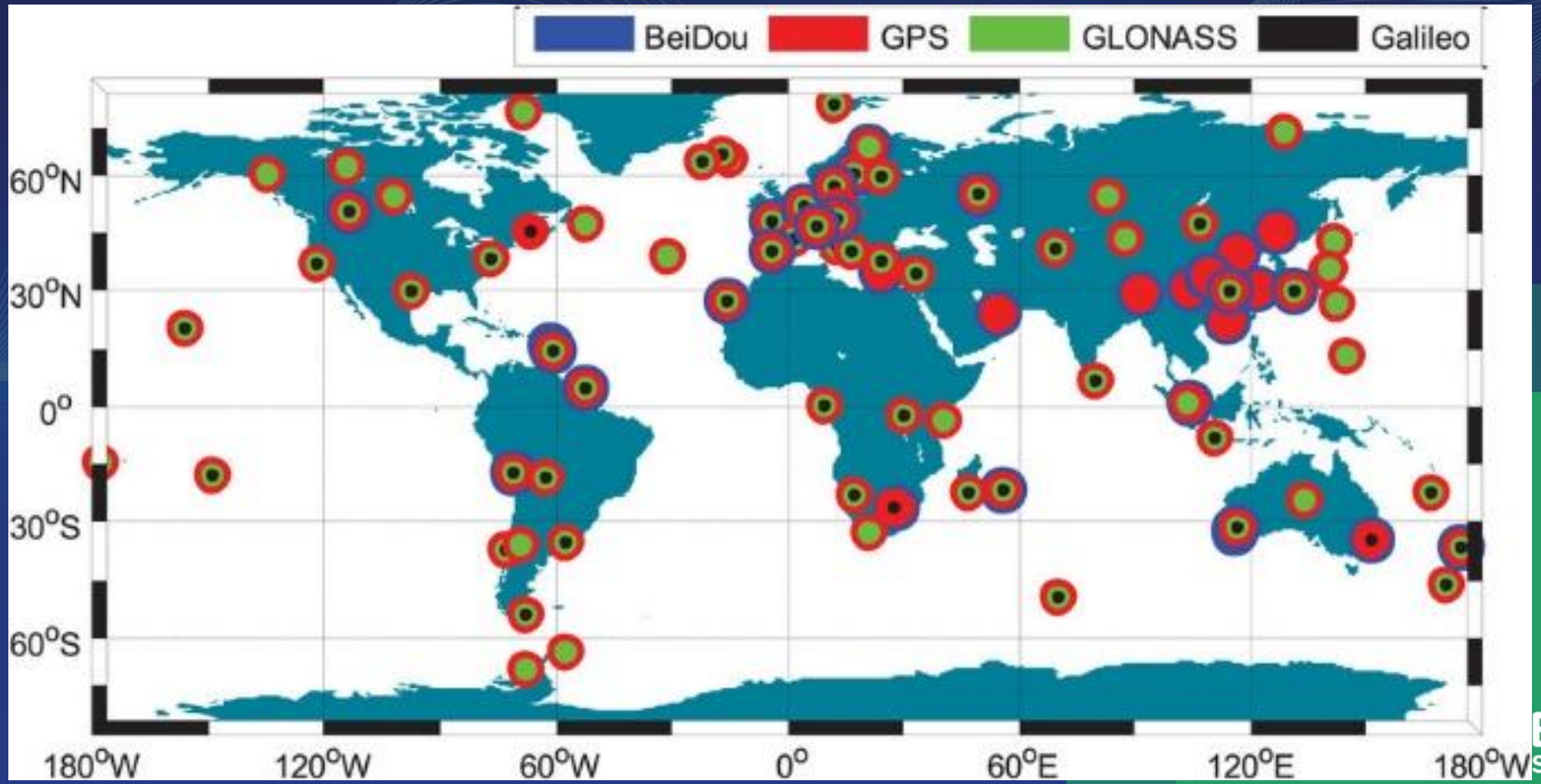
Apple Marketteki Programın Adı GPS Dual

Dual GPS

BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE !

Kontrol ve Ölçüm Referans Noktaları



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BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE !

Kapsama ve Spektrum

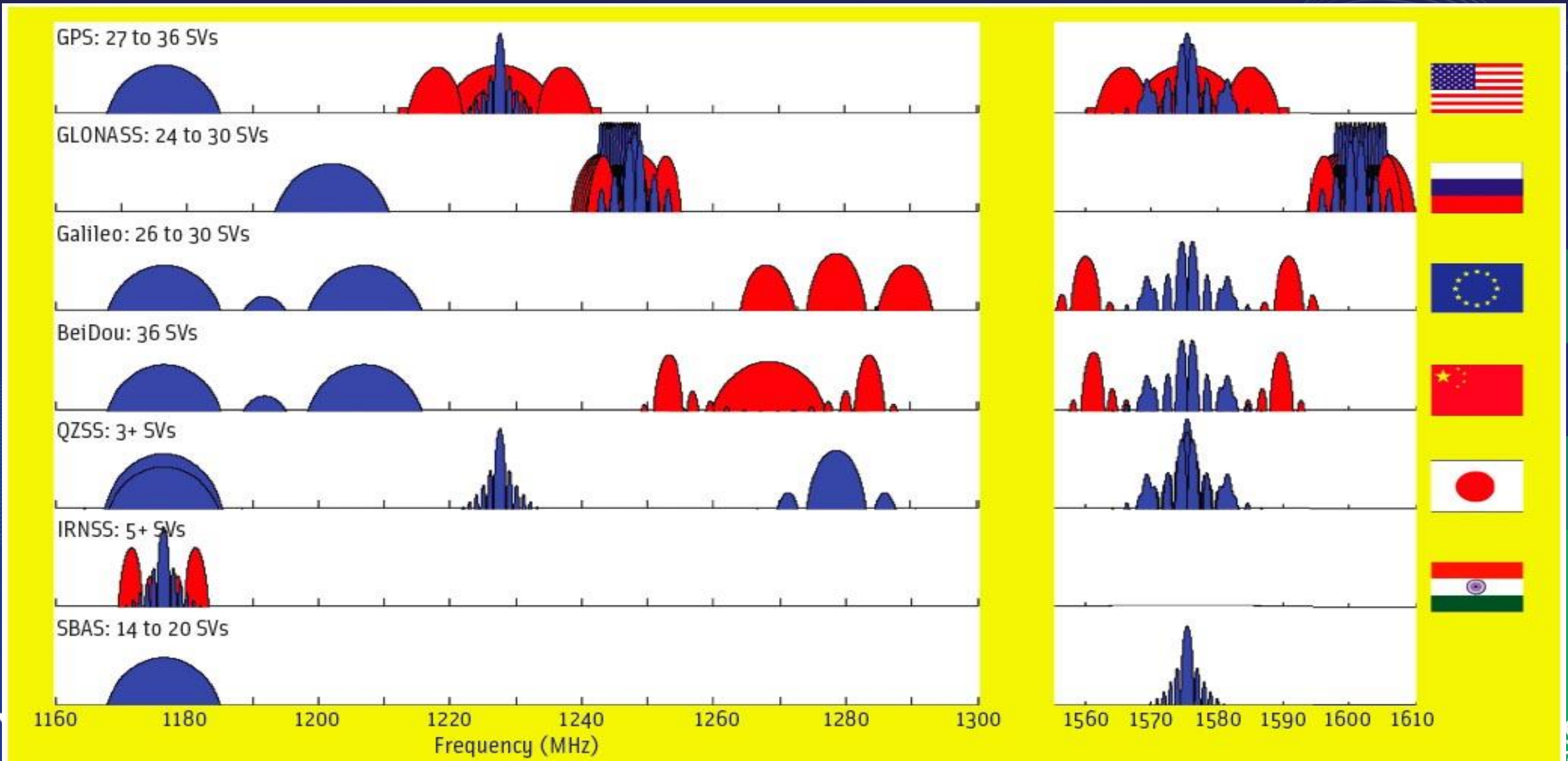
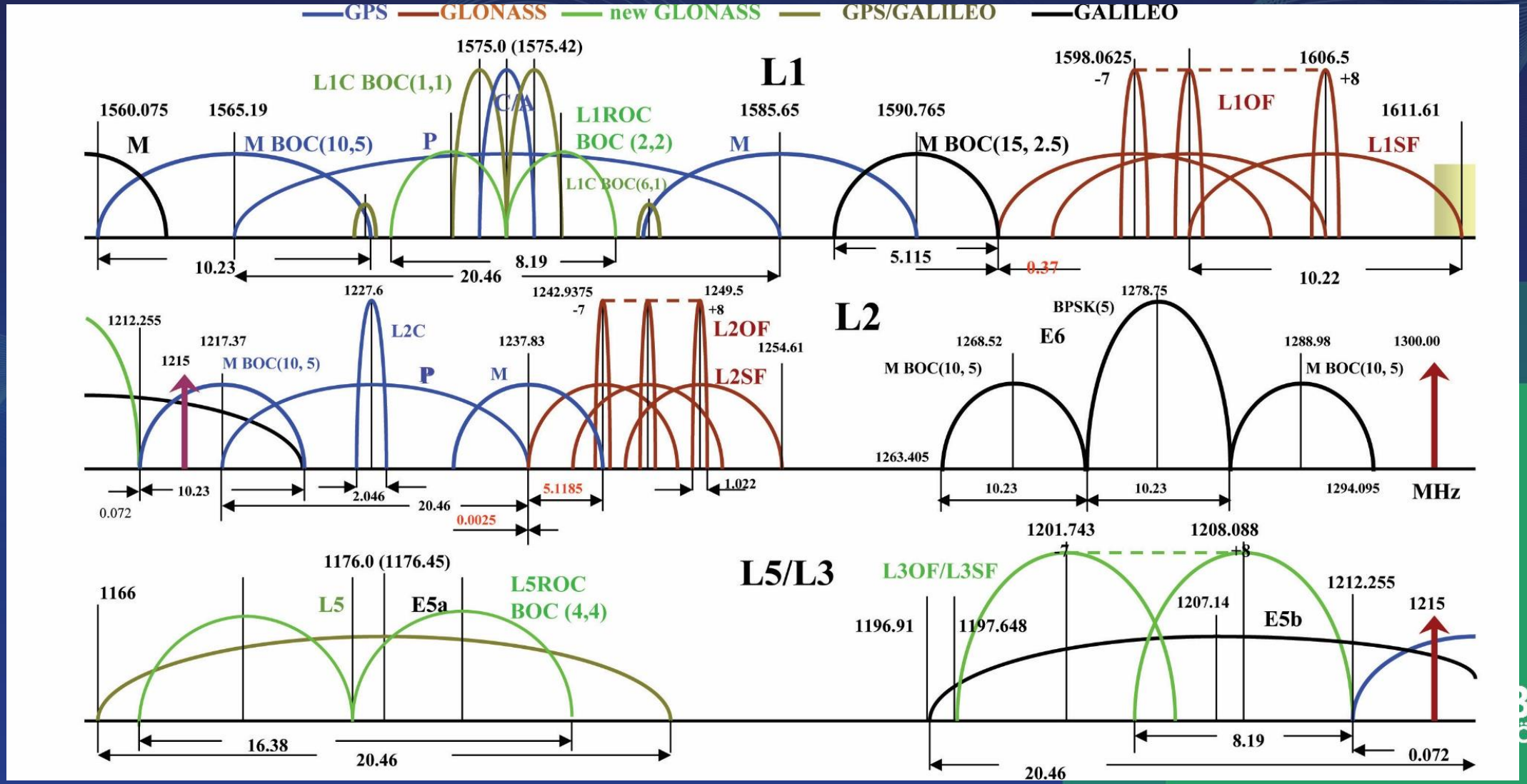


FIGURE 1 Prospective satnav signal structures, with open signals in blue and restricted signals in red

TÜBİTAK SENİNLE !

