

# Safe und reliable navigation of vessels in ocean, coasts and harbor areas based on GNSS and its augmentation systems

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Knowledge for Tomorrow

**rough sea**



Source: Internet



**foggy weather**

**darkness**



Source: Internet



## Challenge

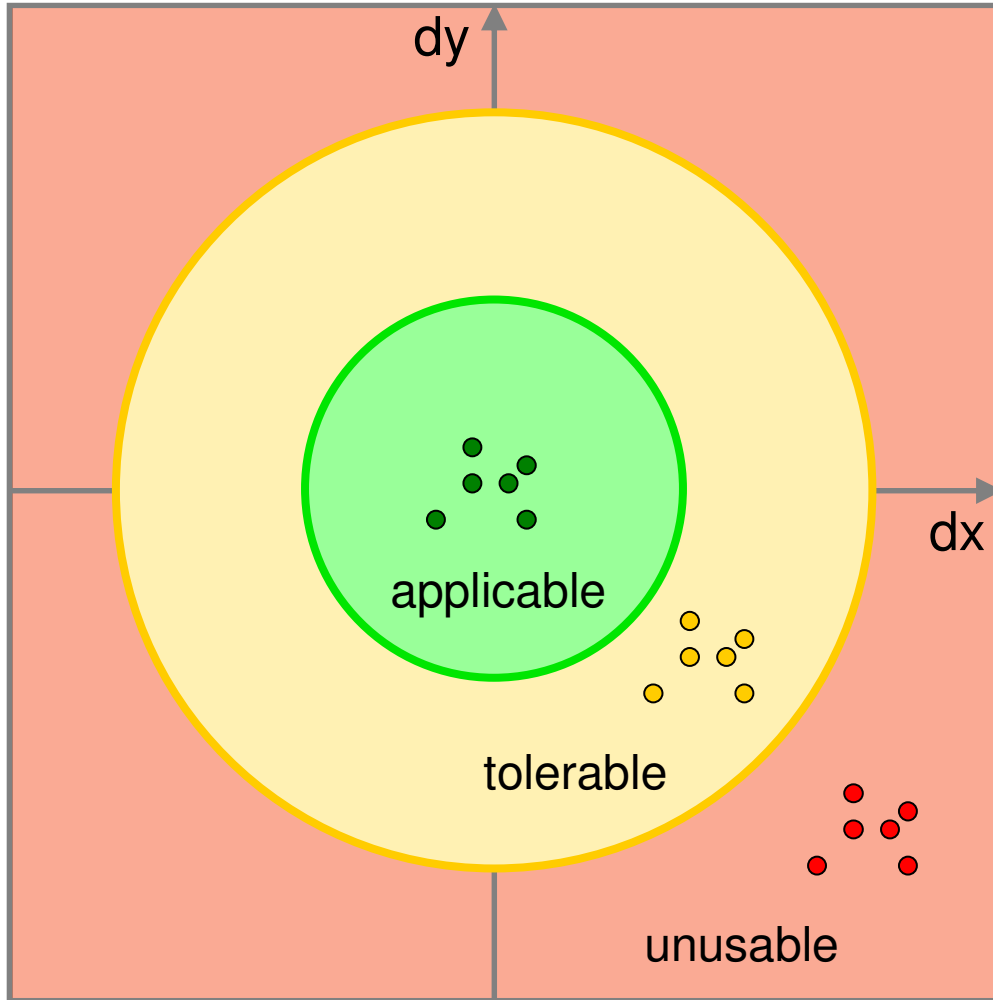


We want to know where we are and we want to know if we **can trust** the information we get !

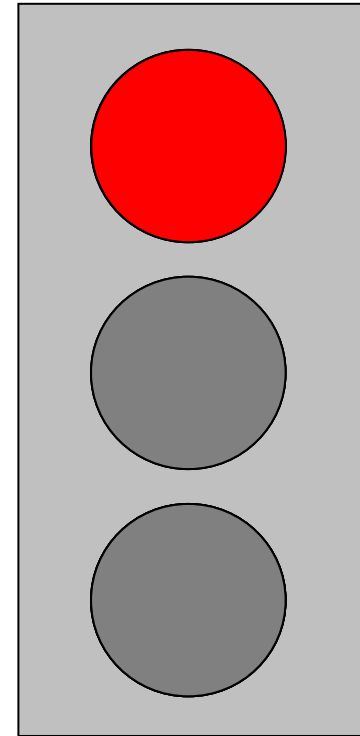
We have to find a way to obtain **reliable** information !



