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ECOMOS Software Structure and Key Features

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ABSTRACT

ECOMOS is a multinational effort within the framework of an EDA Project Arrangement. Its aim is to provide a generally accepted and harmonized European computer model for computing nominal Target Acquisition (TA) ranges of optronic imagers operating in the Visible or thermal Infrared (IR). The project involves close co-operation of defense and security industry and public research institutes from five nations: France, Germany, Italy, The Netherlands and Sweden. ECOMOS will use and combine existing European tools, to build up a strong competitive position.

In Europe, there are two well-accepted approaches for providing TA performance data: the German TRM (Thermal Range Model) model and the Netherlands TOD (Triangle Orientation Discrimination) method. ECOMOS will include both approaches. The TRM model predicts TA performance analytically, whereas the TOD prediction model utilizes the TOD test method, imaging simulation and a Human Visual System model in order to assess device performance. For the characterization of atmosphere and environment, ECOMOS uses the French model and software MATISSE (Modélisation Avancée de la Terre pour l'Imagerie et la Simulation des Scènes et de leur Environnement).

The first software implementation of ECOMOS has been finalized in spring 2019. In this presentation, the key features implemented in the current version are elucidated. In addition, the final ECOMOS software structure as well as an overview of the user guidance within ECOMOS are shown.

Keywords: EO-System Performance, Image Based Assessment, TRM Model, TOD Method, MATISSE Tool, Thermal Imager Assessment, IR-Image Simulation

1. INTRODUCTION

The main ideas behind ECOMOS have been published two years ago [1]. At that time, there has been a lot of discussions within the ECOMOS group [2] about the functionality and gain of the ECOMOS software. The decision has been made to build ECOMOS around existing software packages (TRM, MATISSE) and to develop the missing software components (OSIS, TOD, external Plugins). Additionally, the development of a main program monitoring all the data traffic and user interactions was necessary.

TRM is a stand-alone software package that can be called from ECOMOS. Necessary exchange of data between ECOMOS and TRM takes advantage of TRM's external data file with the filename extension '.tr4'. For ECOMOS only a 'light' version of the stand-alone package MATISSE has been developed, called ECOMOS_MATISSE. All the other software components were either adapted to ECOMOS (like parts of TOD and OSIS) or completely new designed and implemented (like the external Plugins integration).

Due to the mixture of already existing and new tools, it took some time to work out an appropriate structure for the ECOMOS software. Not all features of the different tools are supported by ECOMOS, but only a subset. In the following text sections, this subset of features is described in more details. Also, some screenshots of a preliminary version of ECOMOS are shown.

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2. ECOMOS STRUCTURE

What we call the ECOMOS software is a set of computer executables and libraries for the Windows Operating System (e.g. Windows 10). ECOMOS is only supported on a 64-bit version of Windows 10. Additionally, it has been tested on the 64-bit versions of Windows 8.1 and Windows 7, but this will not be supported in the future.

The ECOMOS software consists in a mixture of 32-bit and 64-bit software modules. The older, already existing software modules have been written in FORTRAN or C computer language, while the newer ones in C++. Most modules have been developed on localized language versions of the Windows operating system and developers' tools (e.g. French, German, etc.) using different character sets (7-bit ASCII, 8-bit ANSI, etc.). The software structure of ECOMOS had to pay tribute to this diversity of software modules. In addition, setting up an ECOMOS software distribution installer was a tricky task due to this diversity.

The software might be grouped by their functionality into five components (ref. [1], Figure 1):

- TRM (camera characterization and analytical performance calculation),
- ECOMOS_MATISSE (atmosphere characterization and calculation of atmospheric features),
- TOD (a set of procedures for image-based camera performance prediction),
- OSIS (infrared image simulation tool),
- MasterGUI (the main process which controls execution order and monitors user interactions).

In this paper, the abbreviation ECOMOS is used for different things. Sometimes it describes the main software control process only - the so called MasterGUI - and sometimes the whole software collection. In addition, sometimes it is used to name the functionality of the software.

TRM uses its own GUI and its own format for the external storage of sensor data. In addition, this file might contain TRM interim results and/or final TRM results, the calculated sensor performance data. OSIS doesn't have a GUI and doesn't have specific data format for the storage of results. Within the TOD branch OSIS purpose is twofold: first, to simulate the infrared sensor images and second, to simulate the display presentation for the TOD human visual system. OSIS is called by TOD and most of time, it is running discreetly in the background.