Taşıyıcılar

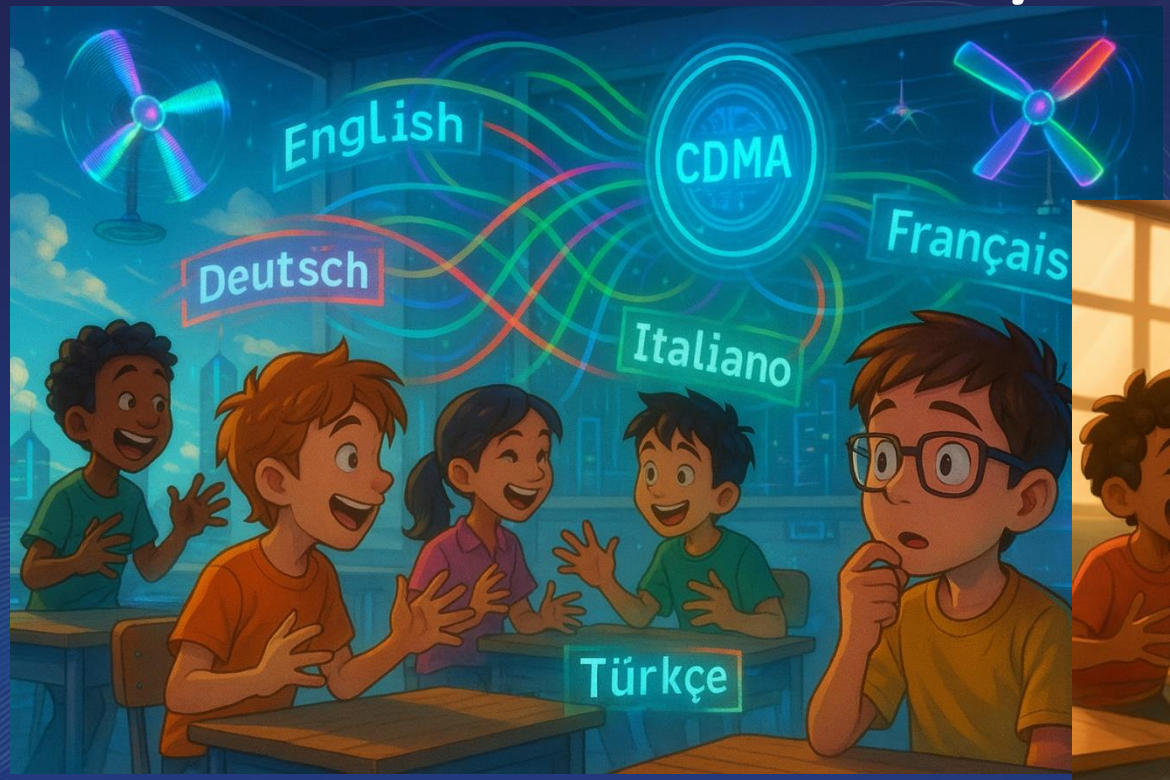


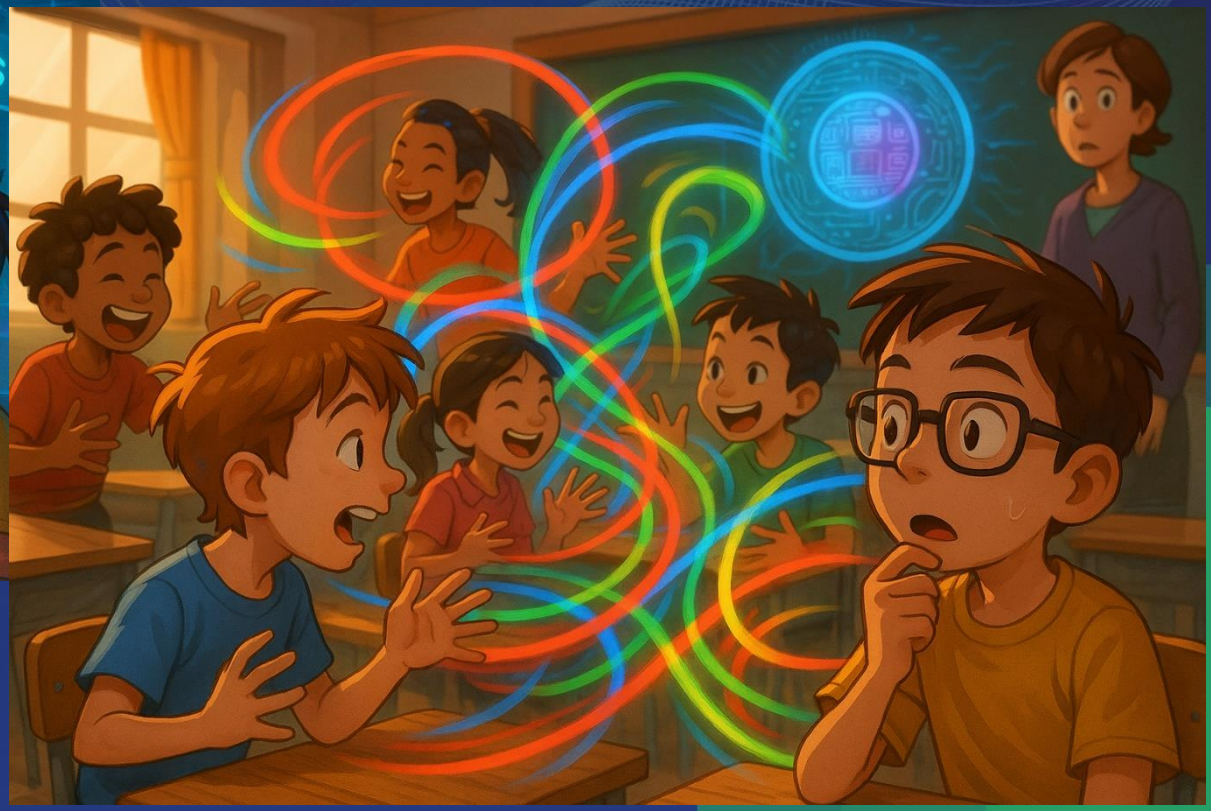
TÜBİTAK

BİLİM ÖYLEŞİLERİ

TÜBİTAK SENİNLE !

Kod Jenerasyonu





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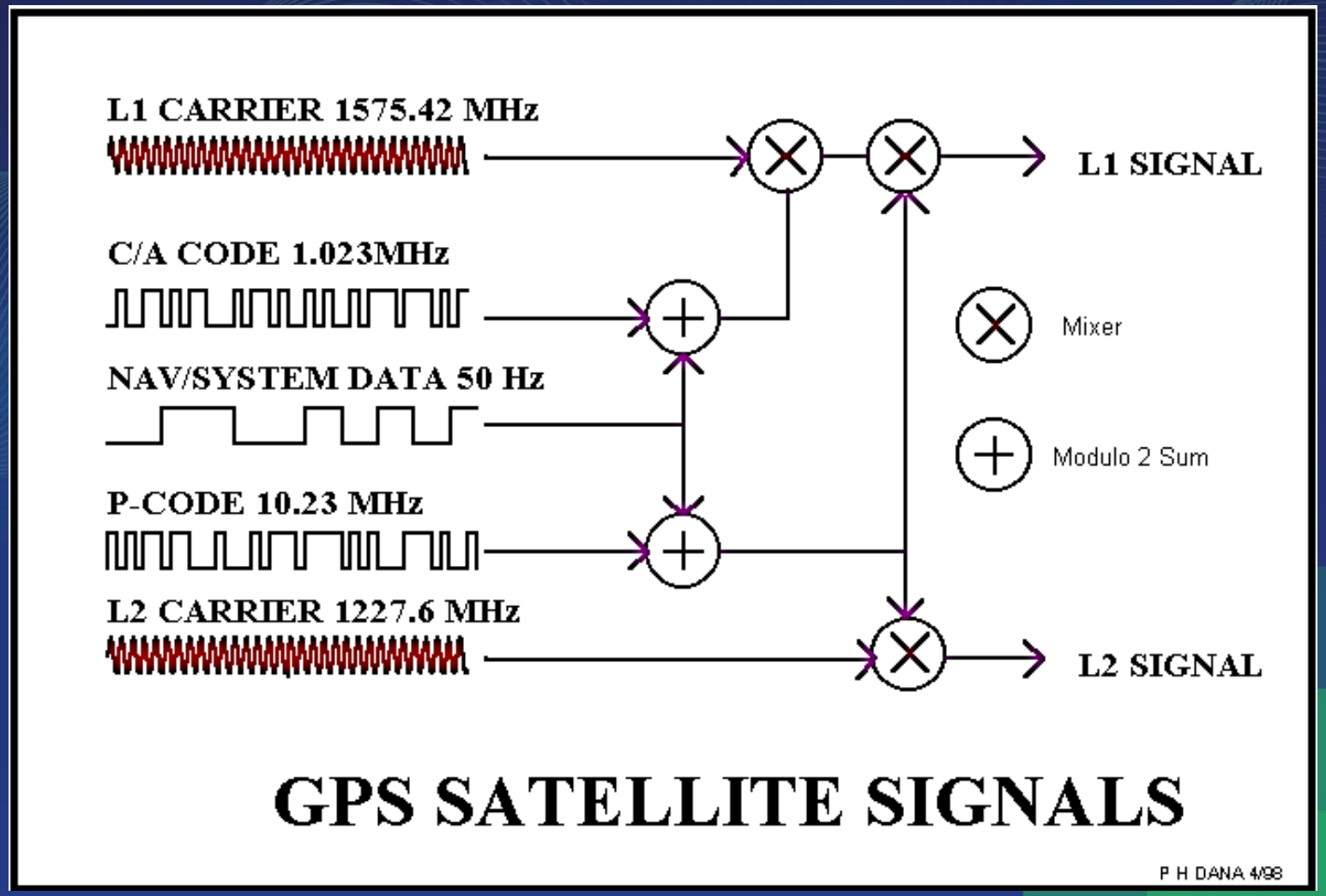
BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE !

