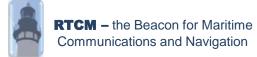


Introduction to RTCM

- RTCM (Radio Technical Commission for Maritime Services): an International non-profit organization, founded on 1947 (US Advisory committee), nowadays members from all over the world
- Started as an organization dealing with maritime radionavigation and communication systems standardization, RTCM is currently working with a broad range of applications and services
- Organized by several Special Committees (SC).
 Some of the SCs are at the base of nowadays GNSS high accuracy positioning and implemented by most of the manufactures



RTCM Special Committees

- Special Committee 101 on Digital Selective Calling (DSC)
- Special Committee 104 on Differential GNSS Service
- Special Committee 109 on Electronic Charting Technology
- Special Committee 110 on Emergency Beacons
- Special Committee 112 on Ship Radar
- Special Committee 117 on Maritime VHF Interference
- Special Committee 119 on Maritime Survivor Locating Devices
- Special Committee 121 on Automatic Identification Systems (AIS) and Digital Messaging
- Special Committee 123 on Digital Message Services over Maritime Frequencies
- Special Committee 127 on Enhanced Loran (eLoran)
- Special Committee 128 on Satellite Emergency Notification and Location Devices
- Special Committee 129 on Portrayal of Navigation-Related Information on Shipboard Displays
- Special Committee 130 on Electro-Optical Imaging Systems
- Special Committee 131 on Multi-System Shipborne Navigation Receivers
- Special Committee 132 on Electronic Visual Distress Signals
- Special Committee 133 on Data Exchange for Navigation-Related Applications for Mobile Devices
- Special Committee 134 on Integrity Monitoring for High Precision Applications
- Special Committee 135 Radio Layer for Real-Time DGNSS Applications
- Special Committee 136 on Beacon Type Approvals
- Special Committee 137 on Electromagnetic Compatibility Requirements for LED Devices and other Unintentional Emitters Located Near Shipboard Antennas



RTCM SC-134 Objectives

Scopes of the SC-134 Committee:

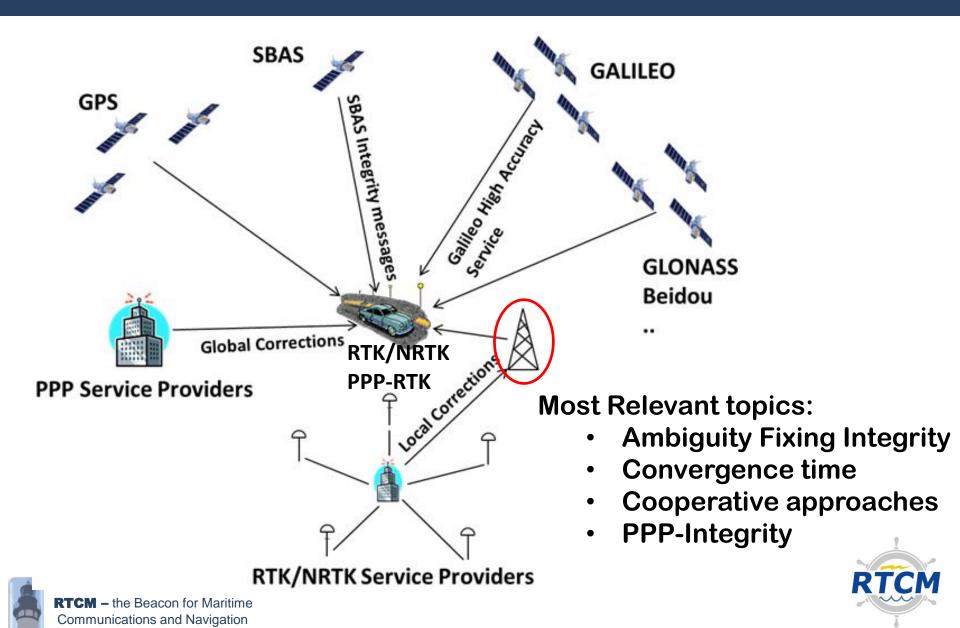
- Definition of a Standard Messages formats for GNSS Integrity Augmentation at User and Service Provider Level, with a Multimodal Approach
- Continuous review of emerging application requirements and safety metrics
- Update of existing single application Fault Models and Integrity Parameters for Integrity Monitoring
- Liaison with application domain and other standardization organizations

