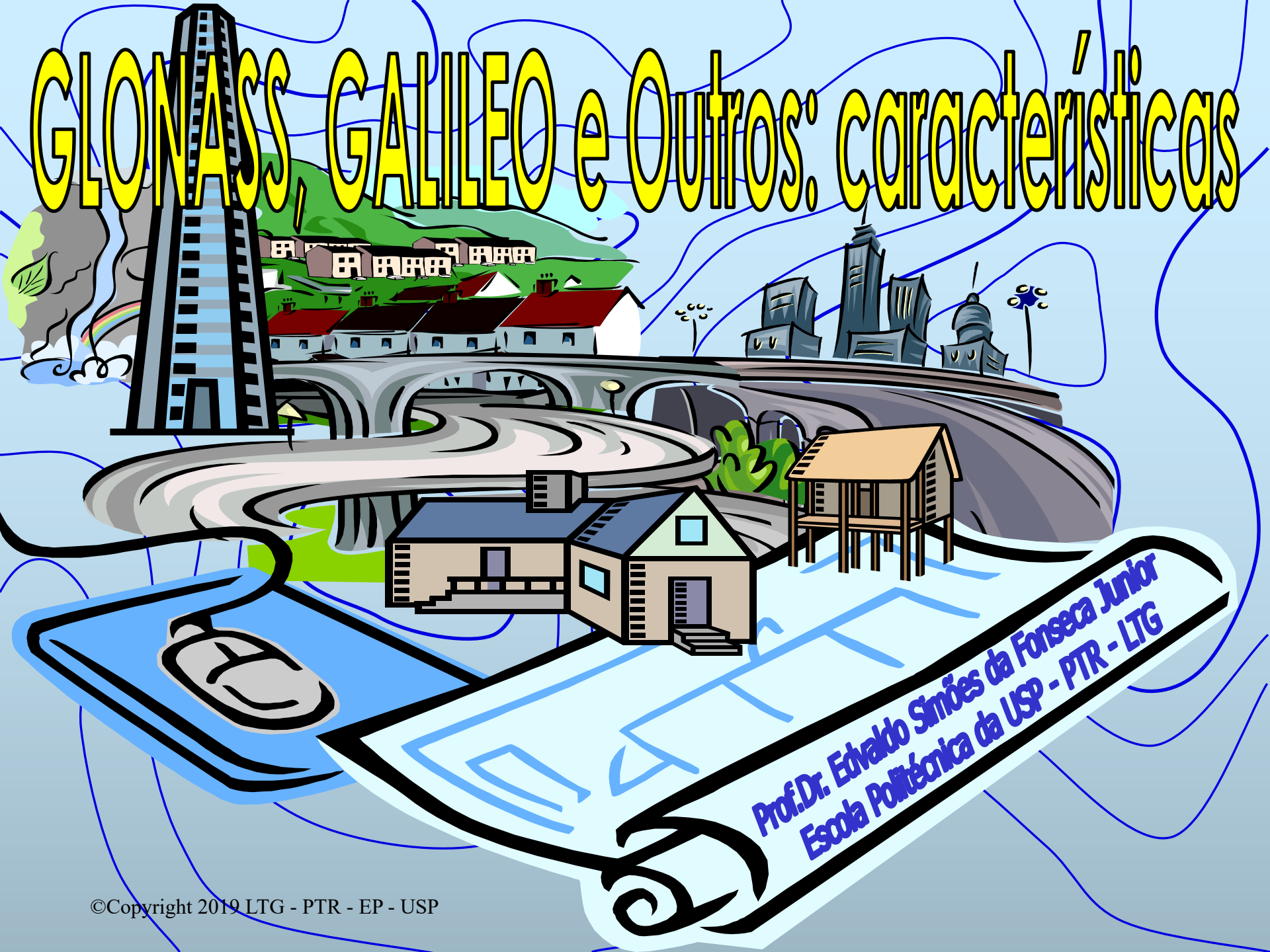
GLONASS, GALILEO e Outros: características



Prof.Dr. Edvaldo Simões da Fonseca Junior
Escola Politécnica da USP - PTR - LTG

GNSS - Histórico

- **Significado de GNSS:**

  Global Navigation Satellite System

- **Sistema de posicionamento por satélites.**
- **Envolve todos os sistemas de navegação via satélite como por exemplo:**
  - **GPS**
  - **GLONASS**
  - **GALILEO**
  - **Etc...**

GLONASS - Rússia

Sistema de posicionamento por satélite similar ao sistema GPS americano.

GLONASS - GLObal **NA**vigation **S**atellite System

Características do Sistema GLONASS

- 1 relógio de césio embarcado
- Acurácia de 1000 nano-segundos
- Órbita circular = 19.100 km
- Inclinação da órbita = 64.8 graus
- Repetibilidade = 8 dias
- 3 planos orbitais
- Vida útil estimada em 1 a 2 anos par os primeiros satélites. A nova geração deve durar pelo menos 7 anos.

Características do Sistema GLONASS

- 1º bloco lançado em 1982

- Estrutura
  - 24 satélites
  - 3 planos orbitais
  - 64.8° de inclinação dos planos orbitais em relação ao plano do equador
  - 19100 km de altura acima da superfície da Terra

Características do Sistema GLONASS

- 2 portadoras com freqüências distintas:

  Frequências

  L1 = 1602MHz **Δf1 = 562.5KHz**

  L2 = 1246MHz **Δf2 = 437.5KHz**

  cada satélites possui uma frequência diferente:

  L1= 1602MHz + n 0.5625MHz

  Onde n é o número correspondente ao satélite

  - 2 tipos de sinais:

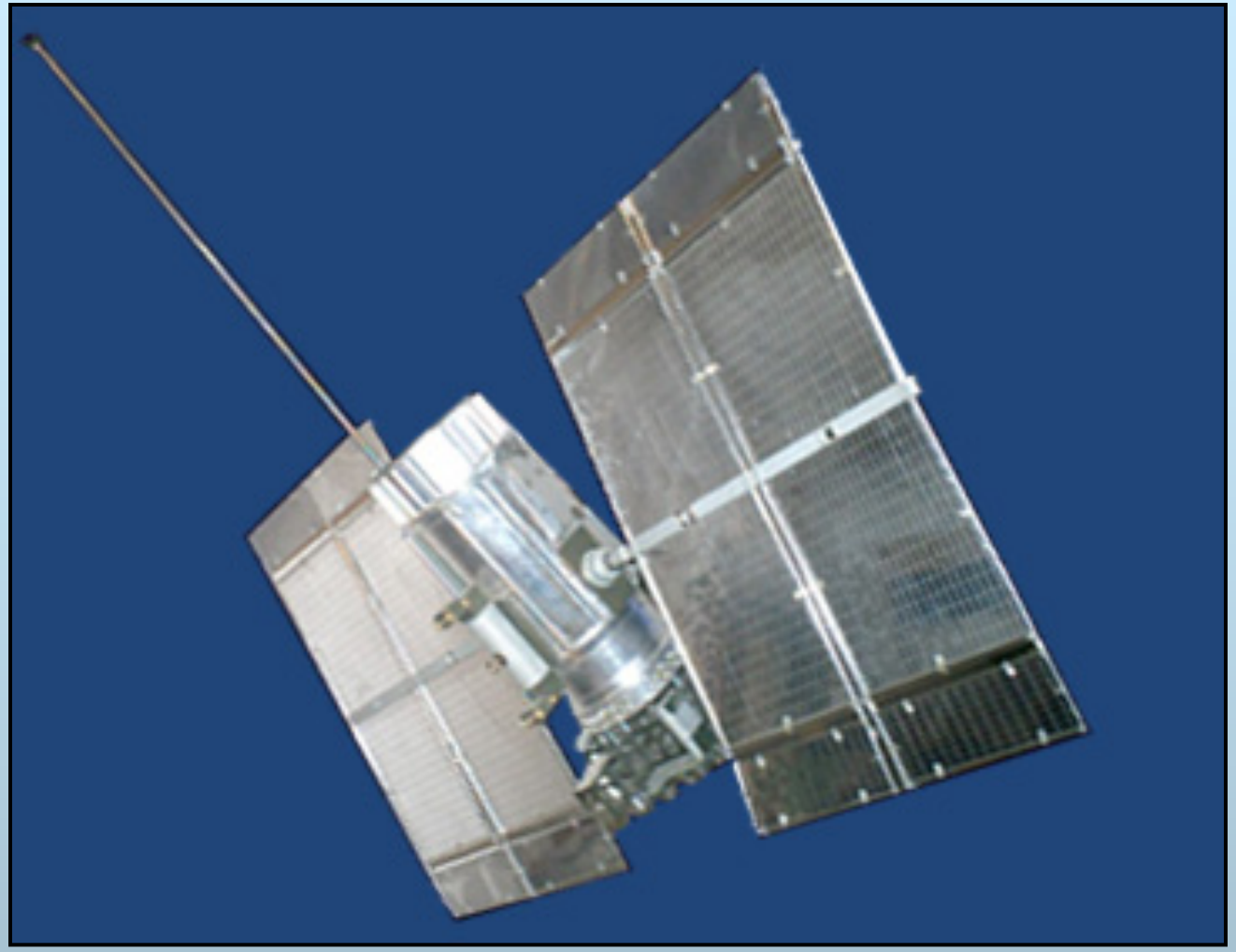
- Precisão padrão (SP) – disponível para uso civil

precisão de 57 a 70m horizontal (99,7%)