Kod Jenerasyonu



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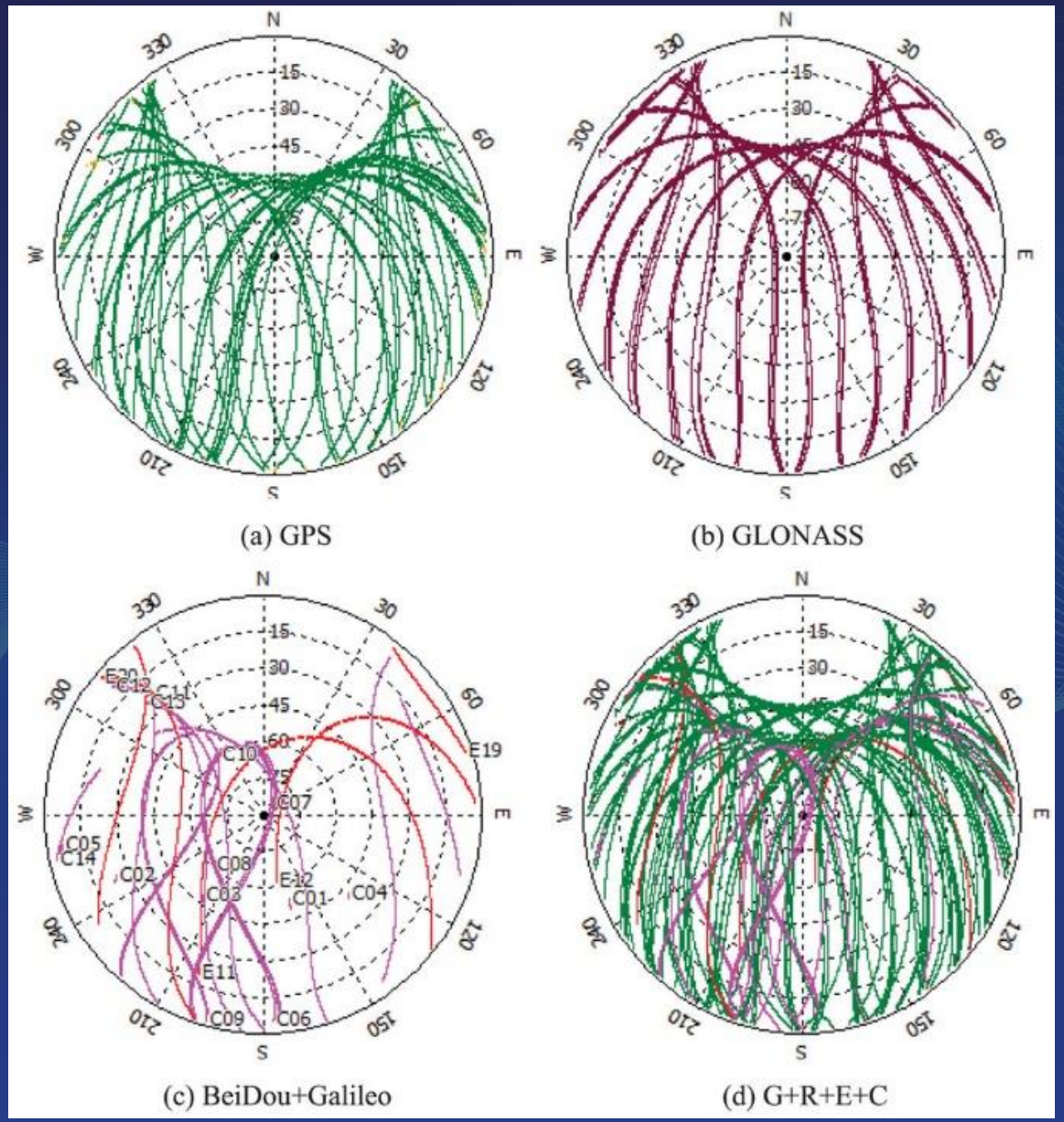
BİLİM SÖYLEŞİLERİ

TÜBİTAK SENİNLE !

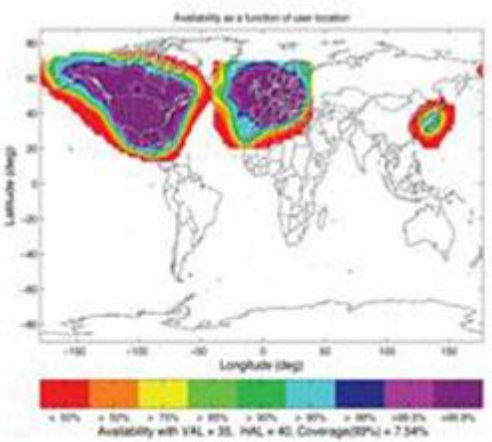
GNSS Uydu İzlemleri



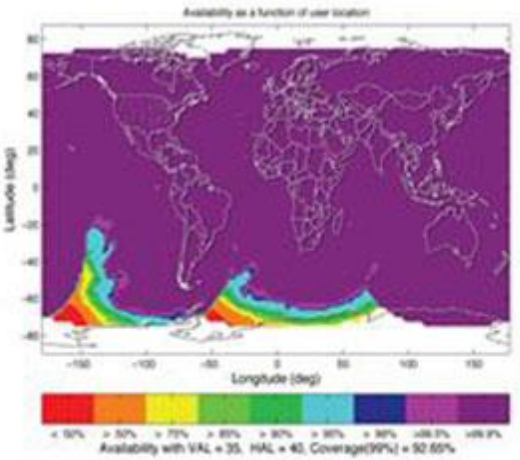
Long term (2020-2025) plan – Global SBAS
Extract of joint presentation SBAS provider IWG23

esa

Current Coverage WAAS-EGNOS-MSAS



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



TÜBİTAK

TÜBİTAK SENİNLE !

Uydular Durumları 30Nisan 2025

ABD

Name	NORAD ID	Int'l Code	Launch date	Period [minutes]	PRN
NAVSTAR 82 (USA 343)	55268	2023-009A	January 18, 2023	717.9	28
NAVSTAR 81 (USA 319)	48859	2021-054A	June 17, 2021	718	11
NAVSTAR 80 (USA 309)	46826	2020-078A	November 5, 2020	718	14
NAVSTAR 79 (USA 304)	45854	2020-041A	June 30, 2020	718	23
NAVSTAR 78 (USA 293)	44506	2019-056A	August 22, 2019	718	18
NAVSTAR 77 (USA 289)	43873	2018-109A	December 23, 2018	718	4
NAVSTAR 76 (USA 266)	41328	2016-007A	February 5, 2016	717.9	32
NAVSTAR 75 (USA 265)	41019	2015-062A	October 31, 2015	718	10
NAVSTAR 74 (USA 262)	40730	2015-033A	July 15, 2015	718	8
NAVSTAR 73 (USA 260)	40534	2015-013A	March 25, 2015	717.9	26
NAVSTAR 72 (USA 258)	40294	2014-068A	October 29, 2014	717.9	3
NAVSTAR 71 (USA 256)	40105	2014-045A	August 2, 2014	718	9
NAVSTAR 70 (USA 251)	39741	2014-026A	May 17, 2014	717.9	6
NAVSTAR 69 (USA 248)	39533	2014-008A	February 21, 2014	718	30
NAVSTAR 68 (USA 242)	39166	2013-023A	May 15, 2013	718	27
NAVSTAR 67 (USA 239)	38833	2012-053A	October 4, 2012	718	24
NAVSTAR 65 (USA 213)	36585	2010-022A	May 28, 2010	718	25
NAVSTAR 64 (USA 206)	35752	2009-043A	August 17, 2009	717.9	5
NAVSTAR 62 (USA 201)	32711	2008-012A	March 15, 2008	718	7
NAVSTAR 61 (USA 199)	32384	2007-062A	December 20, 2007	718	29
NAVSTAR 60 (USA 196)	32260	2007-047A	October 17, 2007	717.9	15
NAVSTAR 59 (USA 192)	29601	2006-052A	November 17, 2006	718	12
NAVSTAR 58 (USA 190)	29486	2006-042A	September 25, 2006	718	31
NAVSTAR 57 (USA 183)	28874	2005-038A	September 26, 2005	718	17
NAVSTAR 56 (USA 180)	28474	2004-045A	November 6, 2004	718	2
NAVSTAR 54 (USA 177)	28190	2004-009A	March 20, 2004	718	19
NAVSTAR 52 (USA 168)	27704	2003-010A	March 31, 2003	718.2	21
NAVSTAR 51 (USA 166)	27663	2003-005A	January 29, 2003	718	16
NAVSTAR 48 (USA 151)	26407	2000-040A	July 16, 2000	718	22
NAVSTAR 47 (USA 150)	26360	2000-025A	May 11, 2000	718	20
NAVSTAR 43 (USA 132)	24876	1997-035A	July 23, 1997	718	13

