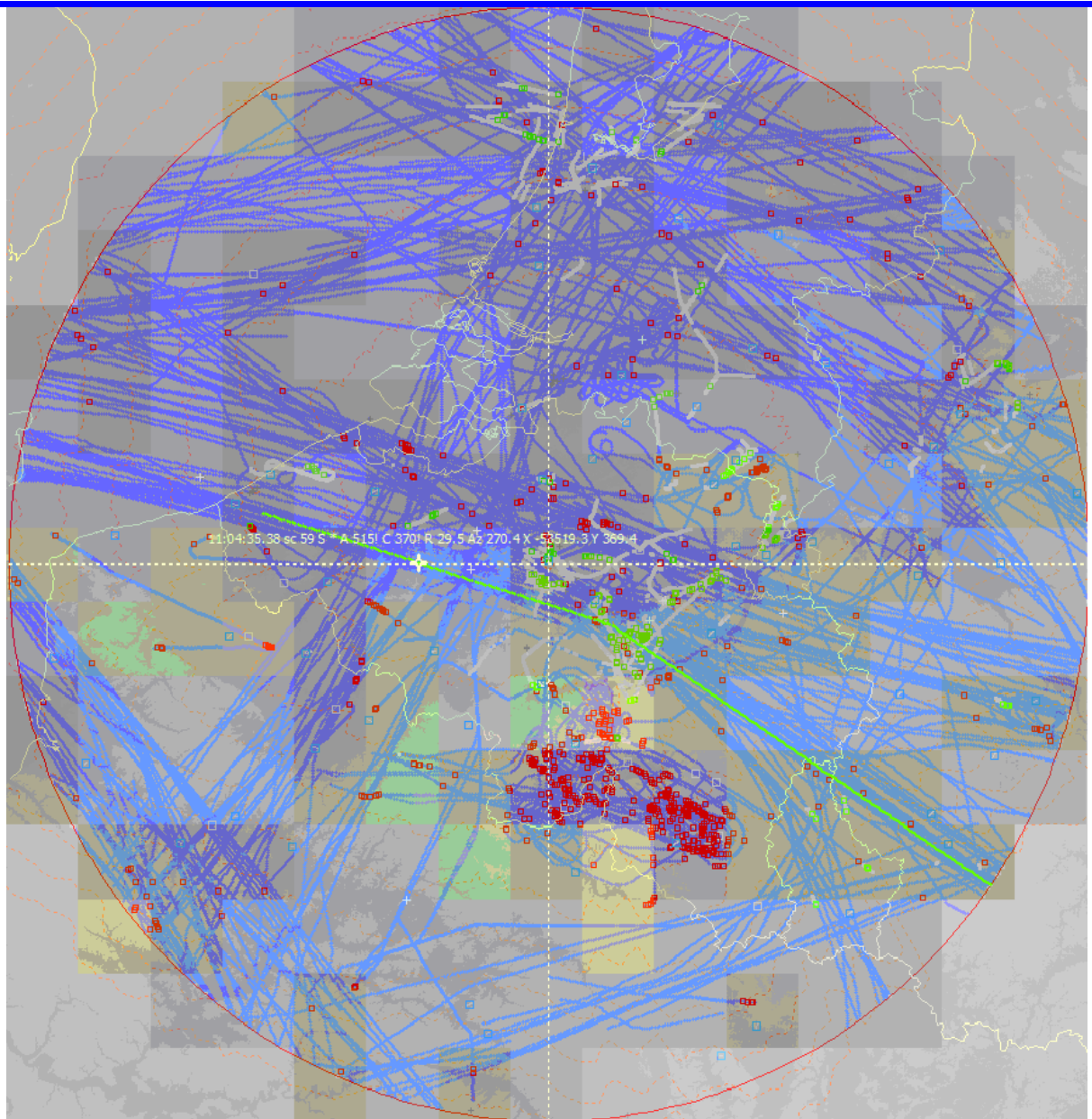


Radar Comparator Mono



User Manual

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Abstract

The Radar Comparator is radar analysis software. Using targets of opportunity data it can predict the majority of the performance parameters required by international ATC documents (ICAO and EUROCONTROL).

The Radar Comparator is available as two separate components: Radar Comparator Mono (RCM) and Radar Comparator Dual (RCD) for mono and dual source radar analysis respectively.

The RCM can be used in order to evaluate the Probability of Detection, Code Probabilities, False Plot Rate and Radar Accuracy. The RCD is generally used to measure the systematic errors. For details please refer to the RCD user manual.

Keywords

Systematic errors	Random errors	Probability of detection	Opportunity data
Barometric correction	Timestamp statistics	Trajectory analysis	Filtering
Trajectory reconstruction	Plot-to-track association	Measurement tolerance	Tabular Pd displays
Coverage volume	Screening angles		

CONTACT PERSON : Glenn Bosmans

TEL : +32 14 231811

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Author	W. Branders	25/10/17
Editors	G. Bosmans M. Martin	25/10/17

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2.2	18/04/08	Corrections	Sections
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006	29/10/09	Basic glossary of terms added; Further updates of user manual to RCM version 3.3.1; Table 6-1 is updated and a note is added; Chapter 7 Tutorial is deleted. The tutorial can be found in the separate RASS-R demo DVD user manual.	All
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009	18-Jun-13	Bookmarks added and converted to named destinations for compatibility with help-files in SEAMP 1.1.3; Updated to RCM version 4.0.0	All
010	02-Sep-13	English Language corrections; Page 4 shift to 4-5	P4-5, P19, P55, P59, P72; P4-80 shifted
011	13-Sep-13	English Language corrections	P4-5, P12, P17-19, P22-23, P35, P38-40, P45, P55, P57,

			P68, P77
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15	16-Aug-16	Updated for version 5.0.0 and RASS-R release 3.8.0	All
16	23-Aug-17	Updated saved processing files explanation on coverage bit	P30
17	25-oct-17	Update to release 3.8.1	P14

Whilst all care has been taken in preparing this document, some parts of this manual might be outdated vs. the latest software releases. Those errors or omissions are unintentional. If you do find any errors or inconsistencies, please contact support@intersoft-electronics.com and the appropriate adjustments will be made.

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CONVENTIONS USED IN THIS MANUAL

The following conventions are used in this manual:



Note: This icon to the left of bold italicized text denotes a note, which alerts you to important information.



Caution: This icon to the left of bold italicized text denotes a caution, which alerts you to the possibility of data loss or a system crash.



Warning: This icon to the left of bold italicized text denotes a warning, which alerts you to the possibility of damage to you or your equipment.

GLOSSARY OF TERMS

ACC	Air traffic Control Centre
ACP	Azimuth Change Pulse
ADS-B	Automatic Dependent Surveillance, Broadcast
ARP	Azimuth Reference Pulse
ASTERIX	All Purpose Structured EUROCONTROL Radar Information Exchange
ATC	Air Traffic Control
CAT001	Monoradar Data Target Reports, from a Radar Surveillance System to an SDPS (plots and tracks from PSRs, SSRs, MSSRs, excluding Mode S and ground surveillance)
CAT002	Monoradar Service Messages (status, North marker, sector crossing messages)
CAT034	Monoradar Service Messages, next version of CAT002
CAT048	Monoradar Data Target Reports, next version of CAT001
COTS	Commercial Off The Shelf
D6	Intersoft Electronics internal Radar data format, plot or track based.
DHM	Data Handling Module
EDR	Intersoft Electronics internal data format for record based data. Also stands for Extended Data Recorder, a device for generating and capturing serial data.
EDR V2	Second version of the EDR format.
Ethernet	A network specification developed by DEC, Intel, and Xerox which provides anywhere from 10 megabits to 1000 megabits per second transmission speeds.
GPS	Global Positioning System
IE	Intersoft Electronics
IP	Internet Protocol
LAN	Local Area Network
MB	Megabytes of memory.
Memory buffer	<i>See</i> buffer.
Monopulse	Radar-receiving processing technique used to provide a precise bearing measurement
MSSR	Monopulse Secondary Surveillance Radar
NM	Nautical Mile, unit of distance
Path	A path can be described as a file's address on your file system, describing where the file lives: An absolute path gives the complete path, starting at the root directory, or the very top of the file system; A relative path looks for a file from the directory you are currently in down.
POEMS	Pre-Operational European Mode-S
PSR	Primary Surveillance Radar
Radar	Radio Detection And Ranging
RASS-R	Radar Analysis Support Systems – Real-time measurements
RASS-S	Radar Analysis Support Systems – Site measurements
RCS	Radar Cross Section
Record	A collection of data forming a complete message.
Resolution	Capability of a sensor system to distinguish two aircrafts in close proximity and to produce target reports for both.

RF	Radio Frequency
SAC	System Area Code
SIC	System Identification Code
SLS	Side Lobe Suppression, a technique to avoid eliciting transponder replies in response to interrogations transmitted via antenna sidelobes
SSR	Secondary Surveillance Radar
TCP	Transmission Control Protocol
TMD	Technical Maintenance Display
Transponder	Airborne unit of the SSR system, detects an interrogator's transmission and responds with a coded reply stating either the aircraft's identity or its flight level
UAP	User Application Profile, used in ASTERIX data for assigning Data Items to Data Fields.
UDP	User Datagram Protocol. A connectionless, unreliable Internet protocol.
UTC	Coordinated Universal Time

1. Introduction

1.1 RCM as a part of RASS-R

The Radar Comparator is a powerful radar evaluation tool. Within RASS-R the Radar Comparator can process data delivered by the DHM in order to generate performance figures for radar according to the international standards. On the other hand the Radar Comparator may produce important correction parameters for the DHM and further production of the data streams.

In the design of the Radar Comparator, a number of general principles have been respected. First, everything was kept as simple as possible so that it is really easy to use the tool and interpret the results. Second, the data processing has been made as transparent as possible facilitating to check what is going on behind the scenes and detect specific problems quickly. The third rule was to process a necessary minimum of the data, in this way it is physically possible to analyse the data with a common human being capacity and within a short period of time. The fourth rule was to use clean data, i.e. corrected for all known (and measured) significant systematic errors. The fifth principle was to provide estimates for the accuracy (tolerance) on the measurement. The ultimate goal of the analysis is to estimate radar performance according to the international standards.

The Radar Comparator has two main components: the Radar Comparator Mono (RCM) and the Radar Comparator Dual (RCD).

The Radar Comparator Mono (RCM) can be used in order to evaluate the probability of detection, code probabilities, false plot rate and accuracy (random range and azimuth errors) generating separate performance figures for PSR-SSR and Mode-S, both plot and track data can be processed.

The Radar Comparator Dual (RCD) is primarily used for the measurement of the biases, and accuracy, or the random errors. It has been shown that in general two radars are necessary and sufficient for the absolute measurement of the systematic errors and the accuracy. That is why the Radar Comparator Dual (RCD) takes data originated from two radars at a time. (Please refer to the RCD user manual)

Prior to radar analysis with the RCM and RCD, the raw radar data might need to be pre-processed in order to take into account the real distribution of the barometric pressure vs. height (as opposed to the ICAO 1964 Standard Atmosphere). Applying the barometric correction to the height of an aircraft is beneficial for more accurate coordinate conversion, and adequate radar coverage and therefore more accurate results. The integrity of the data and timestamp problems need to be routinely checked, this type of analysis is essential for radar measurements and diagnostics.

1.2 Benefits and possibilities of the system

The following list outlines a number of benefits and possibilities of the system:

- Efficient and easy to use software tool for the radar (sensor) performance analysis
- Transparent radar data processing, versatile cross-referencing between various displays and viewers
- User friendly radar and evaluation setup configuration
- S4 format is directly readable by RCM
- Barometric correction of the target altitude based on the barometric sounding data
- Message statistics, and timestamp statistics
- Extended plot, track and trajectory info reporting
- Versatile universal filter

2. RASS-R toolbox





The RASS-R toolbox is installed on your pc and has a shortcut on the desktop. It can also be accessed using the Windows Start-menu. The toolbox is displayed in Figure 2-1. The current version of the RASS-R toolbox is displayed in the right upper corner. The RCM is part of this RASS-R toolbox and can be opened using the corresponding button .




Figure 2-1: RASS-R toolbox

The RASS-R menu bar contains the following pushbuttons:

Table 2-1: RASS-R toolbar

Button	Usage
 Help window	When this button is clicked, the Help window will appear and show help information whenever you point over a button.
 Campaign change	Click this to make an appropriate campaign structure (see further) Or to select a default campaign for the RCM when starting up.
 Exit	Quit the application

If you press the  button, the software will query a location to select an existing (or to create a new) **RASS-R** campaign folder. The measurement campaign directory structure is given in Figure 2-2.

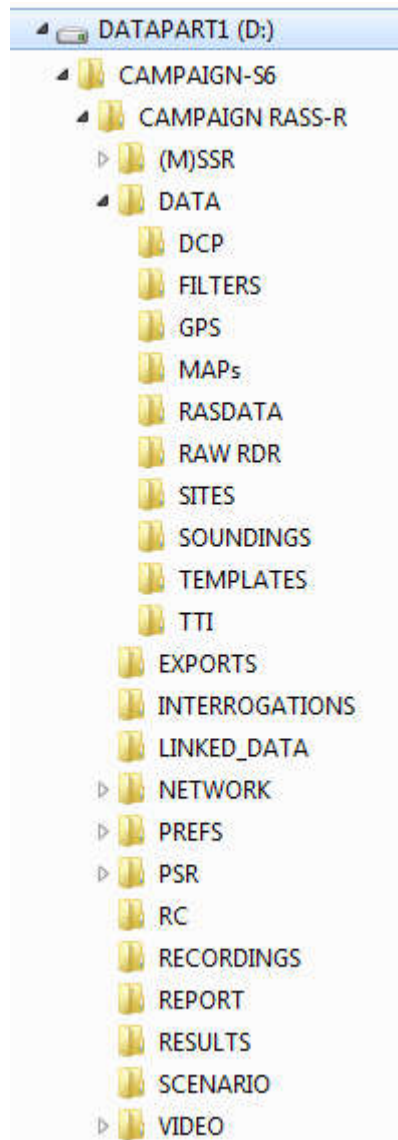


Figure 2-2: Campaign directory structure



When you make a campaign folder with the RASS-R toolbox, it is preferred to make it on a separate drive than the drive where your operation system is on. For example, as in the figure above, a structure named “CAMPAIGN RASS-R” is created on the D-drive.

2.1 RCM File paths

The Radar Comparator software was designed for the RASS-S user society that commonly use RASS-S CAMPAIGN structured folders. These folders can be nested, i.e. usually the root CAMPAIGN-S6 folder contains a number of other campaigns.

Each CAMPAIGN subfolder is designed for a specific content so that the software will typically suggest the standard paths; for example for the radar data recordings, atmospheric soundings, filters etc.

The radar recordings can be located anywhere **within** the current selected campaign, for example “MYCAMPAIGN”. Screening, relief and sounding files **must** be located in **fixed** folders as illustrated in Figure 2-3.

The mandatory “GENERAL” folder must be located at the same level as the “MYCAMPAIGN” folder.

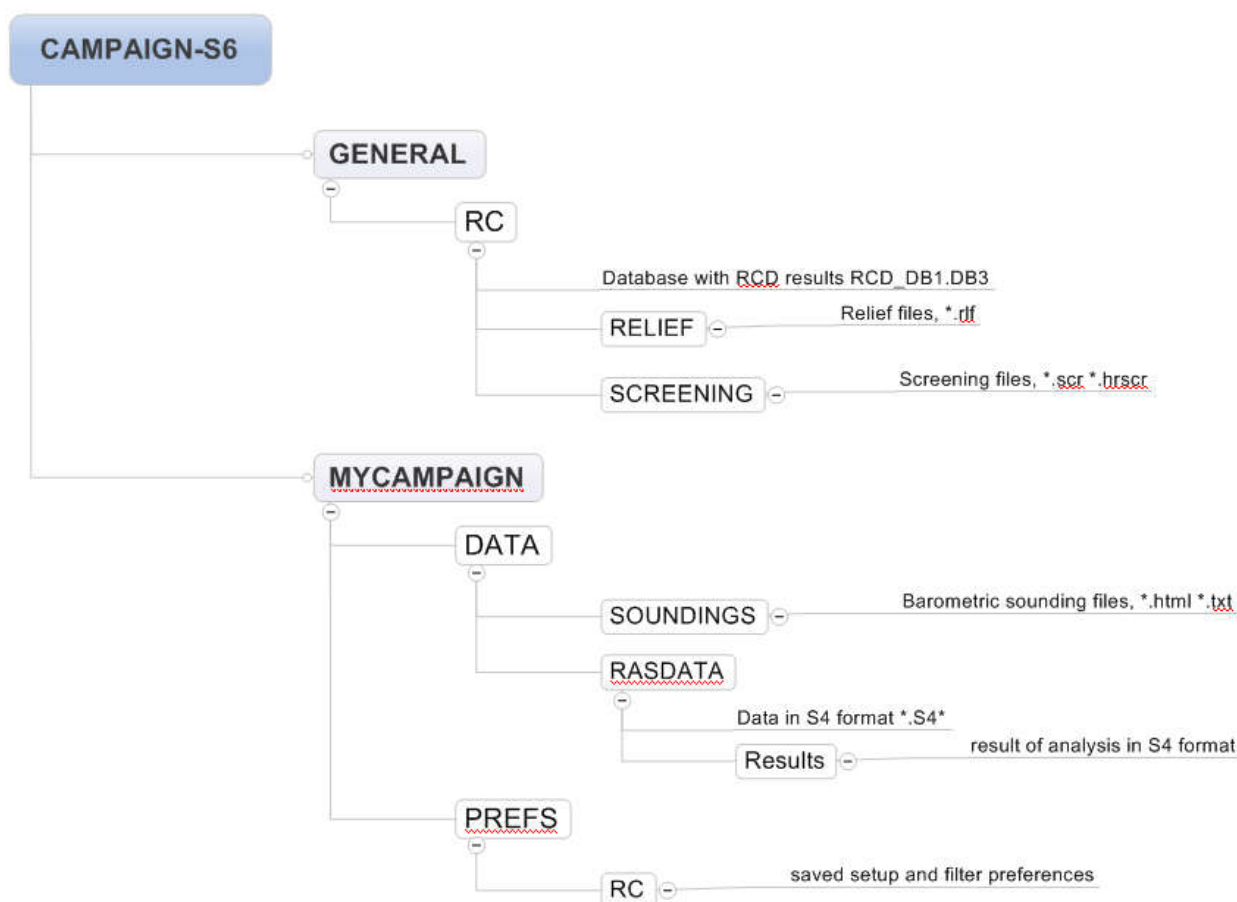


Figure 2-3: RC file structure



The location of the “GENERAL” folder is stored in windows registry whenever a campaign is selected or created with the RASS-R toolbox. This must thus be done at least once.