The ECOMOS_MATISSE module and the whole TOD execution branch are surrounded by a GUI. These user interfaces are used to enter the required data for the follow-on runs, and also to display the results of completed runs to the user. The MasterGUI is designed to allow the user to select one execution path (TRM, TRM+MATISSE or TRM+TOD) and to monitor program execution along the different execution paths. In addition, the final results of a sensor simulation are collected and presented to the user as ECOMOS results. These could be either TRM results or TOD results. Both results might be presented as probability curves of solving a specific military task (e.g. object identification) over range/distance.

3. THE TRM MODEL

TRM is an analytical model assessing the device and range performance of optronic imagers. The model is based on the perception of a standard four-bar test pattern and uses the STANAG 4347 approach to calculate target acquisition ranges.

The distinctive characteristic of TRM is the usage of the AMOP (Average Modulation at Optimum Phase) for the assessment of the spatial transfer characteristics of an imager [3]. It was developed and validated [4] to characterize undersampled imagers for which no system MTF is defined. The AMOP concept can be applied to all kinds of imagers, whether under-sampled or not. Closely connect to the AMOP concept is the overall device figure of merit for thermal imagers in TRM: the MTDP (Minimum Temperature Difference Perceived). It is an evolution of the MRTD (Minimum Resolvable Temperature Difference) and can be measured and calculated for undersampled imagers as well as well-sampled imagers [3]. For imagers in other spectral ranges the MDSP (Minimum Difference Signal Perceived) replaces the MTDP. MTDP and MDSP are the starting points for range performance calculations in TRM4.

ECOMOS includes the latest version of the TRM software, TRM4.v2. A detailed description of the model and an overview over its features are presented in Reference [5].

3.1 TRM4.v2 features available for the TOD branch

In the analytical branch of ECOMOS, all features provided by the TRM4.v2 software are available to the user. For the image-based branch — using imager simulation OSIS [6] and the TOD model — the TRM4.v2 software serves to specify the imager and task. In the current ECOMOS implementation, OSIS cannot simulate all features included into the TRM4.v2 software and thus these features are not available for the performance assessment via the TOD branch. Table 1 gives an overview over the major limitations in the imager specification for the TOD branch.

Table 1: Restrictions of TRM4.v2 features for the image-based approach in the current ECOMOS implementation.

Type of feature	Available in TRM4.v2	Available for TOD branch
Imager categories	<ul style="list-style-type: none"> Thermal VIS/NIR/SWIR General 	<ul style="list-style-type: none"> Thermal
Thermal imager technology	<ul style="list-style-type: none"> 2nd generation – staring 2nd generation – scanning Uncooled 1st generation with horizontal sampling 1st generation without horizontal sampling 	<ul style="list-style-type: none"> 2nd generation – staring 2nd generation – scanning Uncooled
Imager-target scenario	<p>Imager flight path:</p> <ul style="list-style-type: none"> at constant height at constant angle <p>Target view:</p> <ul style="list-style-type: none"> front side diagonal 	<p>Imager flight path:</p> <ul style="list-style-type: none"> horizontal (constant height with an altitude of 0 m) <p>Target view:</p> <ul style="list-style-type: none"> front side
Calculated performance data	<ul style="list-style-type: none"> Field performance data Laboratory performance data (e.g. MTDP) 	<ul style="list-style-type: none"> Field performance data
Measured lab performance data as input	<ul style="list-style-type: none"> Device prefilter MTF MTDP 	-
Specification of external data for (spectral) MTFs	<ul style="list-style-type: none"> Optics MTF Detector MTF Video Signal Processing MTF Display MTF Eye MTF Stabilization error MTF Additional prefilter and postfilter MTFs 	-

3.2 Limitations of the TOD branch due to TRM4.v2

When setting up the ECOMOS structure it was decided that the imager and task are specified using the TRM4.v2 software and that the imager simulation OSIS makes heavily use of TRM4.v2 calculation results and data. The big advantages of this close connection between OSIS and TRM4.v2 are:

- The analytic and image-based branches of ECOMOS use the same input data and data that is derived from the input data (without the user having to take care). This is crucial for the comparability of the range performance assessment of both branches.
- The usage of proven TRM4.v2 user interfaces and software.