RUSYA

Name	NORAD ID	Int'l Code	Launch date	Period [minutes]	SV
COSMOS 2564 (GLONASS)	54377	2022-161A	November 28, 2022	675.7	761
COSMOS 2559 (GLONASS)	54031	2022-130A	October 10, 2022	675.7	707K
COSMOS 2557 (GLONASS)	52984	2022-075A	July 7, 2022	675.7	706K
COSMOS 2547 (GLONASS)	46805	2020-075A	October 25, 2020	675.7	705K
COSMOS 2545 (GLONASS)	45358	2020-018A	March 16, 2020	675.7	760
COSMOS 2544 (GLONASS)	44850	2019-088A	December 11, 2019	675.7	759
COSMOS 2534 (GLONASS)	44299	2019-030A	May 27, 2019	675.7	758
COSMOS 2529 (GLONASS)	43687	2018-086A	November 3, 2018	675.7	757
COSMOS 2527 (GLONASS)	43508	2018-053A	June 16, 2018	675.7	756
COSMOS 2522 (GLONASS)	42939	2017-055A	September 22, 2017	675.7	752
COSMOS 2516 (GLONASS)	41554	2016-032A	May 29, 2016	675.7	753
COSMOS 2514 (GLONASS)	41330	2016-008A	February 7, 2016	675.7	751
COSMOS 2501 (GLONASS)	40315	2014-075A	November 30, 2014	675.7	702K
COSMOS 2500 (GLONASS)	40001	2014-032A	June 14, 2014	675.7	755
COSMOS 2492 (GLONASS)	39620	2014-012A	March 23, 2014	675.7	754
COSMOS 2485 (GLONASS)	39155	2013-019A	April 26, 2013	675.7	747
COSMOS 2475 (GLONASS)	37869	2011-064C	November 4, 2011	675.7	743
COSMOS 2477 (GLONASS)	37868	2011-064B	November 4, 2011	675.7	745
COSMOS 2476 (GLONASS)	37867	2011-064A	November 4, 2011	675.7	744
COSMOS 2460 (GLONASS)	36402	2010-007C	March 1, 2010	675.7	732
COSMOS 2457 (GLONASS)	36112	2009-070B	December 14, 2009	675.7	733
COSMOS 2456 (GLONASS)	36111	2009-070A	December 14, 2009	675.7	730
COSMOS 2436 (GLONASS)	32395	2007-065C	December 25, 2007	675.7	723
COSMOS 2434 (GLONASS)	32393	2007-065A	December 25, 2007	675.7	721
COSMOS 2432 (GLONASS)	32276	2007-052B	October 26, 2007	675.7	719
COSMOS 2433 (GLONASS)	32275	2007-052A	October 26, 2007	675.7	720

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Avrupa Birliği

Name	NORAD ID	Int'l Code	Launch date	Period [minutes]	PRN
GALILEO 31 (10D)	61183	2024-167B	September 17, 2024	844.7	N/A
GALILEO 32 (137)	61182	2024-167A	September 17, 2024	844.7	N/A
GALILEO 30 (10E)	59600	2024-079C	April 28, 2024	844.7	LEO
GALILEO 29 (10C)	59598	2024-079A	April 28, 2024	844.7	LEO
GALILEO 28 (224)	49810	2021-117B	December 5, 2021	844.7	LEO
GALILEO 27 (223)	49809	2021-117A	December 5, 2021	844.7	LEO
GALILEO 24 (2C0)	43567	2018-060D	July 25, 2018	844.7	LEO
GALILEO 23 (2C9)	43566	2018-060C	July 25, 2018	844.7	LEO
GALILEO 26 (2C2)	43565	2018-060B	July 25, 2018	844.7	LEO
GALILEO 25 (2C1)	43564	2018-060A	July 25, 2018	844.7	LEO
GALILEO 22 (2C8)	43058	2017-079D	December 12, 2017	844.7	LEO
GALILEO 21 (2C7)	43057	2017-079C	December 12, 2017	844.7	LEO
GALILEO 20 (2C6)	43056	2017-079B	December 12, 2017	844.7	LEO
GALILEO 19 (2C5)	43055	2017-079A	December 12, 2017	844.7	LEO
GALILEO 18 (26E)	41862	2016-069D	November 17, 2016	844.7	LEO
GALILEO 17 (26D)	41861	2016-069C	November 17, 2016	844.7	LEO
GALILEO 16 (26C)	41860	2016-069B	November 17, 2016	844.7	LEO
GALILEO 15 (267)	41859	2016-069A	November 17, 2016	844.7	LEO
GALILEO 13 (26A)	41550	2016-030B	May 24, 2016	844.7	N/A
GALILEO 14 (26B)	41549	2016-030A	May 24, 2016	844.7	LEO
GALILEO 11 (268)	41175	2015-079B	December 17, 2015	844.7	LEO
GALILEO 12 (269)	41174	2015-079A	December 17, 2015	844.7	LEO
GALILEO 10 (206)	40890	2015-045B	September 11, 2015	844.7	LEO
GALILEO 9 (205)	40889	2015-045A	September 11, 2015	844.7	LEO
GSAT0204	40545	2015-017B	March 27, 2015	844.7	LEO
GSAT0203	40544	2015-017A	March 27, 2015	844.7	LEO
GALILEO 6 (262)	40129	2014-050B	August 22, 2014	776.2	LEO
GALILEO 5 (261)	40128	2014-050A	August 22, 2014	776.2	LEO
GALILEO-FM4	38858	2012-055B	October 12, 2012	874.9	N/A
GALILEO-FM3	38857	2012-055A	October 12, 2012	844.7	LEO
GALILEO-FM2	37847	2011-060B	October 21, 2011	844.7	LEO
GALILEO-PFM	37846	2011-060A	October 21, 2011	844.7	LEO

Çin Halk Cumhuriyet

Name	NORAD ID	Int'l Code	Launch date	Period [minutes]
BEIDOU 3M22	44794	2019-078B	November 23, 2019	773.2
BEIDOU 3M21	44793	2019-078A	November 23, 2019	773.2
BEIDOU 3M24	44543	2019-061B	September 22, 2019	773.2
BEIDOU 3M23	44542	2019-061A	September 22, 2019	773.2
BEIDOU 2 G8	44231	2019-027A	May 17, 2019	1436.1
BEIDOU 3M18	43707	2018-093B	November 18, 2018	773.2
BEIDOU 3M17	43706	2018-093A	November 18, 2018	773.2
BEIDOU 3G1	43683	2018-085A	November 1, 2018	1436.1
BEIDOU 3M16	43648	2018-078B	October 15, 2018	773.2
BEIDOU 3M15	43647	2018-078A	October 15, 2018	773.2
BEIDOU 3M12	43603	2018-067B	August 24, 2018	773.2
BEIDOU 3M11	43602	2018-067A	August 24, 2018	773.2
BEIDOU 3M10	43582	2018-062B	July 29, 2018	773.2
BEIDOU 3M9	43581	2018-062A	July 29, 2018	773.2
BEIDOU IGSO-7	43539	2018-057A	July 9, 2018	1436.1
BEIDOU 3M8	43246	2018-029B	March 29, 2018	773.2
BEIDOU 3M7	43245	2018-029A	March 29, 2018	773.2
BEIDOU 3M6	43208	2018-018B	February 12, 2018	773.2
BEIDOU 3M5	43207	2018-018A	February 12, 2018	773.2
BEIDOU 3M4	43108	2018-003B	January 11, 2018	773.2
BEIDOU 3M3	43107	2018-003A	January 11, 2018	773.2
BEIDOU-3 M2	43002	2017-069B	November 5, 2017	773.2
BEIDOU-3 M1	43001	2017-069A	November 5, 2017	773.2
BEIDOU G7	41586	2016-037A	June 12, 2016	1436.1
BEIDOU IGSO 6	41434	2016-021A	March 29, 2016	1436.4
BEIDOU M3-S	41315	2016-006A	February 1, 2016	773.2
BEIDOU I2-S	40938	2015-053A	September 29, 2015	1436
BEIDOU-3 M2	40749	2015-037B	July 25, 2015	773.1
BEIDOU-3 M1	40748	2015-037A	July 25, 2015	773.2
BEIDOU I1-S	40549	2015-019A	March 30, 2015	1435.9
BEIDOU G6	38953	2012-059A	October 25, 2012	1436.1
BEIDOU M6	38775	2012-050B	September 18, 2012	773.2
BEIDOU M5	38774	2012-050A	September 18, 2012	773.1
BEIDOU M4	38251	2012-018B	April 29, 2012	773.2
BEIDOU M3	38250	2012-018A	April 29, 2012	773.2
BEIDOU G5	38091	2012-008A	February 24, 2012	1436.2
BEIDOU IGSO 5	37948	2011-073A	December 1, 2011	1436.3
BEIDOU IGSO 4	37763	2011-038A	July 26, 2011	1435.9
BEIDOU IGSO 3	37384	2011-013A	April 9, 2011	1436
BEIDOU IGSO 2	37256	2010-068A	December 17, 2010	1436.4
BEIDOU G4	37210	2010-057A	October 31, 2010	1436.1
BEIDOU IGSO 1	36828	2010-036A	July 31, 2010	1435.8
BEIDOU G3	36590	2010-024A	June 2, 2010	1436.1
BEIDOU G1	36287	2010-001A	January 16, 2010	1436.1
BEIDOU G2	34779	2009-018A	April 14, 2009	1523.5
BEIDOU M1	31115	2007-011A	April 13, 2007	812
BEIDOU 1D	30323	2007-003A	February 2, 2007	1452.2
BEIDOU 1C	27813	2003-021A	May 24, 2003	1443.3
BEIDOU 1B	26643	2000-082A	December 20, 2000	1450.9
BEIDOU 1	26599	2000-069A	October 30, 2000	1455.9