# Accuracy vs. Preciseness



Horizontal Positioning Error



Graphical Translation for the user or operator



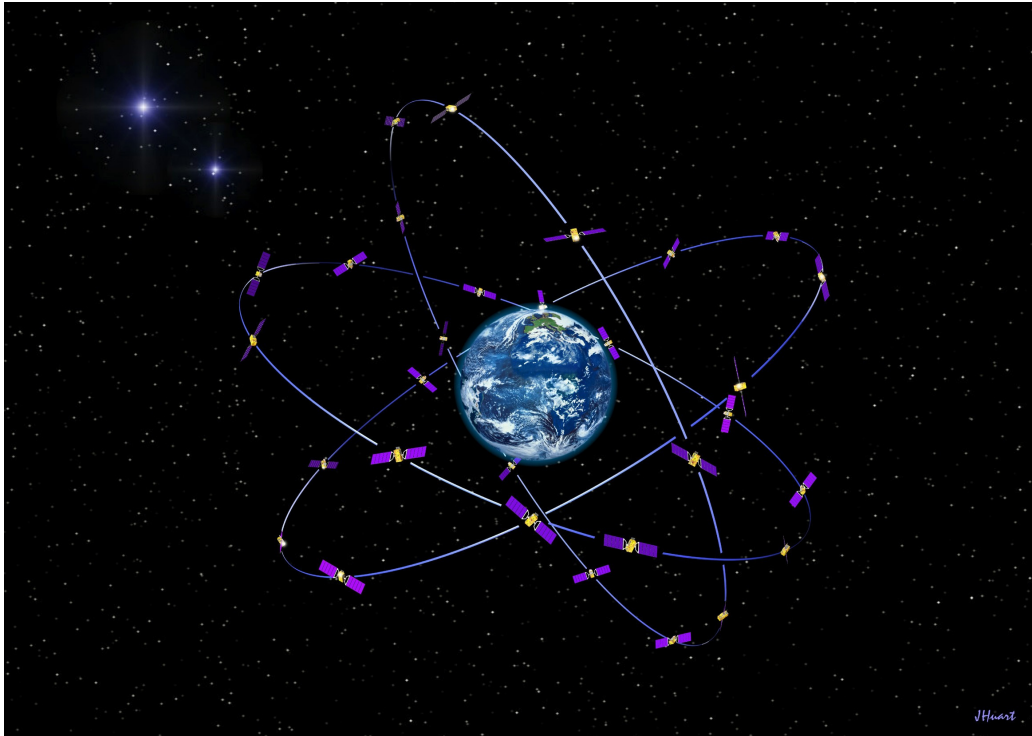
## GNSS

A **Global Navigation Satellite System** is a system of satellites that provides autonomous geo-spatial positioning with global coverage on earth.

It allow receivers/users to determine their location and time using signals transmitted along a line-of-sight by radio channels from satellites.



## The Status Quo in GNSS



### **GPS (USA)**

FOC since 1993

### **GLONASS (Russia)**

FOC since 1996

### **GALILEO (Europe)**

in development

### **COMPASS (China)**

in development

**Achievable horizontal positioning accuracy  
is around 5 up to 10 m**





# IMO A.915(22) Minimum Requirements on future GNSS

	Absolute Accuracy	Integrity
	Horizontal (m)	Alert Limit (m)
Port	<b>1</b>	<b>2,5</b>
Automatic Docking	<b>0,1</b>	<b>0,25</b>



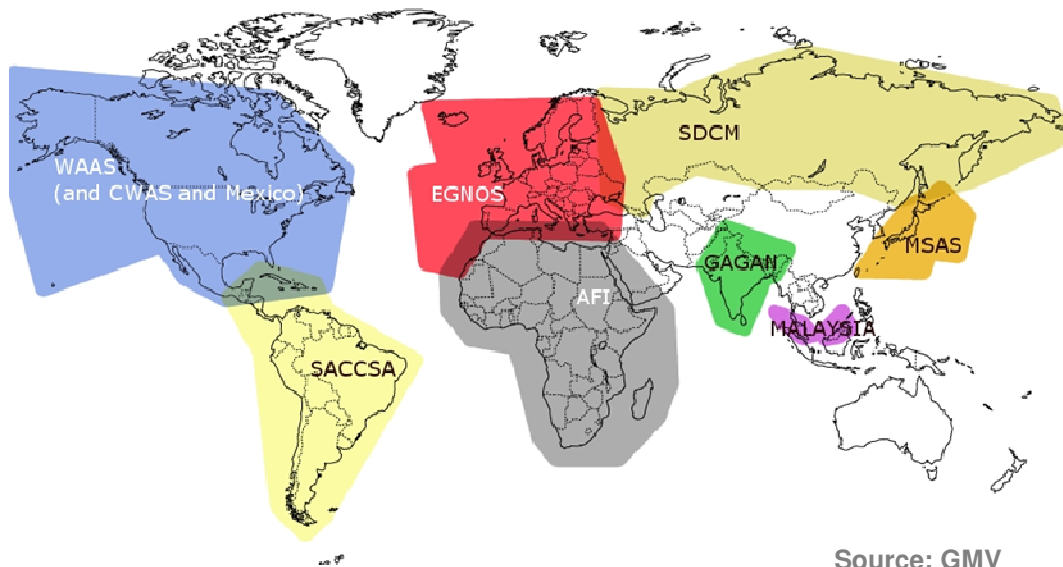
## SBAS (DGNSS)

