ESMERALDA

Integrated station for spectrum monitoring

- Monitoring
- Goniometry
- Location
- Technical measurements
- Radio surveillance
- Wideband signals analysis
- Cellular networks analysis
- Data transmissions decoding
- Automatic spectrum control missions
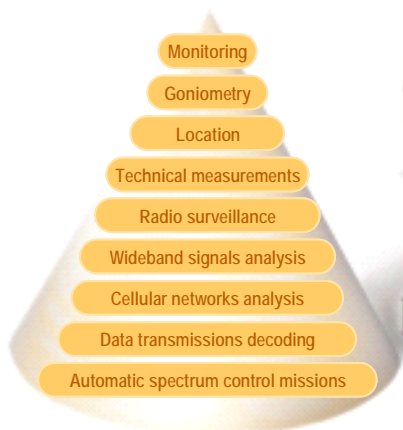
- A unique solution for automatic spectrum monitoring (9 KHz – 3 GHz)

- Compliant with to the latest ITU recommendations and to the Spectrum Monitoring Handbook, edition 2002

- Automatic spectrum monitoring missions

- Reliable and accurate technical measurements and radio direction finding

- Multipurpose and modular: autonomous station or network of remotely controlled stations

- Antennas perfectly adapted to each configuration

- Signal analysis and transmissions identification

- **NEW** Wide band signal analysis (up to 20 MHz) : TDMA, CDMA, OFDM and other digital signals

- **NEW** Cellular networks analysis (GSM, UMTS, IS95, ...)

www.thalesgroup.com

THALES

ESMERALDA: MASTERING THE RADIOELECTRICAL SPECTRUM

Born of THALES Communications expertise as designer, integrator and manufacturer of equipment and Radioelectrical Spectrum Management and Monitoring systems, ESMERALDA is the solution to the challenge of controlling radioelectrical transmissions, classical as well as modern (TDMA, CDMA, OFDM, frequency hoppers), no longer detectable by classical measurement tools.

ESMERALDA is designed to be in total compliance with the latest ITU Recommendations and European Directives; thanks to its modular conception, new ITU Recommendations can easily be included as soon as they are adopted.

As world leader in this field, THALES Communications has installed and set to work the automatic spectrum monitoring system for France's ANFR as well as numerous other national systems worldwide in a highly competitive environment.

ESMERALDA is the corner stone of any integrated Spectrum Management and Monitoring system, in compliance with ITU-R Recommendation SM1537. Its purpose is to control technical parameters of licenses of radioelectrical spectrum usage, thus ensuring accuracy of data stored in the regulator's data base.

ESMERALDA is not only the integration in a unique equipment of an efficient monitoring receiver, a fast and accurate radio direction finder and efficient tools for analysis and identification of signals, but also a complete radioelectrical monitoring station able to be operated autonomously as well as to be integrated into regional, national or international monitoring networks.

ESMERALDA is the perfectly adapted solution to the needs of radioelectrical spectrum regulation agencies, able to process every existing radioelectrical signals. THALES continuously increase its capacities with new capabilities and integrate new ITU recommendations.

TOTAL COMPLIANCE WITH ITU RECOMMENDATIONS

Interactivity
- ❖ ITU-R SM 1537 and SM 1370

Reception
- ❖ SMH-2002 Chapter 3.3, Table 3-2

Radiogoniometry
- ❖ SMH-2002 Chapter 4.7, Class A
- ❖ Mobile: SMH-2002 Chapter 2.4.2
- ❖ SSL, SMH-2002 Chapter 4.7.5.4
- ❖ ITU-R SM 854, SM1269 and SM1598

Signal identification and vector analysis
- ❖ ITU-R SM 1600
- ❖ SMH-2002 Chapter 4.9

SMH: ITU-R Spectrum Monitoring Handbook

THALES

SPECTRUM MANAGEMENT AND MONITORING INTERACTIVITY

For a complete and automated interactivity with spectrum management sub-systems, ESMERALDA provides TCP/IP protocol interfaces linked to communication means: router, modem (wired, radio, cellular phone, RLAN, Internet, VSAT...), In full compliance with the ITU-R Recommendations SM1537, SM1392 and Chapter 3-6 "Automation of monitoring" of the 2002 ITU-R Spectrum Monitoring Handbook.