However, this approach restricts the effects that could be in principle simulated by an imager simulation. The major limitations of OSIS in the current ECOMOS implementation are:

- Noise
 - Temporal noise of the detector is temporally and spatially uncorrelated and assumed to have a Gaussian distribution with the standard deviation defined by the NETD (noise equivalent temperature difference) calculated by TRM4.v2
 - Fixed pattern noise of the detector is spatially uncorrelated and assumed to have a Gaussian distribution with the standard deviation defined by the IETD (inhomogeneity equivalent temperature difference) calculated by TRM4.v2
- Specification of additional imager MTFs
 - Apart from the optics and detector MTF, the user can specify in TRM4 various additional imager MTFs such as MTFs for digital filters or the error in the line-of-sight stabilization. However, the user can only specify one-dimensional MTFs for the horizontal and vertical direction and not a (non-separable) two-dimensional MTF.
 - For the case of digital filters, the limitation is overcome by the ADSP plugin in the imager simulation OSIS. Using the plugin, the user may specify 2D filter kernels as well as ADSP algorithms.

4. MATISSE

The atmosphere, with the presence of molecules, aerosols, clouds and hydrometeors is causing reduction of sensors performances, especially, in terms of detection, recognition and identification. In order to mitigate these effects, an exhaustive modeling of the atmospheric phenomena is needed. The main objective of the development of MATISSE software is to provide to systems developers a powerful tool to easily compute the main atmospheric parameters used in the performance's simulation for natural scenes.

MATISSE [7], [8] represents nearly twenty five years of studies and development which capitalize most of the optronic modeling done at ONERA (France) and in collaboration with research laboratories (IREENA, IRIT, LMD, LOA, Météo-France/CNRM, RDDC...). The code is mainly funded by DGA (French MoD) and is considered as a reference for atmospheric infrared propagation and natural infrared background modeling applied to systems performance evaluation. It is used by French Defense companies and research laboratories.

The latest and current version, Matisse-v3.5 is structured by three main modes:

- A line-of-sight (LOS) mode, computing the transmittance, the radiance and turbulent parameters along different types of paths, in the spectral range from UV (0.25 μm) to LWIR (14 μm).
- An imaging mode (IMG), generating radiance and transmittance images, as seen by spaceborne, airborne or shipborne sensors, including a multiscaling resolution technique (spectral band from 0.4 to 14 μm).
- A software development kit (SDK) mode which enable the user to call core radiative functions in LOS mode from external codes. This mode offers more flexibility in its use and this has been demonstrated through different recent coupling (CHORALE/MATISSE [9], LIBPIR/MATISSE [10]).

In ECOMOS, MATISSE is used to predict sensor performance by the use of its 1D line of sight mode. MATISSE must provide to TRM or TOD different outputs depending on the imager type:

- Effective transmission versus range for thermal imagers,
- Spectral transmission and path radiances versus range for VIS, NIR or SWIR imagers,

Transmission or radiances values need to be provided for all possible target acquisition ranges. In order to produce radiative terms as a function of range, MATISSE has to be called several times (as one standalone calculation corresponds to one range). Furthermore, ECOMOS is aimed at sensor designers and not atmosphere experts. As a result, it has been decided that an atmosphere module will be specifically realized for ECOMOS. This module will be based on the SDK of MATISSE-v3.5 and will be called ECOMOS_MATISSE. Predefined atmosphere will be available (see Section 4.1) and

all calculation involved for producing the radiative terms (as a function of range) will be done automatically (see Section 4.3). One advantage of this approach is that an exact same atmosphere can be used on different sensors.

4.1 Atmosphere definition

The user will be provided with predefined atmosphere set of parameters representing diversity of atmosphere conditions a sensor can encounter. This will prevent the user to get a deeper knowledge of the use of MATISSE while getting the most of it. At this point, the user just has to select in the “Atmospheric condition” tab the one he wants to use in the calculations (see Figure 1). Here are the 6 conditions available in this first version of ECOMOS:

- Clear sunny atmosphere,
- Tropical atmosphere,
- Rainy atmosphere,
- Cloudy atmosphere,
- Polluted atmosphere,
- Desertic atmosphere.

Once the atmosphere is chosen, ECOMOS_MATISSE will be using the tr4 file after the initial TRM4 run to get the other set of parameters needed to proceed with calculations. The current tr4 file will be automatically selected in the ECOMOS_MATISSE GUI from the current run. From the tr4 file, MATISSE will get:

- Sensor/Target geometry conditions,
- Initial maximum range detection,
- Sensor bandwidth,
- Background temperature.