A **S**atellite **B**ased **A**ugmentation **S**ystem is a system that supports **wide-area** or **regional** augmentation through the use of additional **satellite-broadcast** messages.

Ground stations are used to **measure the satellite signals** and **environmental factors** which may impact the signals received by the users.



## The Status Quo in SBAS (DGNSS)



### **WAAS (USA)**

operational since 2003

### **MSAS (Japan)**

operational since 2007

### **EGNOS (Europe)**

operational since 2009

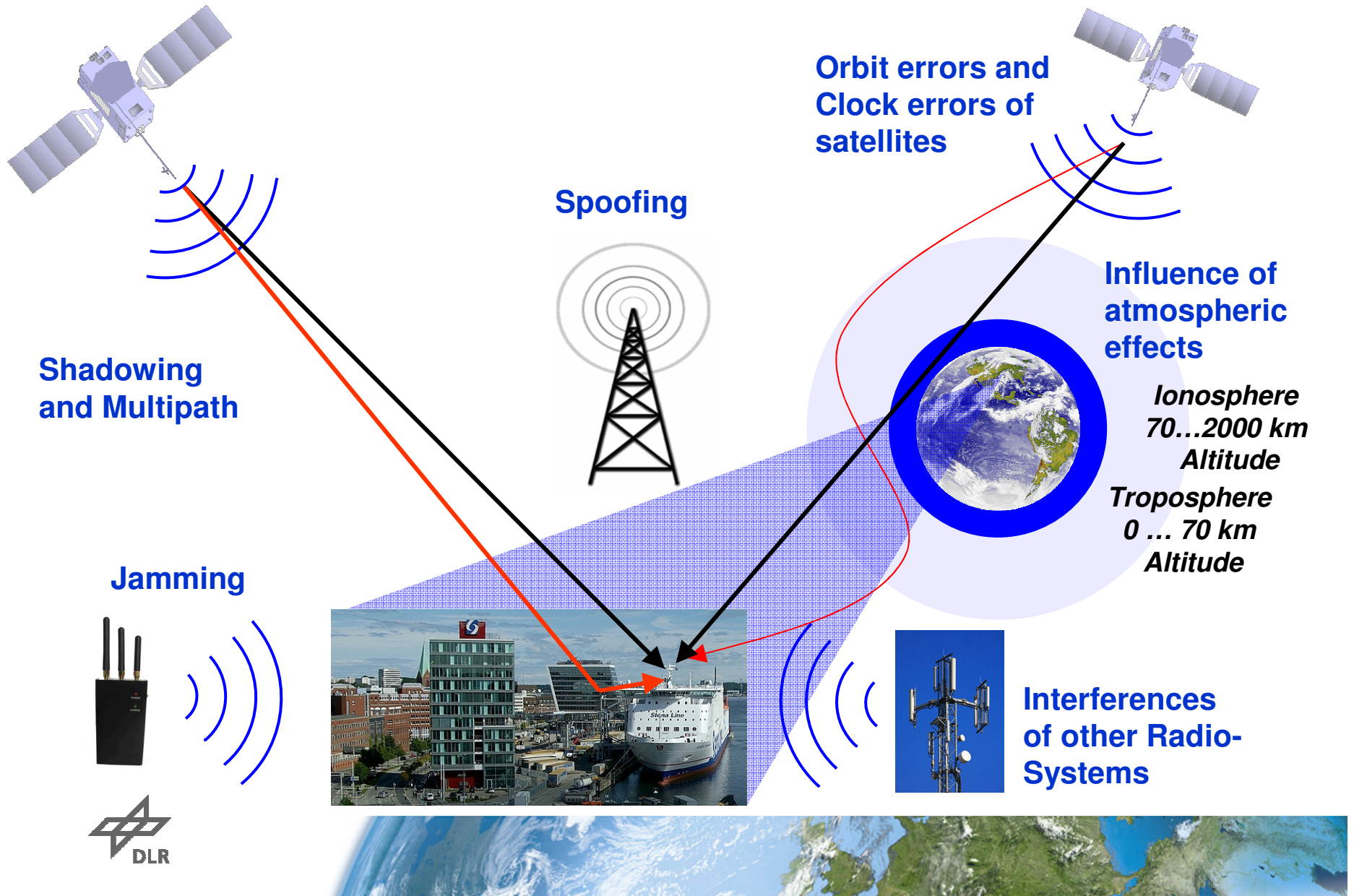
**GAGAN (India), SDCM (Russia),  
SNAS (China),**  
in development