- Preparation of automated spectrum monitoring missions and processing of results, linked with any existing spectrum management administrative and technical database,
- Execution of automated spectrum monitoring missions.
- Direction finding and location by triangulation, from monitoring or management centre or from the ESMERALDA stations upon execution of automated missions.
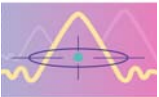
AN EFFICIENT SOLUTION

ESMERALDA offers a complete range of automated missions for optimum effectiveness of spectrum monitoring systems, in full compliance with Chapter 3 of ITU-R Spectrum Monitoring Handbook Edition 2002 and to ITU-R Recommendations SM1050 and SM1500:

- Systematic control of transmitters
- Occupancy rate by transmitters
- Occupancy rate by frequency
- Specific frequency surveillance

- Search for unknown transmitters
- Channel analysis (manual mission).
- Television measurements
- Field measurements along the route (mobile station)
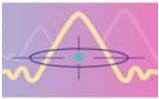
A UNIQUE SOLUTION

ESMERALDA offers a unique solution integrating every spectrum monitoring functions, in full compliance with Chapter 3.3 and 3.4 of ITU-R Spectrum Monitoring Handbook Edition 2002:

- Interceptor/ fast direction finder
- High performance digital receiver
- Spectrum analyzer
- Spectrum occupancy analyzer
- Real time decoder for data transmissions
- Frequency meter
- Field strength analyzer

- Modulation analyzer
- Signal vector analyzer
- Wide band interference analyzer
- Audio recorder
- Wide Band digital RF signal recorder
- TV demodulation and display
- Edition of reports
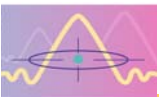
A CONFORME SOLUTION

Actively involved in the ITU, the European Electronic Communication Committee (ECC), working with the French Ministry of Industry and Agence Nationale des Fréquences (ANFR), THALES Communications ensures the conformity of ESMERALDA to the following standards:
- IEC standards
- CISPR standards and EMC directive
- ISO 9001
- CE marking, (RTTE Directive)
- Limits for human exposure 1999/19/EC and ECC Recommendations (02) 04 (Safety and Health)
- European directive on low voltage
- Lightning protection for ground fixed stations
- Lightning/shock protection for antenna cables at building point of entrance

THALES

A MULTIPURPOSE ARCHITECTURE

Thanks to its compact and modular structure, ESMERALDA is adapted to every necessary configuration of a spectrum monitoring system: a dedicated antenna for each configuration, identical functional capacities.

❖ Fixed HF / VHF / UHF Stations:

For HF range, antenna network (composed of 8 cross loop ANT186 antennas) for wide base correlative interferometry direction finding for all polarizations, thus including ground waves and sky waves.

This configuration provides Single Station Location (SSL) allowing limiting the number of fixed HF stations of a spectrum monitoring system.

For VHF/UHF range, antenna network (ANT194A antenna) composed of 3 assemblies of 5 dipoles with the right dimension for wide base correlative interferometry direction finding and measurements of vertically polarized transmissions. This antenna was specially designed for an optimal lightning protection.

This configuration may be completed by monitoring antennas (omnidirectional or directional) for horizontally polarized transmissions.

❖ Mobile and / or semi fixed HF / VHF / UHF Stations:

For HF range, compact antenna adapted to mobile stations (ANT187 antenna) for Watson Watt direction finding and optimal operation while the vehicle is moving.

For VHF/UHF range, compact antenna adapted to mobile stations (ANT184A antenna) for wide base correlative interferometry direction finding, measurements of vertically polarized transmissions and optimal operation while the vehicle is moving as wall as when it is stopped. This antenna can be mounted on an integrated telescopic mast easily and rapidly erectable.

This configuration may be completed by monitoring antennas (omnidirectional or directional) for horizontally polarized transmissions.

ESMERALDA can be integrated in a wide range of vehicle (4 wheel drive, vans, etc.) including GPS receiver, magnetic compass as well as numerous options: remote exploitation from the passenger front seat for homing application, alternator integrated into the vehicle engine or independent power supply, additional air conditioning, etc.
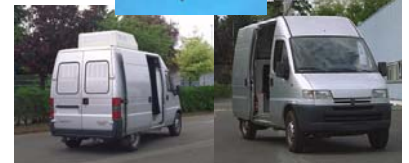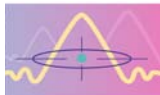
❖ Transportable VHF / UHF Stations:

Hardened casing for equipment and antenna adapted to easy transportation and frequent hoisting / dismantling (ANT206 antenna) for wide base correlative interferometry direction finding, measurements of vertically polarized transmissions.

THALES

- **LG 309: operation software for digital receivers**

  - Reception/ listening-in
  - Transmissions demodulation / filtering
  - ITU measurements operation
  - Graphical and textual displays to take full advantage of the richness of acquired and measured data
  - Automatic spectrum monitoring missions
  - Real time decoding of data transmissions
  - **NEW** Acquisition of digital IF signal for off-line analysis: bandwidth 300 kHz, 2 MHz or 20 MHz
  - Synchronisation of the direction finder on TDMA signal, in compliance with ITU-R Recommendations SM1598
  - **NEW** Integrated Spectrum Analysis: bandwidth 300 kHz, 2 MHz or 20 MHz
  - Remote operation,
  - **NEW** Cellular Network Signal Analysis covering:
    - o GSM trace mobile management for coverage analysis (mobile application),
    - o TDMA, CDMA, OFDM networks signal analysis for interference, occupancy rate and identification
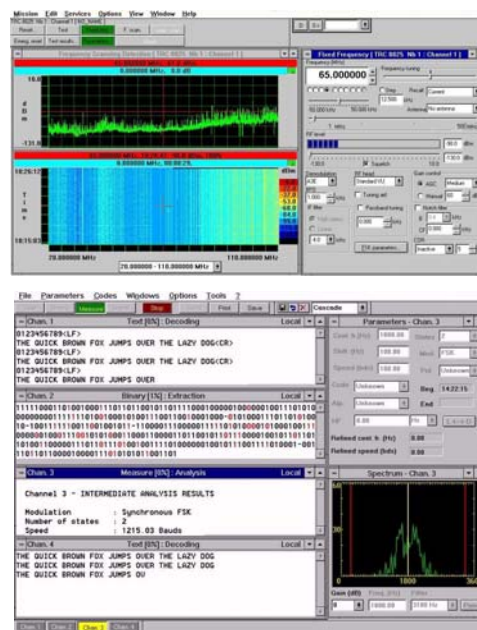
- **LG 111: operation software for direction finders**