RTCM SC-134 Membership:

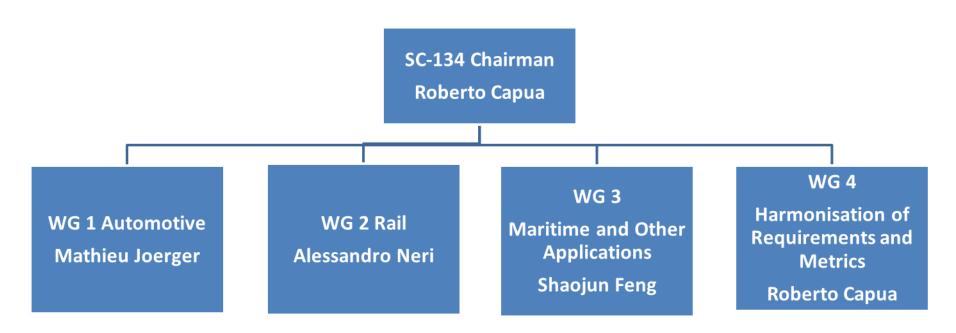
Current number of members: 267
Manufacturers, Service Providers, Universities



GNSS High Accuracy Systems



RTCM SC-134 organization



Specific Task Forces are setup:

- Augmentation Transition Mode integrity
- NRTK Integrity
-





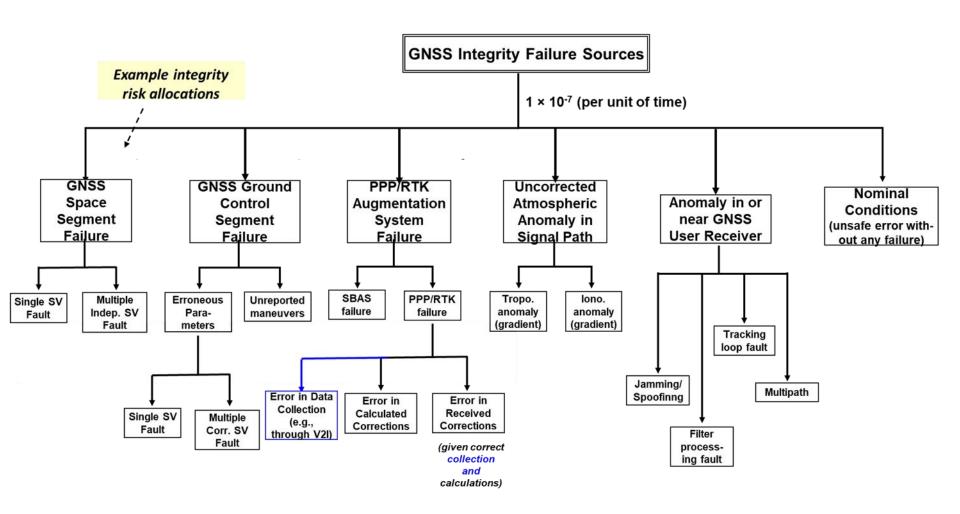
WG1 - Automotive

- Analysis of Error Sources for Automotive
- Analysis and refinement of Fault Models for Automotive
- Definition of Integrity Parameter and messages for the automotive sector
- Comparison and mapping with existing standards (e.g. ISO 26262 and SAE J2735) – monitoring through RTCM Liaisons





Example of Automotive Fault Tree







Automotive Service Levels

Application	Description	Accuracy (95%)	Conti- nuity	Integrity, Alert Limit	Integrity, Time to Alert	Integrity Risk / THR	Avail- ability (%)	Max. Age of Integrity Data	Time to Become Available
High-speed maneuvers (autonomous)	(Highway driving) High- speed merging, lane changes, passing maneuvers	0.25 m (Lat); 0.50 m (Long); 0.45 m (Vert) [2]	10 ⁻⁶ / 15 sec	0.75 m (lat); 1.5 m (long); 1.4 m(vert)[2]	6 / 1 sec (see notes)	10 ⁻⁷ / hr (ASIL C/D) [1-4]	99.9% [1]	~ 30 sec unless alert	~ 1 min (see notes)
Follow temporary traffic control (autonomous) Regulatory	(General) Detect and respond to police, accidents, detours Automatically enforce	0.25 m (Lat); 0.25 m (Long); 0.5 m (Vert) [2] 5 m (2-D horiz.);							~ 1 min (see notes)
Enforcement (non- autonomous)	,	` '							