3. RCM basic operation

3.1 User interface

When launching RCM (from the Windows Start menu or the RASS-R toolbox), the following user interface will open:

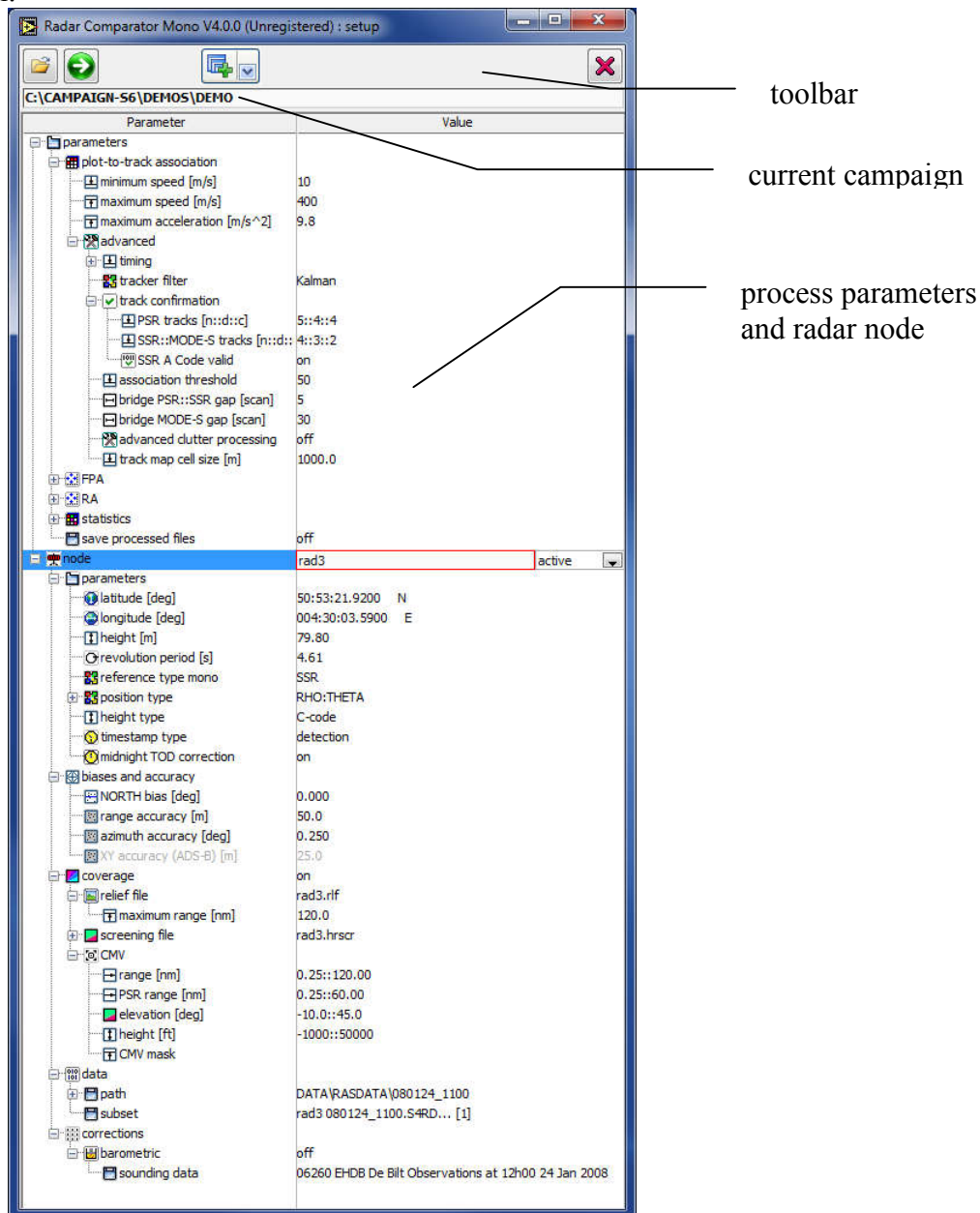


Figure 3-4: RCM user interface



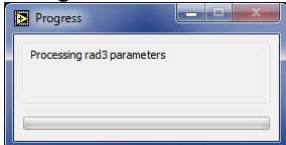
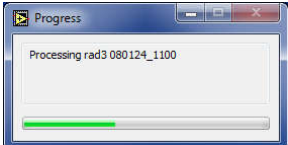
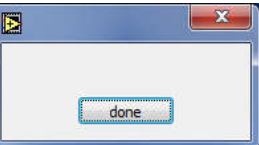

















The RCM contains three main elements:

- The toolbar. (see section 0 Toolbar for details)
- The current campaign field. When running the RCM, it will automatically use the last campaign used by the RCM, or RCD, or one selected using the RASS-R toolbox. (see chapter 2 RASS-R toolbox)
- The field with parameters and node (radar information). (See section 4 Program setup for details)

Toolbar


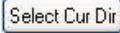
The toolbar allows the user to create new or select existing campaigns and access different displays and tables. An overview of all the toolbar buttons is given in Table 3-2.

Table 3-2: Toolbar overview

Button	Usage
	Press to select an existing campaign or create a new campaign
	Use this button to process (plot-to-track correlation); at the end of the processing the coverage information is applied to produce the final statistical result. After processing, this button becomes inactive until a parameter or node setting is changed. Then, you can press the button again. During the processing, the following dialogs will be shown in consecutive order: <div style="display: flex; justify-content: space-around; margin-top: 10px;">    </div>
	Press and select tools and displays (see the next sections for details) <ul style="list-style-type: none">  data analyser  filter  plot info  track info <hr/> <ul style="list-style-type: none">  XY display  accuracy display  coverage display  cell statistics display  resolution display <hr/> <ul style="list-style-type: none">  radar statistics  track statistics  false plot statistics  resolution statistics <hr/> <ul style="list-style-type: none">  export to SMS
	Press the button to exit, the RCM will exit after your confirmation <div style="margin-top: 10px;">  </div>

As explained above the RCM starts up with the last used campaign (by the RCM, RCD or RASS-R toolbox).

How to select a campaign?

If you want to select another campaign or create a new one, press the  button. The select campaign dialog will appear. Browse to the correct campaign folder, open it and then press  to select the campaign.

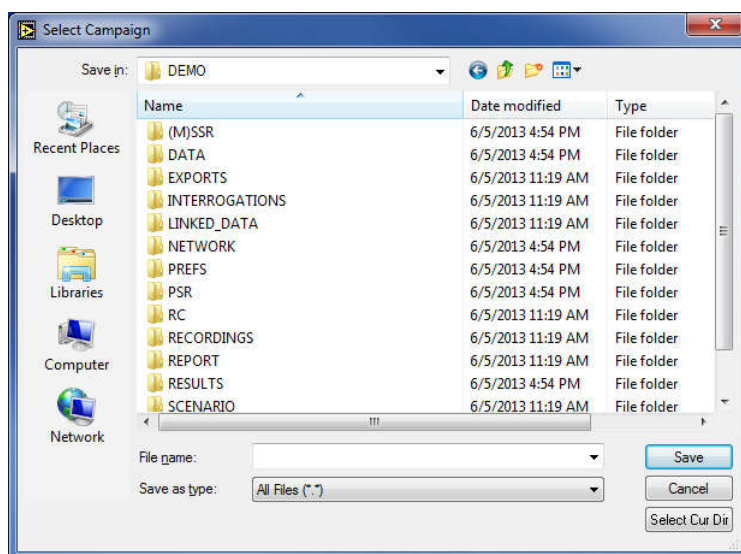


Figure 3-5: Select campaign dialog

How to create a new campaign?

If you want to create a new campaign inside the RCM software make a new folder by clicking . You give a name to the folder, for example “NEW CAMPAIGN”, go inside this folder and then press the button. Alternatively type the new name directly in the current campaign field for example “D:\CAMPAIGN-S6\NEW CAMPAIGN”

The RCM will now make the necessary structure of folders inside this new campaign, so that it is ready to be used for the RCM. When browsing to this folder again using Windows Explorer, the folder looks like this:

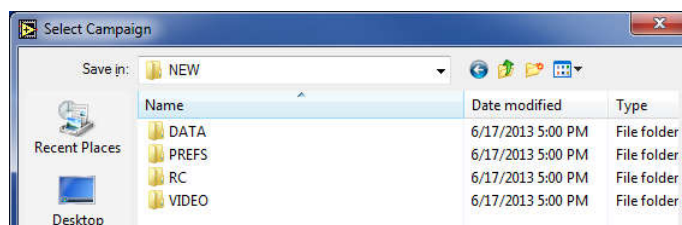


Figure 3-6: Structure of new campaign created inside RCM



Note: After you loaded this campaign in the RASS-R toolbox, the RASS-R toolbox may automatically add other folders inside this campaign structure not used by the RCM. (See Figure 2-2: Campaign directory structure) So it is also possible to create a new campaign for the RCM using the RASS-R toolbox (i.e. outside the RCM software.) Compare Figure 3-6 with Figure 3-5 to see the difference.

3.2 General utilities and displays

The RCM has a number of general tools available for radar evaluation:

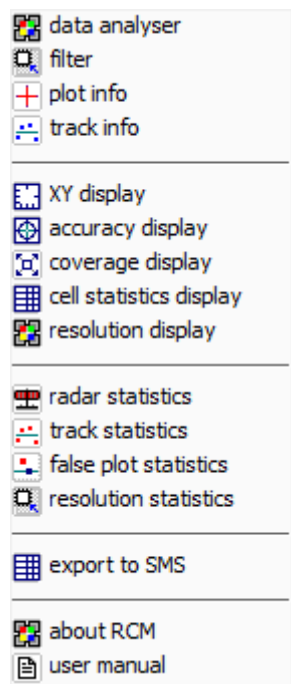


Figure 3-7: General utilities and display menu

These tools include the following:

- **data analyser:** is used to measure a number of possible non-specific errors in the input data, i.e. errors neglected by the used mathematical model but able to have the direct influence on the accuracy of the measurement.
- **filter:** is used to create, edit, load and store various filters. The filter content can be stored and retrieved locally, globally or to a file.
- **plot info:** is used to access the plot (track) information, addressed by the cursor in various graphs.
- **track info:** is used to present the track data based on the plot list.

The following displays use the generic multi-layer display objects so that the handling and configuration procedures for all of them are similar.

- **XY display:** is used for mono-radar plot (track) display. The user can easily redefine the amount and type of the data presented on the display. Relief and cell based statistics can be displayed in this graph.
- **accuracy display:** is used to display the random range and random azimuth errors.
- **coverage display:** is used to display the theoretical coverage of the relief based on the pre-calculated (using RASS-R Coverage Map Calculator software) screening files *.hrscr (RASS-R) or *.scr (SASS-C) formats. The relief and radar data can be displayed simultaneously. This provides powerful coverage analysis tools.
- **cell statistics display:** is used to produce the statistics based on the specified cell volume and configuration. The available types of the display are XY, range vs. azimuth and vertical.

The statistics are produced separately for each plot (track) type for the selected parameter (Pd, range accuracy, azimuth accuracy)

- **resolution display**: will provide a graphical representation, slant range difference (dR) versus azimuth difference (dAz), of all observed resolution cases divided in 3 resolution areas as defined by EUROCONTROL standards *SUR.ET1.ST01.1000-STD-01-01* and *SUR.ET1.ST03.1000-STD-01-01*. SSR resolution is displayed unless reference type parameter is set to PSR.

The following statistics tables are available:

- **radar statistics**: is used to display overall statistics for the analysed data set.
- **track statistics**: is used to present the statistical result for each trajectory.
- **false plot statistics**: is used to present the false plot list.
- **resolution statistics**: provides resolution detection statistics for 3 resolution areas.

Export to SMS allows a user to export the settings and filter to file, formatted for import into a SMS system.

About RCM displays the version numbers of RCM, license and the necessary contact information.

User Manual short opens the RCM user manual.



Most displays, statistics tables and info windows are cross-linked. A selection in one window will thus guide the cursor in other windows to relevant information, allowing swift yet detailed analysis.

4. Program setup

When you run the RCM, the user interface as in the figure below will be displayed. The parameter interface has the universal tree structure. Parameters are grouped according to their meaning and functions into two groups ‘parameters’, and ‘node’. Each group contains several subgroups.

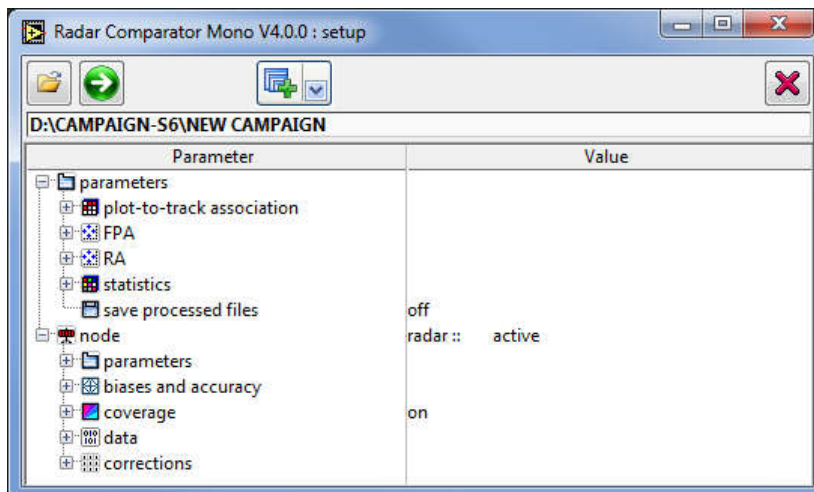


Figure 4-8: RCM User Interface

When you right click inside the tree control, the following popup menu appears:



Figure 4-9: RCM right click

With this menu you may want to perform one of the following operations:

- **Copy to clipboard:** it makes a spreadsheet copy of the parameters that can be pasted to a document for reporting purposes. (E.g. Microsoft Excel, notepad)
- **Load setup:** load the setup from the current campaign. (See Figure 4-10)
- **Load from file:** select a setup file¹ to load stored outside the current campaign. This is handy when the evaluation of the radar has been already conducted before and the setup has been created and stored in a different campaign.
- **Save setup:** save the setup to the current campaign. (See Figure 4-10)
- **Save to file:** select a setup file to store outside the current campaign. This is useful if you want to use the setup file for other purposes later on. Select the path and filename using the standard file dialog.

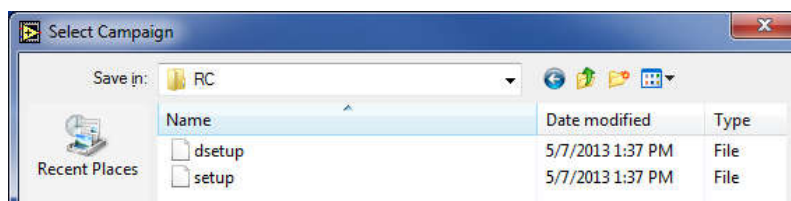


Figure 4-10: RCM setup files inside own campaign



Setup files created using the older RCM versions are limitedly compatible with the newer versions.

¹ RCM setup files do not have a file extension.

4.1 Parameters



Changes of numeric, text and compound configuration parameters must be followed by pressing ENTER. Otherwise the old values will be maintained. Ring controls are updated automatically whenever a different value is selected.

4.1.1 Plot-to-track association

This subgroup contains parameters for the Object Correlator (OC) performing multiple hypothesis plot-to-track association:

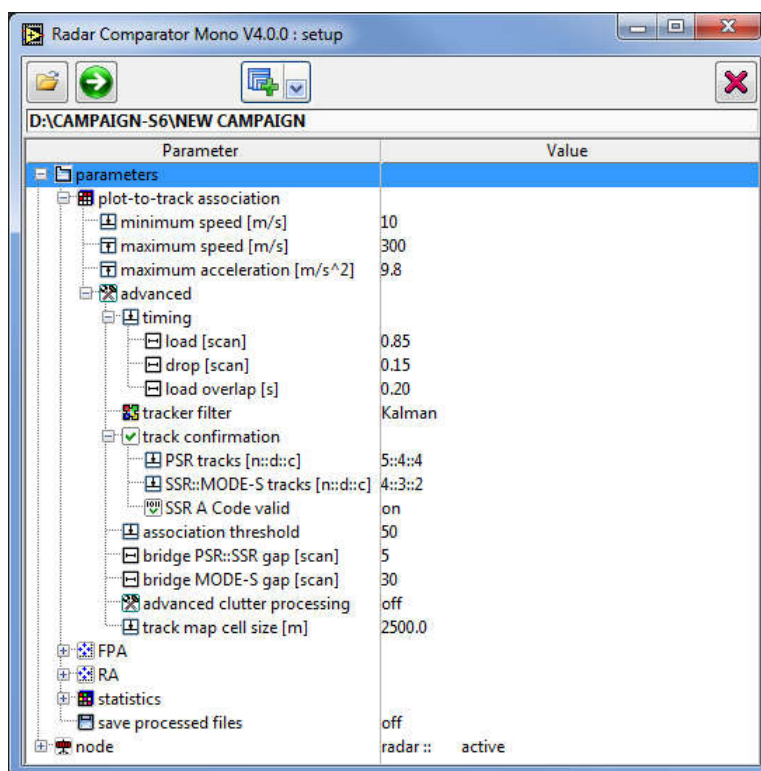


Figure 4-11: Parameters plot-to-track association

- **minimum speed [m/s]²:** [10] Trajectories with lower speed are not initiated. However, once a track is confirmed, the speed is allowed to drop below minimum.
- **maximum speed [m/s]:** [300] Maximum expected ground speed of the air traffic. High values can increase the false plot-to-track association rate and are only useful in very specific cases.
- **maximum acceleration [m/s²]:** [9.8] acceleration characterizes the expected manoeuvrability of the traffic. May need to be adjusted in case of military traffic or unusual mode of flight.
- **advanced**
 - **timing**
 - **Load [scan]** [0.85] for synchronous sensors (such as radar) a portion of the scan (i.e. update rate) fed through the plot-to-track correlation engine. This parameter may never exceed 1 scan to avoid that any track has more than 1 update in one correlation step.