70 m vertical (99,7%)

- Alta precisão (HP) – uso militar

Vista de um satélite do sistema GLONASS



Status constelação Sistema GLONASS

(atualizado em 18/03/2019)

(Rússia)

Fonte: https://www.glonass-iac.ru/en/GLONASS/

GLONASS SCC
GLONASS STATUS
EPHEMERIS
MONITORING
DAILY MONITORING
VISIBILITY ZONE CALCULATION
INTEGRAL AVAILABILITY
INSTANT AVAILABILITY
COORDINATES REFINEMENT (RINEX)
EVALUATION OF CHARACTERISTICS

GLONASS CONSTELLATION STATUS, 18.03.2019

Total satellites in constellation	26 SC
Operational	24 SC
In commissioning phase	-
In maintenance	-
Under check by the Satellite Prime Contractor	-
Spares	1 SC
In flight tests phase	1 SC

GLONASS CONSTELLATION STATUS AT 18.03.2019 BASED ON BOTH THE ALMANAC ANALYSIS AND NAVIGATION MESSAGES RECEIVED AT 10:00 18.03.19 (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		111.2	+	+ 10:44 18.03.19	In operation
2	1	-4	747	26.04.13	04.07.13		70.8	+	+ 10:44 18.03.19	In operation
3	1	05	744	04.11.11	08.12.11		88.5	+	+ 10:44 18.03.19	In operation
4	1	06	742	02.10.11	25.10.11		89.6	+	+ 10:44 18.03.19	In operation
5	1	01	756	17.06.18	29.08.18		9.0	+	+ 10:44 18.03.19	In operation
6	1	-4	733	14.12.09	24.01.10		111.2	+	+ 10:44 18.03.19	In operation
7	1	05	745	04.11.11	18.12.11		88.5	+	+ 10:44 18.03.19	In operation
8	1	06	743	04.11.11	20.09.12		88.5	+	+ 10:44 18.03.19	In operation
9	2	-2	702	01.12.14	15.02.16		51.6	+	+ 10:44 18.03.19	In operation
10	2	-7	717	25.12.06	03.04.07		146.8	+	+ 10:44 18.03.19	In operation
11	2	00	753	29.05.16	27.06.16		33.6	+	+ 10:44 18.03.19	In operation
12	2	-1	723	25.12.07	22.01.08		134.8	+	+ 10:44 18.03.19	In operation
13	2	-2	721	25.12.07	08.02.08		134.8	+	+ 10:44 18.03.19	In operation
14	2	-7	752	22.09.17	16.10.17		17.8	+	+ 10:44 18.03.19	In operation
15	2	00	757	03.11.18	27.11.18		4.4	+	+ 10:44 18.03.19	In operation
16	2	-1	736	02.09.10	04.10.10		102.5	+	+ 10:44 18.03.19	In operation
17	3	04	751	07.02.16	28.02.16		37.3	+	+ 10:44 18.03.19	In operation
18	3	-3	754	24.03.14	14.04.14		59.8	+	+ 10:44 18.03.19	In operation
19	3	03	720	26.10.07	25.11.07		136.8	+	+ 10:44 18.03.19	In operation
20	3	02	719	26.10.07	27.11.07		136.8	+	+ 10:44 18.03.19	In operation
21	3	04	755	14.06.14	03.08.14		57.1	+	+ 10:44 18.03.19	In operation
22	3	-3	731	02.03.10	28.03.10		108.6	+	+ 10:44 18.03.19	In operation
23	3	03	732	02.03.10	28.03.10		108.6	+	+ 10:44 18.03.19	In operation
24	3	02	735	02.03.10	28.03.10		108.6	+	+ 10:44 18.03.19	In operation
15	2		716	25.12.06	12.10.07	24.11.18	146.8			Spares
20	3	-5	701	26.02.11			96.7			Flight Tests

GALILEO - Europa

Sistema de posicionamento por satélites desenvolvido pela Agencia Espacial Européia (ESA) e a Comunidade Européia (UE).

Galileo - European Satellite Navigation System

Características do Sistema GALILEO

- Em fase de Validação (Início de Operação previsto inicialmente para 2008) – (agora a previsão é para 2018 – 2020)
- O primeiro satélite GIOVE-A foi lançado em 28 dezembro de 2005
- O segundo satélite GIOVE-B foi lançado em 27 de abril de 2008

Características do Sistema GALILEO

Estrutura

- 30 satélites
- 3 planos orbitais
- Inclinação da órbita = 56 graus
- Altitude da órbita = 23222 km
- Poderá transmitir até 4/5 frequências da banda L (em fase final de definição)

Características do Sistema GALILEO

- 3 portadoras com freqüências distintas:

  E5 = 1164 – 1215 MHz

  E6 = 1260 – 1300 MHz

  L1 = 1559 – 1593 MHz

- Tipos de Serviços:

  - SERVIÇO ABERTO (OS)

  - SERVIÇO DE SEGURANÇA DA VIDA (SoL)

  - SERVIÇO COMERCIAL (CS)

  - SERVIÇO REGULADO AO PÚBLICO (PRS)

  - SERVIÇO DE PROCURA E RESGATE (SAR)

Sistema GALILEO - Status constelação

(Atualizado em 18/03/2018)

Galileo

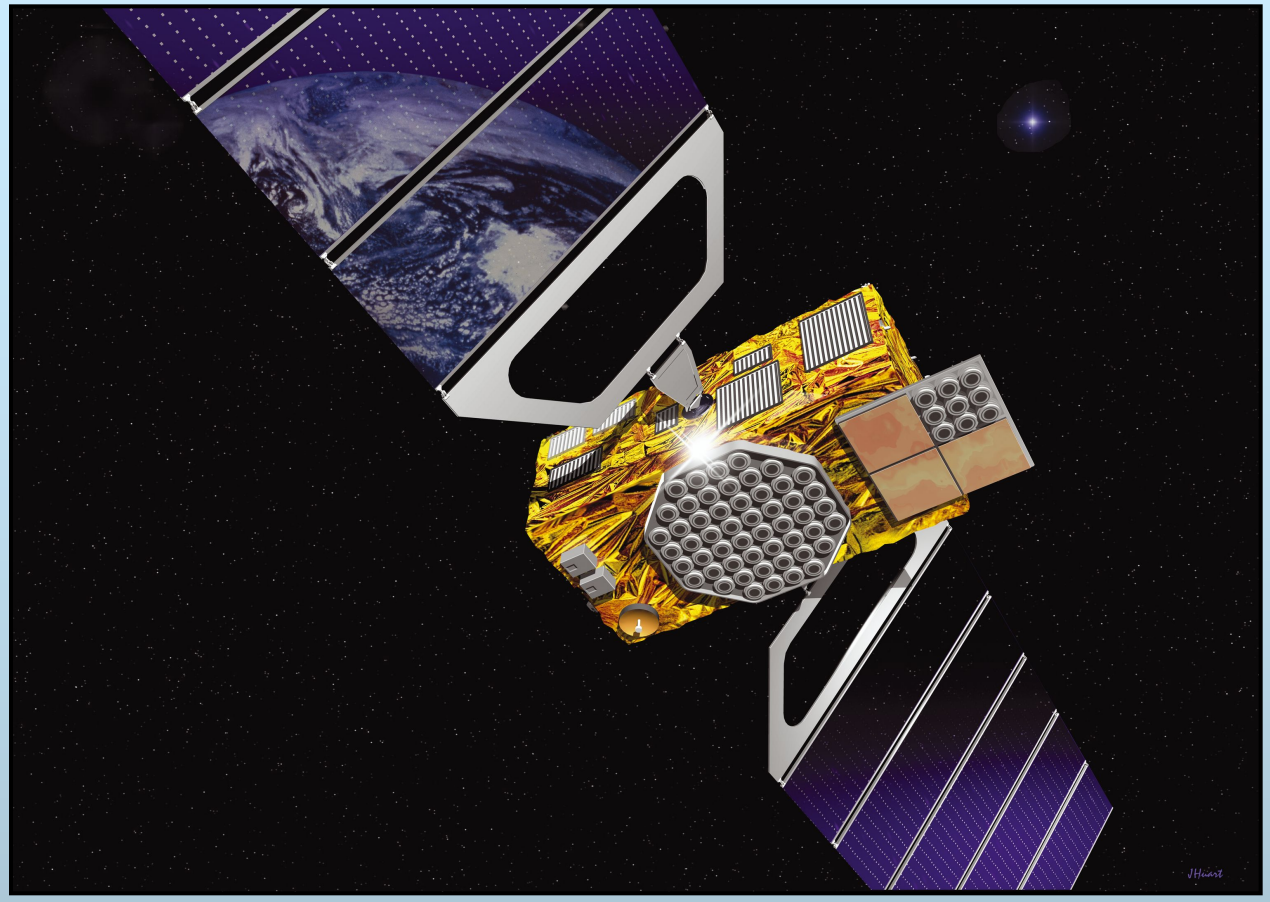
This page provides an overview of the Satellites in the Galileo Constellation. Technical parameters of the indivdual satellites and related conventions applied within the MGEX project are summarized in the Spacecraft Characteristics section. Furthermore, a list of Events of interest for the Galileo data processing is given. Information on the GIOVE satellites is given on a separate page.