Example Service Levels:







TTA for detection of (but failure to exclude) slowly-growing error or PL / TTA for detection of (but failure to exclude) sudden large or rapidly growing error

TBA = time at which some probability of service can be provided, but not necessarily meeting the availability requirement.





WG2 activities

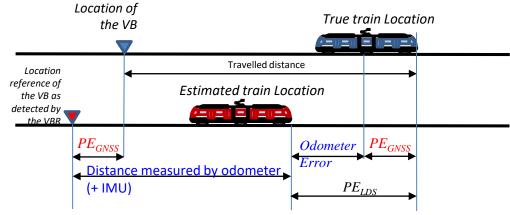
- Rail Safety analysis, following ERTMS and PTC requirements
- Virtual Balises and GNSS Traffic Control
- Multipath characterization





Rail Safety Aportionement (ERTMS)

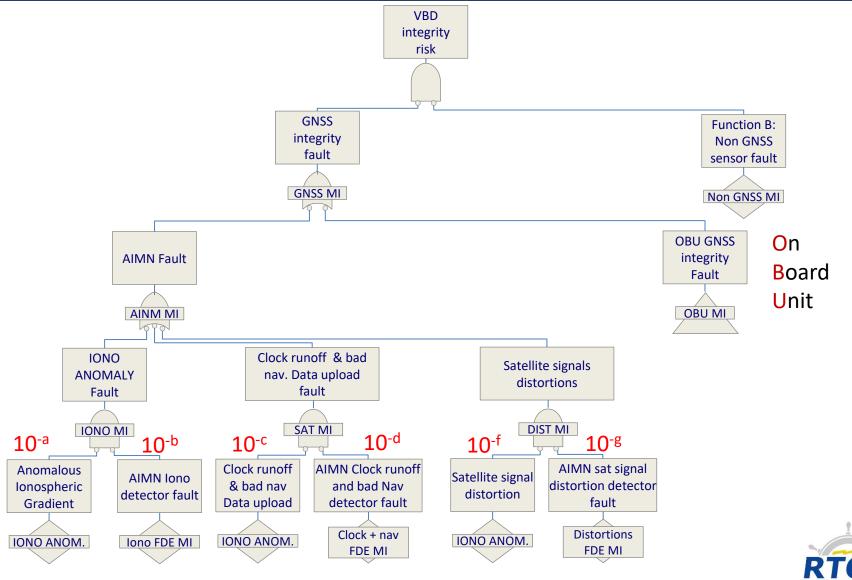
- The core THR parameter with reference to subsystems functions shall be the "exceedance of safe speed or distance as advised to ETCS" and shall be equal to 2.0*e-9 / hour (see UNISIG Subset 088).
- The total THR shall be equally apportioned between
 - ONBOARD,
 - TRACKSIDE
 - TRANSMISSION (components or "gates")







