MARIE
WIDEBAND ANALYZER FOR HF/VHF/UHF/SHF
RECONNAISSANCE

MARIE is a scalable signal analyzer for HF, VHF, UHF, and SHF. It comprises an intercept system consisting of antenna, tuner and pre-processing unit for wideband monitoring, extraction of narrowband signals for production and analysis, a processing and storage unit, and workplaces, at which the operators monitor the system and analysts analyse the signals.

MARIE is widely expandable about many functions that are implemented as ready-to-use Saab Medav Technologies products. The following figure gives an overview:

Therefore, MARIE is the basic platform for all the other Saab Medav Technologies products and is an excellent basis or entry point for reconnaissance with Saab Medav Technologies products.

Once introduced, you may easily close all the gaps that occur during operation by functions of other Saab Medav Technologies products without the need to replace your system – just by adding and enhancing.
OVERVIEW OF MARIE

MARIE uses ComCat tuners and enables online monitoring of a 16 MHz wideband signal (optional 24 MHz) in the frequency range between 100 kHz (opt. 9 kHz) and 3 GHz (optional 18 GHz). Wideband recording of an 8 MHz band (optionally 16 MHz) is possible. Comprehensive signal analysis and processing is supported.

MARIE offers server-supported wideband recording and data storage. The stored data are analysed by different offline functions. MARIE is implemented as a client-server system, so that the number of workstations is flexible and it is simple to add additional analysis stations later.

Special features of MARIE are:

- Online wideband monitoring of a 16 MHz band (opt. 24 MHz) for HF/VHF/UHF/SHF with a display of the spectrum and spectrogram (panorama display)
- Fixed setting of the 16 MHz band (opt. 24 MHz) and scan operation over the complete HF/VHF/UHF/SHF range
- Energy triggered or manual triggered wideband recording of an 8 MHz band (optional 16 MHz) in the HF/VHF/UHF/SHF range on the hard disk server, whereby the recording band lies within the monitoring band
- Production of up to 2 narrowband signals
- Energy triggered or manual triggered narrowband recording of complex and demodulated data
- ComCat tuner for two antennas with internal channel switch-over and raw data processing
- Innovative client-server architecture for network-oriented analysis workstations
- Offline-analysis of wideband signals
- Automatic and interactive demodulation and decoding
- Use of standard modules for acquisition (CCI-Online), recording (ReProS) and offline analysis (CCI-Offline)
- Simple system extension for analysis through plug-ins, e.g. OC-6040 signal analysis software
- Example antenna configuration: Active monopole-antenna for extended HF-band (0.1-50 MHz) and standard-discone-antenna-S13036/201- for VHF/UHF-bands (30-3000 MHz). Other configurations on request.
- Robust device design of the acquisition equipment: standard PCs or ruggedized notebooks, standard network components

MARIE is successfully established in the market.
MARIE – WIDEBAND ANALYZER FOR HF/VHF/UHF/SHF

MARIE

MODULAR CONFIGURATION FROM STANDARD COMPONENTS

The ComCat tuner acquires the antenna signals. Thereby, depending upon the parameter settings of the tuner, internal antenna switching is done automatically, in order to monitor the frequency range set in the HF/VHF/UHF/SHF band. The tuner calculates the short-time spectrum for a freely selectable 16 MHz interval (opt. 24 MHz) for online display and analysis in CCI-Online. The ComCat tuner delivers the complex basic wideband signal of a 4 MHz wide signal on a second output channel to record the data on the ReProS server, which calculates the navigation data.

CCI-Online and CCI-Offline are client programs and need one PC each for simultaneous operation. Their functions are:

- **CCI-Online**: signal acquisition, live signal replay, monitoring, wideband recording, listen-in, classification, production
- **CCI-Offline**: loading wideband recordings, navigation in signals, segmentation, running analysis and processing plug-ins

Tuner, server and client workstations are connected over LAN. CCI-Online and CCI-Offline are usually independent workstations. The number of workstations is scalable.
FUNCTIONALITY

All functionality of the MARIE system is displayed in the left.

The ComCat tuner receives the antenna signal and outputs the wideband signal to recording server ReProS and to the online client on which CCI-Online is running.

CCI-Online

The incoming wideband signal is online displayed to the user in panorama displays for monitoring and facilitating focussing on signal segments of interest. If desired, wideband signal recording can be initiated, and again, the wideband signal is stored on the recording server for later replay.