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Hesaplama Hikayesi





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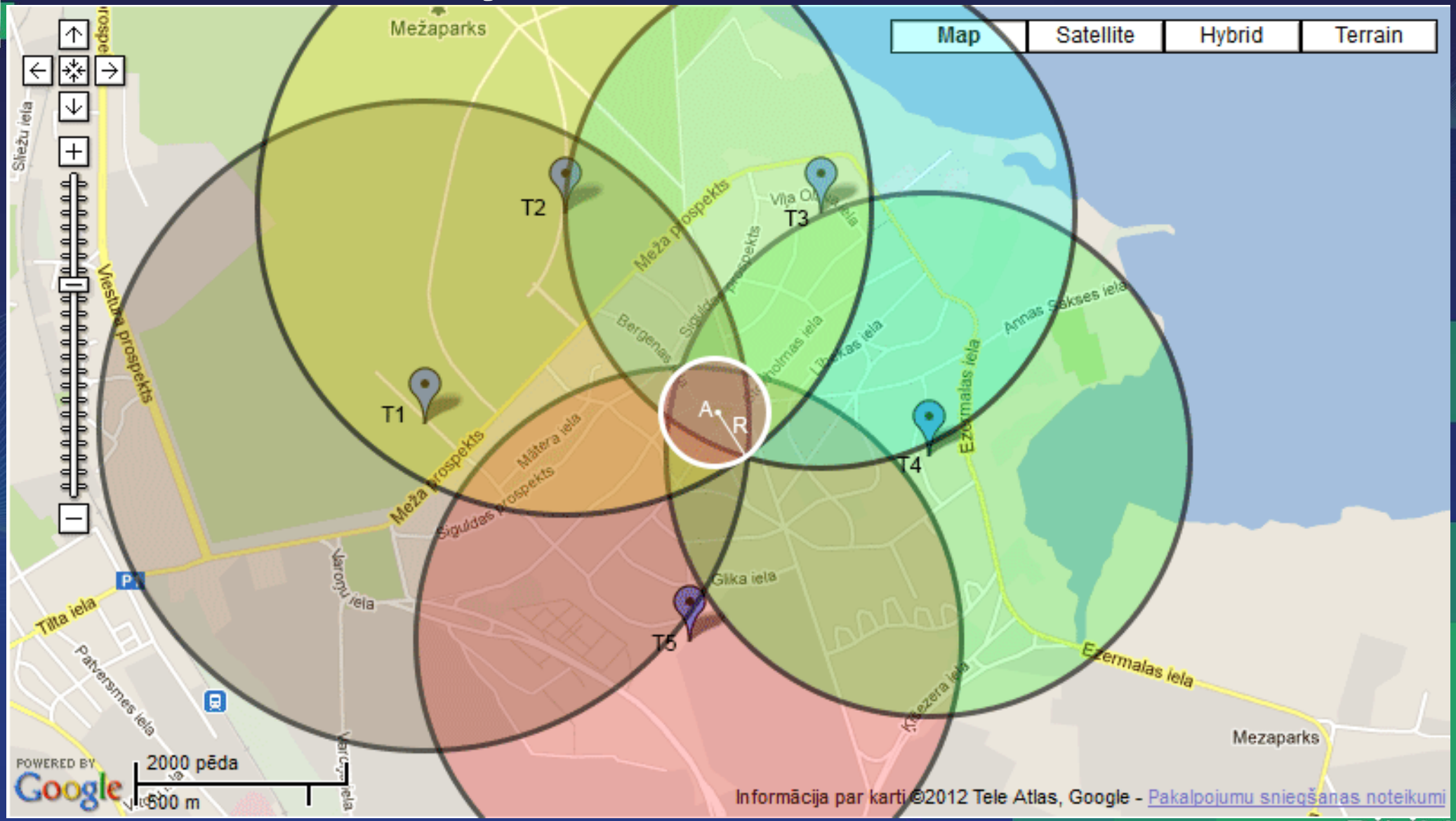
Trileterasyon



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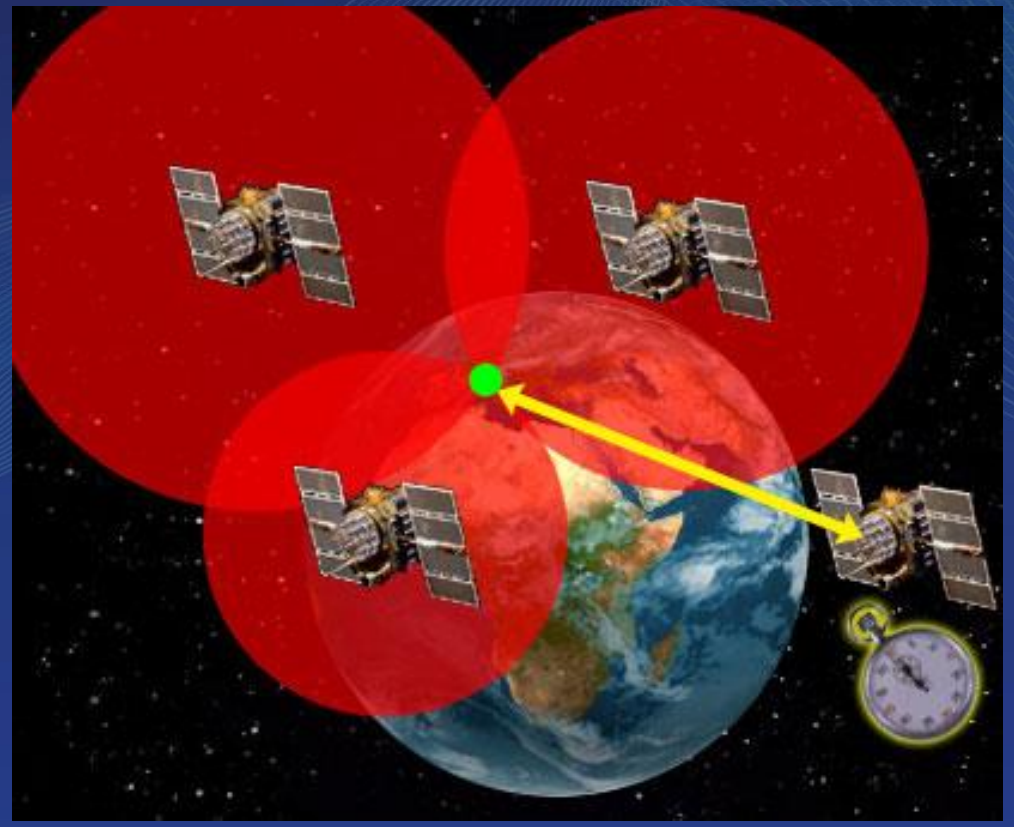
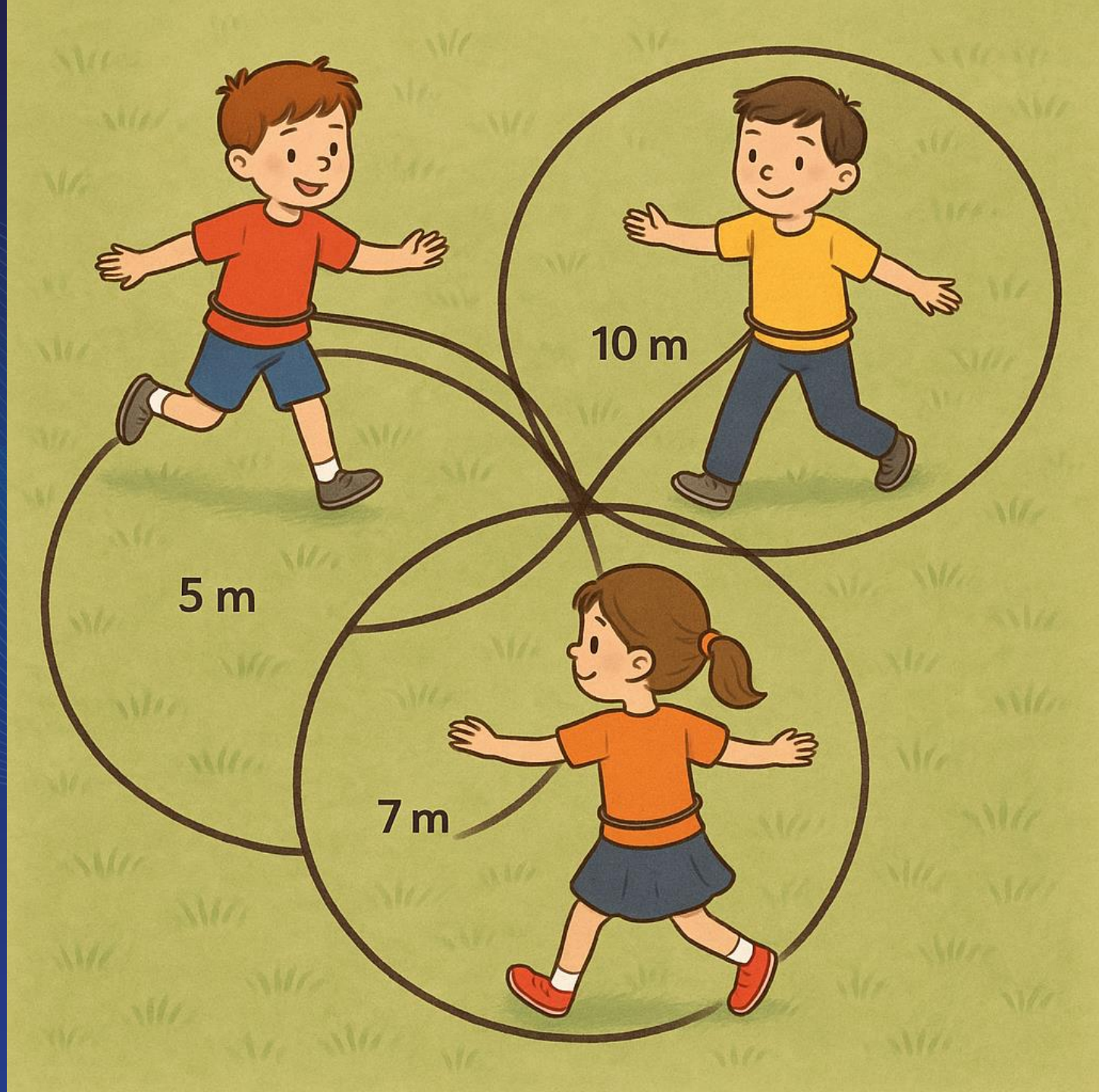
Hesaplama