² Most of the parameters in the tree are organized as follows: **Parameter [Unit] [Default Value, Value2, Value3,...]** Default value is highlighted in bold

- **Drop [scan]** [0.15] for synchronous sensors (such as radar), coastings are produced or track drops are performed after a number of update cycles plus the drop [scan] margin, in order to allow for some timestamp jitter and target dynamics.
 - **Load overlap [s]** [0.2] for synchronous sensors (such as radar) the last portion of the scan (i.e. update rate), selected in seconds, is kept non-updated until the next correlation cycle in order to solve possible resolution cases.
- **tracker filter** [Kalman filter]
- **track confirmation** Trajectories or tracks being established by the software are confirmed and used for the analysis, subject to a number of other conditions (e.g. min track length etc.), if the following initial conditions are met [n::d::c] for PSR tracks, SSR or Mode-S tracks, with (d) detections made out of (n) possible detections, the first (c) detections being consecutive.
 - **PSR tracks [n::d::c]** [5::4::4]
 - **SSR::MODE-S tracks [n::d::c]** [4::3::2]
 - **SSR A Code valid** [on, off] A SSR track is initiated only if the first plot/track has a valid A-code. PSR or Mode-S tracks are unaffected by this parameter.
- **association threshold:** [50] empirical parameter representing likelihood of the plot-to-track association (probability of the track update given a particular update candidate). Increasing this parameter makes the association more strict, however increasing chances of non-associated plots when radar accuracy is poor or/and clutter rate is high. *Recommended values: 50 for Mode-S, 100 for SSR, 150 for PSR.*
- **bridge PSR-SSR gap:** [5] Maximum number of allowed consecutive missed intervals. Any active trajectory ID will be preserved up to the maximum number of consecutive missed updates. A new trajectory ID will be generated when the specified maximum number of consecutive missed updates for PSR and/or SSR plots is reached. This parameter may be increased if number of consecutive misses is higher.
- **bridge MODE-S gap:** [30] a new trajectory ID will be produced and the current trajectory ID terminated, when the specified number of consecutive misses for Mode-S plots is reached. Note, excessive values may produce poor linking capability around the cone of silence, please decrease this parameter in such cases.
- **advanced clutter processing** [on, off] enables the advanced clutter rejection algorithm, to be used in high clutter environments.
- **track map cell size [m]** [2500] The track map cell size helps the tracker to distinguish between possible plot-to-track matches, based on a fixed count of cells (=3) around a new plot. The complete XY coverage extent of the sensor [-Rmax, Rmax] is divided into a number of square cells of the specified size (NxN, where N=2Rmax/cell size). The advanced clutter processing algorithm constraints opening new trajectories in the cells with a substantial amount of clutter. The active tracks are maintained. In other words, for each new plot falling in a cell with indexes (i, j), only tracks located in surrounding cells (i±3, j±3) will be considered as possible candidate matches.

4.1.2 False Plot Analysis

FPA: (False Plot Analysis) subgroup containing parameters for false target (FT) and multiple target (MT) classification. In RCM only MT reports can be classified. For FT classification (synchronous FRUIT or Second Time Around - STA) a second source of data is required. The corresponding fields are kept for the sake of generality.

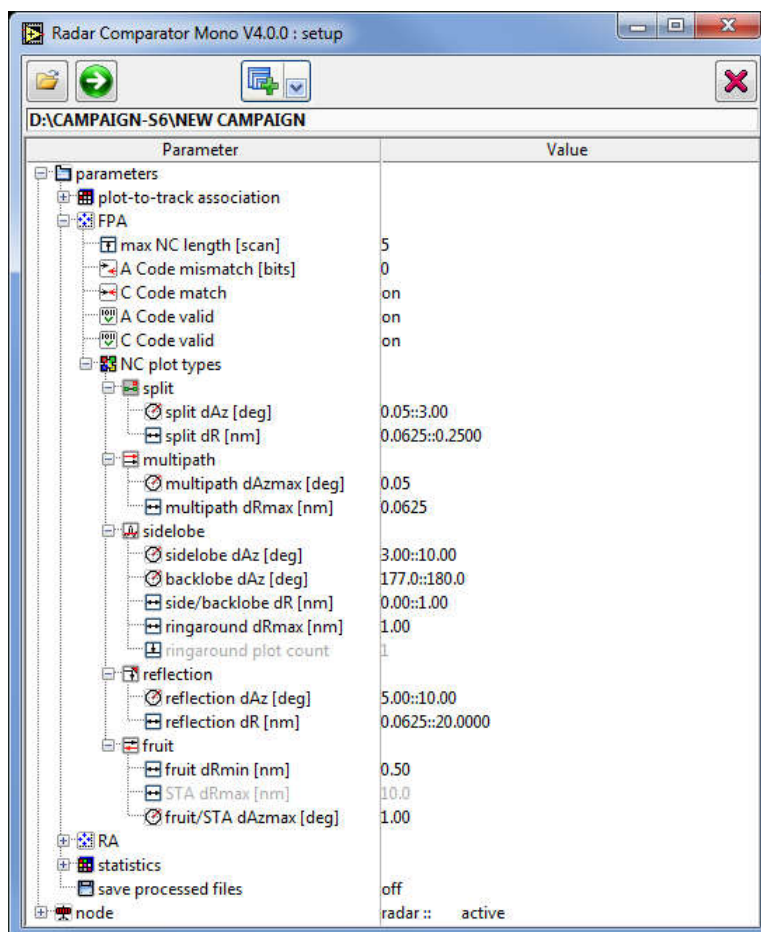


Figure 4-12: FPA parameters

- **max NC length [scan]:** [5] short trajectories with the number of plots less or equal to this parameter, are likely to be composed with false (multiple) detections and processed by the FPA algorithm.
- **A Code mismatch [bits]** [0] typically false (multiple) plots have A-code identical to the corresponding true plot, as defined by EUROCONTROL standard (count of mismatched bits 0), except in cases when the codes of true and multiple(false) plot are allowed to have limited bit error (typically 1, 2)
- **C Code match** [on, off] typically false (multiple) plots have identical C-code, however in practice C-code may be different. To allow for the latter case, the flag must be set to off.
- **A Code valid** [on, off] typically false (multiple) plots are required to have validated A-code, however in practice the codes may be invalid. To allow for the latter case, the flag must be set to off.
- **C Code valid** [on, off] typically false (multiple) plots are required to have validated C-code, however in practice the codes may be invalid. To allow for the latter case, the flag must be set to off.

- **NC plot types:** subgroup, containing parameters for multiple (false) target report classification
 - **split:** FPA subgroup for split target reports
 - **split dAz [deg]:** [0.05÷3.00] minimum and maximum azimuth
 - **split dR [nm]:** [0.0625÷0.2500] minimum and maximum range
 - **multipath:** FPA subgroup for multipath reports
 - **multipath dAzmax [deg]:** [0.05] maximum azimuth difference compared with the true target
 - **multipath dRmax [nm]:** [0.0625] maximum range difference compared with the true target
 - **sidelobe:** FPA subgroup for sidelobe multiple target reports
 - **sidelobe dAz [deg]:** [3.0÷10.0] minimum and maximum azimuth difference compared with the true target
 - **backlobe dAz [deg]:** [177.0÷180.0] minimum and maximum azimuth difference compared with the true target
 - **side/backlobe dR [nm]:** [0.00÷1.00] minimum and maximum range difference compared with the true target
 - **ringaround dRmax [nm]:** [1.00] maximum range difference compared with the true target
 - **ringaround plot count:** [1] minimum number of sidelobe artefacts required for ringaround classification³
 - **reflection:** FPA subgroup for reflection target reports
 - **reflection dAz [deg]:** [5.00÷10.00] minimum and maximum azimuth difference compared with the true target
 - **reflection dR [nm]:** [0.0625÷20.0000] minimum and maximum range difference compared with the true target
 - **fruit:** FPA subgroup for FRUIT target reports
 - **fruit dRmin [nm]:** [0.50] minimum range difference compared with the true target
 - **STA dRmax [nm]:** [10.0] maximum range difference compared with the true target for Second Time Around classification **Error! Reference source not found.**
 - **Fruit/STA dAzmax [deg]:** [1.00] maximum azimuth difference compared with the true target

³ Parameter is no longer used (since RCMv4.0.0).

4.1.3 Resolution Analysis

RA: (Resolution Analysis) subgroup containing parameters for resolution analysis as they are defined by EUROCONTROL standards SUR.ET1.ST01.1000-STD-01-01 (page 28-32) and SUR.ET1.ST03.1000-STD-01-01 (page 39-40).

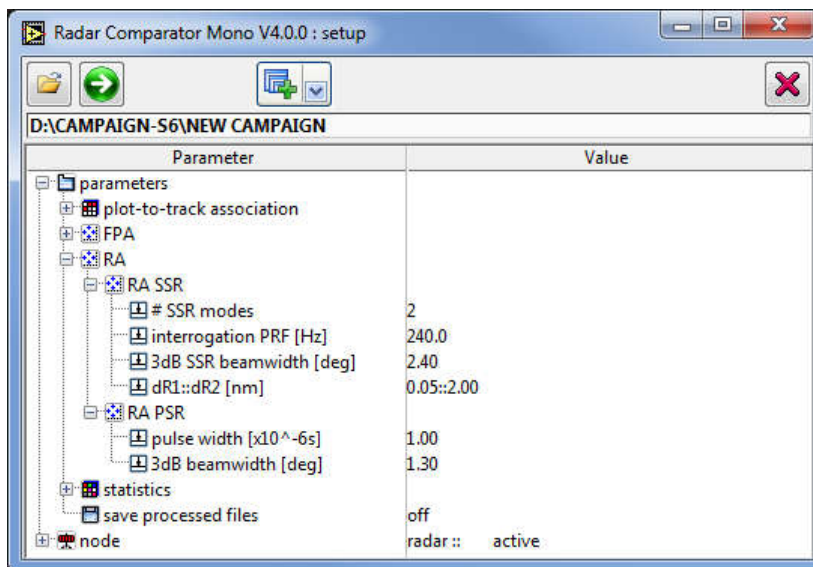


Figure 4-13: RA parameters

- **RA SSR** SSR resolution parameter group
 - **# SSR modes** [2] number of SSR interrogation modes (e.g. mode 3/A, C). It is assumed that 3/A and C code are interrogated equal times. Should a MIP be set where this is not the case, RA analysis should be run separately for the code detection statistics to be correct.
 - **Interrogation PRF [Hz]** [240] Interrogation pulse repetition frequency
 - **3dB SSR beamwidth [deg]** [2.4] nominal 3dB interrogation beamwidth
 - **dR1::dR2 [NM]** [0.05::2.00] minimum :: maximum range difference between 2 aircrafts defining borders of resolution zone 2
- **RA PSR** PSR resolution parameter group
 - **Pulse width [μs]** [1] nominal (compressed) PSR pulse width
 - **3dB beamwidth [deg]** [1.3] nominal 3dB beamwidth



Whenever applicable, different pulse lengths should be used for PSR resolution analysis short or long pulse operating area.



Above default values are typical combined sensor values, they however are radar dependent and should be set according to real radar parameters and operational settings.

4.1.4 Statistics

This subgroup contains parameters for statistical analysis:

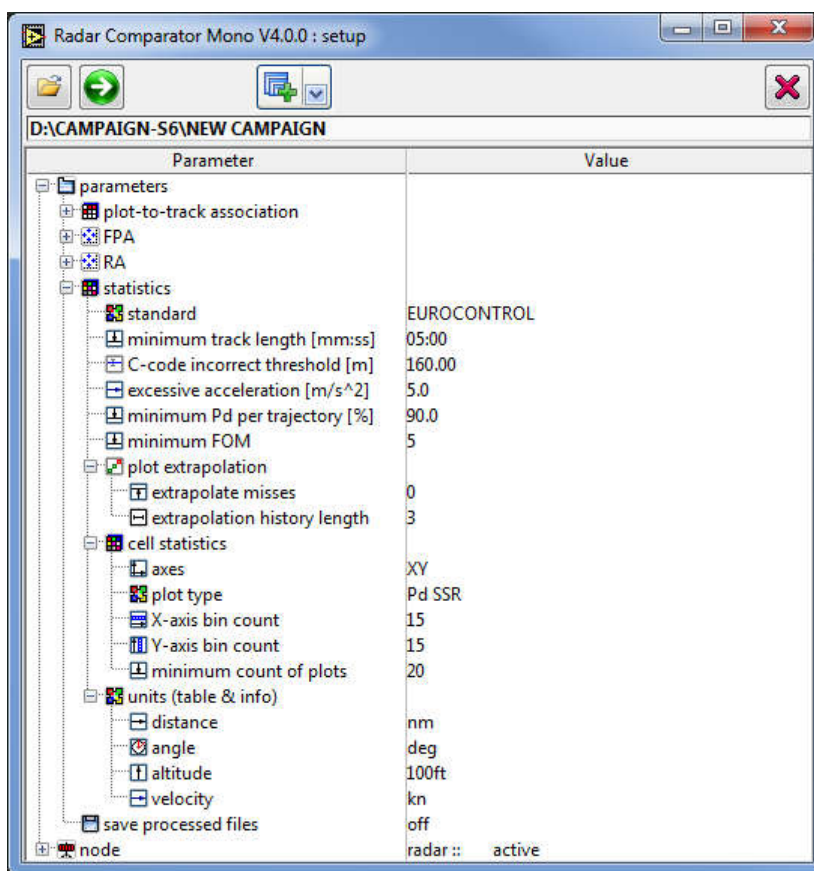


Figure 4-14: Statistics parameters

- standard:** **EUROCONTROL** [Reference 3], ICAO PSR-SSR, ICAO PSR-MSSR [Ref. 2] used standard (the selected standard requirements are given as the 3rd column in Statistics Table)
- minimum track length [min]:** **[05:00]** standard 5-minute filter. Tracks shorter than this minimum track length will not be taken into account for the statistics, however they can be displayed.
- C-code incorrect threshold [m]:** **[160.0]** a parameter for incorrect C-code calculation. This number influences the number of ‘valid and (not) correct C-code’ in the statistics table (See 6.1. General Statistics). This parameter may be adjusted depending on the traffic type (civil, military) and/or sensor update rate.
- excessive acceleration (m/s²)** **[5]** acceleration threshold for target classification accelerating faster than the specified threshold (see 6.1. General Statistics).
- minimum Pd per trajectory [%]** **[90.0]** minimum Pd parameter for counting tracks with a Pd lower than the specified threshold (see 6.1. General Statistics).
- minimum FOM** **[5]** minimum FOM threshold for counting ADS-B plots with a FOM greater than the specified threshold (see 6.1. General Statistics).

- **plot extrapolation:** extrapolation subgroup
 - **extrapolate misses:** [0] number of plots to extrapolate at the beginning and the end of the trajectory, can be used for late in coverage detection, and early in coverage misses.
 - **extrapolation history length:** [3] number of plots at the extremity of a trajectory used to predict target speed and heading, used for plot extrapolation.
- **cell statistics:** cell statistics subgroup configuring the cell display
 - **axes:** [XY, range vs. azimuth, vertical] select axes for the cell statistics display
 - **plot type:** [Pd PSR, Pd SSR, Pd MODES, range accuracy, azimuth accuracy] quantity displayed in the cell display. If you change the plot type from Pd[%] to accuracy [m] or [deg] you should adjust the display colours to the desired range, for example Pd [95÷100], range or azimuth accuracy [3σ÷0] where σ is the expected error in terms of the standard deviation
 - **X-axis bin count:** [15] number of cells along X-axis
 - **Y-axis bin count:** [15] number of cells along Y-axis
 - **minimum count of plots:** [20] minimum count of plots inside a cell to be used for the statistical result
- **units (table & info):** define appropriate units for tables and viewers
 - **distance** [m, nm, km]
 - **angle** [rad, deg]
 - **altitude** [m, ft, 100ft]
 - **velocity** [m/s, kn, km/h]

4.1.5 Save processed files

When **ON** the processed files are saved as a new .S4RA file in the RESULTS folder inside the selected campaign's data folder (See also 2.1 RCM File paths). The file name will indicate time and day when the .S4RA was made and with what software (RCM or RCD). Saved data can be viewed and further analysed in high detail with for example the RASS-S Inventory tool (see *RASS-S user manual, volume 4, chapter III* for further details).