The operator can select a narrowband signal of interest and set up the analogue demodulator, so that he can listen to the signal. He can pass digital narrowband signals to automatic classification which detects all technical signal parameters for demodulation and decoding (=production).

CCI-Offline

With CCI-Offline, the operator has access to the wideband signals stored on the recording server by the ComCat tuner or by the wideband recording function of CCI-Online.

The CCI-Offline operator can navigate within the signal and select parts of it, that are of high interest or relevance. The selected parts are signal segments, mostly single narrowband signals or a frequency section with few adjacent signals, frequency-agile or multichannel signals. These segments can now be passed to detailed analysis.

The analysis is done by CCI-Offline plug-ins, i.e. program parts that are called from CCI-Offline, do their analysis jobs and return the results to CCI-Offline where they are stored and managed. The plug-ins are independently of each other and allow a large degree of flexibility.
WORKSTATIONS

Two workstations are suitable for stationary applications to use the offline and online functions simultaneously. Alternatively, the user can select online or offline mode.

While one workstation PC is used for online monitoring and analysis, the second is used for navigating in the wideband signal and offline analysis.

For better overview, it is recommended to equip the workstation PCs with two TFT-displays: one to visualise signals and results, the other to set plug-ins parameters.

Speakers are needed to listen to audio output of the signals.

Exemplary workstation configuration for stationary application comprising PC, two TFT-displays and speakers.

For mobile applications, e.g. for operation in vehicles, use of ruggedized notebooks or shuttle PCs for online and offline analysis are recommended.
ONLINE ACQUISITION, RECORDING & ANALYSIS IN MARIE WITH CCI-ONLINE

CCI-Online is a software solution in the Saab Medav Technologies’ proprietary ComCat system concept, implemented by using “Virtual Devices”. CCI-Online supports wideband and narrowband signal acquisition and the visualisation of short-time spectra and spectrograms (panorama-displays).

CCI-Online is the operating panel for the ComCat tuner and setting of recording parameters. The narrowband analysis for analogue signals including demodulation, software-driven message extraction as well as the audio output of the demodulated signal are essential processing options of CCI-Online. The performance scope of CCI-Online can be extended extensively through additional virtual devices and plug-ins.

The online displays of the short-time spectrum as well as the spectrogram (panorama display) provide an insight in the signal. The frequency range for the recording is determined with cursors or through keyboard input.

The parameter setting of the tuner and of the recording is done in the corresponding panels.

The user can select two narrowband signals and place them on a channel, which he or she can then produce automatically or analyse in detail.

Analogue signals can be demodulated on the fly and be listened to over audio output. The analogue modulation methods AM, AM_LSB, AM_USB, CW, FM, SSB_LSB, SSB_USB and WideFM are supported.

Automatic and manual signal analysis and production of two channels are possible. Narrowband signals can be stored either individually or parallel in the IF band or AF band.

Different control parameters can be selected for gain control (AGC, MGC).

Parameter panel for demodulation, analogue signals, storage and audio output
Wideband and narrowband signals can be recorded, either manually triggered or triggered by transmission energy. Wideband recordings are stored on the ReProS wideband signal server, narrowband signals are stored to file in complex or real format.

Figure 1: A cursor sets the recording center frequency, the recording bandwidth is indicated in the graphical display.

In the recording band, the user makes use of the graphical zoom functions of CCI-Online, in order to make signal details visible.

The recording range can be set by graphical tools (see figure 1, the recording range is shown in gray) by mouse click.

Centre frequency and bandwidth can alternatively be entered via the keyboard. The same function also exists for the analogue demodulator. Signal amplitudes and field strengths can be measured with cursors.

The entire HF-frequency range of 100 kHz to 3 GHz with the full bandwidth of 16 MHz (opt. 24 MHz) can optionally be scanned. The frequency range and the step width are specified. For each step, a short-time spectrum is calculated and placed adjacent one to another. The graphical zoom function can change the scan parameter, so that only data are acquired and processed that are visible to the user.

To document and reproduce the results, program session information can be stored in setups.

The ComCat tuner operates its internal antenna switch automatically.

Digital narrowband signals can be analysed and automatically be produced (demodulated and if possible decoded). The technical parameters of the signals are stored and help in automatic identification and production of future signals.

Setups store and recall the current program condition allowing to document the results.