Satellites

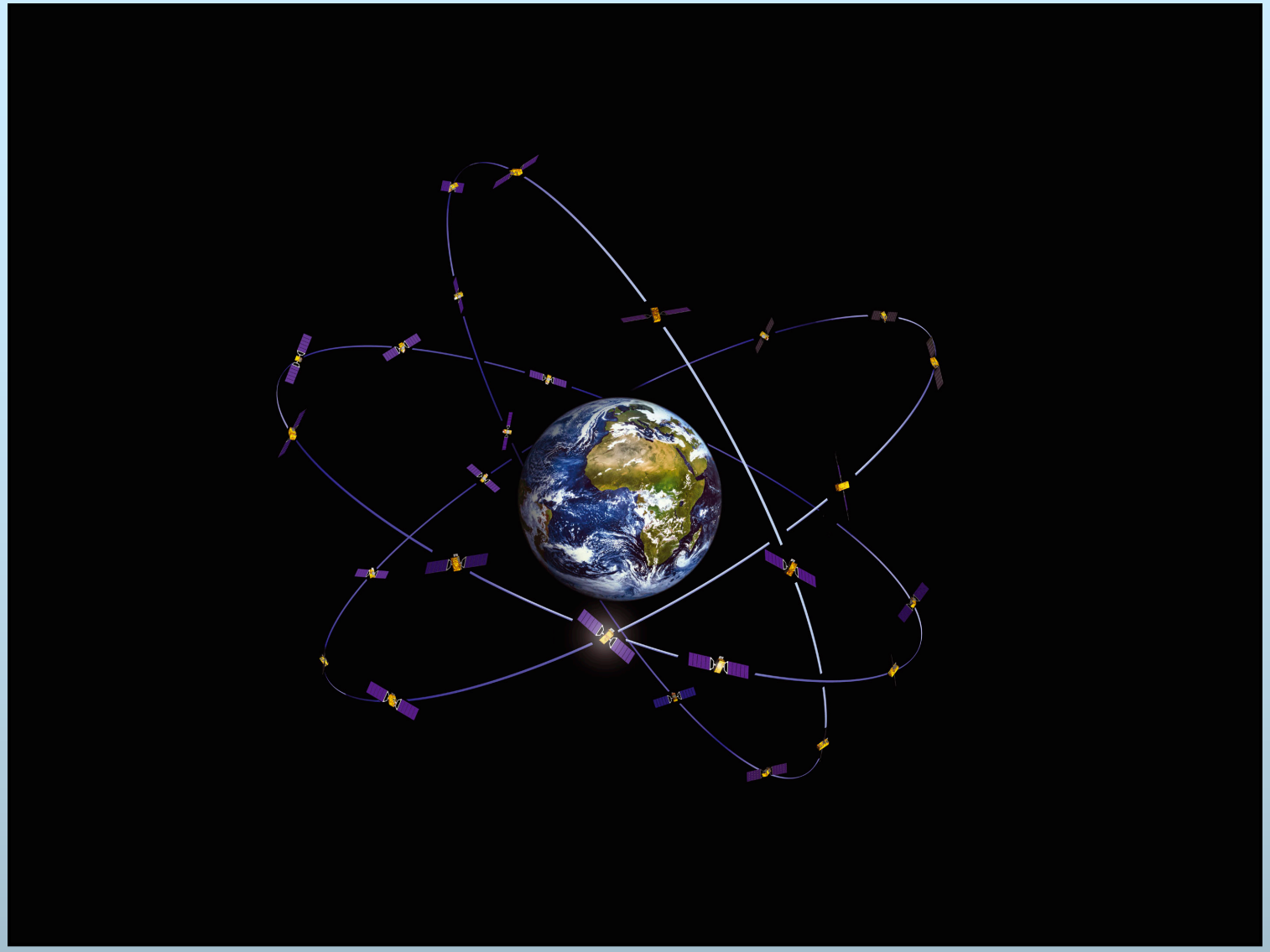
Common Name	SVN	Int. Sat. ID	NORAD ID	NORAD Name	PRN	Notes
IOV-1, Galileo PFM	E101	2011-060A	37846	GALILEO-PFM	E11	Slot B05
IOV-2, Galileo FM2	E102	2011-060B	37847	GALILEO-FM2	E12	Slot B06
IOV-3, Galileo FM3	E103	2012-055A	38857	GALILEO-FM3	E19	Slot C04
IOV-4, Galileo FM4	E104	2012-055B	38858	GALILEO-FM4	E20	Slot C05
FOC-1	E201	2014-050A	40128	GALILEO 5 (261)	E18	Orbit injection failure (i=49.7° e=0.23)
FOC-2	E202	2014-050B	40129	GALILEO 6 (262)	E14	Orbit injection failure (i=49.7° e=0.23)
FOC-3	E203	2015-017A	40544	GALILEO 7 (263)	E26	Slot B08
FOC-4	E204	2015-017B	40545	GALILEO 8 (264)	E22	Slot B03
FOC-5	E205	2015-045A	40889	GALILEO 9 (205)	E24	Slot A08
FOC-6	E206	2015-045B	40890	GALILEO 10 (206)	E30	Slot A05
FOC-8	E208	2015-079B	41174	GALILEO 12 (269)	E08	Slot C07
FOC-9	E209	2015-079A	41175	GALILEO 11 (268)	E09	Slot C02
FOC-10	E210	2016-030B	41550	GALILEO 13 (26A)	E01	Slot A02
FOC-11	E211	2016-030A	41549	GALILEO 14 (26B)	E02	Slot A06
FOC-7	E207	2016-069A	41859	GALILEO 15 (267)	E07	Slot C06
FOC-12	E212	2016-069B	41860	GALILEO 16 (26C)	E03	Slot C08
FOC-13	E213	2016-069C	41861	GALILEO 17 (26D)	E04	Slot C03
FOC-14	E214	2016-069D	41862	GALILEO 18 (26E)	E05	Slot C01
FOC-15	E215	2017-079A	43055	GALILEO 19 (2C5)	E21	Slot A03
FOC-16	E216	2017-079B	43056	GALILEO 20 (2C6)	E25	Slot A07
FOC-17	E217	2017-079C	43057	GALILEO 21 (2C7)	E27	Slot A04
FOC-18	E218	2017-079D	43058	GALILEO 22 (2C8)	E31	Slot A01
FOC-19	E219	2018-060C	43566	GALILEO 23 (2C9)	E36	Slot B04
FOC-20	E220	2018-060D	43567	GALILEO 24 (2C0)	E13	Slot B01
FOC-21	E221	2018-060A	43564	GALILEO 25 (2C1)	E15	Slot B02
FOC-22	E222	2018-060B	43565	GALILEO 26 (2C2)	E33	Slot B07

Fonte:
http://mgex.igs.org/IGS_MGEX_Status_GAL.php

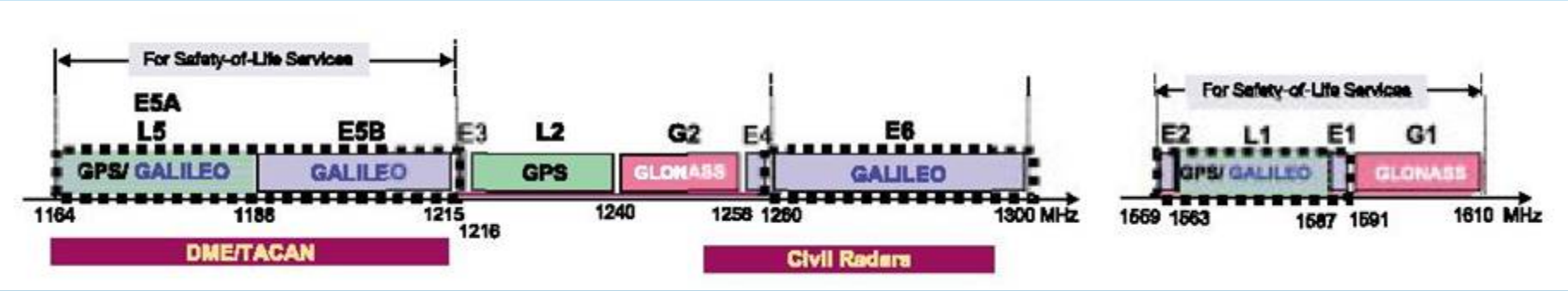
Vista artística de um satélite do sistema Galileo



Concepção da Constelação do Sistema Galileo



Bandas de freqüências dos sinais GNSS
GPS / GLONASS / GALILEO



Há ainda os seguintes sistemas:

- BeiDou - Navigation Satellite System (BDS) / China (atualizado em 18/03/2019)