The RCM will add misses to the result file as a new target report with the detection bits set to false. Further will each target report, which passed the filter, be saved into the new file with the following information added or updated:

- Range error [NM] this field in S4 format is the same field as the latitude field. Therefore if position type used in analysis is longitude/latitude then the range error will be saved in the X field.
- Azimuth error [deg] this field in S4 format is the same field as the longitude field. Therefore if position type used in analysis is longitude/latitude then the range error will be saved in the Y field.
- Altitude [ft] this field will be the original altitude unless barometric correction was set ON. A missed target will have an interpolated altitude. In the inventory plot info window this field is called "SSR Height".
- Target ID [#] The trajectory number (RCM tracking number) is saved in this field. Non-correlated plots get target IDs of 0 or 1.
- Velocity [Nm/h] The velocity calculated by RCM is saved in this field.
- Heading [deg] The heading calculated by RCM is saved in this field.
- Scan number [#] Scan number will be recalculated in case multiple S4 files were selected (see 4.2.4).
- Miss RCM will add miss reports, with i.e. the extrapolated expected position and time, to the result file.
- False plot bit This bit is used for internal RCM processing and displaying. **This bit DOES NOT indicate false plots.** Non-correlated plots can be identified by means of the Target ID.
- Coverage bit Set to true (1) if in coverage. In the inventory target info window this bit is called "Manual designated flag". For filtering in inventory one can however just filter on "Coverage (MDF)" bit.
- A code swap bit Set true if an A code swap event was detected by RCM.
- Correct A code bit Set true if RCM validated the A code as correct.
- Correct C code bit Set true if RCM validated the C code as correct.

4.2 Node

The subgroup contains radar parameters.

node: [*name*] [*active*] is used to specify the name for the data source as well as its current status. The status of the node is always active in the RCM.

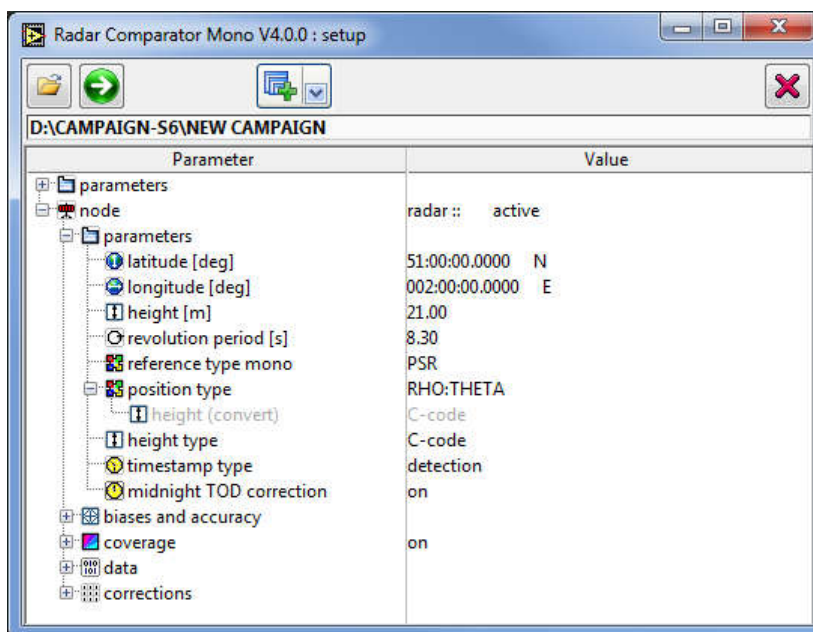


Figure 4-15: Node - parameters

4.2.1 Parameters

The parameters subgroup contains the following settings:

- **latitude [deg]:** [51:00:00.0000][N, S] Geodetic latitude of the radar
- **longitude [deg]:** [02:00:00.0000][E, W] Geodetic longitude of the radar
- **height [m]:** [m] the height of the centre of the radar antenna measured above WGS84 ellipsoid. **All the heights used are heights above WGS84 ellipsoid (not WGS84 geoid).**
- **revolution period [s]:** [s] antenna revolution period in seconds. For asynchronous reference type this parameter will define the update rate required to calculate Pd.
- **reference type:** [PSR, SSR, PSR::SSR, MODE-S, MODE-S::SSR::PSR, ADS-B, MLAT, ASDE, MRT] set up according to the required reference type. The selected data type will determine the used mathematical model and set of statistics that will be computed (see 6.1. General Statistics).



EUROCONTROL or ICAO standards have been applied. In case no standard method is available, e.g. ADS-B probability of detection, methods according ICAO recommendation and guidance material are implemented.

- **position type:** [RHO::THETA, XY (radar plane), XY (Cartesian), LONG::LAT] set to the corresponding coordinate type applied by the sensor. The radar plane stays for the **azimuthal projection**, **XY Cartesian** is the orthogonal projection to the local horizontal plane
 - **height (convert)** [C-code,3D Height] this setting becomes only active when the position type is LONG::LAT. Then, if available C-code or 3D Height field can be used for conversion (LONG::LAT, Height) to (RHO::THETA, Height) or (X,Y,Z, Height).
- **height type:** [C-code, 3D Height] is selectable according to the available height data. *For ADS-B reference geometric height will be used when 3D height is selected.*
- **timestamp type:** [recording, **detection**] is selectable according to the available timestamp data, time of detection should be used whenever available.
- **midnight TOD correction:** [off, **on**] must be set on if the data recording is taken over midnight and time of **detection** is used.

4.2.2 biases and accuracy

The accuracy subgroup contains the following parameters:

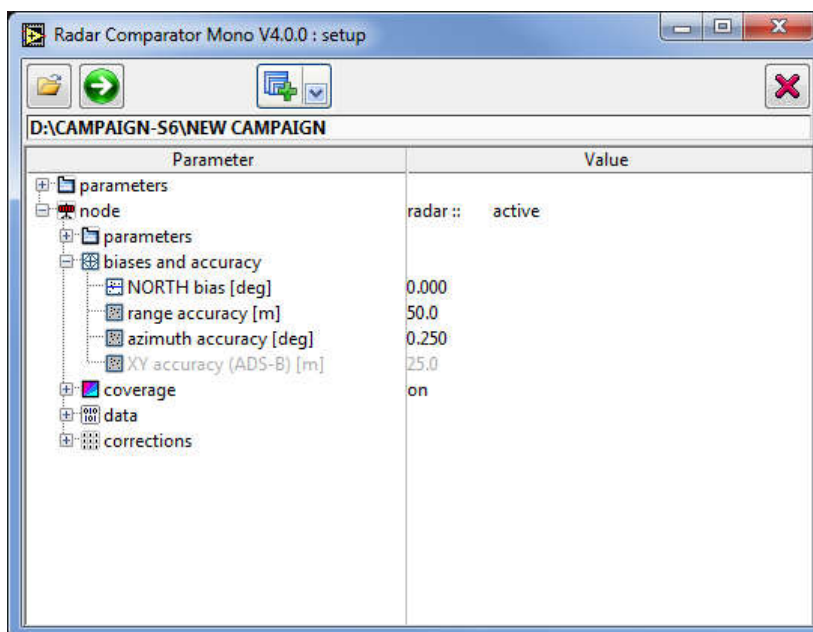


Figure 4-16: Node - accuracy

- **NORTH bias [deg]:** [0.000] set here the magnetic inclination if radar is aligned with the magnetic north. *Required to correctly apply screening (see coverage in next section).*
- **range accuracy [m]:** [m] expected range accuracy of the radar (one sigma). *Inactive when the source data is ADS-B, MLAT or MRT.*
- **azimuth accuracy [deg]:** [deg] expected azimuth accuracy of the radar (one sigma). *Inactive when the source data is ADS-B, MLAT or MRT.*
- **XY accuracy [m]:** [m] expected range accuracy of the ADS-B data (one sigma). *Active when the source data is ADS-B, MLAT or MRT.*

4.2.3 Coverage

The RCM can use screening files and relief files created by the RASS-R Coverage Map Calculator software (*.rlf and *.hrscr).

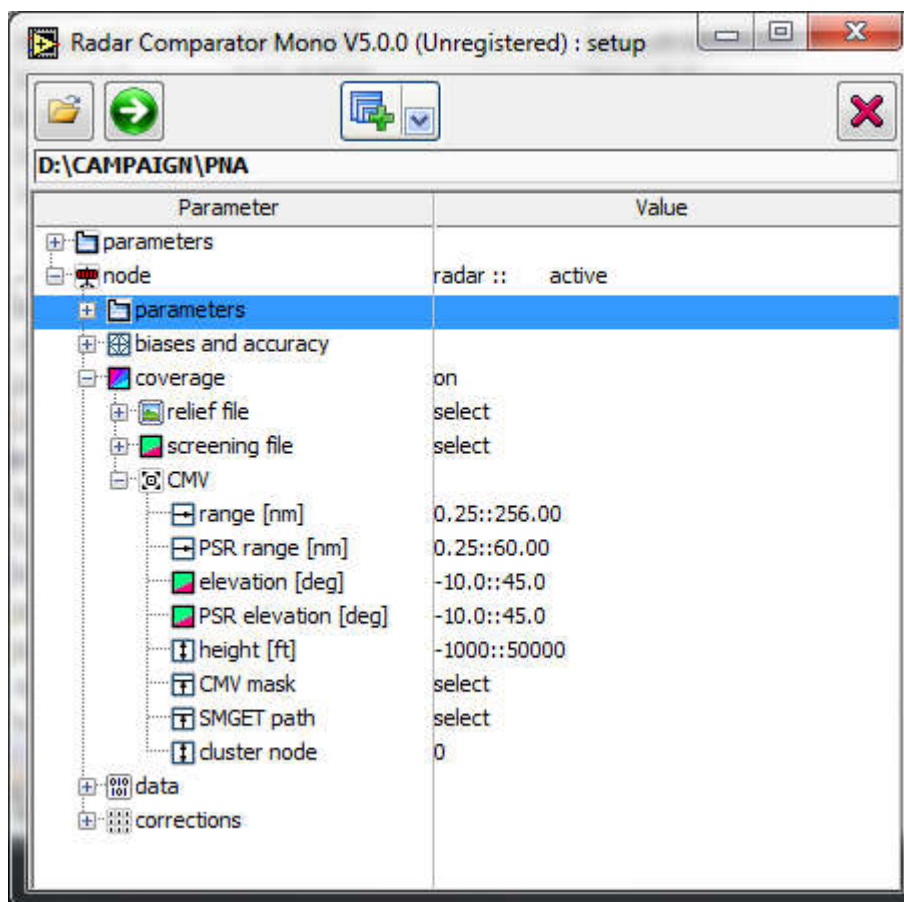


Figure 4-17: Node - coverage

The coverage subgroup contains the following parameters:

- **relief file:** [filename.rlf] file name for the corresponding relief file, located under [D:\CAMPAIGN-S6\General\RC\relief] (see also Chapter 2 RASS-R toolbox)
 - **maximum range [nm]:** [nm] is used for displaying purposes and tracker map cell count calculation (See also 4.1.1 Plot-to-track association). Target reports falling outside the tracker map limited by the maximum range will not be correlated. The maximum range should be set the same as the maximum range of the relief file generated with the CMC, if relief is to be displayed and scaled correctly in the coverage and X/Y display. The viewable area of the XY display is adjusted to this parameter. A circle will be drawn in the XY display according to this maximum range.
- **screening file:** [filename.hrscr] file name for the corresponding screening file, located under [D:\CAMPAIGN-S6\General\RC\screening] (see also Chapter 2 RASS-R toolbox). The screening info is used for the coverage bits calculation and coverage maps generation

- **coverage resolution:** [256] number of cells along X and Y axes for the tabular coverage visualization
- **FL resolution:** [FL] difference in FL between two consecutive FL coverage contours. Only 10 contour lines will be displayed.



Currently only 1° azimuth resolution screening files are supported.

- **CMV:** subgroup defining the coverage measurement volume that will be taken into account for the statistics analysis. Plot/track data outside the CMV area shall be displayed as “plot (track) out coverage” or “missed out coverage” in the XY display.
 - **range [nm]:** [0.0, 250.00] minimum and maximum range
 - **PSR range [nm]:** [0.0, 60.00] minimum and maximum range for the PSR
 - **elevation [deg]:** [-10.0, 45.0] minimum and maximum elevation
 - **PSR elevation [deg]:** [-10.0, 45.0] minimum and maximum elevation for the PSR
 - **SMGET path** [filename.dat] file name for the corresponding real (M)SSR coverage file.
 - **Cluster node** [0] index which coverage volume to use from the SMGET file



If reference type is PSR the elevation information/parameters are discarded.



If a SMGET and CMC map is selected both will be used for performance calculations, but only the SMGET map will be displayed in the XY graph.

- **height [ft]:** [-1000, 50000] minimum and maximum height
- **CMV mask:** [filename.cgm] file name for the corresponding Coverage Map Volume mask file, located under [D:\CAMPAIGN-S6\General\RC\screening]. The CMV mask is a single continuous and closed polygon in CGM (Computer Graphics Metafile) format. Each plot outside the polygon will be considered out of coverage.

```
BEGPIC;
SCALEMODE ABSTRACT, 1.0;
COLRMODE INDEXED;
BEGPICBODY;
% APPLDATA AREA AREAID 1 "Coverage area"; %
% APPLDATA AREA ATTRIBUTES "COVERAGE"; %
LINECOLR 10;
LINEWIDTH 1;
INTSTYLE HOLLOW;
POLYGON
(-584.881, -1554.12)
(-427.717, -1619.67)
(-363.392, -1655.69)
(-352.528, -1667.06)
(-348.321, -1677.55)
(-348.631, -1690.9)
(-355.633, -1704.83)
(-365.496, -1714.25)
(-378.912, -1716.9)
(-387.776, -1715.22)
(-401.95, -1750.5)
(-1059.5, -1374.77)
(-1048.81, -1376.47)
(-1038.28, -1380.94)
(-1032.21, -1386.71)
(-1026.48, -1394.12)
(-1025.74, -1408.29)
(-981.575, -1426.17)
(-977.068, -1419.2)
(-972.243, -1414.93)
(-964.341, -1410.79)
(-954.831, -1410.2)
(-872.822, -1432.35)
(-713.784, -1499.19);
ENDPIC;
ENDMF;
```

Figure 4-18: example of a CMG polygon



Make sure the relief, screening and CMV mask file paths are correct (see chapter 2).

4.2.4 Data

The data subgroup contains the following parameters:

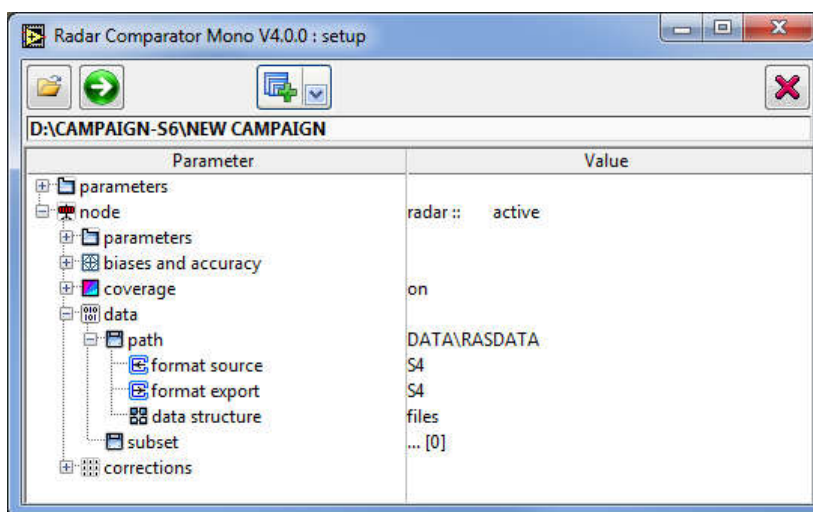


Figure 4-19: Node - data

- **path:** [path] relative path to the map where the data recording are stored
 - **format source:** [S4*] format of the source data recording.
 - **format export:** [S4*] format of the export data recording.
 - **data structure:** [files, folders] the recorded data can be organized as files stored under **path**, or subfolders each containing one S4 file.
- **subset:** [list] in a case when the data recording is segmented (for example into 15 minute chunks files or folders), one or multiple files can be selected using Shift+{left mouse button} or Ctrl+{left mouse button}.



Make sure you have selected the data file to be used and you pressed Enter to confirm.



**** D6 format is no longer supported. With RASS-R DHM a D6 file can be converted to S4.***

4.2.5 Corrections

The corrections subgroup contains the following parameters:

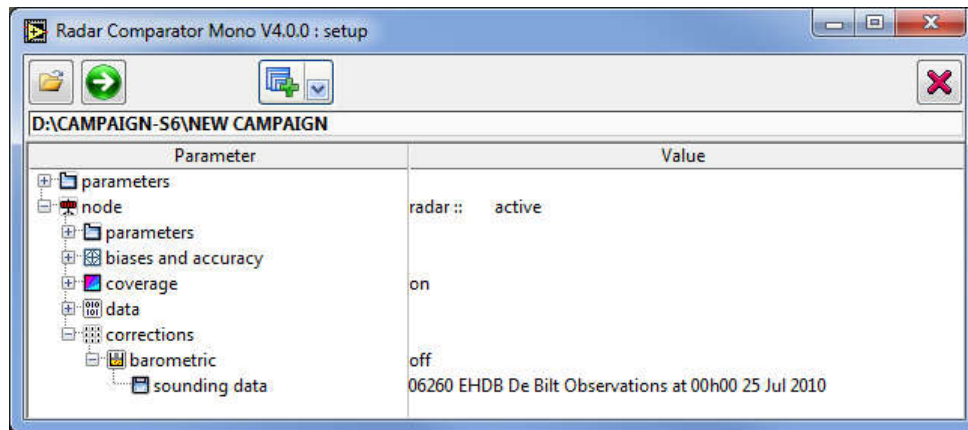


Figure 4-20: Node - corrections

- **barometric:** [off, on] enables barometric correction of the data. Use the **data analyser** first in order to measure the existing errors and retrieve the barometric data.
 - **sounding data:** [filename] a filename of the sounding data retrieved from Atmospheric Sounding Website (<http://weather.uwyo.edu/upperair/sounding.html>)

5. Tools and Displays

All tools and displays can be accessed using the same menu button as shown in Figure 5-21.