  - Local operation of radio direction finders
  - Homing for mobile stations
  - Single Station Location (SSL) for direction finders in HF range
  - Graphical and textual displays to take full advantage of the richness of acquired and measured data
  - Remote operation
  - **NEW** TDMA / CDMA signal direction finding in compliance with ITU-R Recommendation SM1598 when used with LG118 Software
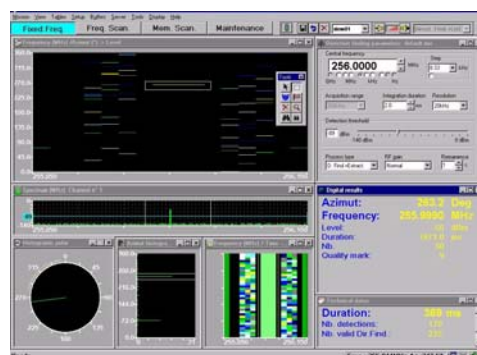
- **LG 112: location processing on integrated cartography**

  - Digital cartography management
  - Networking of remote ESMERALDA stations for location by triangulation
  - Direction finding and / or location results (including SSL) display on cartographic background
  - Management of automatic spectrum monitoring missions, at Monitoring Control Centre level
  - Interface with Management administrative and technical database, at Monitoring Control Centre level
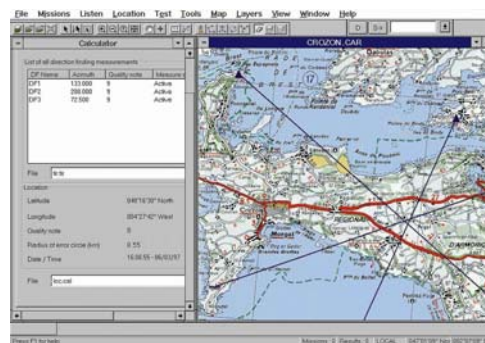
- **LG 118: Identification and complex digital signals analysis**
  Off line analysis software for signals recorded thanks to LG 309 digital receivers software in compliance with ITU-R Recommendations SM1600 and Chapter 4.9. of Spectrum Monitoring Handbook Edition 2002.

- **LG 115: software for new decoding process analysis**
  Off line analysis software for signals recorded thanks to LG 309 digital receivers software.

- **LG 105: software for new decoders creation**
  Off line analysis software for signals recorded thanks to LG 309 digital receivers software.
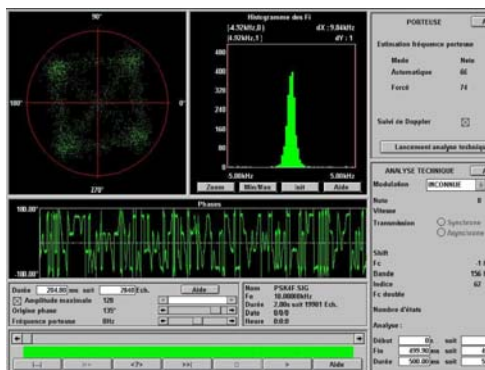
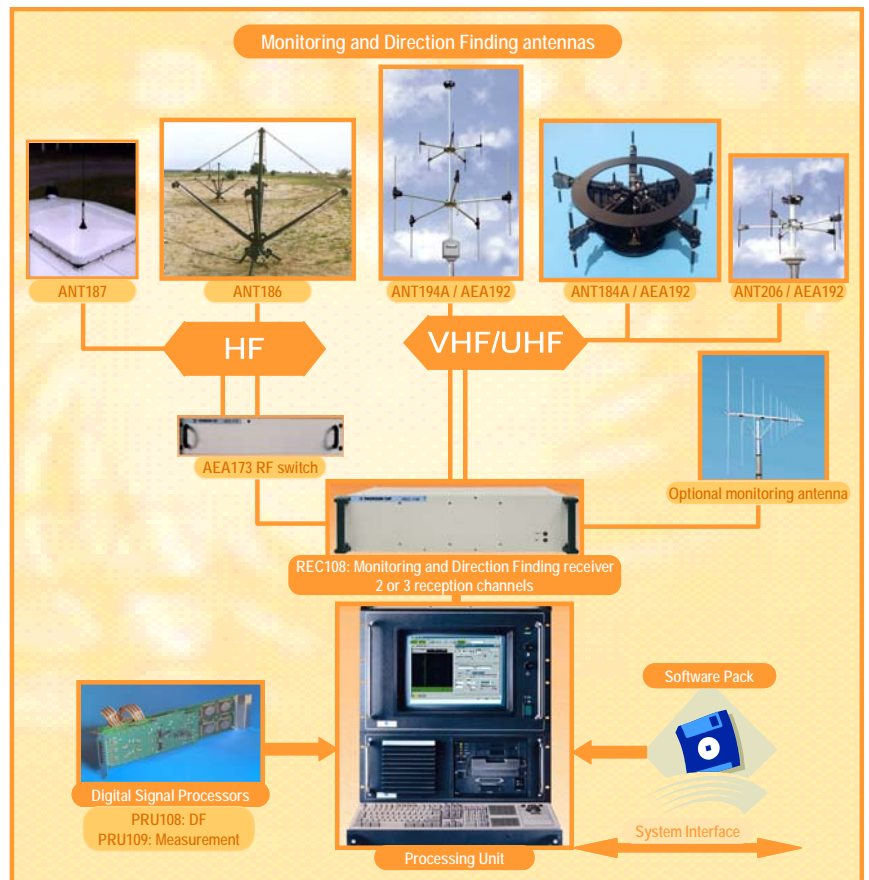Some functions depend on selected configuration.