BEIDOU CONSTELLATION STATUS 18.03.19

Total satellites in constellation	38
SV is included in operational orbital constellation	17
SV is not included in operational orbital constellation	21

BEIDOU CONSTELLATION STATUS 18.03.19

Satellite Number	NORAD	Satellite Name	Type of sistem	Launch date	Life-time (months)	Notes
C01	36287	GEO01	BeiDou-2	17.01.10	3347	In operation
C02	38953	GEO06	BeiDou-2	25.10.12	2335	In operation
C04	37210	GEO04	BeiDou-2	01.11.10	3059	In operation
C05	38091	GEO05	BeiDou-2	25.02.12	2578	In operation
C06	36828	IGSO01	BeiDou-2	01.08.10	3151	In operation
C07	37256	IGSO02	BeiDou-2	18.12.10	3012	In operation
C08	37384	IGSO03	BeiDou-2	10.04.11	2899	In operation
C09	37763	IGSO04	BeiDou-2	27.07.11	2791	In operation
C10	37948	IGSO05	BeiDou-2	02.12.11	2663	In operation
C11	38250	MEO03	BeiDou-2	30.04.12	2513	In operation
C12	38251	MEO04	BeiDou-2	30.04.12	2513	In operation
C13	38774	IGSO06	BeiDou-2	30.03.16	1083	In operation
C14	38775	MEO06	BeiDou-2	19.09.12	2371	In operation
C03	41586	GEO07	BeiDou-2	12.06.16	1009	In operation
C19	43001	MEO01	BeiDou-3	05.11.17	498	In operation
C20	43002	MEO02	BeiDou-3	05.11.17	498	In operation
C21	43207	MEO03	BeiDou-3	12.02.18	399	In operation
C22	43208	MEO04	BeiDou-3	12.02.18	399	In operation
C27	43107	MEO07	BeiDou-3	12.01.18	430	In operation
C28	43108	MEO08	BeiDou-3	12.01.18	430	In operation
C29	43245	MEO09	BeiDou-3	30.03.18	353	In operation
C30	43246	MEO10	BeiDou-3	30.03.18	353	In operation
C16	43539	IGSO07	BeiDou-2	10.07.18	251	In operation
C23	43581	MEO05	BeiDou-3	29.07.18	232	In operation
C24	43582	MEO06	BeiDou-3	29.07.18	232	In operation
C25	43602	MEO11	BeiDou-3	25.08.18	205	In operation
C26	43603	MEO12	BeiDou-3	25.08.18	205	In operation
C32	43622	MEO13	BeiDou-3	19.09.18	180	In operation
C33	43623	MEO14	BeiDou-3	19.09.18	180	In operation
C34	43647	MEO15	BeiDou-3	15.10.18	154	In operation
C35	43648	MEO16	BeiDou-3	15.10.18	154	In operation
C36	43706	MEO17	BeiDou-3	19.11.18	119	In operation
C37	43707	MEO18	BeiDou-3	19.11.18	119	In operation
C31	40549	IGSO01-S	BeiDou-3S	30.03.15	1449	Not in operational orbital constellation
C18	40938	IGSO02-S	BeiDou-3S	30.09.15	1265	Not in operational orbital constellation
C57	40748	MEO01-S	BeiDou-3S	25.07.15	1332	Not in operational orbital constellation
C58	40749	MEO02-S	BeiDou-3S	25.07.15	1332	Not in operational orbital constellation
C59	43683	GEO01	BeiDou-3	01.11.18	137	Not in operational orbital constellation

Fonte: https://www.glonass-iac.ru/en/BEIDOU/

Há ainda os seguintes sistemas:

- NAVIC – Navigation with Indian Costellation/ Índia
- (atualizado em 18/03/2019)

NAVIC

This page provides an overview of the Satellites in the "Navigation with Indian Constellation" (NAVIC), formerly known as the Indian Regional Navigation Satellite System (IRNSS). Technical parameters of the indivdual satellites and related conventions applied within the MGEX project are summarized in the Spacecraft Characteristics section. Furthermore, a list of Events of interest for the NAVIC data processing are given.

Satellites

The Navigation with Indian Constellation (NAVIC) comprises 3 geostationary (GEO) satellites located at 34°E, 83°E and 129.5°E as well as two pairs of satellites in inclined geosynchronous orbit (IGSO) with their ascending nodes at 55°E and 111.75°E and an inclination of 29°.

Common Name	SVN	Int. Sat. ID	NORAD ID	PRN	Notes
IRNSS-1A	I001	2013-034A	39199	I01	IGSO 55°E; launched 1 July 2013
IRNSS-1B	I002	2014-017A	39635	I02	IGSO 55°E; launched 4 April 2014
IRNSS-1C	I003	2014-061A	40269	I03	GEO 83°E; launched 15 Oct. 2014
IRNSS-1D	I004	2015-018A	40547	I04	IGSO 111.75°E; launched 8 Mar. 2015
IRNSS-1E	I005	2016-003A	41241	I05	IGSO 111.75°E; launched 20 Jan. 2016
IRNSS-1F	I006	2016-015A	41384	I06	GEO 32.5°E; launched 10 Mar. 2016
IRNSS-1G	I007	2016-027A	41469	I07	GEO 129.5°E; launched 28 Apr. 2016
IRNSS-1I	I009	2018-035A	43286	I0?	IGSO ???°E; launched 11 Apr. 2018

Fonte: http://mgex.igs.org/IGS_MGEX_Status_IRNS.html

Há ainda os seguintes sistemas:

- QZSS / Japão
  - com 4 satélite já lançado (atualizado em 18/03/2019)

Satellites

The Quasi-Zenith Satellite System (QZSS) currently comprises three satellites in an inclined geo-synchronous orbit and one satellite in geo-stationary orbit.

Common Name	SVN	Int. Sat. ID	NORAD ID	PRN	Notes
QZS-1 (Michibiki)	J001	2010-045A	37158	J01	launched 2010/09/11
QZS-2 (Michibiki-2)	J002	2017-028A	42738	J02	launched 2017/06/01
QZS-3 (Michibiki-3)	J003	2017-048A	42917	J07	launched 2017/08/19
QZS-4 (Michibiki-4)	J004	2017-062A	42965	J03	launched 2017/10/09

Fonte: http://mgex.igs.org/IGS_MGEX_Status_QZSS.html

Há ainda os seguintes sistemas:

- SBAS – Satellite Based Augumentation Sytems (atualizado em 18/03/2019)
  - EGNOS,
  - WAAS,
  - GAGAN,
  - MSAS,
  - Etc...

Satellites

System	Common Name	Long.	Int. Sat. ID	NORAD ID	PRN	Signals	Notes
EGNOS	Inmarsat 3-F2 (AOR-E)	15.5°W	1996-053A	24307	120	L1	Inmarsat 3-F2 began Safety-of-Life Service on March 2, 2011, and is transmitting message type 2.
	SES-5 (Sirius-5, Astra-4B)	5°E	2012-036A	38652	136	L1/L5	Launched 2012/07/10, operational since Sep. 02, 2015.
	Astra-5B	31.5°E	2014-011B	39617	123	L1/L5	Launched March 22, 2014. Transmission of L1 test signals started Dec. 11, 2014.
GAGAN	GSAT-8	55°E	2011-022A	37605	127	L1/L5	Launched May 20, 2011. Certifed horizontal/vertical service since Feb. 2014/April 2015.
	GSAT-10	83°E	2012-051B	38779	128	L1/L5	Launched Sep. 28, 2012. Certifed horizontal/vertical service since Feb. 2014/April 2015.
GATBP	Inmarsat 4-F1 (PAC-W)	143.5°E	2005-009A	28628	122	L1/L5	Transmitting message type 0; not for safety-of-life use. L1 transmissions began May 31, 2017.
MSAS	MTSAT-1R	140°E	2005-006A	28622	129	L1	MSAS commissioned for aviation use on September 27, 2007. Either satellite can transmit both PRN signals if necessary.
	MTSAT-2	145°E	2006-004A	28937	137	L1	MSAS commissioned for aviation use on September 27, 2007. Either satellite can transmit both PRN signals if necessary.
NSAS	NigComSat-1R	42°E	2011-077A	38014	147	L1/L5	L1 tests
QZSS	QZS-1	137.5°E	2010-045A	37158	183	L1	See QZSS Status Page
	QZS-2	136°E	2017-028A	42738	184/196	L1/L5	See QZSS Status Page
	QZS-3	127°E	2017-048A	42917	189/197	L1/L5	See QZSS Status Page
	QZS-4	136°E	2017-062A	42965	185/200	L1/L5	See QZSS Status Page
SDCM	Luch-5A	167°E	2011-074B	37951	140	L1	Launched on December 11, 2011. Initially positioned at 58.5°E, it was shifted to 95°E between about May 30 and June 28, 2012, then shifted 167°E between about Nov. 30 and Dec. 22, 2012. Transmissions as PRN 140 began on July 12, 2012. Transmitted occasional, non-coherent code/carrier test signals.
	Luch-5B	16°W	2014-023A	39727	141	L1	Launched April 28, 2014. Testing may have started using PRN 140, not 141.
	Luch-5V	16°W	2012-061A	38977	125	L1	Launched Nov. 2, 2012, and started transmitting signals on Jan. 17, 2013.
WAAS	TeleSat Anik F1R (CRE)	107.3°W	2005-036A	28868	138	L1/L5	Anik F1R ranging supports enroute through precision approach modes. The payload, operated by Lockheed Martin for the FAA, is known as LMPRS-2.
	Intelsat Galaxy 15 (CRW)	133°W	2005-041A	28884	135	L1/L5	Galaxy 15 ranging supports enroute through precision approach modes. Switched to backup satellite oscillator on Jan. 6, 2012. The payload, operated by Lockheed Martin for the FAA, is known as LMPRS-1.
	EUTELSAT 117W B	117°W	2016-038B	41589	131	L1/L5	Not yet approved for operational use