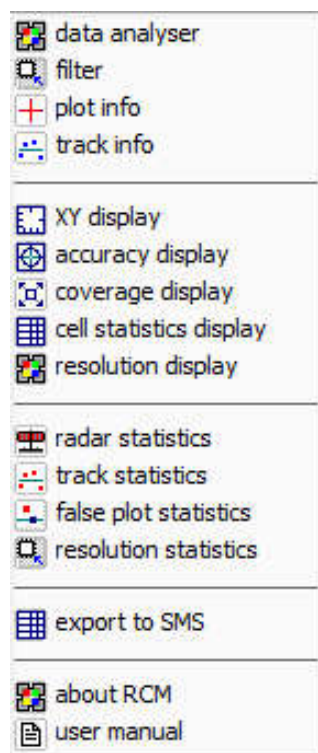


Figure 5-21: General utilities and display menu

You can change the transparency of the displays, tables and dialogs. The transparency can be circularly changed from 0 to 80 percent in 5 steps by pressing the **F3** key. Transparency of the setup window and data analyser window cannot be changed.

5.1 Displays configuration

5.1.1 Basic display configuration

The basic configuration of a display is the same for all displays: XY/accuracy/coverage/cell display but also the display for timestamp analysis and barometric correction. By right clicking in the display pane, the following popup menu is evoked:

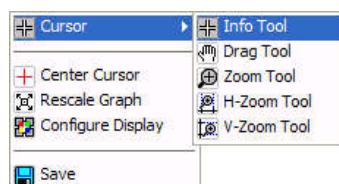


Figure 5-22: Displays configuration popup menu

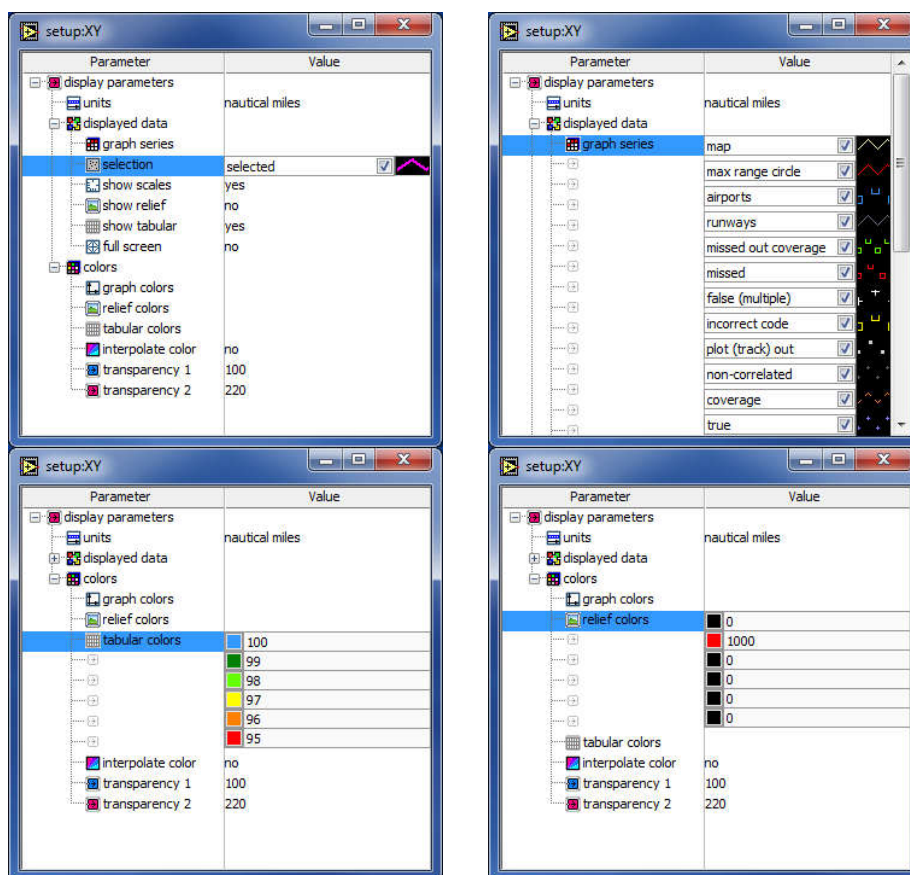
Depending on the selection, the following actions can be performed:

- **Cursor:** use to change the type of the cursor.
 - **Info tool:** use to address the plot (track) coverage profiles etc. information.
 - **Drag Tool:** use to pan the graph

- **Zoom Tool:** use to change the scale of the viewable area in the screen (xy-mode) Zooming can be done by drawing a rectangular over the area of interest. You can also use the scroll-wheel of the mouse to zoom in/out.
- **H-Zoom Tool:** use to change the scale of the viewable area in the screen (x-mode)
- **V-Zoom Tool:** use to change the scale of the viewable area in the screen (y-mode)
- **Center Cursor** use to bring the cursor to the centre of the viewable area of the graph (attention the graph must not be empty.) Use the **Home** key to produce the same effect.
Use **Arrows keys** ← and → to move the cursor along the selected plots, trajectory, cells etc.
- **Rescale Graph:** use to bring the viewable extent of the display to the default value
- **Configure Display:** use to invoke the display configuration tool. (see next paragraph)
- **Save:** use to save the current display settings (scale and position) for the future use. This setup data is saved in the setup file in the RCM installation folder and not in the current campaign.

5.1.2 Advanced display configuration

The advanced configuration of a display is **similar** for all displays: XY/accuracy/coverage/cell/RA display and the display for timestamp analysis and barometric correction. By clicking ‘Configure display’ in the popup menu of a display the following configuration window is opened:



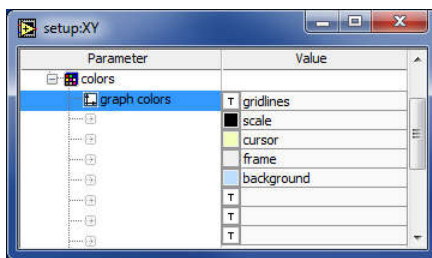
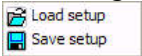


Figure 5-23: Display setup (typical entries values)

The display configuration tool typically contains the following entries

- **Units:** depends on the type of the screen (different units for each physical quantity can be selected, e.g. nautical miles, meters, kilometres, or degrees, radians etc.)
- **Displayed data:** subgroup
 - **Graph series:** changes colour and symbol for all the displayed series. Some series can be presented in multicolour, to do this there is a button next to the series name which makes this option active. When the multicolour presentation is enabled the colour of the series is ignored.
 - **Selection:** changes colour and style of the selected series.
 - **Show scales:** shows the scales of the graph (hide the scales to increase the viewable area of the graph)
 - **Show relief:** shows the relief in one layer of the graph
 - **Show tabular:** shows the tabular (or cell based information) as the second layer of the graph
 - **Full screen:** hides the title bar of the window and resize the viewable area of the display to the screen size
- **Colours:** subgroup
 - **Graph colours:** changes colour of the elements in the graph (background, frame, scale etc.)
 - **Relief colours:** the colours and heights correspond to the MSL values expressed in meters and the corresponding colour presentation in the display (when the relief data are available and the display is shown).
 - **Tabular colours:** (**Cell Colours**) correspond to the Probability of Detection, range accuracy, or azimuth accuracy depending on the mode of the cell statistic parameter configuration (main window). It may also represent other quantities, for example in the coverage display it represents the FL coverage extent.
 - **Interpolate colours:** is related to the tabular (cell based) colours mixing layer
 - **Transparency 1:** alpha blending coefficient between 1st and 2nd display layers if available (min max, 254 equals to the fully opaque)
 - **Transparency 2:** alpha blending coefficient between 2nd and 3rd display layers if available.

When you do a right mouse click in the display setup window, the following popup menu

appears: . This will be saved in a setup file in the RCM installation folder.



You must press ENTER to enable any parameter and display update in the display configuration setup.

5.2 Data Analyser

The radar data analyser (in older versions of the Radar Comparator it was named preprocessor) has been developed to measure errors of different nature that might be present in the data and therefore affect the radar performance analysis. In RCM data analysis it is possible to measure/correct the timestamp errors and barometric errors.

The barometric height correction should be performed in order to produce more accurate CMV (Coverage Measurement Volume) estimates and therefore more accurate radar statistics.

Timestamp errors can only be evaluated not corrected. Timestamp error analysis is often important for radar diagnostics and the program parameter adjustment, to check the integrity of the data, find scan based Pd drops etc.

The data analyser in RCD additionally provides eccentricity and refraction corrections as these were found to be important only when performing dual-source analysis (see RCD).

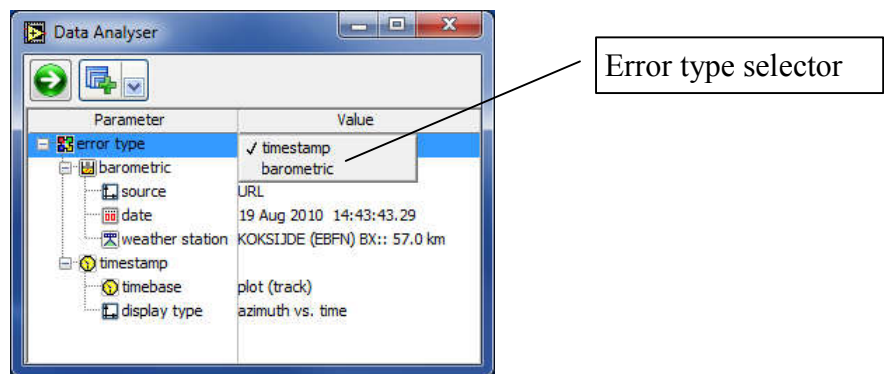

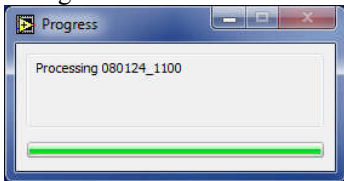
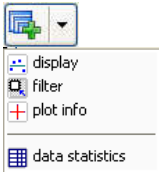


Figure 5-24: Data Analyser

The Data Analyser has a tree-structure configuration interface similar to the main window (see Figure 5-24)

Table 5-3: Data Analyser window: Control buttons

Button	Usage
	<p>Press to process the data according to the selected error type. Upon pressing this button, the RCM will read the data, indicated with following dialog:</p> 
	<p>Press 'display' to open the data analyser display for timestamp statistics and barometric sounding analysis. (See Figure 5-28: Timestamp display (Azimuth vs. Timestamp) and Figure 5-35: Sounding information display)</p> <p>Press 'filter' to open the filter. (See paragraph 5.3)</p> <p>Press 'plot info' to open the plot info dialog. (See paragraph 5.4)</p> <p>Press 'data statistics' to open a table for timestamp statistics. (See Figure 5-26:)</p>



The data analyser is only used for error analysis. To correct the selected errors the user must enable the corresponding correction flags in the RCM main window (subgroup Corrections).

5.2.1 Timestamp analysis

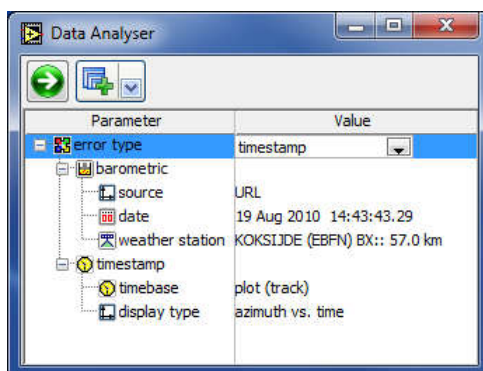


Figure 5-25: Data Analyser Timestamp Analysis

The timestamp analysis subgroup contains the following parameters:

- **timebase:** [north, sector 0, plot (track)] time reference.
- **display type:** [azimuth vs. time, error vs. azimuth, error vs. time, plot density vs. time] different displaying options for timestamp analysis.

Timestamp is an important parameter characterizing the overall accuracy of the radar. Investigating the radar plot (track) message dynamics in time provides the powerful tool for the radar diagnostics and troubleshooting.

Radars may produce various messages, non-synchronous with the main stream messages for e.g. RFM (remote field monitors) and synthetic targets, these messages can be synchronous but delayed from the ATC traffic plot (track) data. These non-related to the traffic data must be filtered out for timestamp analysis. Keeping them in the data set usually significantly affects the results. Any other irrelevant timestamp messages containing timestamp equal to 0, or abnormally high values should also be filtered out. (See section 5.3 for further details)

The timestamp error is generally calculated as follows. Using the north messages, sector 0 messages or plot messages (set by timebase) for a number of scans are grouped to produce a linear regression formula in order to measure the actual antenna rotation speed. Using this value and the azimuth of the plot the “true” timestamp value can be obtained. Difference between timestamp of the plot and the “true” timestamp is the time error.

Note this method has the following limitation, it assumes that the antenna performs uniform rotary motion, and the azimuth errors (as for example eccentricity, and/or mechanical vibration) are negligible. In presence of the non-uniform azimuth vs. time dependencies *the azimuth error may appear as the timestamp error*. **The timestamp error may actually point out to the eccentricity problem, but cannot be used to confirm the eccentricity. To confirm the ACP eccentricity use RASS-S gyroscope measurement.**

5.2.1.1 Data statistics

Running the timestamp analysis also produces data message statistics see table **Data statistics** (see Figure 5-26). It shows the message statistics and the timestamp statistics. Only explicit filtering is applied for this operation.

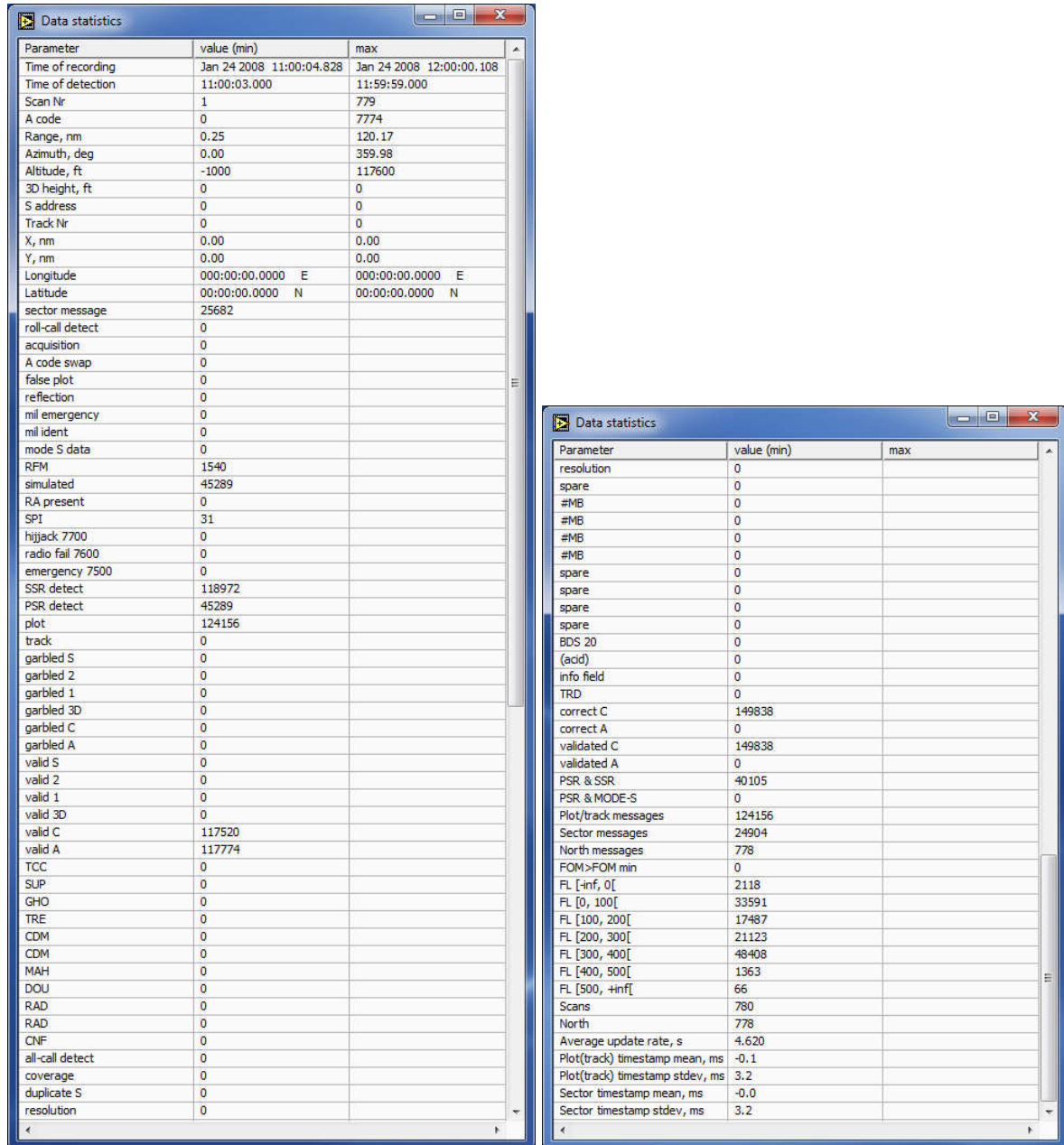


Figure 5-26: Data statistics

5.2.1.2 Timestamp analysis displaying options

In order to compute timestamp statistics select the error type [**timestamp**] and specify the desired graph type. The graph type control provides a number of possible display types [**azimuth vs. time**, error vs. time, error vs. azimuth, plot density vs. time].