THALES

ESMERALDA, (standard configuration) integrates a measurement receiver coupled to a radio direction finder:

♦ Measurement receiver: digital technology with numerous filters and demodulators

♦ 2 channel radio direction finding, Class A, ensuring a high stability of measures, thanks to the automatic compensation of drifts of the 2 reception channels and an entirely digital process for radio goniometry. High measurement precision, guaranteed by systematic calibration, for fixed configurations (1° RMS) as well as for mobile configurations (2° RMS): announced performance are field proven

ESMERALDA, may be completed by a 3rd reception channel allowing:

NEW ■ Wideband signal analysis up to 20 MHz

■ Direction finding synchronization for GSM signals

NEW ■ Cellular networks analysis (GSM, GPRS, UMTS, IS95, …)

Monitoring and Direction Finding antennas

ANT187 ANT186 ANT194A / AEA192 ANT184A / AEA192 ANT206 / AEA192

HF **VHF/UHF**

AEA173 RF switch

Optional monitoring antenna

REC108: Monitoring and Direction Finding receiver 2 or 3 reception channels

Software Pack

Digital Signal Processors
PRU108: DF
PRU109: Measurement

System Interface

Processing Unit

ESMERALDA has also other configurations: independent direction finder (also referenced TRC8000) or monitoring and measurement receiver fitted with 1 up to 4 independent channels (also referenced TRC8025).

ESMERALDA : A HIGH LEVEL OF PERFORMANCE

■ High sensitivity and linearity (IP2/IP3) allowing processing of distant low-level signals in a dense radio electric environment

■ High interception speed: up to 1000 channels/s and 300 MHz/s in VHF/UHF and up to 750 channels/s et 75 MHz/s in HF

■ Radio surveillance of very wide bandwidth emissions (up to 20 MHz in VHF/UHF)

■ Multi-channel digital direction finding thanks to Fast Fourier Transform (FFT)

■ Very fast simultaneous interception and direction finding, up to 150 MHz/s in VHF/UHF and 30 MHz/s in HF

■ Minimum signal duration for direction finding of 2 ms in VHF/UHF and 3 ms in HF; optimized mode down to less than 500 μs for GSM bursts

■ Specific processing optimizing monitoring by using existing V/UHF direction finding antenna, avoiding the need of additional monitoring antennas

■ Windows NT or Windows XP environment: multitask, multiwindows, and easy to use

■ Easy diagnostic and maintenance (BITE)
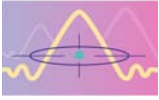
THALES

ESMERALDA : TECHNICAL SPECIFICATIONS
ESMERALDA is compliant with Recommendation ITU-R SM 1537 as well as the ITU-R Spectrum Monitoring Handbook, Edition 2002

RECEPTION SPECIFICATIONS (DIGITAL RECEIVER)
According to :
Chap. 3.3, table 3.2 of ITU-R SMH, ed. 2002