To document the results, the results are stored in messages. Both, wideband and narrowband signals can be stored on the ReProS signal server.
OFFLINE ANALYSIS IN MARIE
USES CCI-OFFLINE

CCI-Offline is a software solution in the Saab Medav Technologies’ proprietary ComCat system concept. CCI-Offline supports the user in navigation in the recorded wideband data, signal segmentation and analysis.

With CCI-Offline, the operator views and navigates within the wideband signal. Emissions are easily visible by the spectrogram visualisation (waterfall diagram). Just as easy as with any other graphics editing program, portions of the wideband signal containing emissions can be selected. These segments can be extracted and be treated as narrowband signals.

Tools for narrowband signal analysis and the interactive transmission type analysis have special significance. A set of plug-ins help the analysts to interactively determine the desired signal details or contents. Further plug-ins are available for special tasks or modulation types.

Today, the following CCI-Offline plug-ins are available for narrowband signal processing and analysis:

- Audio: to make the narrowband signal audible to the analysts. Functions to navigate within the signal are available and a recording function allows to store the signal segment as audio file.
- File Export: to quickly export the segment to file (IF file format)
- Integrated Classification: to determine all important signal parameters (Burst, Transmission Mode, Speech Detection, Spectral Waveform, FSK Detection, Modulation Type)
- Hopper Detection: to transform a hopper signal to a common narrowband signal for further processing (“dehopping”)
- Direction Visualization: to display direction information of a narrowband signal
- Emitter Detection/Transmission Detection: to detect emitters/transmission in a signal segment.
- OC-6040: Detailed signal analysis and measurements in signals in order to determine the signal parameters as exact as possible

Production: to demodulate and decode the narrowband signal in order to make its contents accessible.
WORKING WITH CCI-OFFLINE

The wideband signal to be analyzed is to be stored on the recording server ReProS by CCI-Online.

In the course of this, ReProS calculates navigation data (signal portions in time and frequency domains and in lower resolution) for each stored signal that allows very quick access to and visualization of the signal. This method of advance calculation of the navigation data results in far less data to be transferred when users access parts of the signal by the graphical viewers.

The analyst may view the wideband signal in the spectrogram viewer in order to select parts of it (segments) for detailed analysis by them in the display as shown in the left upper screenshot.

The analyst can then extract the segments to file. Thereby, meta data are automatically assigned to the signal data, for instance, time-stamp and signal duration, and can be completed by the analyst.

Deeper analysis can then be based on these extracted narrowband signal files which also be saved on the ReProS server, along with their meta data.
The analyst can retrieve files on the base of meta data in order to visualise and analyse the signals in CCI-Offline.

Here too, the signal segments can be highlighted, stored, and are ready for further analysis.

The figure on the left shows a signal with a relevant signal portion, which can be studied in more detail.

Below the list of files on the server is visible.

The figure on the left shows the panorama-display of the above example.

But now a signal segment is marked by a red rectangle and can be transferred e.g. to the analyzer OC-6040. Below the signal display, now the data of the segment are shown.

In OC-6040, the averaged short-time spectrum and the spectrogram of this signal segment are shown (see third screenshot on the left).

OC-6040 is a versatile analyzer, with the following functions (partly options):

- Interactive modulation type analysis
- Automated modulation type classification
- Demodulation & decoding of digital signals
- Bit-stream analysis
- Signal generator
- OFDM signals (recognition, demodulation, generation)
- Special modems
- Speech signal recognition
- Speech signal enhancement
OC-6040: OFFLINE ANALYSIS, CLASSIFICATION, DEMODULATION

MARIE provides numerous plug-ins with methods for offline analysis of wideband and narrowband signals. One of them is the optional signal analysis software OC-6040, which is briefly introduced here. For more detailed information on OC-6040, request the Saab Medav Technologies OC-6040 information brochure.

In addition to the spectrum and spectrogram, various properties of narrowband signals, which are important for the analysis of digitally modulated signals, can be displayed:

- Instantaneous magnitude
- Instantaneous frequency
- Instantaneous phase
- Constellation diagram (eye diagram)

The analysis and the display of the instantaneous values over time is a proven method for exact determination of carrier frequency and modulation rate.

The analyses granularity can be so fine, that even the information on the level of a fingerprint can be derived.