Example of Rail Fault Tree





RTCM – the Beacon for Maritime Communications and Navigation

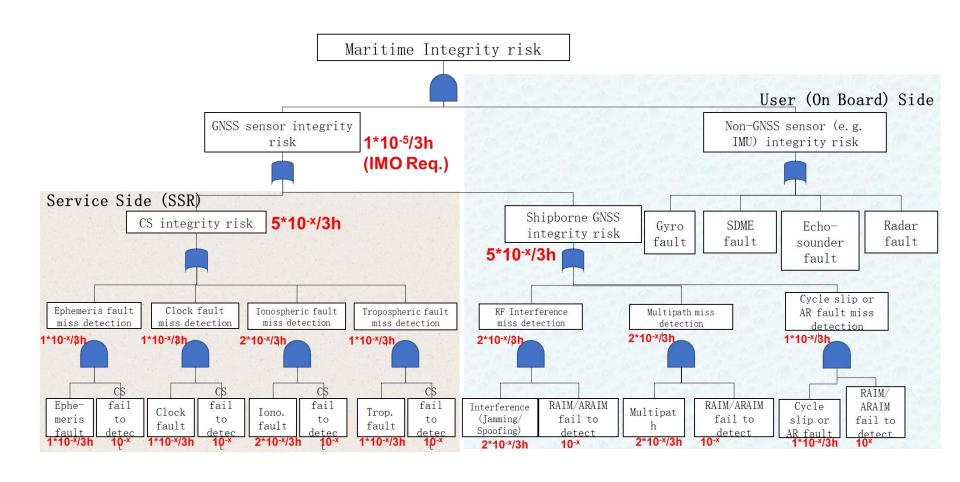
WG3 activities

- Maritime application Safety Analysis
- Emerging applications (IoT, Red Ligth, etc..)
- PPP and PPP-RTK application and preliminary messages definition





Exmple of Maritime Fault Tree







PPP Integrity Messages

Group Name	Message Type			Positioning Method					
Network Integrity	N.A.			TOWN PROPERTY OF					
Local Integrity	Area Definition	-		Table of Contents					
	Area Satellite Mask	1.		Message Summary					
	Area Grid Integrity	2.	Signal	In Space Integrity Message					
	Area Satellite Integrity		2.1.						
	Area Grid Satellite Integrity		2.2.	Satellite SIS Integrity (MT 51-1)	2				
	Troposphere Polynomial Correction	3.	Globa	l Integrity Message					
	Troposphere Grid Correction		3.1.	Satellite Mask (MT 52-0)	4				
	Ionosphere Polynomial Correction		3.2.	Satellite Signal Mask (MT 52-1)	1 2 2 2 2 2 3 2 3 3 3 3 3 3 3 3 3 3 3 3				
	Ionosphere Grid Correction		3.3.	Satellite Orbit Correction (MT 52-2)	5				
			3.4.	Satellite Clock Correction (MT 52-3)	5				
			3.5.	Satellite Yaw Attitude (MT 52-4)	6				
			3.6.	Satellite Code Bias Correction (MT 52-5)	7				
			3.7.	Satellite Phase Bias Correction (MT 52-6)	7				
			3.8.	Satellite Global Integrity (MT 52-7)					
		4.	Local	Integrity Message	10				
			4.1.	Area Definition (MT 53-0)	10				
			4.2.	Area Satellite Mask (MT 53-1)	10				
			4.3.	Area Grid Integrity (MT 53-2)	11				
			4.4.	Area Satellite Integrity (MT 53-3)	12				
			4.5.	Area Grid Satellite Integrity (MT 53-4)	13				
			4.6.	Troposphere Polynomial Correction (MT 53-5)	14				
			4.7.	Troposphere Grid Correction (MT 53-6)	15				
			4.8.	Ionosphere Polynomial Correction (MT 53-7)	16				
			4.9.	Ionosphere Grid Correction (MT 53-8)					
		5	Data I		10				





WG 4 activities

- Requirements collection and continuous update
- Requirements Harmonization and Service Level Definition
- Metrics Harmonization
- Network RTK IntegrityTask Force





WG 4 activities

Application Group	Application	Description		Accuracy (95%)	Continuity	Integrity	Integrity- Time	Integrity	Availability (%)	Frequency	Reliability	Maximum			
Application circuip	Application	Description		Accuracy (93.0)	Continuity	Alert Limit (PNT)	to Alert	Risk/THR	Peranatomy (10)	Stability	Acutouty	of Integrity			
Automotive	Obey Rules of the Road (autonomous)	(General) Detect and respond to traffic signals, determine right-of-way, etc.	15	×								1			
	High-speed maneuvers (autonomous)	(Highway driving) High-speed merging changes, passing maneuvers													
	Low-speed maneuvers (autonomous)	(Road driving and parking) Low-speed lane changes, detect and respond to of vehicles													
	Navigate intersections (autonomous)	(Road driving) Handle turns and round	Accura												
	Follow temporary traffic control (autonomous)	(General) Detect and respond to police detours		××											
	Regulatory Enforcement (non-autonomous)	Automatically enforce zone-based road speed restrictions (where applicable)		×											
	Smart Mobility Guidance (non-autonomous)	Crowdsource user data and provide re traffic guidance and warnings													
Rail	Longitudinal position of along a track - Staff Responsible	the arc length of the track path with ori predefined reference point (e.g. last last reference) and ending in the train ref point	7.5												
	Longitudinal position of along a track - Start of Mission	reference to the track		×											
	Longitudinal position of along a track - Full supervision	the arc length of the track path with or predefined reference point (e.g. last 1 as reference) and ending in the train ref point		t	ł .		×								
	Train orientation	indication in which direction a train is p													
							×								
				×											
				× × ×											
				** * * ** * * ** * * *								×			
			0.0025 0.				1000.005					2000			
			0.	01			1000.003					2000			