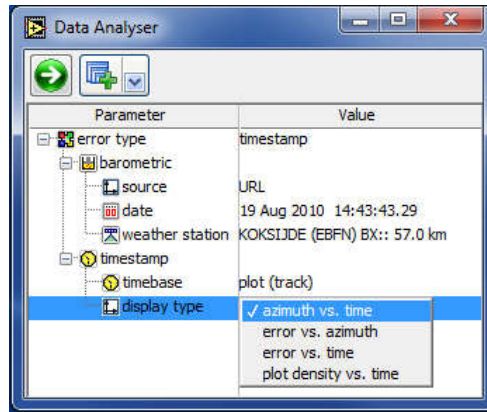



Figure 5-27: Display type

The plot density vs. time is particularly useful to detect scan based misses. Scan based misses are very dangerous, because their effect in Pd figures are usually limited, but if some targets may be missed for a number of scans this must be reported and investigated since it increases the possibility of an accident. Plot and sector messages are shown in the graphs if they are present (and not filtered out). To measure the specified type of error press .

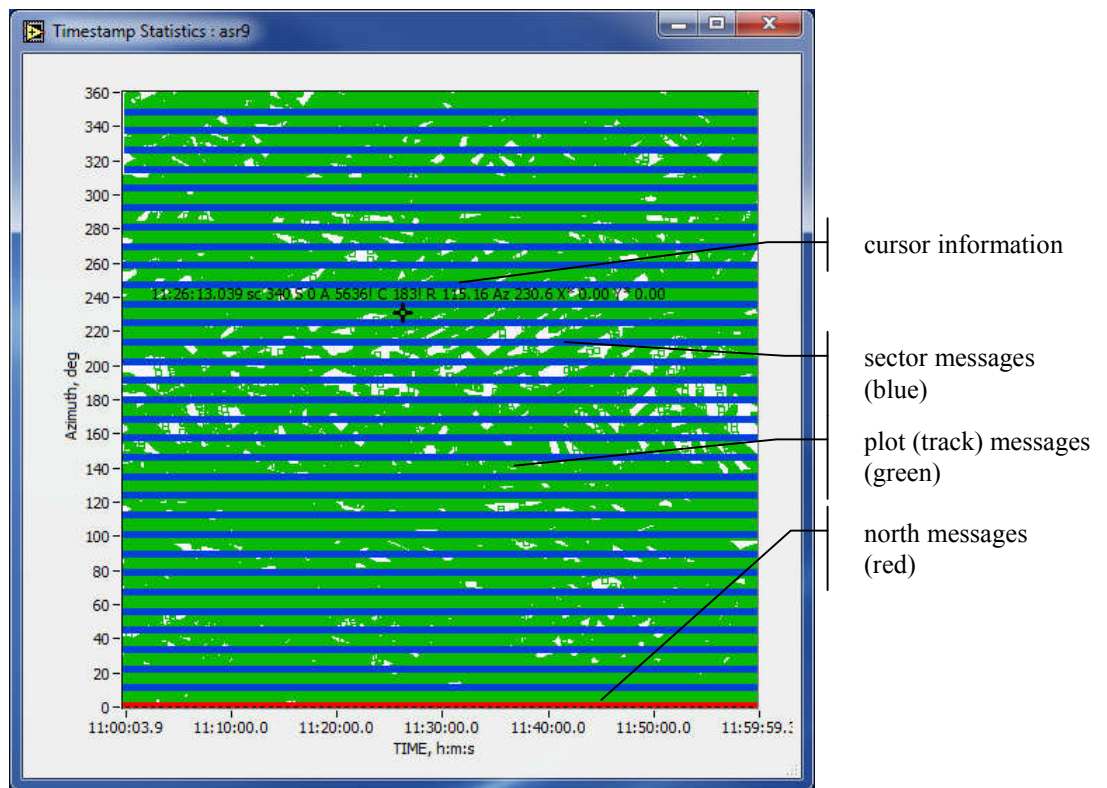


Figure 5-28: Timestamp display (Azimuth vs. Timestamp)



The data analyser doesn't apply the North bias information on the data.

The timestamp display has a cursor which produces the short info about the plot, containing radar ID, timestamp, A and C codes. For additional plot info data the **Plot Info** window (See paragraph 5.4) must be active, its content is updated with the plot data corresponding to the present cursor position.

The method for calculating the timestamp random error is the following. It is assumed that the antenna conducts a uniform rotation. Then the unwrapped plot azimuth vs. the timestamp must be a linear function. Using typically a few rotations of the antenna the linear regression fit (intercept and slope) are produced, the timestamp accuracy (random error) is calculated as the deviation of the actual timestamp from the established linear fit. For modern radar the timestamp jitter of <3 milliseconds (one sigma) is a typical result (See also Figure 5-26). Significantly higher timestamp jitter can be encountered, especially for the formats that don't contain the time of detection field. The timestamp is then produced by the recording device that depends on the data load and so may generate errors of an order of magnitude of a second.



The tool might not be able to measure the timestamp errors on the data acquired at a rate comparable with or exceeding the time of the antenna revolution as well as in the cases when the plot density is low or the traffic pattern vs. azimuth is very restricted due to the mountainous relief.

However this kind of problem with the measurement can be observed using the **data analyser display** window.

Timestamp accuracy is very important for radar analysis, because timing error becomes positional error. One must realize that the timestamp jitter of 100 milliseconds (standard deviation) is typically converted to 2-5 m extra random range error depending on the radar range accuracy orientation of the traffic and rotation speed of the antenna.

5.2.1.3 Timestamp Analysis and Correction: typical cases

Radars may produce non-synchronous as well as synchronous delayed messages for example remote field monitors and synthetic targets. These target reports may significantly affect the measured antenna rotation speed and generate additional errors in the timestamp error measurement.



Non-synchronous target reports, or any other irrelevant messages, must be filtered out before the timestamp analysis. (See section 5.3 for further details)

Performing timestamp statistics (data analyser) is directly beneficial for both types of the analysis (RCM and RCD). First of all the user should verify **integrity of the recording**, should the stream be interrupted (a number of empty scans), the reason for such an artefact should be investigated prior to conducting the further analysis.

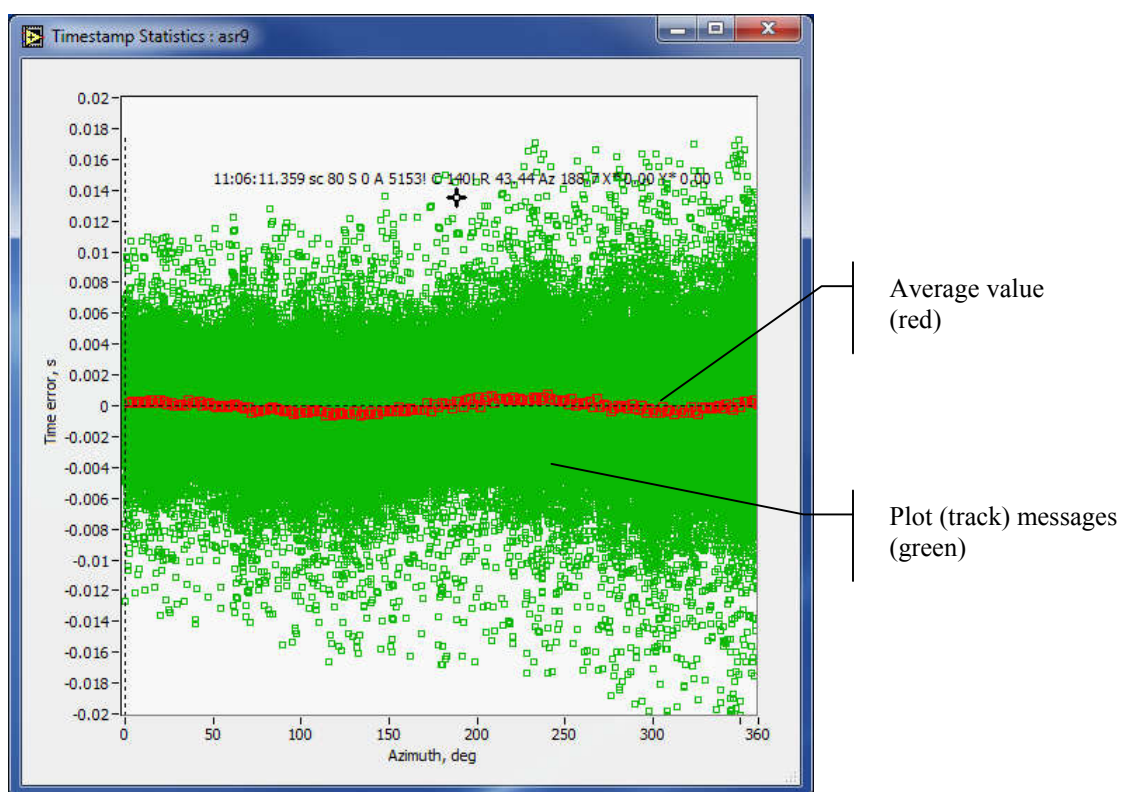


Figure 5-29: Error vs. Azimuth (sector messages filtered)

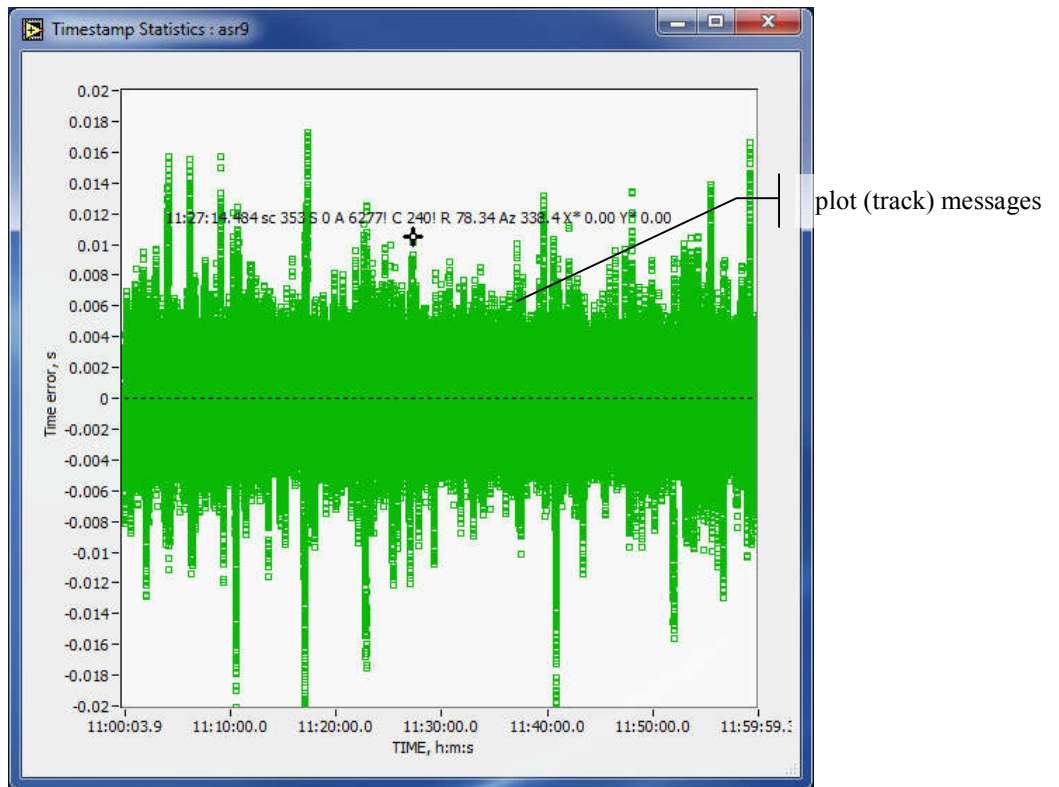


Figure 5-30: Error vs. Time (sector messages filtered)

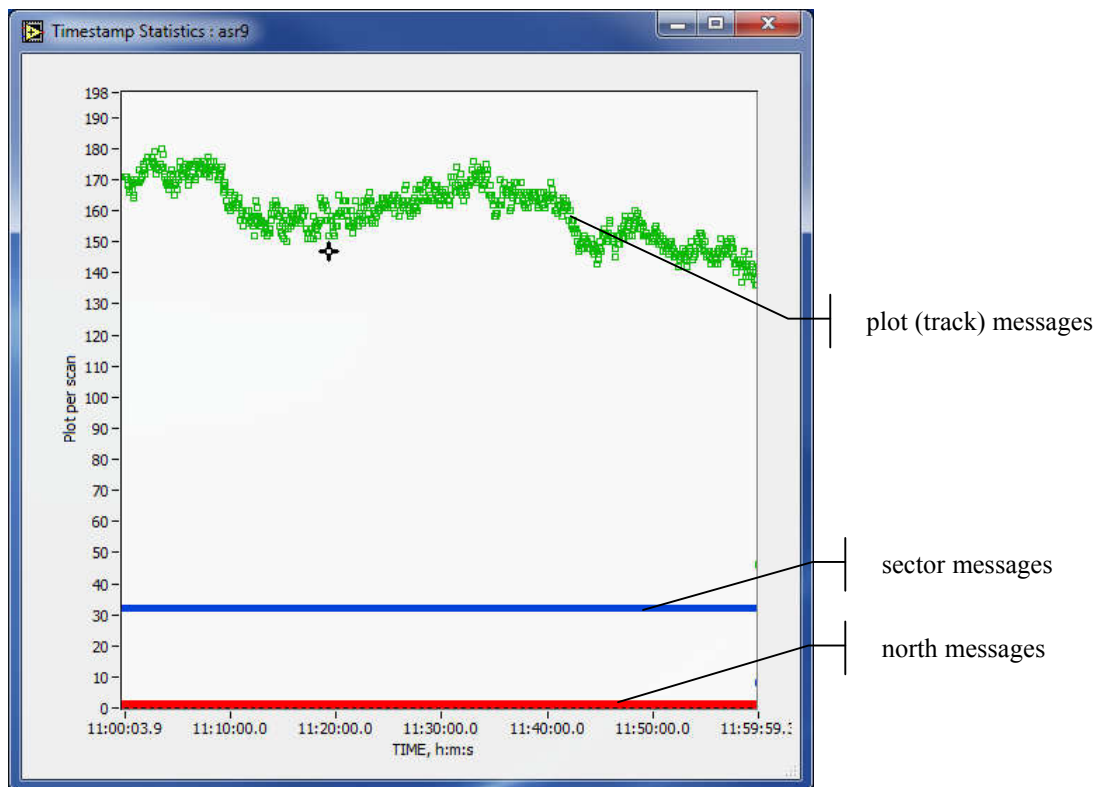


Figure 5-31: Plot density vs. Time

5.2.2 Barometric error analysis and correction

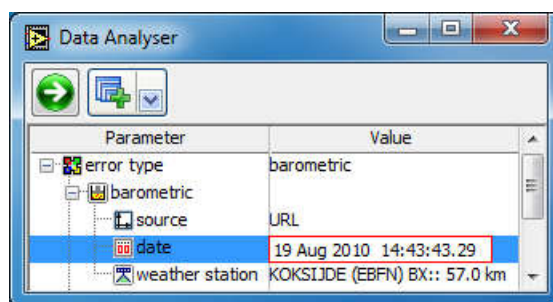


Figure 5-32: Data Analyser: Barometric correction


The barometric error analysis contains the following parameters:

- **source:** [URL, file] download barometric sounding file(s) from internet or analyze the file selected in the radar node.
- **date:** [current date] the current date or the date of the last stored setup.
- **weather station:** [list] list of the world weather stations containing 10 nearest stations according to the specified coordinates in the radar node.



If the weather station list is not updated indicates that the tool doesn't find a balloon sounding nearby. It is recommended to go to the website and download it manually.

5.2.2.1 Retrieve soundings from internet

In order to retrieve the relevant barometric sounding data over the Internet select the error type [barometric] and specify the date and hour of the recording. The hour is important because most Western countries make the soundings measurements twice a day. The closest match in time will be selected. The time of the sounding will be present in the downloaded filename. Then select one of the stations proposed in the list [weather station], for example **06260 De Bilt (EHDB) :: 147.2 km**. The displayed distance is the distance from the radar position to the measurement station. Press  to proceed. The web browser window will appear (see Figure 5-33), wait till the contents is retrieved from the web, then press **Save**. If there is no sounding available for the selected date time station or the data appear to be corrupted, please close the window without saving the file, and try again using other stations from the list as an alternative.

Whenever the sounding is stored, the name will be automatically generated using your query [station #, date, and hour] the display will popup and graphically display the obtained data.