Fonte: http://mgex.igs.org/IGS_MGEX_Status_SBAS.html

Status constelação Sistema GPS

(Atualizado em 18/03/2019)

(USA)

Fonte:
https://www.navcen.uscg.gov/?Do=constellationStatus

GPS CONSTELLATION STATUS FOR 03/18/2019

Plane	Slot	SVN	PRN	Block-Type	Clock	Outage Date	Nanu-Type	Nanu-Subject
A	1	65	24	IIF	CS			
A	2	52	31	IIR-M	RB			
A	3	64	30	IIF	RB			
A	4	48	7	IIR-M	RB			
B	1	56	16	IIR	RB	15 MAR 2019	FCSTSUMM	2019038 - SVN56 (PRN16) FORECAST OUTAGE SUMMARY JDAY 074/0821 - JDAY 074/1434
B	2	62	25	IIF	RB			
B	3	44	28	IIR	RB			
B	4	58	12	IIR-M	RB			
B	5	71	26	IIF	RB			
C	1	57	29	IIR-M	RB	22 MAR 2019	FCSTDV	2019037 - SVN57 (PRN29) FORECAST OUTAGE JDAY 081/0455 - JDAY 081/1655
C	2	66	27	IIF	RB			
C	3	72	8	IIF	CS			
C	4	53	17	IIR-M	RB			
C	5	59	19	IIR	RB			
D	1	61	2	IIR	RB			
D	2	63	1	IIF	RB			
D	3	45	21	IIR	RB			
D	4	67	6	IIF	RB			
D	5	46	11	IIR	RB			
D	6	34	18	IIA	RB	11 MAR 2019	UNUNOREF	2019034 - SVN34 (PRN18) UNUSABLE JDAY 070/1335 - JDAY 070/1336
						13 MAR 2019	UNUNOREF	2019036 - SVN34 (PRN18) UNUSABLE JDAY 072/1325 - JDAY 072/1327
E	1	69	3	IIF	RB			
E	2	73	10	IIF	RB			
E	3	50	5	IIR-M	RB			
E	4	51	20	IIR	RB			
E	6	47	22	IIR	RB			
F	1	70	32	IIF	RB			
F	2	55	15	IIR-M	RB			
F	3	68	9	IIF	RB			
F	4	60	23	IIR	RB			
F	5	41	14	IIR	RB			
F	6	43	13	IIR	RB			

Saiba mais ...

Órbitas precisas: http://igscb.jpl.nasa.gov

Informações sobre GPS: http://tycho.usno.navy.mil/gps.html

GALILEO home-page: www.galileo-pgm.org

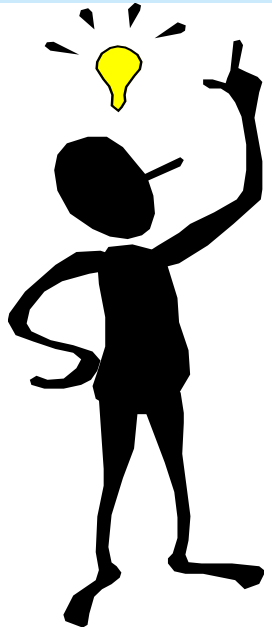
GLONASS home-page: http://www.glonass-center.ru/frame_e.html

PMRG/IBGE: http://www.ibge.gov.br/home/geografia/geodesico/srg/

Projeto SIRGAS: http://www1.ibge.gov.br/home/geografia/geodesico/sirgas/principal.htm

Dados da RBMC: http://www.ibge.gov.br/home/geografia/geodesico/rbmcpesq.shtm

Rede GPS do Estado de São Paulo: http://www.ptr.poli.usp.br/ltg/proj/RedeSP/Rede-SP.htm



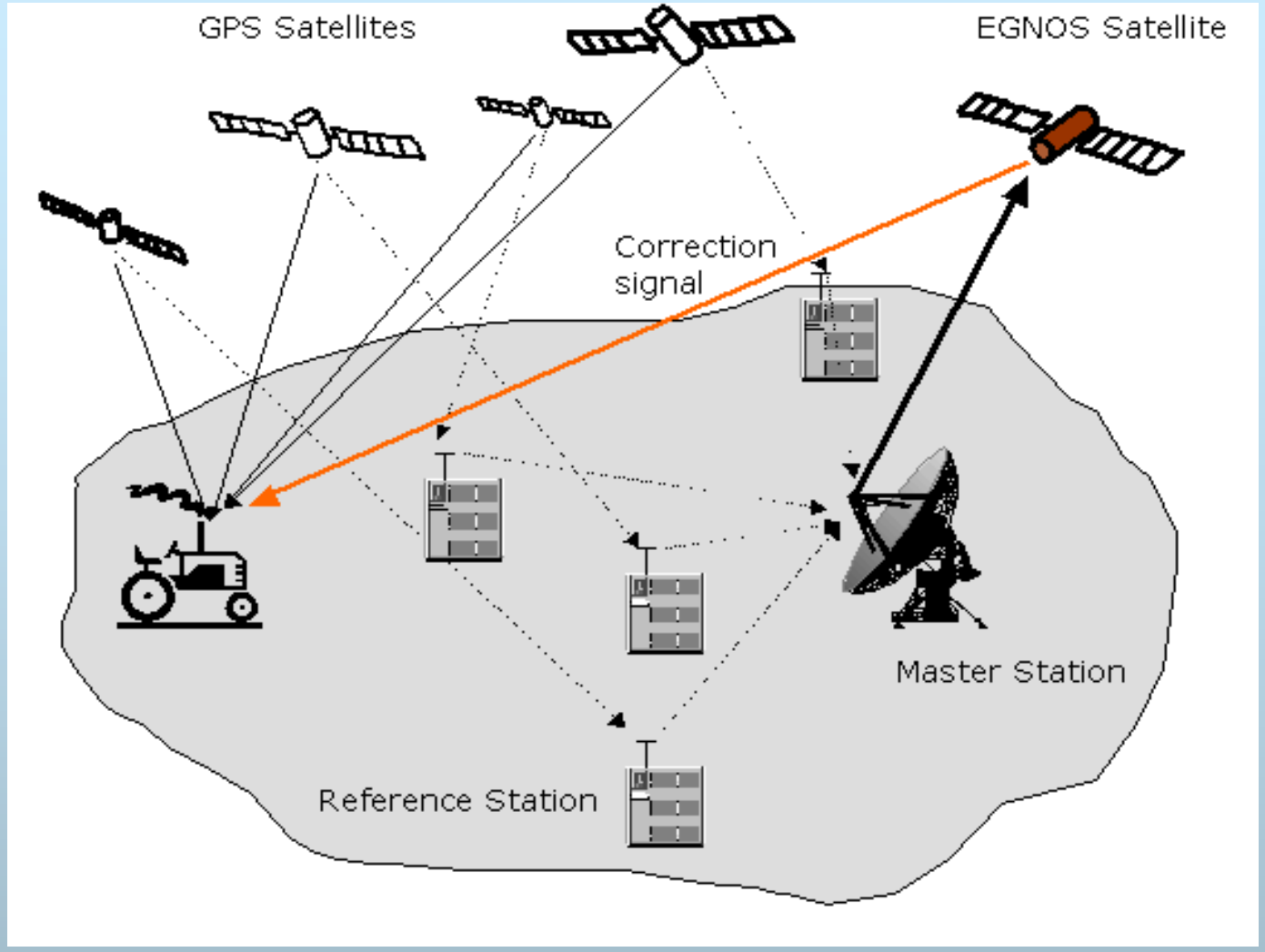
Dúvidas ?

Perguntas ?