Performance	HF	VHF / UHF
Frequency range	9 KHz - 30 MHz	20 - 3000 MHz
Frequency resolution	1 Hz	10 Hz
Frequency stability	2×10^{-8} or 2×10^{-10} with GPS external pilot	
Scanning speed: Continuous independent or adjacent channels	up to 750 channels/s	1000 channels/s
Interception scanning speed	Up to 75 MHz/s	300 MHz/s
Reception modes	AM : A2A, A2B, A3E, CW : NON, A1A, A1B USB/LSB (SSB) : J2A, J2B, J7B, H3E, J3E, R3E ISB : B8E (2 reception channels) FM : F3E φM : G3E FSK : F1A, F1B	AM : A2A, A2B, A3E, CW : NON, A1A, A1B USB/LSB (SSB) : J2A, J2B, J7B, H3E, J3E, R3E ISB : B8E (2 reception channels) FM : F3E φM : G3E FSK : F1B
Noise figure	14 dB (typical)	9 dB (typical)
PI2	+ 75 dBm (above 3 MHz)	+ 40 dBm
PI3	+ 35 dBm (above 3 MHz)	+ 20 dBm
Sensitivity A1A : 300 Hz ; S/N = 10 dB A3E : m = 0,5 ; Filter 6 KHz ; S/N = 12 dB J3E : 3 KHz ; S/N = 10 dB F3E : S/N = 20 dB	- 124 dBm (0.28 μV e.m.f.) - 103 dBm (3.17 μV e.m.f.) - 114 dBm (0.89 μV e.m.f.) Filter 8 KHz ; Deviation ± 2.4 KHz - 100 dBm (4.48 μV e.m.f.)	- 128 dBm (0.18 μV e.m.f.) - 107 dBm (2 μV e.m.f.) - 118 dBm (0.56 μV e.m.f.) Filter 30 KHz ; Deviation ± 10 KHz - 108 dBm (1.78 μV e.m.f.)
Instantaneous bandwidth	300 KHz Signal can also be recorded with LG309 software for off line analysis.	300 KHz (2 MHz or 20 MHz option) Signal can also be recorded with LG309 software for off line analysis.
IF rejection	90 dB	90 dB
IF filters	24 filters from 0,1 to 300 KHz	12 filters from 0,3 to 300 KHz
Band-pass tuning	± 10 KHz – (filter bandwidth ÷ 2)	± (filter bandwidth) ÷ 2
Notch filter	0.1 – 0.2 – 0.4 – 0.8 – 1.6 – 3.2 KHz	0.1 – 0.2 – 0.4 – 0.8 – 1.6 – 3.2 KHz
Phase noise	- 110 dBc/Hz at 1 KHz - 120 dBc/Hz at 20 KHz	- 110 dBc/Hz at 20 KHz (typical) - 120 dBc/Hz at 2 MHz (typical)
Automatic Gain Control	120 dB (4 speeds available)	
BFO	- 10 KHz to + 10 KHz; steps of 10 Hz	
Squelch	Range > 120 dB; steps of 1 dB	

OUTPUTS		
Broad band IF	IF = 1.5 MHz; Bw = 20 KHz or 300 KHz	IF= 70 MHz ; Bw = 20 MHz or IF = 1.5 MHz ; Bw = 325 KHz
Analog IF	5 KHz to 15 KHz ; level 0 dBm ± 5 dB on 600 ohms	
Headset AF output	Level < 5 mW on 600 ohms	
AF output (line)	Level 0 dBm ± 10 dB on 600 ohms	
Digital	Digital I/Q	
COR	Switch off delay adjustable from 0 to 9 s	
Frequency reference	10 MHz	

ELECTRICAL INTERFACES

ETHERNET LAN
Option: IEEE 488 for optional equipment control
Option: Actuators and environment sensors
Option: WAN through router (X25, ISDN, PSTN, INTERNET, VSAT…)

## DIRECTION FINDING SPECIFICATIONS
According to:
Recommendations ITU-R SM.854,SM1053, SM1269, SM1598
Class A : compliant with chap. 4.7. of ITU-R SMH, ed. 2002
Mobile : compliant with chap. 2.4.2. and 3.2.4.1 of ITU-R SMH, ed. 2002

Performance	HF (fixed) (8 ANT 186 network)	HF (mobile) (ANT 187)
Frequency range	0.3 - 30 MHz	1.5 - 30 MHz
Polarization	All polarization (V, H, Circ, Ellip.) Ground and ionospheric wave	Vertical Ground wave
Azimuth accuracy*	1 ° RMS for f > 1 MHz	2° RMS for f > 2.5 MHz
Direction Finding technology	2 channel correlative interferometry	Watson Watt
Sensitivity	0.5 μV/m to 2 μV/m	10 μV/m to 30 μV/m
DF interception scanning speed	Frequency scanning mode : 30 MHz/s Memory scanning mode : 300 channels /s	
FFT Resolution	2 switchable filters: 20 KHz filter - resolution: 75 Hz, 150 Hz, 300 Hz, 600 Hz, 300 KHz filter - resolution: 600 Hz, 1200 Hz, 2400 Hz, 4800 Hz	
Direction finding modulation	All modulations	
Minimum direction finding time	3 ms	