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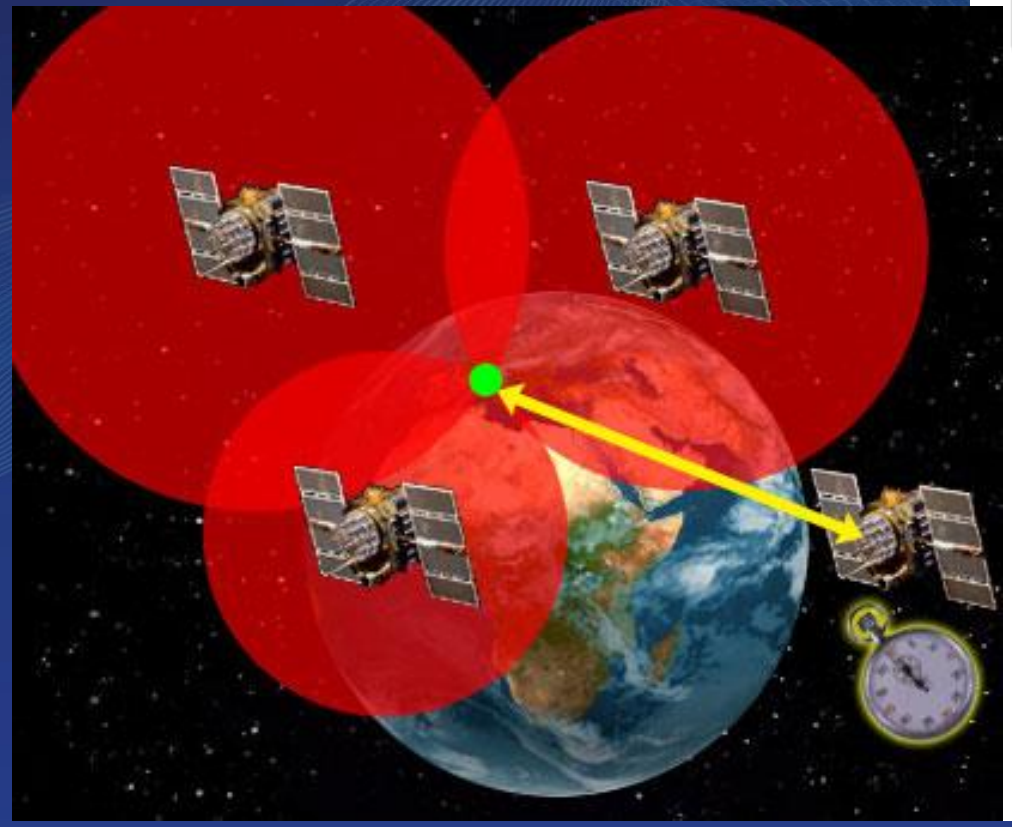
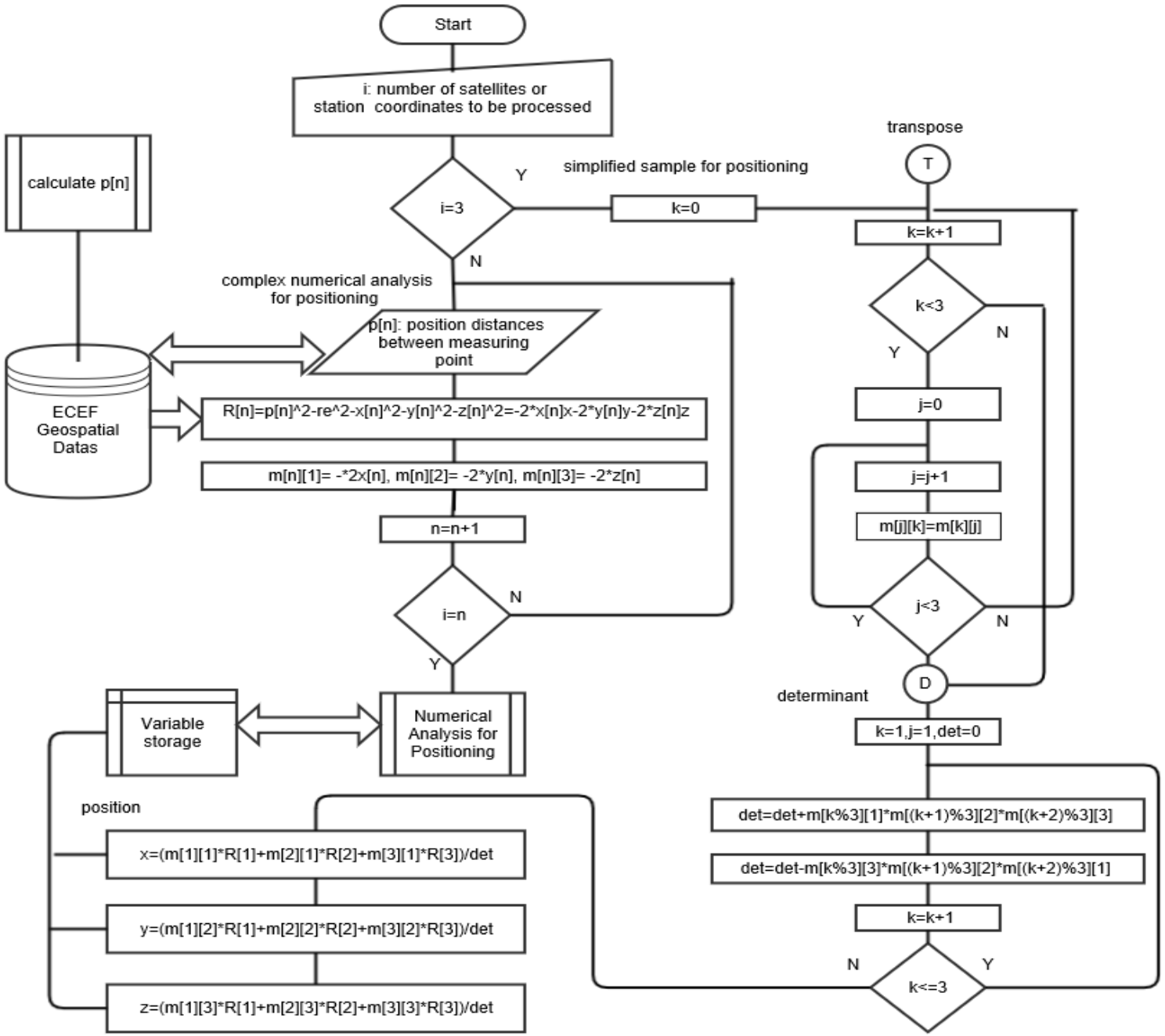
Hesaplama





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Saat Farkı&Hataları

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

TÜBİTAK

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 Bi

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

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

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

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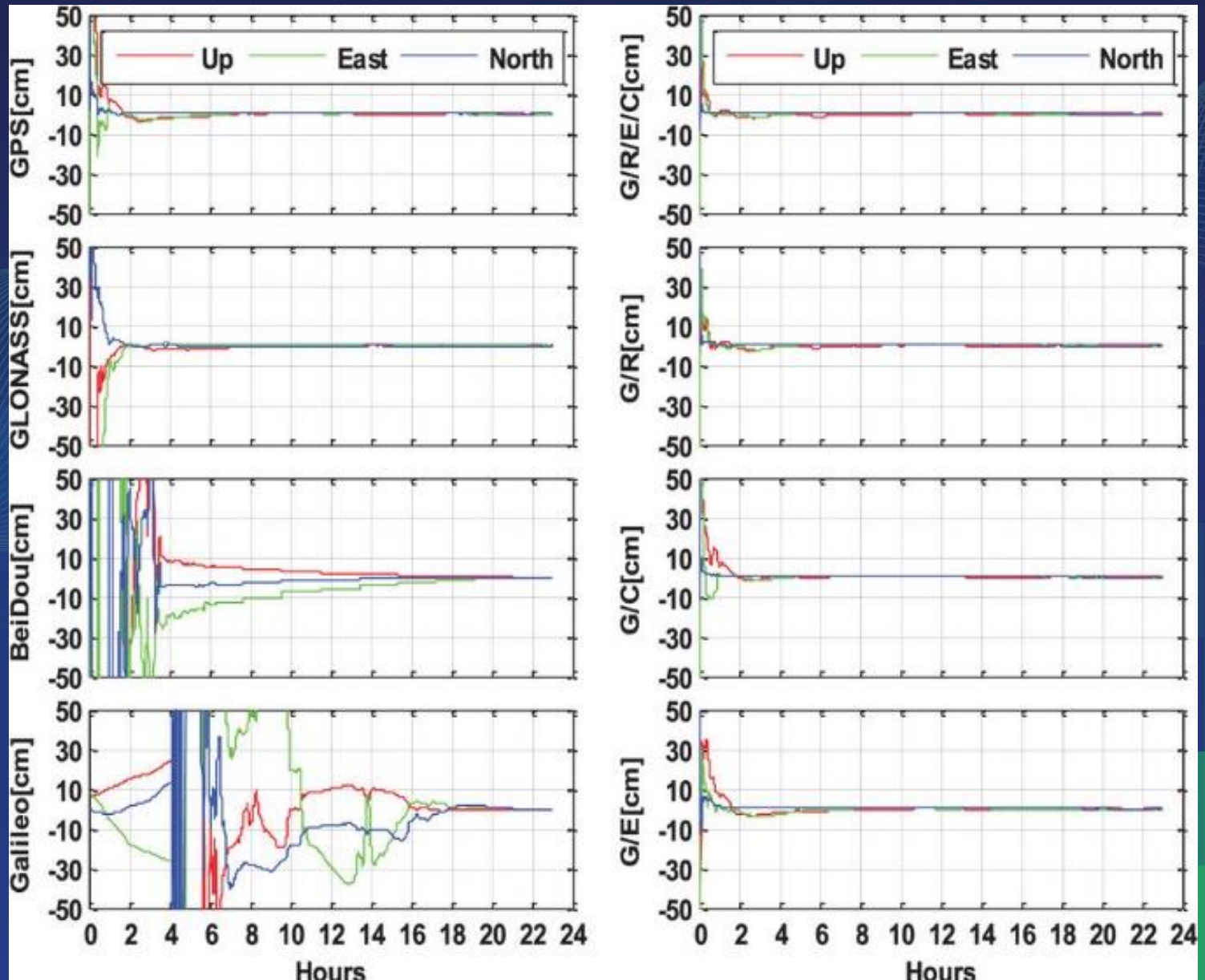
Sabit Nokta Ölçümleri