Useful displays when determining the modulation types of narrowband signals

HOPPER DETECTION AND DEHOPPING

MARIE optionally also supports the recognition of narrowband signals of frequency-agile transmitters (frequency hoppers). The signals, the parts of which can be distributed over some hundred kHz in the HF-Band, are recognized.

The plug-in is based on Saab Medav Technologies’ proven VD technology.

The hops are recognised automatically and the signal is reconstructed by concatenating the hops in their order on one carrier frequency. The result is a continuous narrowband signal which can be further processed and analysed.

Hopper signals are recognised automatically according to the search guidelines and marked. The list of hits can be extended or modified manually e.g. by mouse.
COMCAT-TUNER

The ComCat tuner is suitable to be used for HF/VHF/UHF/SHF. It is characterized by a gap-less real-time capability, large signal dynamics and internal signal processing possibilities. The ComCat tuner is a Saab Medav Technologies standard product, which can be used for the HF range up to 3 GHz.

The high computing power of the ComCat tuner allows data preprocessing, other than common wideband tuners with digital down converter. The ComCat tuner is configured and parameterized via software.

The tuner incorporates two input and four output channels. The operator can connect two antennas in parallel. An internal switching unit selects the necessary antenna signal. For each output channel the desired signal type can be selected:
- CBB: complex base band (IF-wideband signal)
- CFFT: complex FFT
- PSD: power spectral density

The “Sync”-signal is needed to synchronise tuners, e.g. in direction finding applications.

The antenna configuration in MARIE requires HF antenna at the input 1 and the V/UHF antenna at input 2. Other configurations can be supported.

RECORDING SERVER REPROS

The recording server ReProS is a standard module of the ComCat system. ReProS records the IF wideband signals and computes and stores navigation data. A desired signal section in the wideband signal can be located quickly via CCI-Offline and be marked for analysis. ReProS requires the use of the ComCat tuner (other tuners upon request).

ReProS can handle large data quantities for online acquisition and for the offline analysis clients.

The available memory capacities can be implemented according to customer requirements. The storage is done on High Speed RAID (Redundant Array of Independent Discs) hard disks.

INTEGRATING OWN SOFTWARE MODULES

Third party demodulators and decoders can be incorporated via the VD (Virtual Device) interface. The new VDs are operated and parameterised in the same panels as the other VDs and thus fit perfectly into the concept: the entire system appears homogeneous despite individual software.

A detailed interface specification for DCE (Digital Content Extraction) is available upon request.
ANTENNAS
SAMPLE CONFIGURATION

Technically, MARIE does not require specific antennas, just interface requirements for the ComCat tuner need to be considered. Two antenna inputs are available at the ComCat tuner. An internal switch in the tuner supports the automatic signal acquisition over the frequency range of the individual antennas. Two antennas are listed below, which can be used for HF/VHF/UHF/SHF ranges.

HF-Active Monopole-Antenna A0029

**Electrical characteristics:**
- Frequency Range: 100 kHz – 60 MHz
- Nominal Input Impedance: 50 Ω
- VSWR: < 2.0 : 1
- Connector: BNC female
- Feed power handling: Monitoring
- Elevation 3dB beamwidth: 177° (+/- 5°)
- Azimuth 3dB beamwidth: 360° (+/- 5°)

**Power Supply:**
- 12-30 V DC, 100mA power supply is required (Not supplied as standard). This source power is normally supplied by the relevant receiver/amplifier RF input connection.

**Mechanical characteristics:**
- Length x Base Diameter: 1500 mm x 150 mm
- Weight: 4 kg
- Mounting Method: PCD – 115 mm: 6x6 mm holes

**Environmental:**
- Temperature (operational): -30°C to +55°C (no icing)
- Wind survival: 160 km/h
- Shock: 40 G for 10ms
- Thermal Shock: -20°C to +70°C : 10 cycles
- Water Ingress rating: IP 65 (NEMA 4X)
- Lightning and ESD Protection: Yes

Wideband Discone S13036/201

**Electrical characteristics:**
- Frequency Range: 30 MHz – 3000 MHz
- Antenna Gain: approx. 0 - 5 dBi
- Polarization: vertical
- Antenna-pattern: omni-directional
- Output Impedance: 50 Ohm
- VSWR: < 2.0 : 1 type; < 3.0 :1 max

**Mechanical characteristics:**
- HF – Connector: N socket
- Dimensions:
  - sloping radials: 1143 mm
  - horizontal radials: 491 mm
- Weight: approx. 18 kg