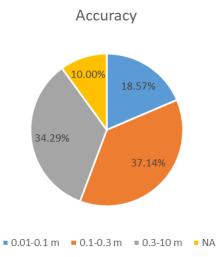




Requirements Analysis

Accuracy

Accuracy Classification	% applications
0.01-0.1 m	18.57%
0.1-0.3 m	37.14%
0.3-10 m	34.29%
NA	10.00%



Integrity (THR/SIL)

General IEC-61508	Dangerous Failure/h	ISO 26262	Rail CENELEC 50126/128/1	
SIL-1	10 ⁻⁵ -10 ⁻⁶	ASIL-A	SIL-1	50.79%
SIL-2	10 ⁻⁶ -10 ⁻⁷	ASIL-B/C	SIL-2	0.00%(*)
SIL-3	10 ⁻⁷ -10 ⁻⁸	ASIL-D	SIL-3	9.52%
SIL-4	10 ⁻⁸ -10 ⁻⁹	-	SIL-4	4.76%
NA				41.27%

(*) On the boundary of two levels





Message Definition Process

Application Group	Арр	lication	Description	Accuracy (95%)	Continuity	ity Alert Limit Time		te grity- Time to Alert Integrity Risk/THR. T		Availability (%)	Fin S
	Obey R Road (autono		(General) Detect and respond to traffic signs and signs ls, determine right- of-way, etc.	0.25	10 ⁻⁶ /15 sec	0.75 m (Lat); 0.75 m (Long); 1.5 m (Vert) [2]	10 / 2 sec (see notes)	1.00E-07	1.51E-06	99.5 [1]	T <
	High mans (auto	DF#	DF N	ame	I	OF Range	Res	DF solution	Data Type		Data Field Notes
Automotive	Low- mans (auto	DF908	Satellite H Mask	lealth	0-1		1		bit(64)	not us	or each satellite (64 at maximum) describe the health status: '0' do e, '1' use nessage is transmitted together with the DF909
	Navi inter (auto	DF909	Satellite Monitorin	g Status	0-1		1		bit(64)	'0' not Satelli	or each satellite (64 at maximum) describe the Monitoring status: monitored, '1' monitored; for not monitored state, the respective ite Health in DF908 (in the same position) is set by default to 1; e of such satellite is under the responsibility of the user
	Follow	temporary	ond resonand to	I I	10-6 / 15	0.75 m (Lat);	10/2	l I	1		

DF

		NUMBER	TYPE	BITS	
Satellite Monitoring Status		DATA FII	ELD		
Satellites Integrity Mask					
TOTAL	Message Numb	er			
	GPS Epoch Tin	ne (TOW)			
	Reference Station	on ID			
	Reference Station	on Monitor	ing Statu	ıs	
	Reference Station	on Integrity	Flag		
		TOTA	L		

DATA FIELD

- 1. Requirements definition
- 2. Fault Analysis and models
- 3. Message Definition
- 4. Interoperability Test
- 5. Standard Update



Possible Collaboration Activities

- Analyis of Safety and Integrity for emerging applications
- Common definition and harmonization of GNSS application requirements
- Collaboration on the development of application standards for next generation Satellite Navigation Systems
- Analysis of interfacing standard between Ground and Service Segments
- Mutual Participation to Plenary Meetings