**SACCSA (South America),  
AFI (Africa), Malaysia**  
feasibility studies

**Achievable horizontal positioning accuracy  
is between 0.5 and 3 m (partly with integrity)**



# GNSS Error Sources



## GBAS (DGNSS)

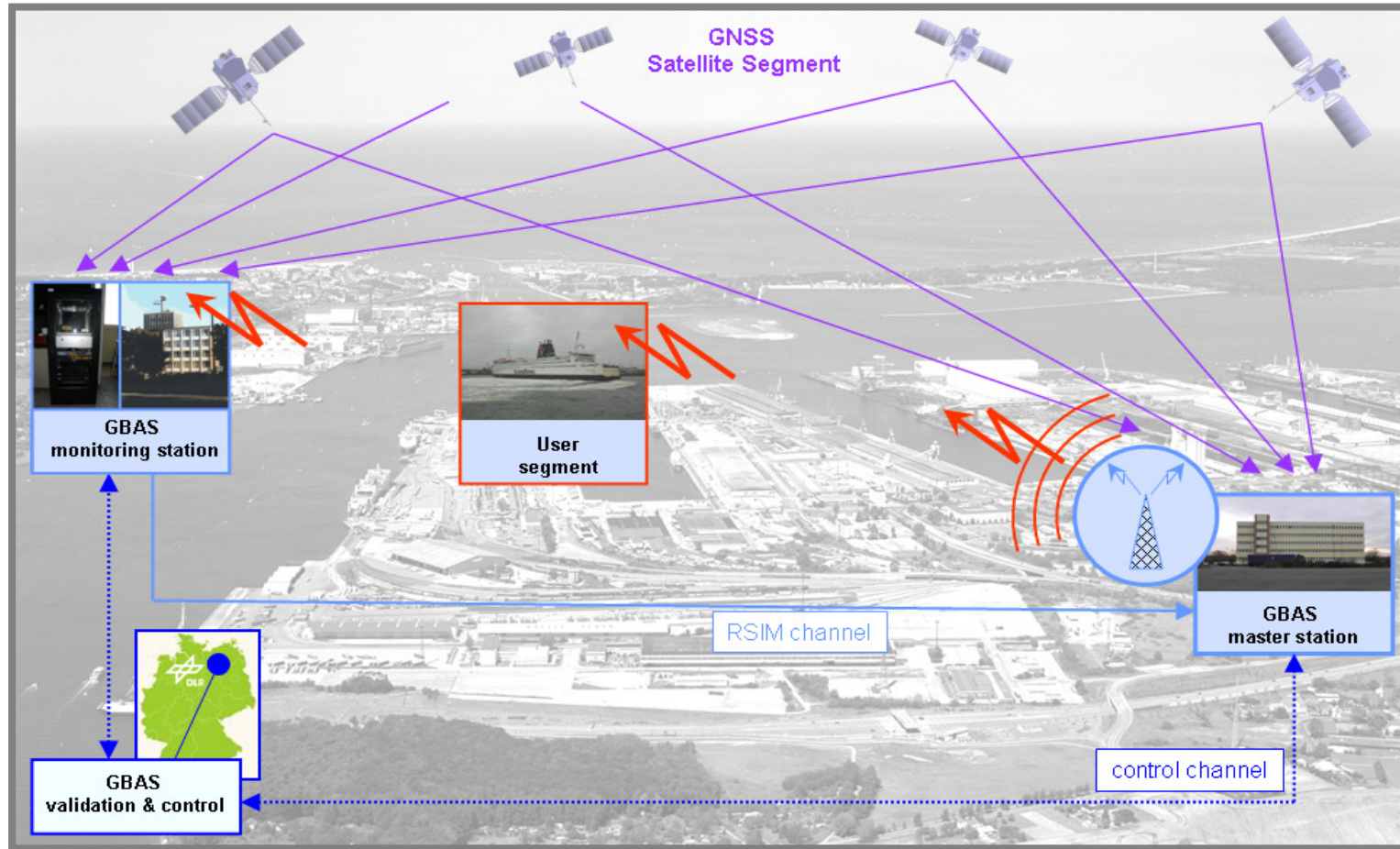
A **Ground Based Augmentation System** is a system that supports **small-scale** or **local** augmentation through the use of additional **terrestrial-broadcast** messages.