**Environmental requirements:**
- Temperature range: -20°C to +55°C (operation)
- Max. wind strength: 108 km/h
**MARIE – TECHNICAL DATA**

*(EXCERPT, PARTLY OPTIONALLY)*

- **Signal capturing (by means of ComCat-Tuner)**
  - Channels: 1
  - ADC: 120 M samples / sec
  - Dynamic range: 90 dB (SFDR)
  - Gain Control: Automatic / manual
  - Impedance: 50 Ω
  - Plug: N-type - female

- **Spectral analysis (CCI-Online)**
  - Frequency range: 100 kHz - 3 GHz (18 GHz optional)
  - Frequency zoom
  - Analysis bandwidth: 16 MHz (24 MHz optional)
  - Frequency resolution: 0.15 kHz @ 0.5 MHz
  - 4.8 kHz @ 16 MHz, (7.3 kHz @ 24 MHz optional)
  - Adjustable centre frequency
  - Display types: Colour spectrogram, spectrum
  - Averaging: Smoothing function
  - Operating modes: online

- **Audio monitoring (listening)**
  - Demodulation: AM/USB/LSB/FM/CW with selectable BFO
  - Transmitter selection: per mouse click, marker, input
  - Volume: manual, AGC

- **Signal recording and -archiving (ReProS)**
  - Mode: online parallel
  - Stored signals: from one antenna
  - Bandwidth: 4 MHz (CBB)
  - Memory capacity (ReProS):
    - 1 TByte (max 400 minutes @ 4 MHz on HD-array)
    - Long-term archiving: 10 min @ 4 MHz on Blu Ray Disc

- **Spectral analysis (CCI-Offline)**
  - Frequency range: 100 kHz – 18 GHz
  - Navigation: in the time and frequency window
  - Interactive segmentation
  - Plug-ins: Listening-in function, OC-6040
  - Display types: Color spectrogram
  - Mode type: offline

- **Hopper detection**
  - (Plug-in CCI-Offline)
  - Frequency range: 100 kHz – 3 GHz
  - Input bandwidth of the non-linear signal: 4 MHz (8 MHz optional)

- **Narrowband analysis of the modulation type**
  - Frequency range: 100 kHz – 3 GHz
  - Frequency zoom
    - Analysis bandwidth: any
    - FFT length: 64 - 2048
    - User-defined centre frequency
  - Window functions:
    - Rectangle, Hamming, Hanning, Blackmann, Taylor
  - Display types:
    - Color spectrogram / spectrum
    - Instantaneous magnitude / frequency / phase
    - Constellation diagram (phase star)
  - Calculation operations: Exponentiation (2 / 4 / 8)
  - Mode type: offline (narrowband)

- **Signal analyzer OC-6040**
  - Mode type: offline

- **Automatic signal classification**
  - Bandwidth: up to 30 kHz
  - Result output: list on screen or file
  - Mode type: offline (narrowband)

- **Demodulation of digitally modulated signals**
  - Demodulator bandwidth: max. 30 kHz
  - Demodulation: absolute, differential, CCITT
  - Number of channels: 1 - 64
  - Sum baud rate: 1 - 4800 Bd
  - Display types: Status, eye-, constellation diagram
  - Mode type: offline (narrow band)

- **Cursors for data import**
  - Number: two line cursors for each axis in the display window
  - Type: line and harmonic cursor

- **Miscellaneous**
  - Multi-channel demodulation and decoding
  - Free analysis and viewer configuration
  - Wideband panorama display
  - Open for incorporation of own developed demodulator and decoder software

- **PC requirements for the workstation PC or notebook**
  - Recommended minimum equipment: Core2Duo, 2 GB RAM, 250 GB hard disk, network card (10/100/1000 MBit Ethernet), USB 2.0, DVD-ROM, Windows or LINUX (in the VM-mode).
  - MARIE is delivered alternatively with 2 shuttle PCs and 4 TFT displays, or with one ruggedized notebook.
  - Other configurations on request.

- **Mass:** ~ 60 kg (80 kg incl. PC and display)
- **Dimension W x H x D [mm]: 534 * 348* 820**
- **Power:** ~ 540 W

- **HMI (Human-Machine-Interface)**
  - Selectable in German or English; other languages on request

- **Documentation**
  - English documentation;
    - Third party products with original documentation

- **Variants**
  - HF-, VUHF, SHF configurations