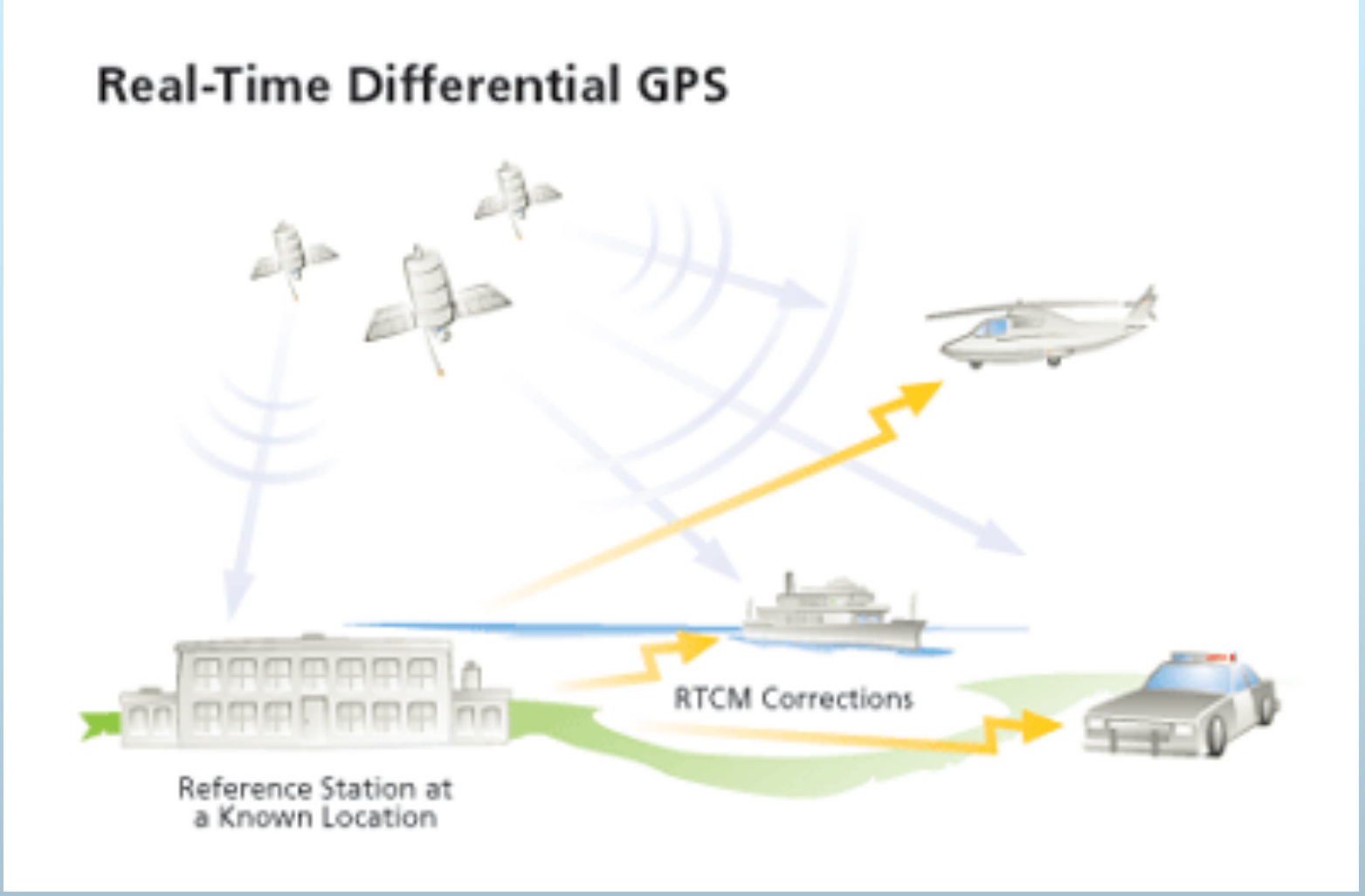
Efeitos que afetam o posicionamento por satélites

- **Ionosfera ± 5m**
- **Erro nas efemérides ± 2.5m**
- **Deriva relógio satélites ± 2m**
- **Multicaminho ± 1m**
- **Troposfera ± 0.5m**
- **Erros Numéricos ± 1m ou menos**