06260 EHDB De Bilt Observations at 12Z 19 Aug 2010

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot
1014.0	4	17.6	12.6	72	9.11	250	6
1009.0	46	17.4	12.0	71	8.82	235	10
1000.0	123	17.0	11.0	68	8.30	240	13
944.0	609	12.6	9.1	79	7.73	255	20
925.0	781	11.0	8.4	84	7.53	255	19
911.0	908	9.8	7.9	88	7.39	256	20
885.0	1149	8.4	3.5	71	5.59	258	21
850.0	1481	5.6	2.5	80	5.42	260	22
845.0	1529	5.2	3.1	86	5.69	260	22
839.0	1587	5.0	2.7	85	5.57	260	21
814.0	1834	4.3	0.9	79	5.06	245	18
812.0	1854	4.2	0.8	79	5.02	246	18

Figure 5-33: Sounding file browser

When you press the Save button, the data is automatically saved in the following path: MYCAMPAIGN\DATA\SOUNDINGS, for example:

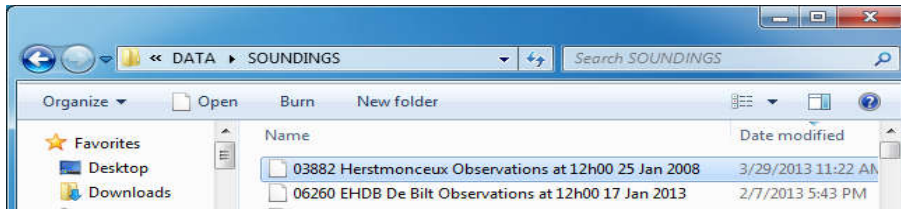



Figure 5-34: Saved sounding files

When the data is downloaded to inspect the result you may press the menu button  in the data analyser window and select **display** option. Then, the display below will be shown:

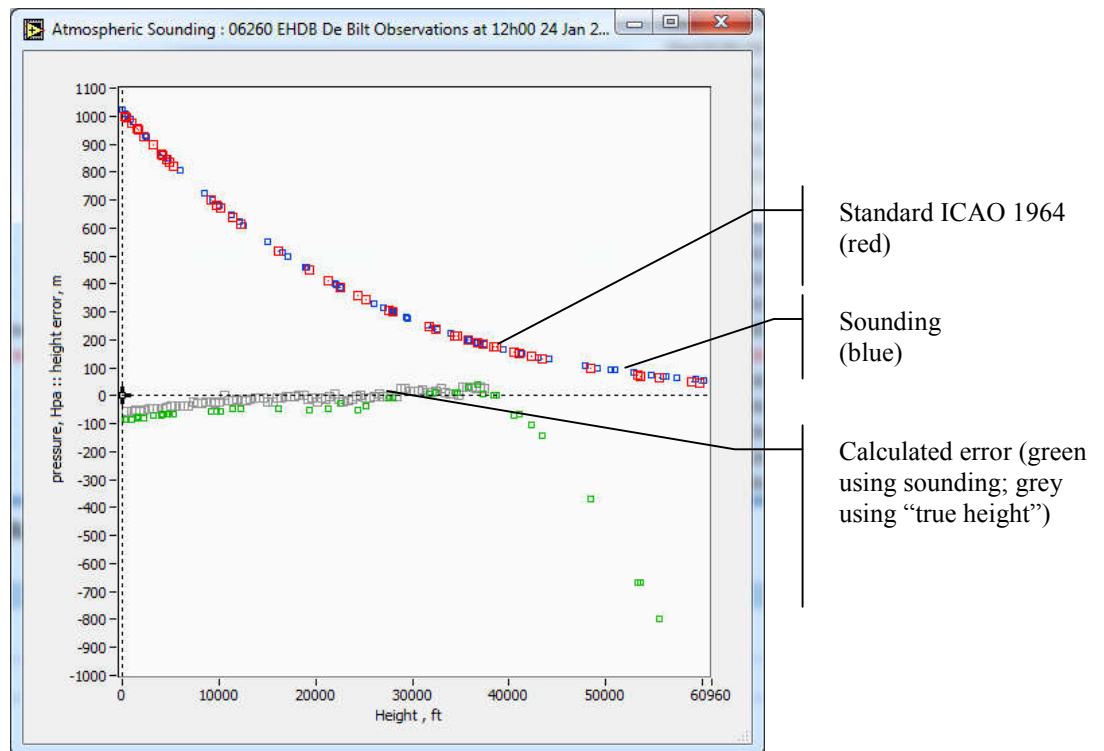


Figure 5-35: Sounding information display

When the data is received the graph indicator will show the sounding consisting of 3 or 4 curves. The red curve is the default relation between atmospheric pressure and height, as being defined in ICAO 1964.

The blue curve in the example above, represent the sounding data retrieved from the internet. So there are as many points as the sounding data contains measurements.

The green curve is the calculated height error in [m] by comparing the balloon sounding to ICAO 1964 standard atmosphere.

An optional 4th grey curve is available whenever an ADS-B recording with GPS height is selected in the main setup window. The error is the average height difference in [m] between the GPS height and barometric height.

The user always should inspect the sounding data integrity and consistency before applying the barometric correction.



Some sounding files contain height vs. pressure data only up to a few km high, probably due balloon damage. In such cases it is advisable not to use the data for the correction. Routinely there are two soundings a day in most European countries and USA, taken at 00:00 and 12:00. However for some world locations the data were found to be available only once a week⁴. If sometimes for the selected station the data is unavailable, another station in the neighbourhood might be used. In general the pressure vs. height distribution stays quite uniform for hundred kilometres areas except for abrupt weather changes.

⁴ Even soundings obtained on the weekly basis might be useful to draw a conclusion about the errors that might exist if no barometric correction is applied. In general there are always a number of recordings taken on the dates when the soundings data are available. So that significant discrepancies might be discovered when performing the Radar Comparator Dual analysis with and without the barometric correction. The user must realize that whenever the barometric correction is unavailable the results might be contaminated (range bias and range gain) with an errors of the similar magnitude. ADS-B data typically do not require the barometric correction if they contain the true height.

When the sounding file is saved to the disc (MYCAMPAIGN\DATA\SOUNDINGS) the main window will be updated as given in Figure 5-36.

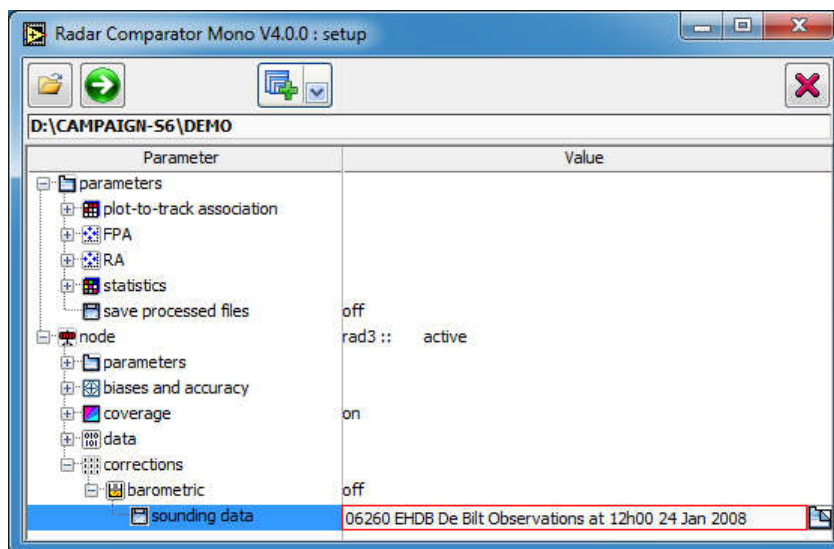



Figure 5-36: Select a sounding file

You may still want to download other soundings and select one of the files afterwards using **sounding data** selector: . When pressing this, the following file dialog showing the current content of the subfolder where the sounding files are stored will appear:

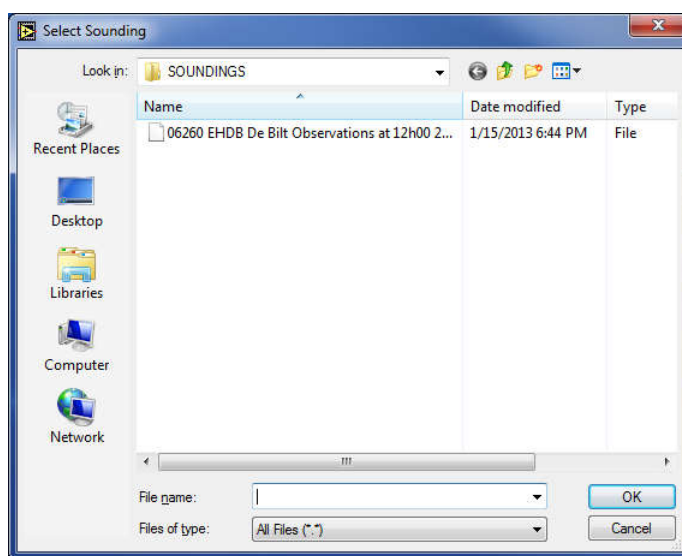


Figure 5-37: Select sounding file

When no file or an invalid sounding file is selected while running data analyser set to barometric error type and file as source, the following dialog will appear:

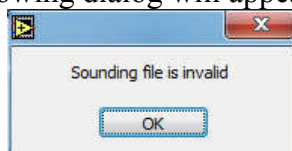


Figure 5-38: Invalid sounding file



Test a file with data analyser before running the main process. No warning message will be displayed at runtime should an invalid, corrupt or even no sounding file been selected.

5.2.2.2 Sounding files from any internet browser

You can alternatively use any internet browser software on a standalone computer and save the downloaded page as *.txt (or *.html), if you do not have the direct network access on the RASS-R computer. (<http://weather.uwyo.edu/upperair/sounding.html>)

A sample of the sounding file is given below in Figure 5-39. You must copy the file(s) into MYCAMPAIGN/DATA/SOUNDINGS folder. Select the file you want to use using **sounding data** control in the main window (see Figure 5-36).

06260 EHDB De Bilt Observations at 12Z 24 Jan 2008											
PRES	HGHT	TEMP	DWPT	RELH	MIXR	DRCT	SKNT	THTA	THTE	THTV	
hPa	m	C	C	%	g/kg	deg	knot	K	K	K	
1023.0	4	10.0	8.3	89	6.76	230	12	281.3	300.0	282.5	
1022.0	12	9.9	8.3	89	6.75	210	16	281.3	300.0	282.5	
1010.0	111	9.2	8.0	92	6.69	200	21	281.6	300.1	282.7	
1000.0	195	8.6	7.7	94	6.63	210	21	281.8	300.1	282.9	
989.0	286	7.6	7.3	98	6.52	225	24	281.6	299.8	282.8	
978.0	378	7.3	7.0	98	6.48	240	27	282.2	300.3	283.3	
931.0	783	6.0	5.9	100	6.31	270	35	284.9	302.7	286.0	
925.0	836	5.8	5.8	100	6.29	270	35	285.2	303.0	286.3	
868.0	1354	2.6	2.6	100	5.36	270	31	287.2	302.6	288.1	
850.0	1524	1.6	1.6	100	5.08	265	31	287.8	302.5	288.7	
804.0	1967	-1.0	-1.3	98	4.35	250	39	289.7	302.4	290.4	
726.0	2779	-5.7	-6.6	93	3.23	250	46	293.1	302.8	293.6	
700.0	3065	-6.7	-7.0	98	3.25	250	49	295.0	304.9	295.6	
679.0	3303	-7.3	-9.1	87	2.84	250	51	296.9	305.7	297.4	
647.0	3678	-9.9	-13.2	77	2.15	250	55	298.1	304.9	298.5	
622.0	3981	-12.5	-15.1	81	1.91	250	59	298.5	304.6	298.9	
611.0	4117	-13.3	-15.7	82	1.85	250	60	299.1	305.0	299.5	
550.0	4913	-17.9	-19.5	87	1.49	242	59	302.8	307.7	303.1	
512.0	5445	-21.7	-22.4	94	1.25	237	59	304.4	308.6	304.7	
500.0	5620	-23.1	-24.2	91	1.09	235	58	304.8	308.5	305.0	
461.0	6209	-27.2	-29.8	79	0.71	230	60	306.9	309.4	307.0	
458.0	6257	-27.5	-30.2	78	0.68	230	61	307.1	309.4	307.2	
400.0	7220	-32.7	-36.1	72	0.44	240	82	312.4	314.0	312.5	
399.0	7238	-32.9	-36.5	70	0.42	240	82	312.4	313.9	312.4	
389.0	7411	-34.4	-38.3	68	0.36	240	85	312.6	314.0	312.7	
329.0	8559	-44.5	-50.5	51	0.11	246	84	314.1	314.6	314.2	
314.0	8870	-46.5	-53.5	45	0.08	248	84	315.6	315.9	315.6	
302.0	9126	-48.5	-52.8	61	0.09	250	84	316.3	316.7	316.3	
300.0	9170	-48.7	-53.0	61	0.09	250	84	316.6	317.0	316.6	
297.0	9236	-49.1	-57.1	39	0.06	250	84	316.9	317.2	317.0	
279.0	9646	-52.3	-66.3	17	0.02	250	85	318.1	318.1	318.1	
278.0	9669	-52.5	-66.3	17	0.02	250	85	318.1	318.2	318.1	
250.0	10350	-58.1	-66.1	35	0.02	245	87	319.6	319.7	319.6	
237.0	10683	-60.4	-67.9	36	0.02	240	91	321.1	321.1	321.1	
221.0	11120	-63.3	-70.3	38	0.01	240	87	323.0	323.1	323.0	
200.0	11740	-59.9	-77.9	8	0.00	250	80	337.8	337.8	337.8	
198.0	11803	-59.9	-77.9	8	0.00	252	77	338.7	338.7	338.7	
190.0	12063	-53.9	-77.9	4	0.00	258	68	352.4	352.4	352.4	
188.0	12131	-53.6	-78.2	3	0.00	260	66	353.9	353.9	353.9	
183.0	12304	-52.9	-78.9	3	0.00	258	63	357.8	357.8	357.8	
166.0	12930	-53.7	-80.7	2	0.00	250	51	366.6	366.6	366.6	
152.0	13495	-54.4	-82.3	2	0.00	255	60	374.7	374.8	374.7	
150.0	13580	-54.5	-82.5	2	0.00	255	60	376.0	376.0	376.0	
138.0	14104	-55.7	-82.9	2	0.00	265	51	382.9	382.9	382.9	
130.0	14480	-56.6	-83.2	2	0.00	255	43	387.9	387.9	387.9	
107.0	15704	-59.5	-84.2	3	0.00	260	58	404.6	404.6	404.6	
100.0	16130	-60.5	-84.5	3	0.00	270	51	410.6	410.6	410.6	
93.0	16579	-62.4	-86.4	3	0.00	280	37	415.4	415.4	415.4	
91.2	16700	-62.9	-86.9	3	0.00	275	37	416.8	416.8	416.8	
82.0	17359	-61.6	-87.2	2	0.00	265	41	432.2	432.2	432.2	
74.4	17961	-60.5	-87.5	2	0.00	271	32	446.8	446.8	446.8	
70.0	18340	-61.5	-88.5	2	0.00	275	27	452.5	452.5	452.5	
69.0	18428	-61.8	-88.5	2	0.00	275	25	453.7	453.7	453.7	
65.0	18796	-63.1	-88.5	2	0.00	255	33	458.6	458.6	458.6	
58.3	19465	-65.5	-88.5	3	0.00	270	44	467.7	467.8	467.7	
56.0	19710	-65.5	-88.5	3	0.00	275	49	473.1	473.2	473.1	
50.0	20400	-65.5	-88.5	3	0.00	275	39	488.7	488.7	488.7	
49.0	20523	-65.6	-88.6	3	0.00	270	37	491.2	491.3	491.2	
44.0	21178	-66.3	-89.3	3	0.00	260	47	505.0	505.0	505.0	
43.9	21191	-66.3	-89.3	3	0.00	260	47	505.3	505.3	505.3	
40.6	21668	-64.3	-88.3	2	0.00	273	49	521.7	521.7	521.7	
39.0	21911	-65.3	-89.0	2	0.00	280	51	525.1	525.1	525.1	
35.0	22565	-68.1	-90.8	3	0.00	305	41	534.5	534.5	534.5	
31.8	23144	-70.5	-92.5	3	0.00	296	38	542.8	542.8	542.8	
30.0	23490	-70.7	-92.7	3	0.00	290	37	551.4	551.4	551.4	
28.0	23898	-71.1	-93.1	3	0.00	275	43	561.1	561.2	561.1	
26.0	24336	-71.6	-93.6	3	0.00	280	51	571.9	571.9	571.9	
25.5	24451	-71.7	-93.7	3	0.00			574.7	574.7	574.7	

Station information and sounding indices
 Station identifier: EHDB
 Station number: 6260
 Observation time: 080124/1200
 Station latitude: 52.09
 Station longitude: 5.17
 Station elevation: 4.0
 Showalter index: 4.19
 Lifted index: 5.76
 LIFT computed using virtual temperature: 5.82
 SWEAT index: 147.64
 K index: 26.00
 Cross totals index: 24.70
 Vertical totals index: 24.70

```
Totals totals index: 49.40
Convective Available Potential Energy: 0.00
  CAPE using virtual temperature: 0.00
    Convective Inhibition: 0.00
      CINS using virtual temperature: 0.00
        Bulk Richardson Number: 0.00
          Bulk Richardson Number using CAPV: 0.00
Temp [K] of the Lifted Condensation Level: 280.47
Pres [hPa] of the Lifted Condensation Level: 982.31
Mean mixed layer potential temperature: 281.91
  Mean mixed layer mixing ratio: 6.58
    1000 hPa to 500 hPa thickness: 5425.00
Precipitable water [mm] for entire sounding: 21.78
Description of the data columns or sounding indices.
```

```
-----
Interested in studying meteorology? Check out our graduate program or undergraduate degree in Earth System Science.
-----
Questions about the weather data provided by this site can be addressed to Larry Oolman (lcoolman@uwo.edu)
-----
```

Figure 5-39: An example of the sounding file saved as text

5.3 Filter

To select a subset from the data for analysis (main process and/or data analyser) one can set a filter.

Open the filter from the main window by pressing  and selecting **filter** from the list.