Performance	VHF / UHF (fixed) (ANT 194-A)	VHF / UHF (mobile) (ANT 184-A)
Frequency range	20 - 3000 MHz	20 - 3000 MHz
Polarization	Vertical	Vertical
Azimuth accuracy*	1° RMS	2° RMS
Direction Finding technology	2 channel correlative interferometry	2 channel correlative interferometry
Sensitivity	20-500 MHz : 3 to 0.5 μV/m 500-2000 MHz : 3 to 9 μV/m 2000-3000 MHz: 10 to 20 μV/m	20-500 MHz: 20 to 1 μV/m 500-2000 MHz: 3 to 9 μV/m 2000-3000 MHz: 10 to 20 μV/m
DF interception scanning speed	Frequency scanning mode: 150 MHz/s Memory scanning mode: 500 channels /s	
FFT resolution	Instantaneous band: 300 KHz Resolution: 0.6 KHz, 1.2 KHz, 5 KHz, 10 KHz, 20 KHz	
Direction finding modulation	All modulations, including TDMA and CDMA (with LG118 option)	
Minimum direction finding time	2 ms, down to 500 μs for GSM bursts (option)	

* Measured on THALES terrain test facilities under the conditions described by the ITU-R SM 1269 and ITU-R SMH, ed. 2002, section 4.7 for class A direction finder. For mobile applications, discrepancies introduced by the vehicle are compensated, thanks to calibration.

LOCATION PERFORMANCE

By Triangulation (all configurations, with LG112 software)	According to chap. 4.7.5 of ITU-R SMH, ed. 2002 and ITU-R P1239 and P1240 5% of the distance (typical)
By Single Station Location (SSL) in HF (With antenna ANT 186network and LG111 software)	According to chap. 4.7.5.4 of ITU-R SMH, ed. 2002 15 % of the distance (up to 1200 Km) Practical experience: 10% (statistical average)

ENVIRONMENT CHARACTERISTICS
According to :
Chap. 3.3, table 3.2 of ITU-R SMH, Ed. 2002

Environmental withstand capacity	Storage: In operation: - 40°C / + 70°C (outdoor equipment) - 40°C / + 70°C - 10°C / + 55°C (indoor equipment) - 10°C / + 40°C (Industrial PC)
Relative humidity	95% to 40°C non condensing
Mechanical withstand capacity	IEC 68-2-6
EMC protection	IEC 6100-4-2, IEC 6100-4-3, CISPR II group 1 Class B IEC 6100-4-4
Lighting protection	Including antennas and cables
MTBF (without PC)	12000 to 20000 hours depending on configuration

PHYSICAL CHARACTERISTICS

SUB-ASSEMBLIES	FIXED APPLICATION		MOBILE APPLICATION	
HF antenna (direction finding)	ANT186 Weight: 22 kg	Diameter: 2600 mm (unfolded), 500 mm (folded) Height: 2000 mm (unfolded), 1800 mm (folded)	ANT187 Weight: 10 kg	Base: 440 mm x 440 mm Height: 45 mm (470 with monopole)
VHF/UHF antenna (direction finding)	ANT194-A Weight: 140 kg	Diameter: < 3000 mm Height: < 5100 mm	ANT184-A Weight: 15 kg	Diameter: 1100 mm Height: 400 mm
HF DF antenna switch	AEA173:	Weight: < 10 kg	Dimensions: 88.1 x 483 x 520 mm (2U/19'')	
VHF/UHF DF antenna switch	AEA192:	Weight: < 10 kg	Diameter: 400 mm Height: 150 mm	
Receiver unit (HF or VHF/UHF or HF/VHF/UHF)	REC108:	Weight: 15 kg	Dimensions: 132.5 x 483 x 468 mm (3U/19'')	
Processing Unit (HF or VHF/UHF or HF/VHF/UHF)	Example for industrial computer mounted in 19" rack :		Weight: 15.5 kg Dimensions: 177 x 483 x 410 mm (4U/19'')	
Power supply for antennas	Designed for installation at rear of cabinet			
Resistance to wind	120 to 200 Km/h			
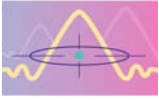
THALES

ESMERALDA : TECHNICAL SPECIFICATIONS

ESMERALDA is compliant with Recommendation ITU-R SM 1537 as well as the
ITU-R Spectrum Monitoring Handbook, Edition 2002

ITU-R MEASUREMENTS (Option PRU 109 and LG309) (ITU1) to (ITU7)
According to Recommendations ITU-R SM 1050 , SM 1370, SM 1537
According to chap. 4 of ITU-R, SMH, ed. 2002

Nominal duration for automatic ITU-R measurements (ITU1) + (ITU2) + (ITU3) + (ITU4) + DF	From 200 ms to 1 second in VHF and UHF depending on bandwidth From 200 ms to 4 s in HF depending on bandwidth
Programmable acquisition time for ITU-R measurements	(ITU1) + (ITU2) + (ITU3) + (ITU4): 200 ms to 60 s
Automatic repetition of measurements and spectrum	Programmable from 1 to 1000 recurrences or continuous
Integration of measurements and spectrum (linear, rms, max. detection)	Programmable from 1 to 1000 recurrences or continuous