Esquema com o princípio do posicionamento preciso

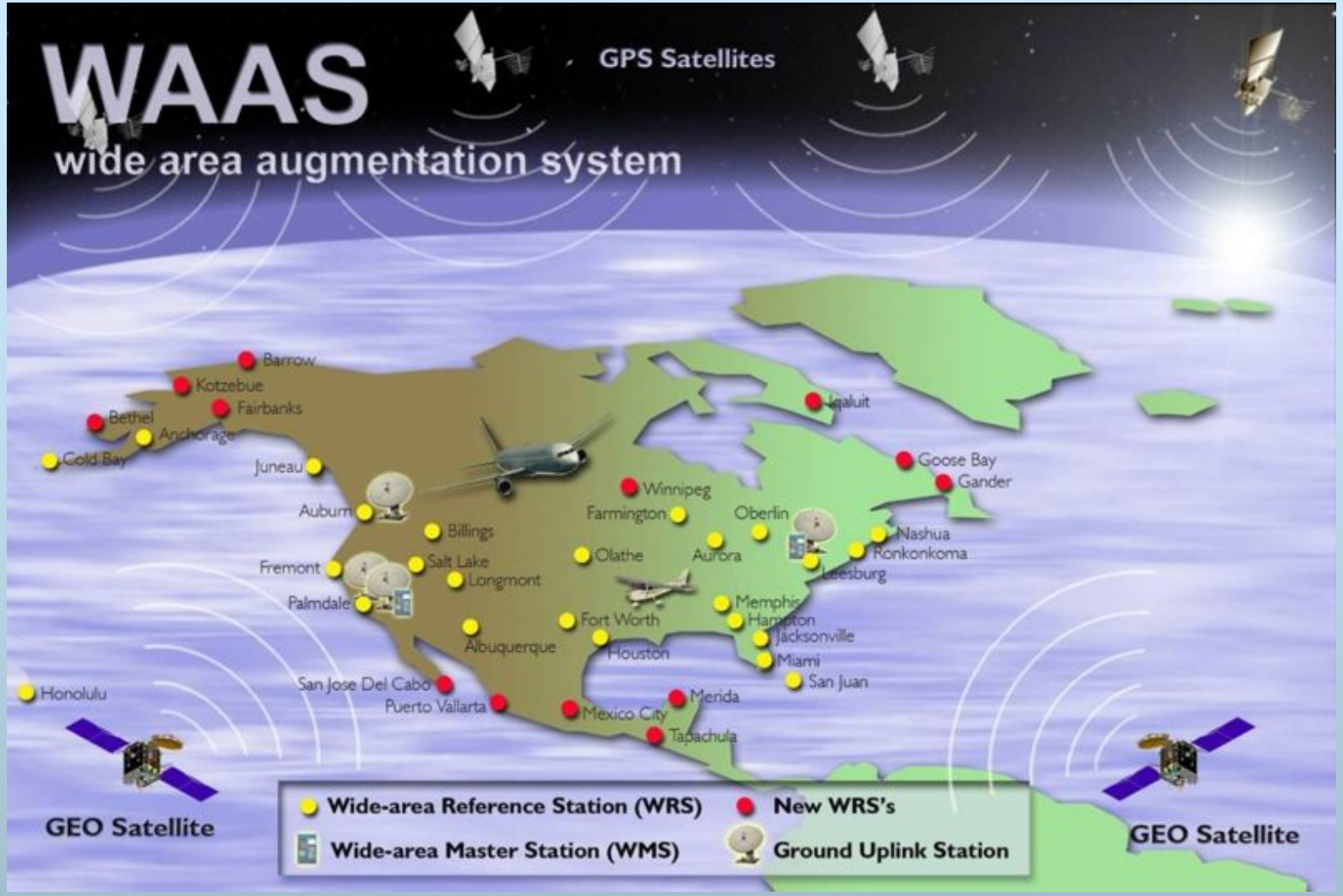


Esquema de rede para DGPS

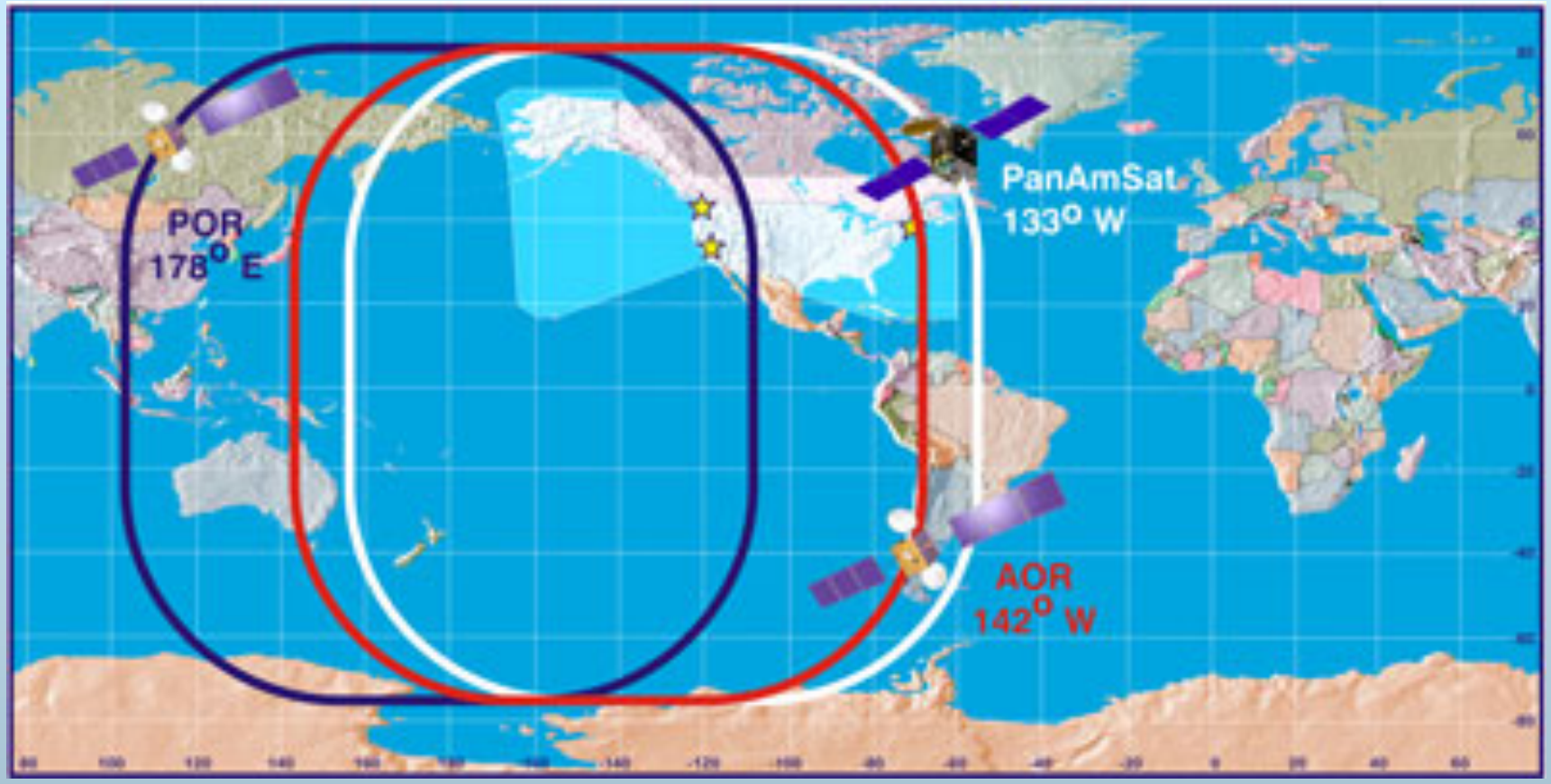


CDGPS - Canadá

Esquema da rede WAAS - USA



Cobertura WAAS

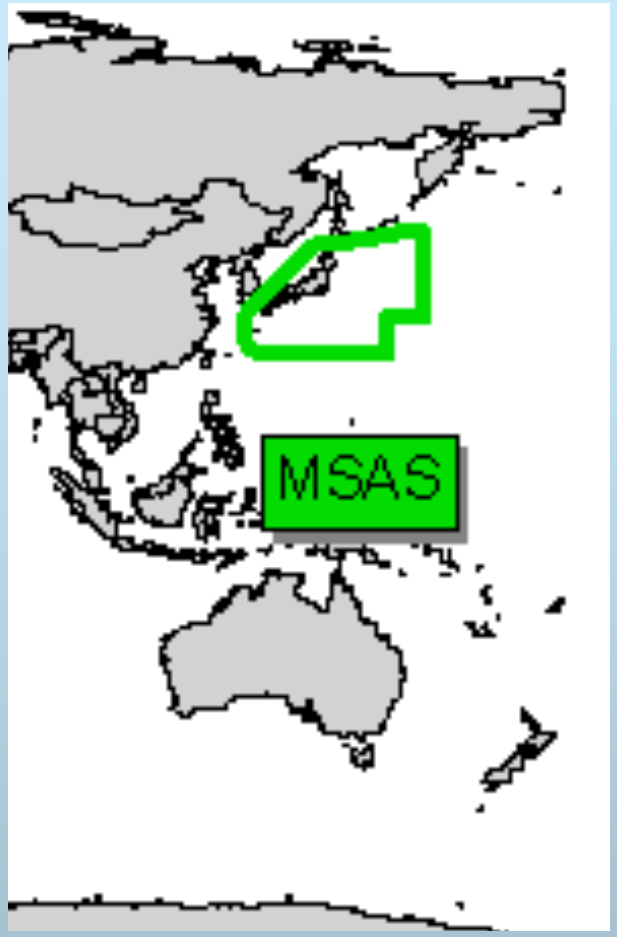


EGNOS – Europa

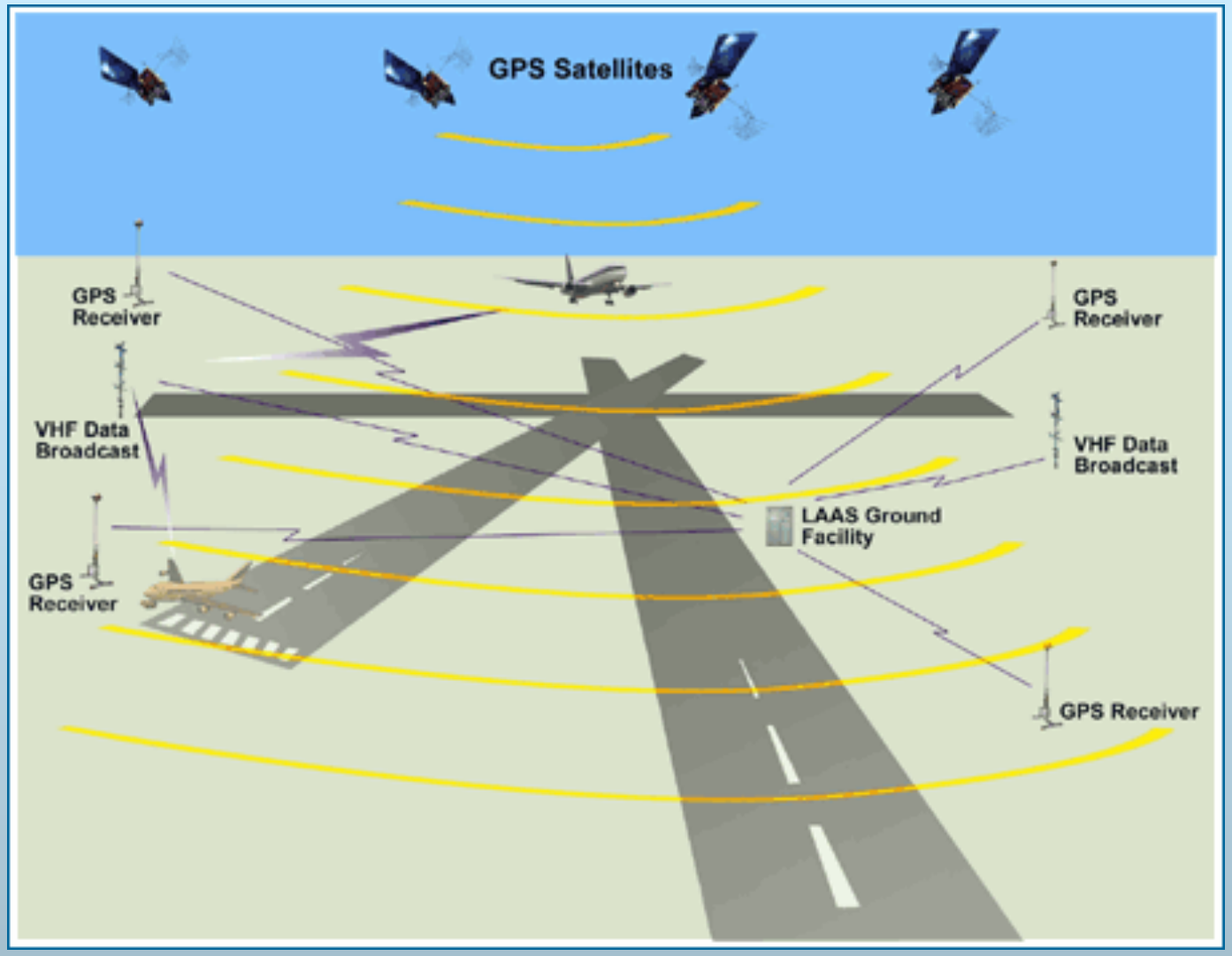
European Geostationary Navigation Overlay Service