Figure 1: ECOMOS_MATISSE GUI (left: predefined atmosphere tab; right: user defined mode)

There is another option for ECOMOS user: User defined atmosphere. In this mode, the user can specify its main parameters that will define its own atmosphere conditions. Only major parameters from MATISSE that will have strong impact on results are set here (as shown in Table 2), rest of the parameters are set with default values.

Table 2: MATISSE parameters for user defined mode.

Date/Time	Date and hour of simulation	dd/mm/yyyy & hh:mm:ss:t
Atmospheric profile	Index of vertical composition of the atmosphere for a given state (altitude, P, T, molecule concentration) in MATISSE database	AFRL 6 profiles available : Tropical, Mid-Latitude Summer, Mid-Latitude Winter, Sub-Arctic Summer, Sub-Arctic Winter, 1976 US Standard [10]
Aerosols profile (low altitude)	Index of vertical aerosols optical properties for given type in MATISSE database	Fogs and main categories: Maritime, Rural, Urban, And Tropospheric. (Winter/Summer) and Desert [11]
Clouds	Clouds type (will indicate the optical properties to use in RT calculations) in MATISSE database	Altostratus, Nimbostratus, Stratus, Cirrus, Stratocumulus, Cumulus Congestus or No Clouds
Base cloud altitude	Minimal altitude of clouds	(km)
Cloud maximum thickness	Thickness of the chosen cloud	(km)
Ground emissivity	Spectral average emissivity to be used in calculation	-
Ground Temperature	Surface temperature	(K)

4.2 Sensor – target geometry conditions

TRM can handle three different imager-target configurations shown in Figure 2:

- Case 1: Imager and target at same altitude: Horizontal line of sight
- Case 2: Imager and target at different, but constant altitudes
- Case 3: Imager and target at varying altitudes but constant angle

Figure 2: Sensor-Target geometry definition in TRM

Spectral transmission data for Cases 1 and 3 can be obtained without any major effort from ECOMOS_MATISSE. When calculating transmission data for Case 2 applications, one should observe that the viewing angles change with the imager approaching the target. Transmission data for Case 2 applications must be provided for target distances larger than the specified constant altitude value. The number of necessary transmission data depends on the altitude specified and on the inhomogeneity of the atmosphere. The Figure 3 shows as an example the distance between imager and target for different viewing angles and a target altitude of 1 km for Case 2.

Figure 3: Distance between imager and target for different viewing angles and for an imager altitude of 1 km above the target

TRM does not specify geographic location. MATISSE will use a default location consistent with the predefined atmosphere file. TRM does not specify the absolute altitude, e.g. above ground. Only relative altitudes are considered. In ECOMOS-v1.0, only case 1 is implemented. If Case 2 is specified, then altitude must be set to 0m and if Case 3 is specified then angle must be set to 0°.

4.3 Data flow

Figure 4 shows an overview of MATISSE/TRM data flow chart. The interface between MATISSE and ECOMOS is based on the TRM4 file. This file already contains all imager input parameters and, at the same time, the results from the TRM calculation. The same scheme is used for the atmosphere results i.e. the file will include a reference to the MATISSE output file path as well as all radiative results.

Figure 4: Simplified data flow chart for ECOMOS MATISSE interaction

The run sequence is as follow:

- Step 1: User chooses option TRM+ECOMOS_MATISSE from Master GUI ‘ECOMOS’
- Step 2: TRM4 opens and user specifies all sensor parameters, geometric configuration between sensor and target and a fictitious atmosphere in tab ‘Atmosphere’ with the assumption of beer’s law using a spectral average extinction coefficient near zero.
- Step 3: Initial TRM4 run and calculation of the maximum detection range for MATISSE to use in its calculation.

- Step 4: ECOMOS Master GUI generates a subset file for MATISSE gathering information from the TR4 file like sensor spectral parameters, geometry parameters
- Step 5: ECOMOS_MATISSE GUI is launched; user selects its atmosphere by either choosing a predefined file or setting its own parameters.
- Step 6: user run ECOMOS_MATISSE by clicking on ‘Calculate’ button
- Step 7: once calculation successfully done, results are displayed in GUI to the user and he can go back to TRM to change its settings or go Step 8.
- Step 8: user goes on with “Continue with TRM’ button and is notified that the current TR4 file will be overwritten with external atmospheric data.
- Step 9: user is back to TRM to calculate DRI with new atmospheric data from MATISSE and the file is ready to be used in TOD simulation as well.