AUTOMATIC MEASUREMENT OF CARRIER FREQUENCY (ITU1)
According to Recommendations ITU-R SM 377
According to chap. 4.2 of ITU-R, SMH, ed. 2002 IFM or FFT (2048)

Resolution	0.01 Hz
Measurement bandwidth	Up to 300 KHz
Precision on CW signal with 200 ms duration	≤ ±1 Hz ± (frequency received) x Master oscillator precision or ≤ ±1 Hz, with rubidium or GPS-locked frequency standard or ≤ ±0.5 Hz for filters ≤ 1 KHz
Precision on A3E signal with 200 ms duration	≤ ±1.5 Hz ± (frequency received) x Master oscillator precision or ≤ ±1.5 Hz with rubidium or GPS-locked frequency standard
Precision on F3E signal with 200 ms duration	≤ ±2 x Hz Δf/fm ± (frequency received) x Master oscillator precision or ≤ ±2 Hz Δf/fm with rubidium or GPS-locked frequency standard

AUTOMATIC MEASUREMENT OF FIELD INTENSITY AND LEVEL (ITU2)
According to Recommendations ITU-R SM 326, SM 378
According to chap. 4.3 of ITU-R, SMH, ed. 2002

Resolution (level; field)	0.1 dBm ; 0.1 dBμV/m
Measurement bandwidth	Up to 300 KHz + 9 KHz CISPR filter, 120 KHz CISPR filter
Detection method	Peak value, near-peak, rms, linear average, log average
Absolute precision of level in CW mode (calibrated)	±0.5 dB typical ≤ ±1 dB below 30 MHz, ≤ ± 1.5 dB above 30 MHz
CW level fidelity	≤ ±0.5 dB
Field strength accuracy	±2 dB below 30 MHz, ±3 dB above 30 MHz

Antennas have to be installed in a clear environment to hold the absolute accuracy of field measurement. Otherwise, measurements will have a statistic or relative value

AUTOMATIC SPECTRUM OCCUPATION MEASUREMENT (ITU3)
According to Recommendations ITU-R, SM 182, SM 1045, SM 1356
According to chap. 4.4 of ITU-R, SMH, ed. 2002

Resolution	< 1 Hz with FFT or 300 Hz in memory scanning mode
Speed (continuous frequency)	300 MHz/s with simultaneous level estimation
Speed (memory scanning mode)	1000 independent channels per second with simultaneous level estimation

AUTOMATIC MEASUREMENT OF BANDWIDTH (ITU4)
(β % method and -x dB method (2 values x1 and x2))
According to Recommendations ITU-R SM.328, SM 443, SM 853, SM 1138, RR 1.153 (Geneva 03)
According to chap. 4.5 of ITU-R, SMH, ed. 2002

β % method Programmable β ratio Bandwidth Resolution Measurement bandwidth Accuracy	 1% to 99% (1% nominal) 0 to 300 KHz 0.1 Hz All digital filters up to 300 KHz ≤ 1 % of bandwidth for IF filters > 1 KHz ≤ 2 % of bandwidth for IF filters ≤ 1 KHz
-x dB method Programmable x1, x2 thresholds Bandwidth Resolution Measurement bandwidth Accuracy	 2 x values simultaneously selected between 0 and 50 dB (increments of 1 dB) 0 to 300 KHz 0.1 Hz All digital filters up to 300 KHz ≤ 1 % of bandwidth for IF filters > 1 KHz ≤ 2 % of bandwidth for IF filters ≤ 1 KHz

VISUAL ANALYSIS OF SPECTRUM (ITU7)
According to ITU-R SMH, ed. 2002, Chap. 3.5.4, 4.2.3, 4.4, 4.5, 4.9

Panoramic mode and spectrogram	See Reception Specifications
FFT mode Spectrum capture range	 300 Hz to 300 KHz (VHF / UHF); 100 Hz to 300 KHz (HF)
Spectral resolution	14 mHz to 4700 Hz (depending on filter and selected resolution)
Level resolution	0.1 dBm
Windowing	Blackman-Harris, rectangular, Flat-top, Hanning
Method	FFT, 128 to 16384 lines, basic capture or refresh
Dynamic range	90 dB with Blackman-Harris windowing
Relative read of spectral lines	≤ ±0.5 dB with Blackman-Harris windowing ≤ ±0.2 dB with Flat-top windowing

AUTOMATIC MODULATION MEASUREMENT (ITU5)
(Modulation depth, frequency deviation, phase deviation)
According to Recommendations ITU-R SM 1268-1 (appendix 2), SM 328, BS 412-6
According to chap. 4.6 of ITU-R, SMH, ed. 2002