MSAS - Japão

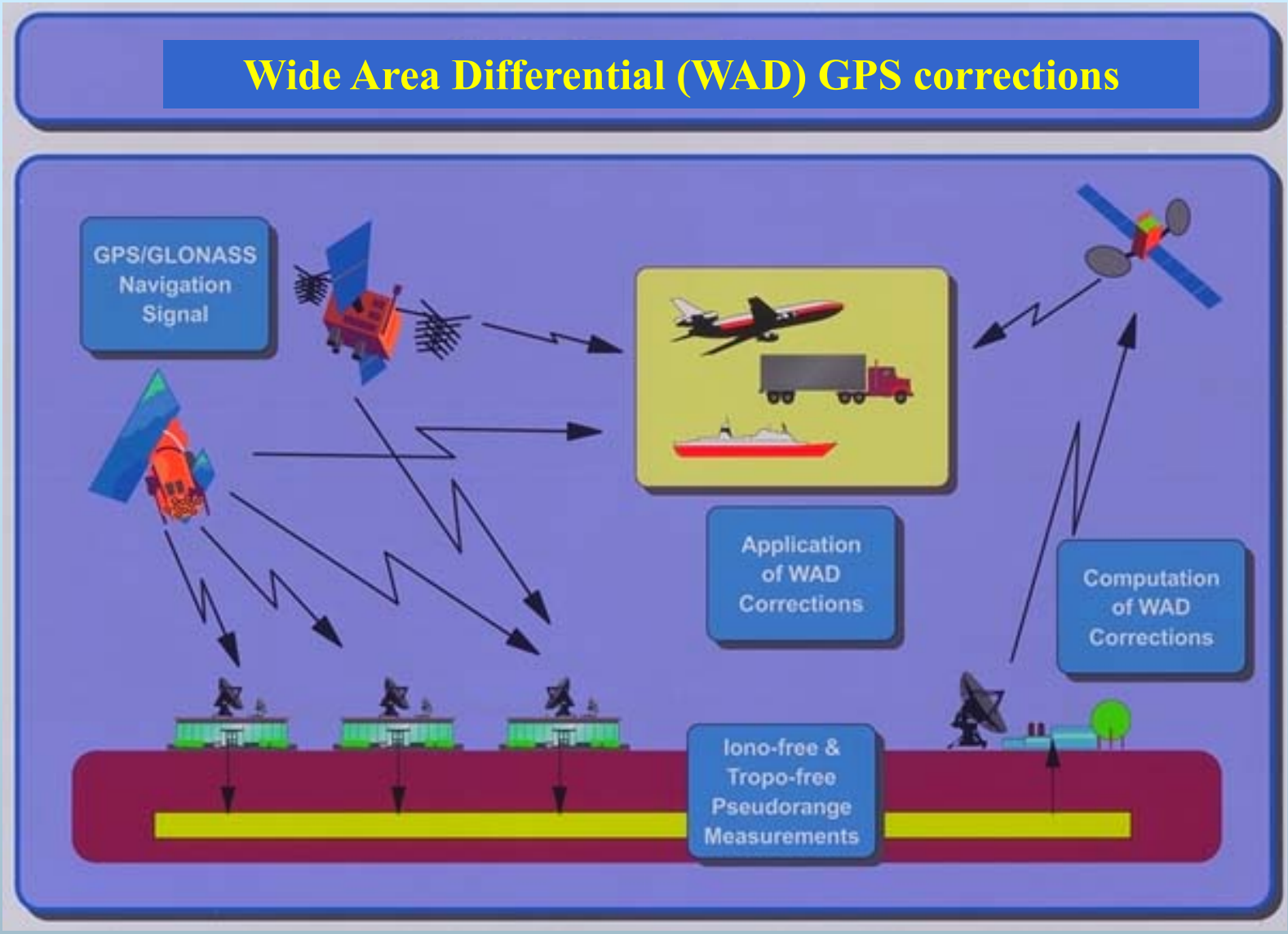
MTSAT Satellite based Augmentation System



LAAS - Local Area Augmentation System



Configuração



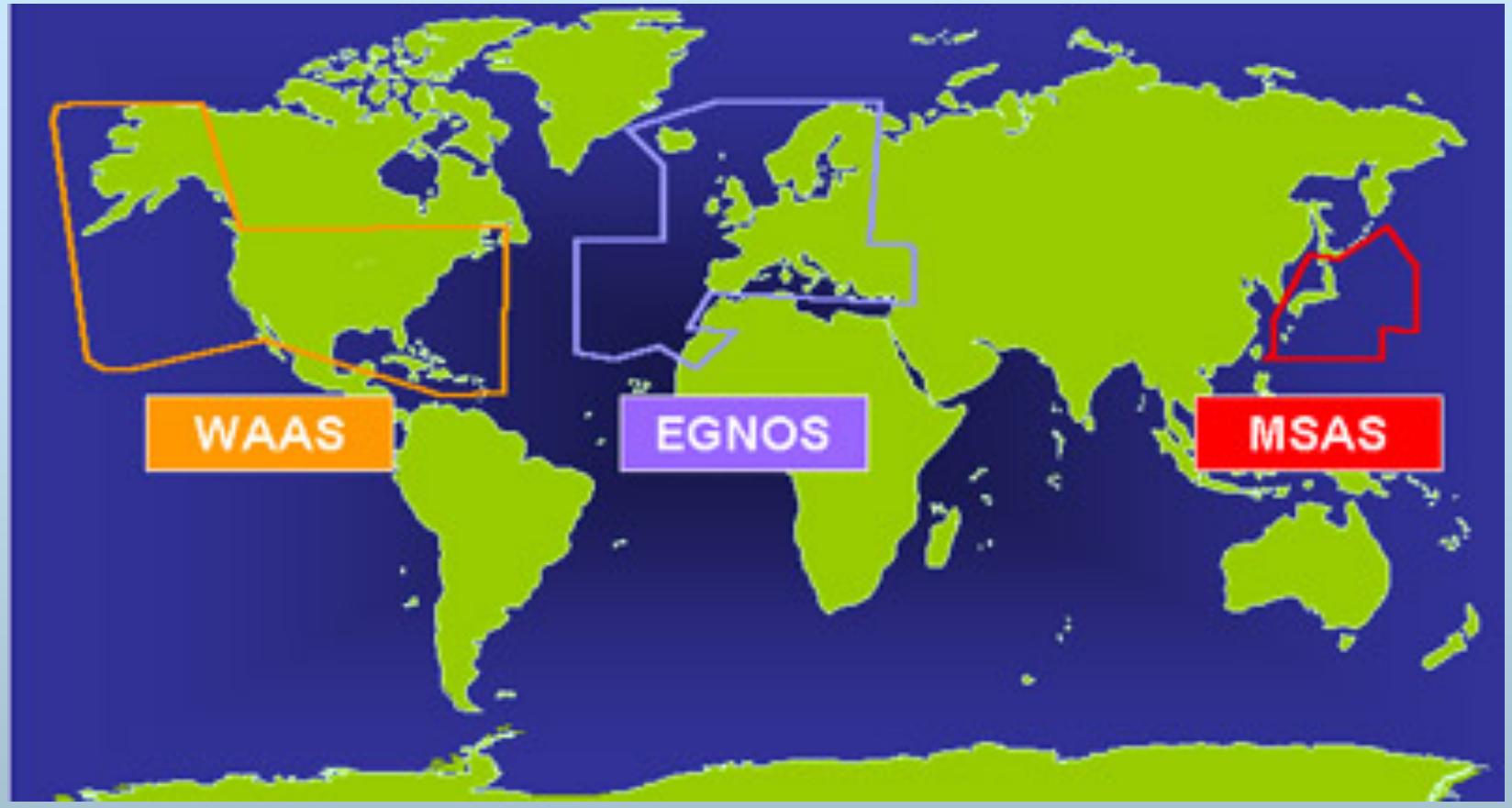
Comparação de vários sistemas de radio navegação: acurácia

sistema	95% Acurácia (Lateral / Vertical)	Detalhes
LORAN-C Specification	**460 meters / 460 meters**	**The specified absolute accuracy of the LORAN-C system.**
Distance Measuring Equipment (DME) Specification	**185 meters / 185 meters**	**DME is a radionavigation aid that can calculate the distance from an aircraft to ground equipment.**
GPS Specification	**100 meters / 150 meters**	**The specified accuracy of the GPS system with the Selective Availability (SA) option turned on. SA was employed by the U.S. Government until May 1, 2000.**
LORAN-C Measured Repeatability	**50 meters / 50 meters**	**The U.S. Coast Guard reports "return to position" accuracies of 50 meters in time difference mode.**
loran Repeatability	**10 meters / 10 meters** [citation needed]	**Modern LORAN-C receivers, which use all the available signals simultaneously and H-field antennas.**

Comparação de vários sistemas de radio navegação: acurácia

sistema	95% Acurácia (Lateral / Vertical)	Detalhes
Differential GPS (DGPS)	**10 meters / 10 meters**	**This is the Differential GPS (DGPS) worst-case accuracy. According to the 2001 Federal Radionavigation Systems (FRS) report published jointly by the U.S. DOT and Department of Defense (DoD), accuracy degrades with distance from the facility; it can be < 1 m but will normally be < 10 m.**
Wide Area Augmentation System (WAAS) Specification	**7.6 meters / 7.6 meters**	**The worst-case accuracy that the WAAS must provide to be used in precision approaches.**
GPS Measured	**2.5 meters / 4.7 meters**	**The actual measured accuracy of the system (excluding receiver errors), with SA turned off, based on the NSTB's findings.**
WAAS Measured	**0.9 meters / 1.3 meters**	**The actual measured accuracy of the system (excluding receiver errors), based on the NSTB's findings.**
Local Area Augmentation System (LAAS) Specification	**1.0 meter / 1.0 meter** *[citation needed]*	**The goal of the LAAS program is to provide Category III ILS capability. This allows aircraft to land with zero visibility utilizing 'autoland' systems and indicates a very high accuracy of < 1 m.**

Cobertura dos Sistemas WAAS, EGNOS e MSAS



Obrigado!

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