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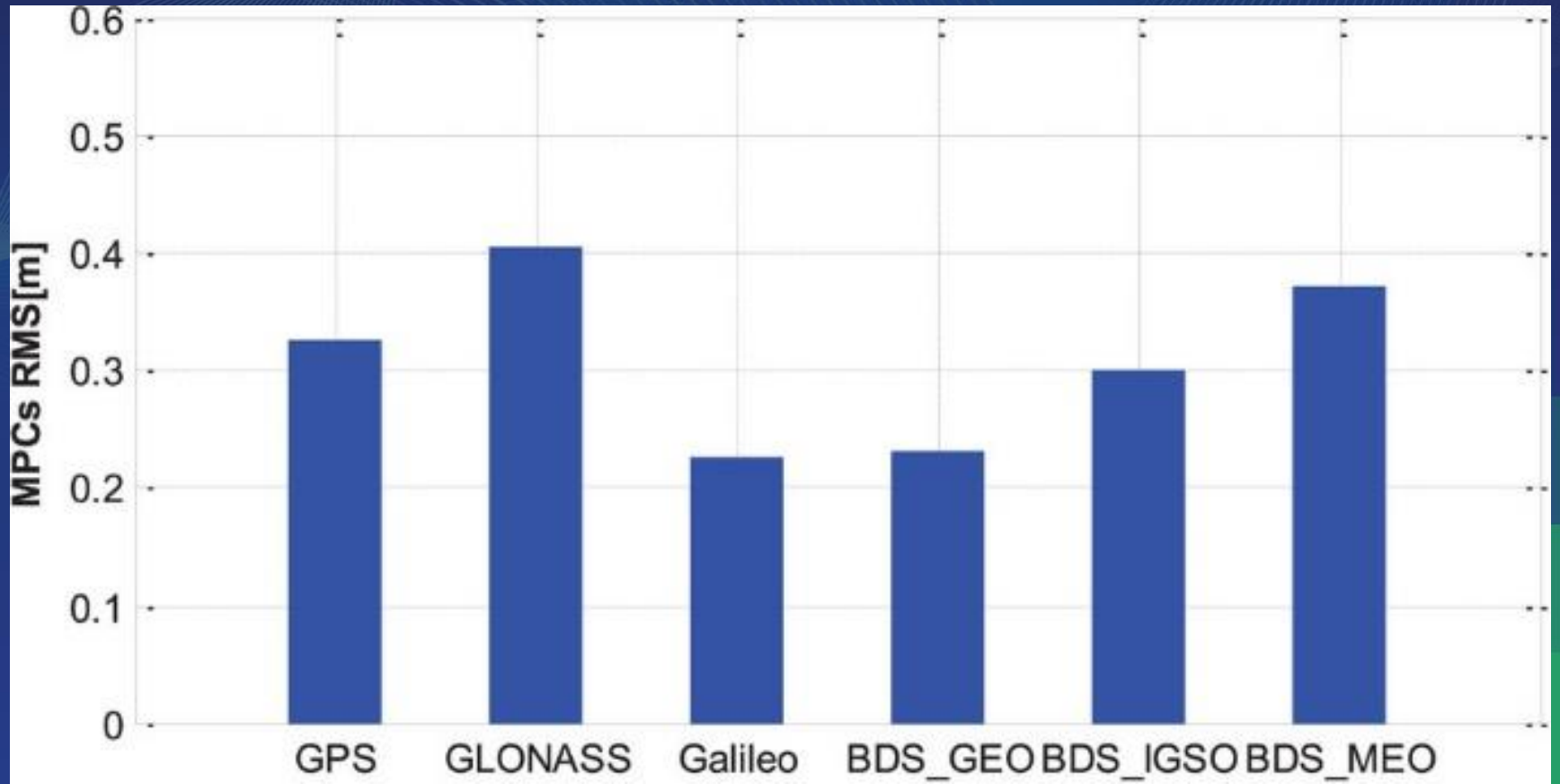
Standart Sapma

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



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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:

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

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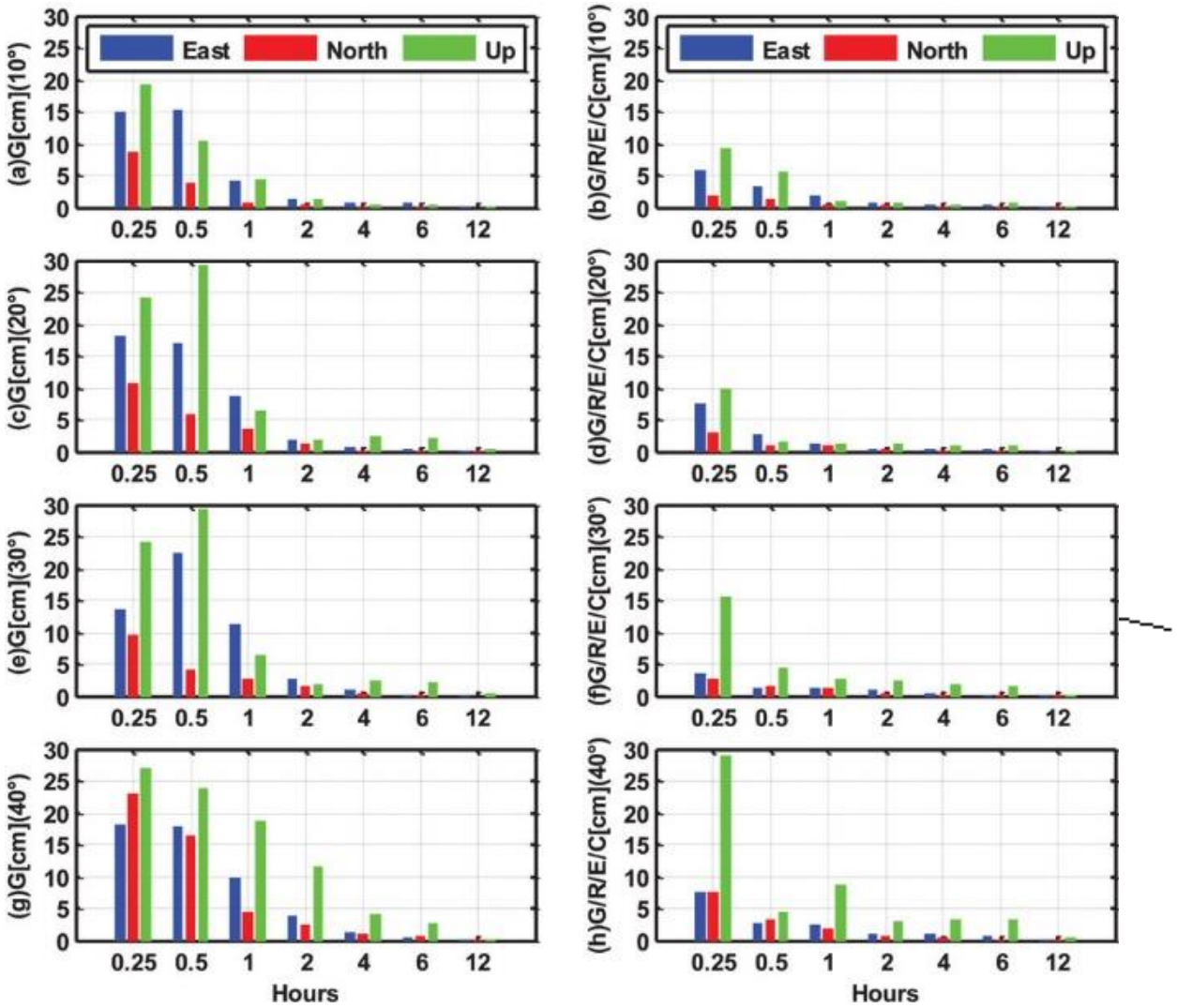
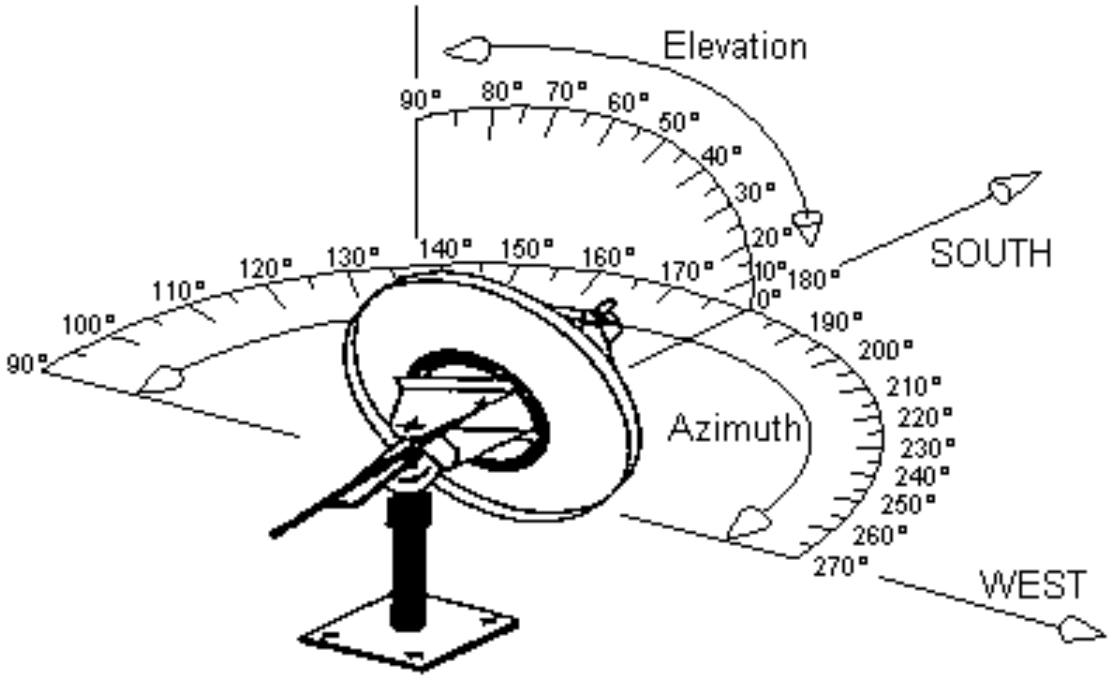
Elevasyon Açısına Bağlı Zayıflama