Selectable video filters for modulation measurements	High-pass filter 10 Hz or 300 Hz Low-pass filter 4 KHz or 15 KHz or none
Modulation depth measurements (AM) Range Resolution Measurement bandwidth Modulation frequency Measurement functions Accuracy	 1% to 99.9% 0.1 % All digital filters up to 300 KHz 10 Hz to 100 KHz Positive peak, negative peak, rms x γ γ = √ 2 nominal, programmable from 1 to 10) ≤ 1% depending on modulation frequency (input voltage ≥ 3 mV) ≤ 5% for m = 30 to 99.9 %, S/N ≥ 40 dB, AF of 10 Hz to 120 Hz ≤ 0.1% for 1 KHz modulation and frequency excursion of 50 KHz
Frequency excursion measurement (FM) Range Resolution Measurement bandwidth Modulation frequency Measurement functions Accuracy	 0 to 150 KHz 0.1 Hz All digital filters up to 300 KHz 10 Hz to 100 KHz Positive peak, negative peak, rms x γ γ = √ 2 nominal, programmable from 1 to 10) 0.5 to 2% depending on modulation frequency (input voltage ≥ 3 mV) ≤ 1 % of IF filter, S/N ≥ 40 dB, AF of 10 Hz to 100 KHz
Phase excursion measurement (φ M)) Range Resolution Measurement bandwidth Modulation frequency Measurement functions Accuracy	 0 to 10 rad 0.01 rad All digital filters up to 300 KHz 10 Hz to 100 KHz Positive peak, negative peak, rms x γ γ = √ 2 nominal, programmable from 1 to 10) ≤ 2% depending on modulation frequency (input voltage ≥ 3 mV) ≤ 0.1 rad + 5%, S/N ≥ 40 dB, AF of 10 Hz to 5 KHz, Δφ of 0 to 8 rad

IDENTIFICATION (DECODING) SPECIFICATIONS (ITU6)
According to Recommendation ITU-R SM.1052
According to chap. 4.8, ITU-R, SMH, ed. 2002

Demodulation	Measurements	Coding methods (basic version)				Alphabets
OOK BPSK FSK 2 to 34 QPSK	Modulation speed Central frequency Shift (for FSK) Transmission bandwidth	RTTY-5 RTTY-7 Morse AZA	TOR 1 TOR 2 TOR 4 TOR ARQ	FEC 100 ARQ 1A Coquelet 8 Coquelet 12	Piccolo 32, Piccolo 34,	Morse CCITT2, 3, 5 Coquelet, Piccolo, Spector

IDENTIFICATION BY DECODING OF SELECTIVE CALL SIGNALS	
According to	5-tone signaling system (CCIR, EEA, EIA, ZVEI1, ZVEI2, TR20-01…) DTMF 2-tone signaling system (standard) CTCSS (sub-audio tones) CDCSS (EIA603) User customized codes

SIGNAL VECTOR ANALYSIS 300 KHz, 2 MHz or 20 MHz Bandwidth
(LG118 software option)
According to Recommendation ITU-R SM 1600
According to Section. 4.9, ITU-R SMH, ed. 2002

Signal bandwidth	Acquisition of 300 KHz, 2 MHz or 20 MHz signals with LG 309 software
Demodulation	Double modulation: FM-FSK, FM-PSK, AM-FSK, AM-PSK OOK, FSK 2-34 filtered or not, PSK 2/4/8 filtered or not	QAM 8, QAM 16, QAM 32, OQPSK or SQPSK Pi/2 DBPSK, Pi/4 DQPSK, any CPM (including MSK, GMSK…)
Protocol Techniques	FDMA, TDMA, CDMA, OFDM
Protocol Characterisation	TDMA
Predefined systems	GSM, DECT, TETRA, D-AMPS (IS54, IS136)
Filtering	Cosine (Nyquist), 0.5 Nyquist, √Nyquist, Gaussian, 0.5 gaussian, 0.3 gaussian, Rectangular, Non-filtered, Passband, band rejection
Parameter measurement	Carrier and sub-carrier frequencies Modulation rate / rhythm, modulation rate for amplitude Frequency excursion	Shift on FSK2-34 modulation CPM modulation index ITU measurement on narrow band signals
Displays	I/Q, amplitude demodulation, frequency demodulation, phase demodulation as a function of time Pattern in raw polar coordinates with recovery of carrier and rhythm, constellation, spectrum analysis, Log. Lin, markers	Instantaneous spectrum, average spectrum, spectrogram, water fall Eye-pattern on amplitude, frequency, phase demodulated signal, I/Q Histogram of amplitude frequencies and instantaneous phases Phase pattern, autocorrelation, correlation with sampling of pre-recorded signal

OTHER OPTIONS

Integrated Spectrum Analyser	Absolute value marker (Frequency Fa, level La) with automatic tuning of receiver on marker frequency Relative value marker
Wide Band Spectrum Analyser	20 MHz instantaneous bandwidth acquisition coupled with Integrated spectrum analyser
Cellular Network Signal Analyser	TDMA, CDMA, OFDM On-line, coupled with a network trace mobile Off-line in-depth signal and interference analysis