One or more ground stations are used to measure the **satellite signals** and **local environmental factors** which may impact the signals received by the users.





## An example for a GBAS (DGNSS)

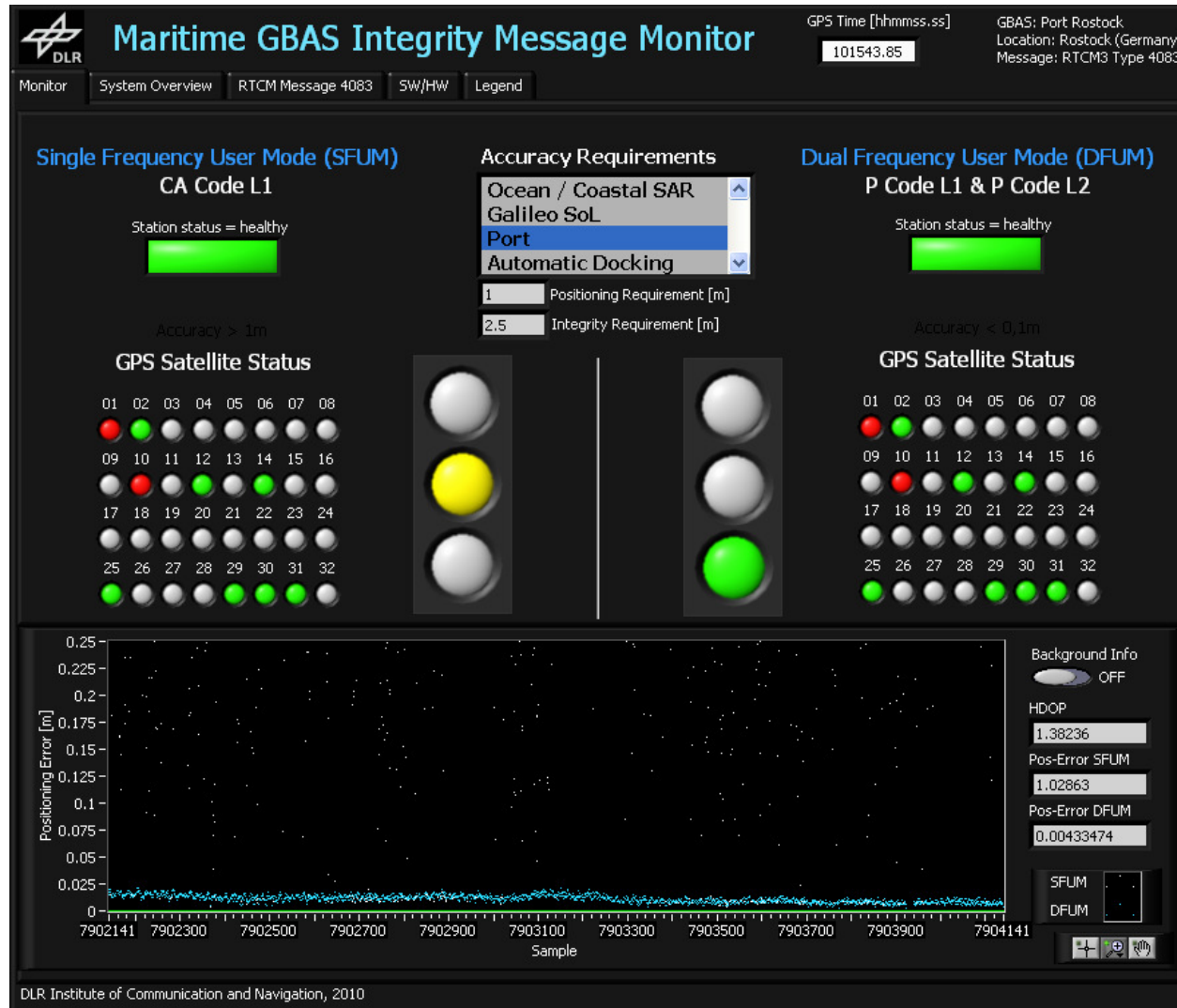


Source: DLR

**Achievable horizontal positioning accuracy is in a range of dm up to cm (with integrity)**



# GBAS Integrity Monitor for GPS



Source: DLR



# GBAS Integrity Monitor for GNSS

Maritime GBAS - GNSS Integrity Message Monitor

Time [hhmmss.ss] 83854.000

GBAS: Port Rostock  
Location: Rostock (Germany)  
Message: RTCM3 Type 4083

Full Monitor
Positioning Monitor
System Overview
RTCM Message 4083
SW/HW

**Application Area**

Ocean / Coastal SAR

Galileo SoL

Port

Automatic Docking

**Accuracy Requirements**

0.1 Positioning [m]

0.25 Integrity [m]

**Mode Selection for Satellite Status**

GPS Dual Frequency

GALILEO Single Frequency

GALILEO Dual Frequency

Multi GNSS Single Frequency

Multi GNSS Dual Frequency

Type of Service Mode	GBAS Status	Positioning Status
<b>Mode 1 (M1)</b> GPS Single Frequency GPS L1 (CA Code)	healthy <div style="width: 15px; height: 15px; background-color: green; margin: 2px;"></div>	<div style="width: 15px; height: 15px; background-color: red; border-radius: 50%; margin: 2px;"></div>
<b>Mode 2 (M2)</b> GPS Dual Frequency GPS L1 & L2 (P Code)	healthy <div style="width: 15px; height: 15px; background-color: green; margin: 2px;"></div>	<div style="width: 15px; height: 15px; background-color: yellow; border-radius: 50%; margin: 2px;"></div>
<b>Mode 3 (M3)</b> GALILEO Single Frequency GALILEO E1	healthy <div style="width: 15px; height: 15px; background-color: green; margin: 2px;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%; margin: 2px;"></div>
<b>Mode 4 (M4)</b> GALILEO Dual Frequency GALILEO E1 & E5a	healthy <div style="width: 15px; height: 15px; background-color: green; margin: 2px;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%; margin: 2px;"></div>
<b>Mode 5 (M5)</b> Multi GNSS Single Frequency GPS L1 (CA Code) + GALILEO E1	healthy <div style="width: 15px; height: 15px; background-color: green; margin: 2px;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%; margin: 2px;"></div>