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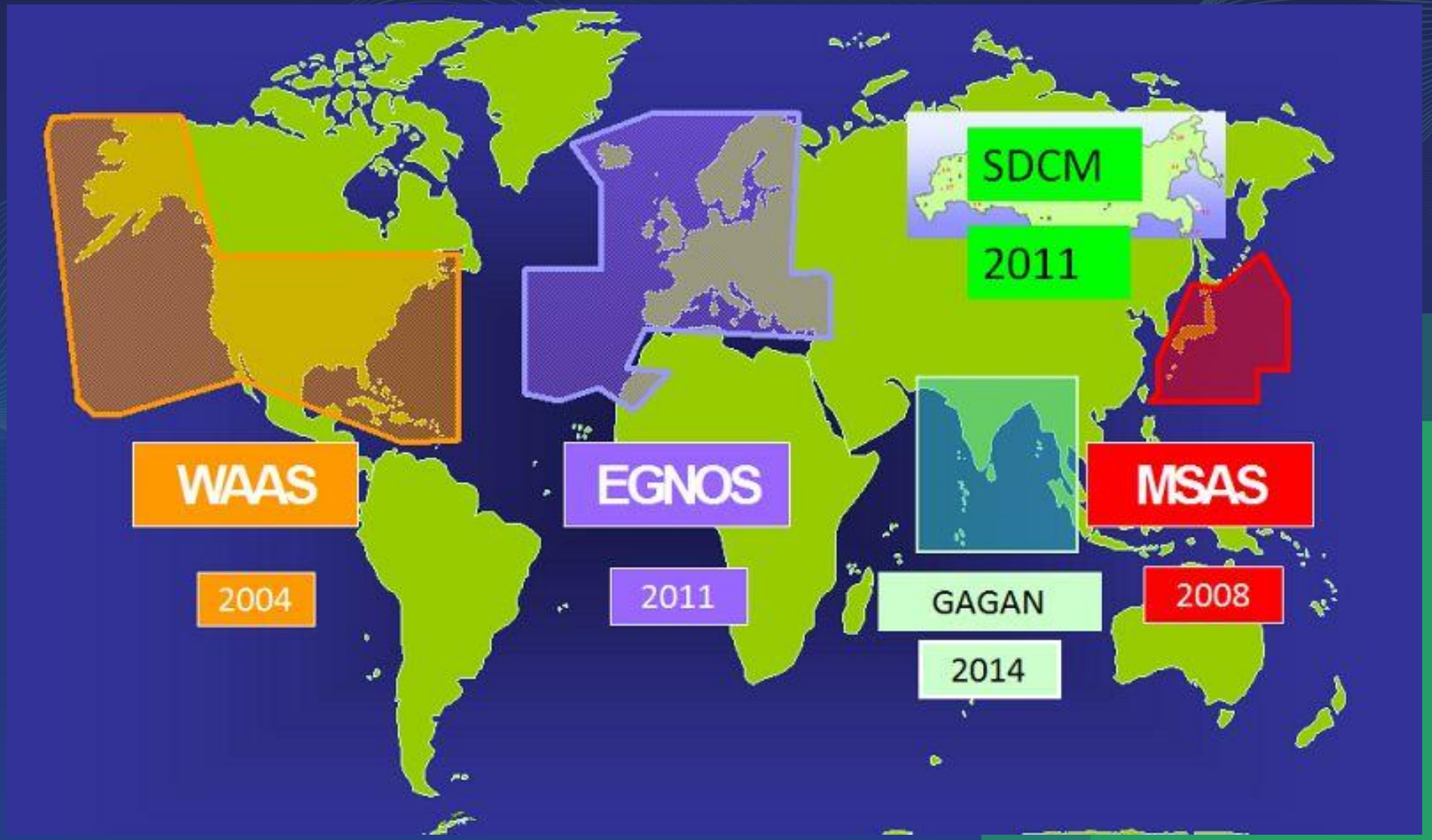
Takviye –Geosenkron Uydu Destekli Sistemler-SBAS's



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Hava Araçlarında Yakıt Tasarrufu



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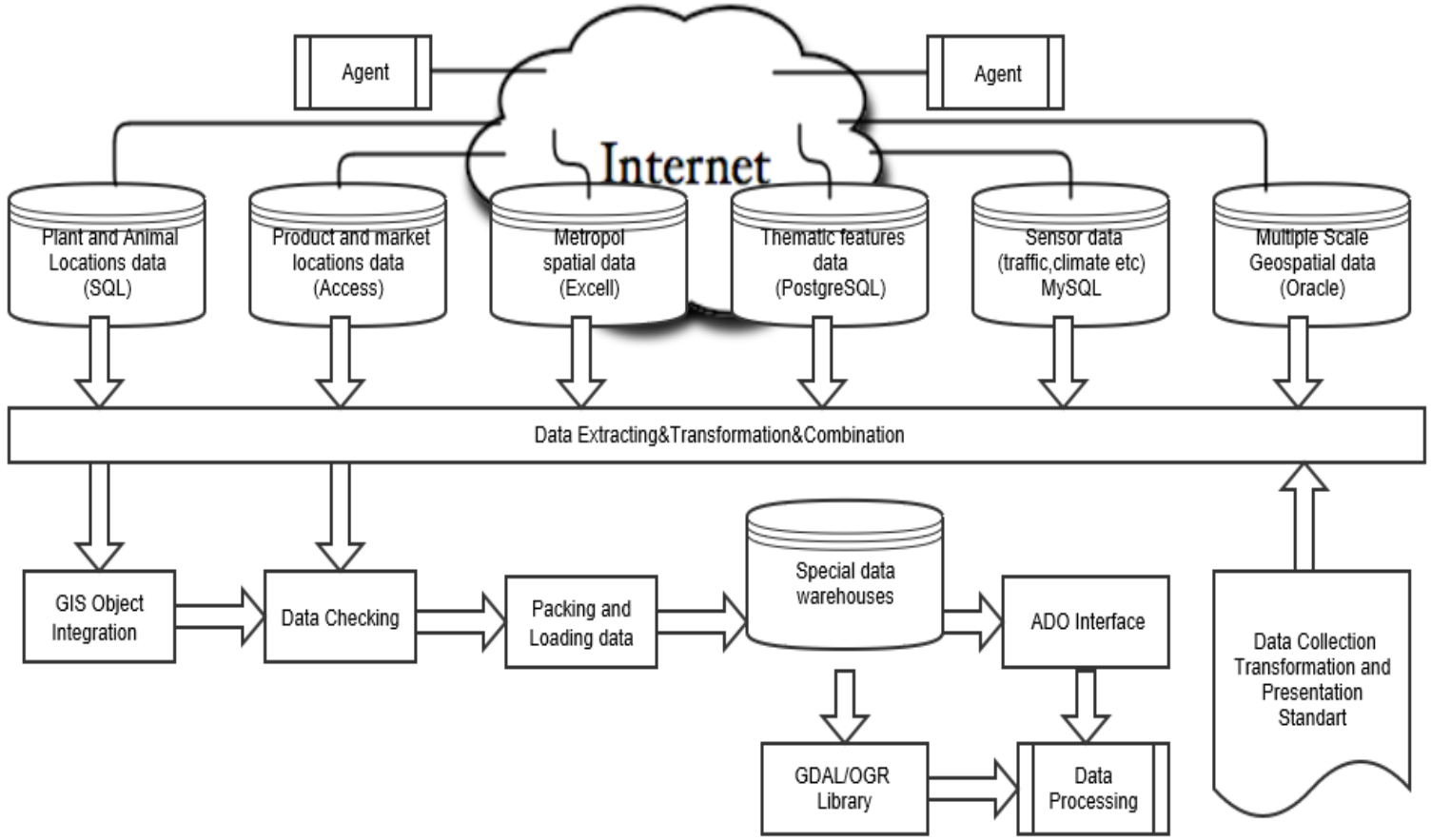
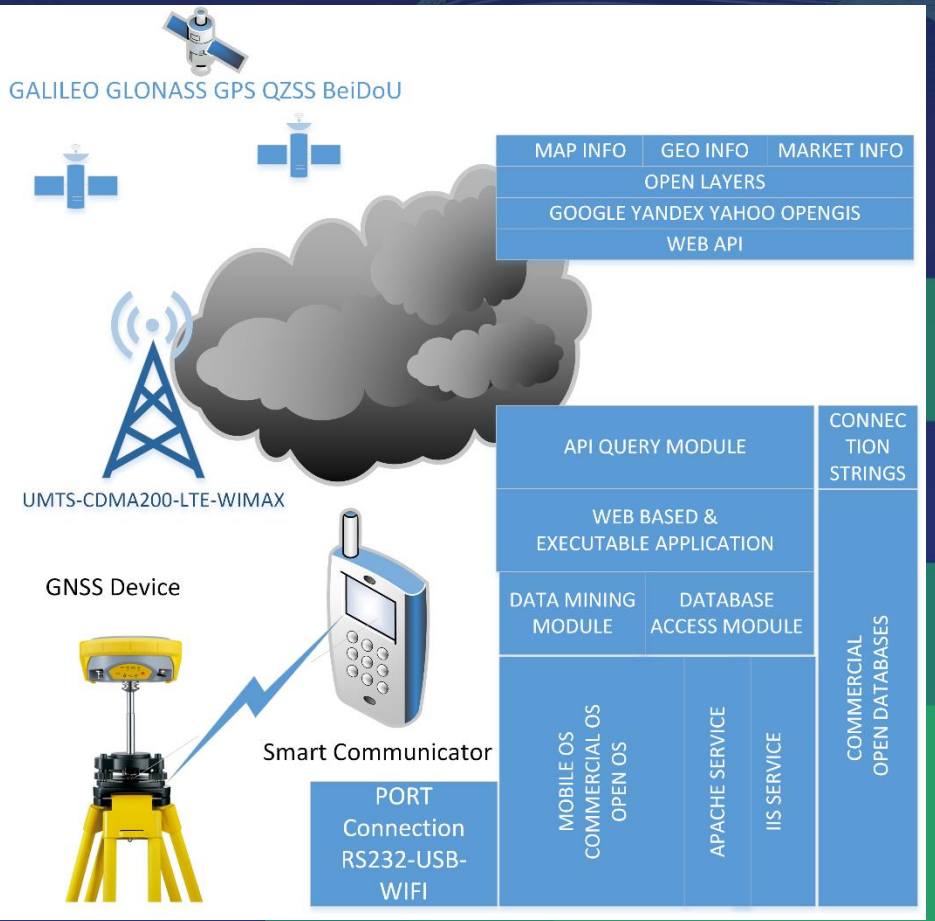
GNSS Uygulamaları





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Serkan Aydin* and Hakan Kaptan

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Article first published online: 23 FEB 2009

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