4.4 ECOMOS_MATISSE calculation assumptions

Only major parameters are set through the atmosphere definition as explained in Section 4.1 by either the predefined files or the user defined mode. For the rest of parameters, MATISSE core will assume default values linked to these assumptions [11]:

- 1D atmosphere with 2 streams model for multiple scattering calculation,
- use of wideband correlated-K radiative Transfer model,
- homogenous ground characterized by average spectral emissivity and temperature,
- AFRL aerosols only with their default visibility,
- use of background stratospheric aerosol model,
- spectral integration over the specified sensor bandwidth if necessary,
- Turbulence is not taken into account in this version so it has to be neglected when specifying sensor in TRM4.

4.5 ECOMOS_MATISSE outputs

For thermal imagers, ECOMOS_MATISSE generates spectral transmission calculated at several ranges (to maximum detection range). The MasterGui then import these data into TRM as an effective transmission vs range data integrating the data over the sensor bandwidth. An example of these outputs is given Figure 5 below:

Figure 5: Effective Transmission vs range for thermal imagers calculated by ECOMOS_MATISSE

For VIS, NIR or SWIR imagers, ECOMOS_MATISSE can generate spectral transmissions and path radiances at several ranges (to maximum detection range). An example of these outputs is given Figure 6 and Figure 7 below:

Figure 6: Spectral Transmission vs range calculated by ECOMOS_MATISSE

Figure 7: Spectral path radiances vs range calculated by ECOMOS_MATISSE

A full functional workflow has been designed for TRM4 or TOD users to include MATISSE results in sensor performance evaluation. Calculation in ECOMOS_MATISSE can be completely automatized thanks to predefined atmosphere files and SDK use of MATISSE. Additionally, a new GUI is designed for ECOMOS-v1.0.

Only thermal imagers are available for both TRM4 and TOD with MATISSE coupling. VIS, NIR or SWIR imagers can be only be evaluated through TRM4 and MATISSE. Only horizontal paths are taken into account in this very first ECOMOS version. These aspects will be considered in future ECOMOS II project.

As a result, ECOMOS users can decide either to use a homogenous atmosphere characterized by a constant extinction coefficient or to use MATISSE to get benefit from the accuracy of its calculation and the possibility that this code offers to describe a more relevant atmosphere for performance prediction.

5. THE TOD BRANCH

5.1 General Description of the TOD Method

The Triangle Orientation Discrimination (TOD) methodology includes a sensor test, an analytical sensor performance model, an image-based sensor performance model that simulates the physical test, the sensor system and a standard human observer, and a TA range prediction model. The test was developed as an alternative to the standard MRTD and MTDP in order to:

- i. cope with sensors that are under-sampled, and
- ii. yield thresholds that are free from observer bias.

An essential difference is the use of non-periodic test patterns: equilateral triangles in four possible orientations representing target features to be discriminated instead of a periodic bar pattern. Another difference is the psychophysical test procedure: a bias-free forced-choice test procedure instead of a Yes/No procedure.

Basically, a human observer judges the orientation (apex Up, Down, Left or Right) of equilateral triangle test patterns of various sizes and contrasts using the sensor under test. See Figure 8 (left picture). The threshold is defined at the 75% correct contrast at a given angular size or the 75% correct angular size at a given contrast. A thorough statistical test has been implemented to convert the observer response collection into the TOD curve: a threshold curve of contrast versus reciprocal triangle angular size S^{-1} (see Figure 8, right picture). This threshold curve characterizes the quality of the imaging system. Bijl & Valetton [30] provided a detailed description of the test.

The method has been applied to many types of conventional and advanced image-forming systems. Until now the validity of the method has not been violated despite many validation studies covering the effects of target contrast, aspect angle, amount of under-sampling, motion, dynamic super resolution, local adaptive contrast enhancement, smear and combinations of these [14], [15], [16], [17], [18], [19], [13], [20]. The relationship with the US TTP metric and the underlying tactical vehicle perception dataset has been assessed in several studies [13], [20], [21], [22].

The TOD method has been implemented in UN regulation ECE-46 [23] for indirect vision in vehicles, is recommended in ITU G.1070 [24] for videophony and is a candidate for updates of STANAGs 4347-4351 [25], [26], [27], [28], [29] for the performance measurement and modeling of thermal imagers and image intensifiers.