<b>Mode 6 (M6)</b> Multi GNSS Dual Frequency GPS L1 & L2 (P Code) + GALILEO E1 & E5a	healthy <div style="width: 15px; height: 15px; background-color: green; margin: 2px;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%; margin: 2px;"></div>

**GPS Satellite Status**

01	02	03	04	05	06	07	08	33	34	35	36	37	38	39	40
<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>
09	10	11	12	13	14	15	16	41	42	43	44	45	46	47	48
<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>
17	18	19	20	21	22	23	24	49	50	51	52	53	54	55	56
<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>
25	26	27	28	29	30	31	32	57	58	59	60	61	62	63	64
<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: green; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>	<div style="width: 15px; height: 15px; background-color: gray; border-radius: 50%;"></div>

Satellite Status: OK unmonitored do not use not in view

**Positioning Monitor (Positioning Error of Virtual User)**

M1 •  
 M2 •  
 M3 •  
 M4 •  
 M5 •  
 M6 •

Background Info  OFF

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Source: DLR



## Embedding of solutions into an international framework

### E-Navigation (E-NAV) Strategy of the IMO

- Framework and working program bringing harmony and interoperability into maritime information systems to enhance safety and operations
- Utilisation of all electronic means to integrate these information into ship navigation systems and vessel management systems
- PNT Working work of IALA E-NAV is authorized to propose standardized solutions to fulfil these requirements



## Key issues addressed by E-NAV related to GNSS

Detection of malfunctions in core elements of navigation

Provision of support information (e.g. warnings, alerts) for the mariner or operator

Harmonisation of equipment and processes



**Safe, secure** and **efficient** realisation of all processes inside the Global Maritime Traffic System





## Is it possible to avoid such pictures ?



**75 percent of accidents are induced by human errors**

**Around 50 percent of accidents have navigational causes**





**Thank you for  
your attention**