Figure 8. Left: TOD test pattern: an equilateral triangle with one of four possible orientations: apex Up, Down, Right or Left. The observer must indicate its orientation. Right: Example TOD threshold curves for an imaging system in the center of the Field of View (FOV, continuous line) and near the edge (dashed line), plotted with $1 / \text{angular size}$ on the ordinate, and test pattern contrast on the abscissae (from [31])

5.2 Features of the method

The use of non-periodic test patterns enables a wide applicability of the method. This includes dynamic performance assessment with moving targets or moving imaging systems, and the inclusion of a variety of advanced signal-processing techniques in the imaging chain. Extensions such as the use of non-uniform or realistic scene backgrounds are possible.

The forced-choice decision task does not only eliminate bias with human observers, it also allows automated measurement using relatively simple classification models (i.e. without the necessity of a judgement threshold) mimicking the Human Visual System (HVS).

The image-based sensor performance model is a simulation of the real test, so basically it has the same features whenever the sensor and the HVS are modeled with sufficient detail and accuracy. An interesting feature is that black box signal processing can be included in the imaging chain. This will characterize the combined effect of all system parts, but also the effect of interactions between operations in different parts of the chain.

An extension to the TRM approach is that the target contrast on the display is included in the results. For this reason, additional display parameters are required as input, such as the minimum and maximum display luminance, and display gamma. Also, the contrast magnification from scene to display may be set constant for the whole set of test patterns or set individually to enhance the presentation of low contrast targets.

The TA range model is very similar to the ACQUIRE model used in TRM. A difference is the use of M_{75} (default) instead of the N_{50} Johnson criteria adopted in TRM. For the sake of simplicity, in ECOMOS we decided to use the M_{50} values (resulting in 50% instead of 75% correct DRI ranges) and to take $M_{50} = N_{50}$. It can be shown that this is the case for a sensor system that is in the transition region between a well-sampled and an under-sampled camera.

5.3 The TOD branch in ECOMOS

Running the TOD model is a simulation of the test and the sensor system. The TOD branch consists of the following elements:

- First, a TOD GUI:
 - reads the required input parameters from a TRM4 file,
 - collects the additional parameters required to calculate the test pattern contrasts on the display (see previous paragraph),
 - asks for a plugin containing signal processing software,
 - asks to perform an analytical or image-based calculation.
- Next, the analytical TOD model provides a first order estimate of the expected performance. If this was requested, the program jumps to the TOD TA range prediction model.
- If an image-based simulation was selected, then sets of images with triangle test patterns (in the best possible range of combined sizes and contrasts) are generated on the basis of the analytical predictions to do an efficient Monte Carlo simulation in the image-based calculation.
- The sensor simulation model processes the effects of the sensor on the input triangles one by one.
- If the plug-in option was selected, advanced signal processing is applied.
- The display is simulated.
- A Human Visual System (HVS) model judges the orientation of the degraded test pattern (see [32]).
- The responses are analyzed and new test pattern sets closer to the actual threshold are generated if necessary.
- This process is repeated until the thresholds' estimates are accurate enough.
- The TOD TA range prediction model is applied to provide the DRI ranges.
- The TOD branch jumps to the output GUI presenting the results.

6. OUTLOOK

ECOMOS is the first approach to extend the analytical performance assessment of thermal imagers by image-based performance assessment. The first implementation is called 'ECOMOS I' and it enables the assessment of thermal imagers. The joint work on ECOMOS will continue and the next version, called 'ECOMOS II', will include the assessment of cameras operating in the VIS, NIR and SWIR spectral bands. Additional features for the next ECOMOS version are currently reviewed by the ECOMOS group.

The diversity of ECOMOS software modules is briefly addressed in Section 2. Important technical aspects of ECOMOS software could not be freely designed, e.g. a consistent user interface. ECOMOS had to pay tribute to already existing program implementations. These implementations utilize different methods of user guidance, data flow, results presentation, error message handling, etc. There is plenty of rooms for software harmonization and system improvements. Just to mention two of them, the ECOMOS project file, and a better support of national languages. An ECOMOS project file would help a user to interrupt/save his work, and enable him to load the interrupted session at a later time, and continue with his work. A better support for the international distributions of ECOMOS software can be achieved by consistent use of the Unicode character set by the main software components. This requires rewriting and recompilation of a few software modules. There is a risk that changes to the main software modules might require changes of other software libraries and/or existing data bases.

Besides the introduction and implementation of new features, the software issues mentioned in the preceding text section will be addressed in the future releases of ECOMOS.

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