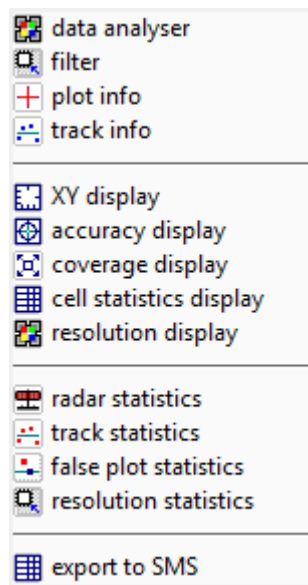


Figure 5-40: General utilities and display menu

The **Filter** window is organized just as the rest of the setup interfaces of the software i.e. using the tree-structure to create new (and edit existing) filters. The filter may contain a number of units logically ANDed. Each unit may be active or idle; if idle the content of the unit is ignored

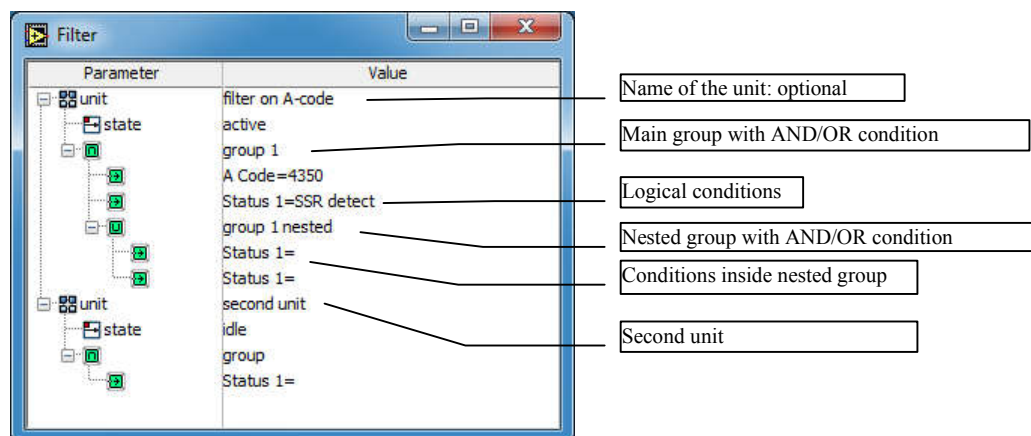




Figure 5-41: Filter dialog

The unit can contain a number of nested conditions structured as a group of conditions. The relation between these conditions are determined by the Boolean operator of the group  for AND and  for OR.

A group can again contain other groups, determining an AND/OR relation for its own conditions. AND/OR operator type can be toggled using the popup menu.

The filter window doesn't contain controls; filter editing, storage and loading are performed by using the corresponding popup menus. Right mouse click to popup the menu which contains the following items:

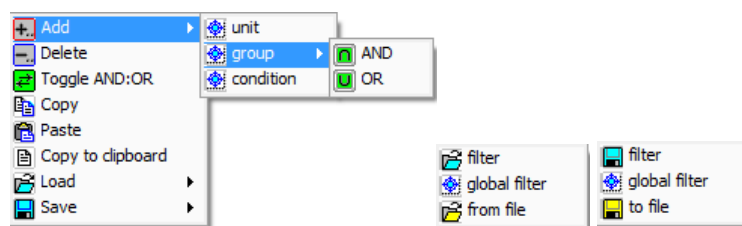



Figure 5-42: Right click menu in filter (with right the Load and Save options)

- **Add:**
 - **Unit** adds a new filter unit to the tree
 - **Group** adds a new AND/OR group inside the main group of the selected unit
 - **Condition** adds a condition to the selected group
- **Delete:** deletes selected content (condition, group, or unit). The removal of the selected content can also be produced by pressing the Delete key.
- **Toggle AND::OR:** toggles the current group operator between **AND** and **OR**.
- **Copy:** copies an existing unit/group/condition selected by the cursor.
- **Paste:** pastes the copied unit/group/condition at the specified location.
- **Copy to clipboard:** it makes a spreadsheet copy of the parameters that can be pasted to a document for reporting purposes. (E.g. Microsoft Excel, notepad)
- **Load**
 - **Filter:** loads the last stored filter from the setup file in its own campaign folder, the storage is locally accessible. (See Figure 4-10)
 - **Global filter:** loads the last stored global filter from the setup file in the RCM installation folder, the global filter storage is visible from any campaign
 - **From file:** loads the filter from any other setup file (any other location)
- **Save**
 - **Filter:** saves the current filter to the setup file in current campaign folder, the storage is locally accessible. (See Figure 4-10)
 - **Global filter:** saves the current filter to the setup file in the RCM installation folder, the global filter storage is visible from any campaign
 - **To file:** select in which setup file to save the current filter (any location). This is useful if you want to use filters throughout different campaign folders as well. A standard file dialog is invoked to specify filename and location.

A unit, and or a group can contain a comment field making the filter configuring more user-friendly.

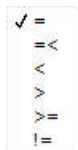
If the filter content is changed after the processing has been done the processing button  in the main window becomes active again and you can redo the plot to track association.



The filter dialog doesn't have to be open in order to be used when processing.

5.3.1 Filter fields

To add a condition for a filter, you can select fields given in Table 5-4 and use one of the



available conditions:

The fields which you can filter on represent items in S4 files data, originating from an original data type (for example ASTERIX CAT001/048). For correct understanding of all fields, use the different ICD's from the radar data protocols as well.

Table 5-4: Filter fields

Item	Filter on [explanation]						
Radar	Filter on radar ID for RCD, Ref is 0 and RUT is 1.						
# PSR Refl.	Number of PSR reflections or hits used by the radars plot extractor						
# SSR Refl.	Number of SSR reflections or replies used by the radars plot extractor						
# seg CC/CA							
# seg CD/AICB							
1 Code	Mode-1 [octal representation]						
2 Code	Mode-2 [octal representation]						
3D Code							
A Code	A-code [octal representation]						
ARP/ACP							
Altitude	Altitude [meters] (C-code)						
Azimuth	Azimuth [deg]						
CAP/STS							
Com/FS/ACAS							
Coverage							
Cubicle ⁵	<table border="1"> <tr><td>50</td></tr> <tr><td>100</td></tr> <tr><td>25</td></tr> <tr><td>75</td></tr> <tr><td>0</td></tr> <tr><td>500</td></tr> </table> upon confirmation the entry will show: Cubicle! = x[50.0,100.0]nm y[25.0,75.0]nm h[0,500]FL	50	100	25	75	0	500
50							
100							
25							
75							
0							
500							
D6 Spec 1							
D6 Spec 2							
DRN							
Datalink Counters							
Datalink type							
Flight Level	Flight level						
FOM	Figure Of Merit (ADS-B)						
Format							
Heading	[deg]						
I048/230	Communications / ACAS Capability and Flight Status						
ID 1							
ID 2							
Index							
Lat	Latitude [hh:mm:ss.sss]						
Long	Longitude [hh:mm:ss.sss]						
MB1-7	Mode-S MB data [hex]						
Offset							
Overlap							
Power	Reported Power (SSR or PSR power depending on convert setup, typically SSR power in case of a combined target report)						
RDIF 8&9							
Range	Range [NM]						
Ref Code							
Ref 43 till 60							
Ref code 1							
Ref code 2							
Reflector							
Run Length							
S Address	S-address						

⁵ Temporarily not supported (RCM v4.0.0)

S/D	3D height (PSR height or GPS height if source is ADS-B)
Scan Nr	Scan number
Set	
Source/Dest	
Status 1	
↳ Sector message	Sector message
↳ Roll-call detect	Roll-call detect bit set
↳ Coverage	Coverage bit set
↳ Correct C	Correct C bit set
↳ False plot	False plot bit set
↳ reflection	Reflection bit set
↳ Mil emergency	Military emergency bit set
↳ Mil ident	Military identification bit set
↳ Mode S data	Mode-s data bit set
↳ Simulated	Simulated target bit set
↳ RFM	Remote field monitor bit set
↳ RA Present	
↳ SPI	Special Purpose Indicator bit set
↳ Hijack 7700	
↳ Radio fail 7600	
↳ Emergency 7500	
↳ SSR detect	SSR detected
↳ PSR detect	PSR detected
↳ Plot	Plot target
↳ Track	Track target
↳ Valid S/2/1/3D/C/A	Valid bit for selected mode set
↳ Garbled S/2/1/3D/C/A	Garbled bit for selected mode set
Status 2/3	(the status 3 field definition is highly dependent on original data source, refer to S4 ICD)
↳ TCC	TCC bit in I048/170 (type of plot coordinate transformation mechanism)
↳ SUP	SUP bit in I048/170
↳ GHO	GHO bit in I048/170 (Ghost vs. true target)
↳ TRE	TRE bit in I048/170 (signal for end of track)
↳ CDM	CDM bit in I048/170 (climbing/descending mode)
↳ MAH	MAH bit in I048/170 (manoeuvre detection in horizontal sense)
↳ DOU	DOU bit in I048/170 (signals level of confidence in plot to track association process)
↳ RAD	
↳ RAD	RAD bit in I048/170 (type of sensor maintaining track)
↳ CNF	CNF bit in I048/170 (Confirmed vs. Tentative Track)
↳ all-call detect	All-Call detect bit set
↳ manual	
↳ SPI	SPI bit set
↳ duplicate S	
↳ resolution	
↳ #MB	
↳ BDS20	BDS 20 (AC ID) data present
↳ (acid)	
↳ Info field	
↳ TRD	
↳ Track start	
↳ Track drop	
↳ spare	
↳ Correct A	
Surveillance	
TIS	
Timestamp TOD	Time Of Detection [hh:mm:ss.sss]
Timestamp TOR	Time Of Recording [hh:mm:ss.sss]
TP nr	
Target Gen	
Target ID	
Target IDh	
Target IDl	
Track Nr	Track number
Track X	Calculated X position (NM) (only in result file from previous analysis with RC or Pd&Acc.)
Track Y	Calculated Y position (NM) (only in result file from previous analysis with RC or Pd&Acc.)
Type	
Velocity	Velocity according to I048/200 (calculated track velocity in polar coordinates)
X (Nm)	Reported X position (NM)
Y (Nm)	Reported Y position (NM)
Δ Azimuth	
Δ Range	

Δ Time	
---------------	--

5.3.2 Typical filter examples

Example 1: Filter on S-address

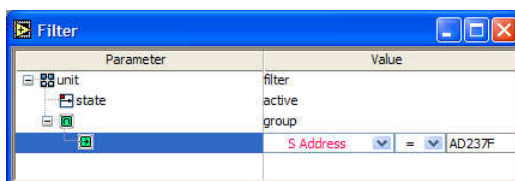


Figure 5-43: Filter example 1

Example 2: Filter on S-address AND A-code

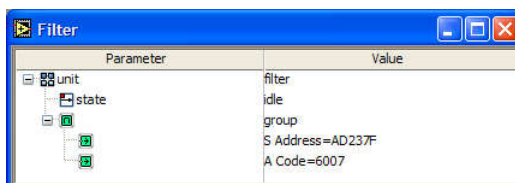


Figure 5-44: Filter example 2

Example 3: remove track ends and zero time stamped messages from the data set (for example when you noticed zero timestamp messages in the timestamp data analyser)

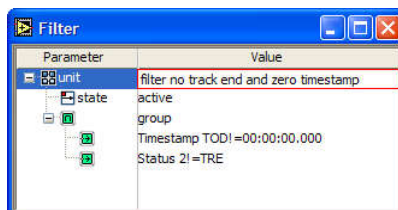


Figure 5-45: Filter example 3

Example 4: remove sector messages

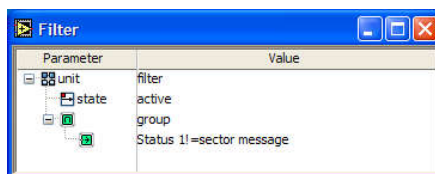


Figure 5-46: Filter example 4



From RCM version 3.4.2, north messages are be implicitly kept for the processing for the scan boundaries calculations

Example 5: only select Mode-S all-calls and roll-calls in the data set. (Or condition.)

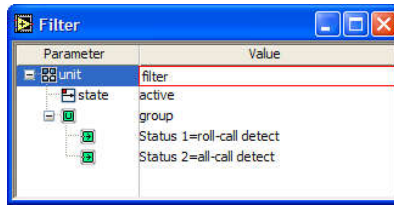



Figure 5-47: Filter example 5

5.4 Plot (track) info

Open the plot (track) info from the main window by pressing  and selecting **plot info** from the list.

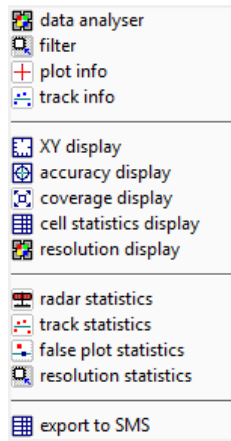


Figure 5-48: General utilities and display menu

The plot (track) info window shows info for a plot selected by the cursor in one of the RCM (RCD) displays. A number of lines can be highlighted (blue) in order to improve the readability. Validity of 3/A- and C-codes is shown by an exclamation mark next to the code. By selecting the Status fields, the detailed status information becomes available.



Figure 5-49: Plot to track info

From RCM version 3.4.2 and further on, the content of the Info window can be configured by the user. By right clicking in the Info window, the user can add or delete a field, and save the setup.

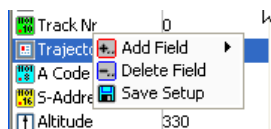
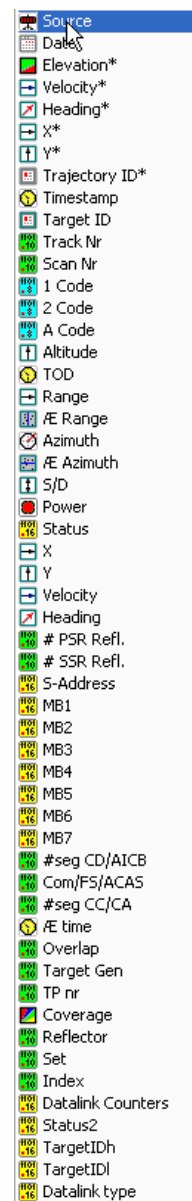


Figure 5-50: Right click in Info window

The following table further explains a few of the information fields which are available in the S4 data per ICD. (See reference [7] and [8]). Values with an asterisk (*) are calculated by the RCM.

Table 5-5: Info window explanation

Name	Explanation
Source	Name of the radar source
Date	Date of recording
Elevation*	Elevation of the target
X*	Calculated X position
Y*	Calculated Y position
Trajectory ID*	Trajectory ID, assigned by the RCM
Timestamp	TOR
Δ E Range	Delta range
Δ E Azimuth	Delta azimuth
S/D	3D height (PSR) or GPS height (ADS-B)
Status field	See Annex [7] and Annex [8]
X	Reported X position
Y	Reported Y position
# PSR Reflections	Number of PSR reflections (or depend on the converter tool used)
# SSR Reflections	Number of SSR replies (or depend on the converter tool used)
Δ E Time	Delta time
Coverage	The plot is in or out coverage with respect to the coverage file
Status2	See Annex [7] and Annex [8]



5.5 Track Data

Users may need to export a particular track to another program or document for reporting purposes. The Track Data table (see Figure 5-51), launched by selecting Track Info in the main menu, lists the most significant parameters for all plots linked by the RCM to a selected track. When scrolling in the track data table, the plot number is cross linked with the XY display and the accuracy display.

#	TOD	Timestamp	Track Nr	Scan Nr	S Address	A Code	Altitude	Range	Azimuth	X*	Y*	Type
0	11:00:04.156	11:00:04.983	0	1	0	6615	360	217.81	0.338	72.16	205.38	SSR...3/A!..C!
1	11:00:08.773	11:00:09.608	0	2	0	6615	360	217.70	0.334	71.25	205.58	SSR...3/A!..C!
2	11:00:13.398	11:00:14.250	0	3	0	6615	360	217.58	0.329	70.35	205.76	SSR...3/A!..C!
3	11:00:18.015	11:00:18.890	0	4	0	6615	360	217.47	0.326	69.60	205.90	SSR...3/A!..C!
4	11:00:22.632	11:00:23.483	0	5	0	6615	360	217.38	0.321	68.62	206.13	SSR...3/A!..C!
5	11:00:27.257	11:00:28.140	0	6	0	6615	360	217.29	0.317	67.73	206.34	SSR...3/A!..C!
6	11:00:31.875	11:00:32.750	0	7	0	6615	360	217.20	0.313	66.91	206.51	SSR...3/A!..C!
7	11:00:36.492	11:00:37.358	0	8	0	6615	360	217.12	0.309	65.93	206.74	SSR...3/A!..C!
8	11:00:41.109	11:00:41.968	0	9	0	6615	360	217.03	0.305	65.11	206.90	SSR...3/A!..C!
9	11:00:45.726	11:00:46.593	0	10	0	6615	360	216.94	0.301	64.21	207.09	SSR...3/A!..C!
10	11:00:50.335	11:00:51.233	0	11	0	6615	360	216.86	0.296	63.23	207.30	SSR...3/A!..C!

Figure 5-51: Track data table

Labels shown in the “Type”-column are: PSR (PSR detected), SSR (SSR detected), all-call, roll-call, 3/A! (valid 3/A code), C! (valid C code). ADS-B targets are displayed as “roll call” and “C!”.

In RCM version 3.4.2 and further on the user can add any field, available in the S4 data, to the track data table. By right clicking in the Track data table, the following options are possible:

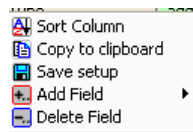


Figure 5-52: Right click in the track data table

Adding a field invokes the same table as in Table 5-5: Info window explanation.

5.6 Displays

5.6.1 XY Display

The XY display can display trajectories, detections (true), misses, false plots, incorrect code reports, maps, relief, airports and runways, screening information expressed with equipotential FL lines, cell based statistical results depending on the settings, in coverage and out coverage plots(tracks), The display can be readjusted to fit the available viewable area, and easily reconfigured to display required amount of the data. The cursor will show the data items of the selected plot. Moving the cursor in this display cross-links the cursor with the accuracy display, the track data table and the track statistics table.

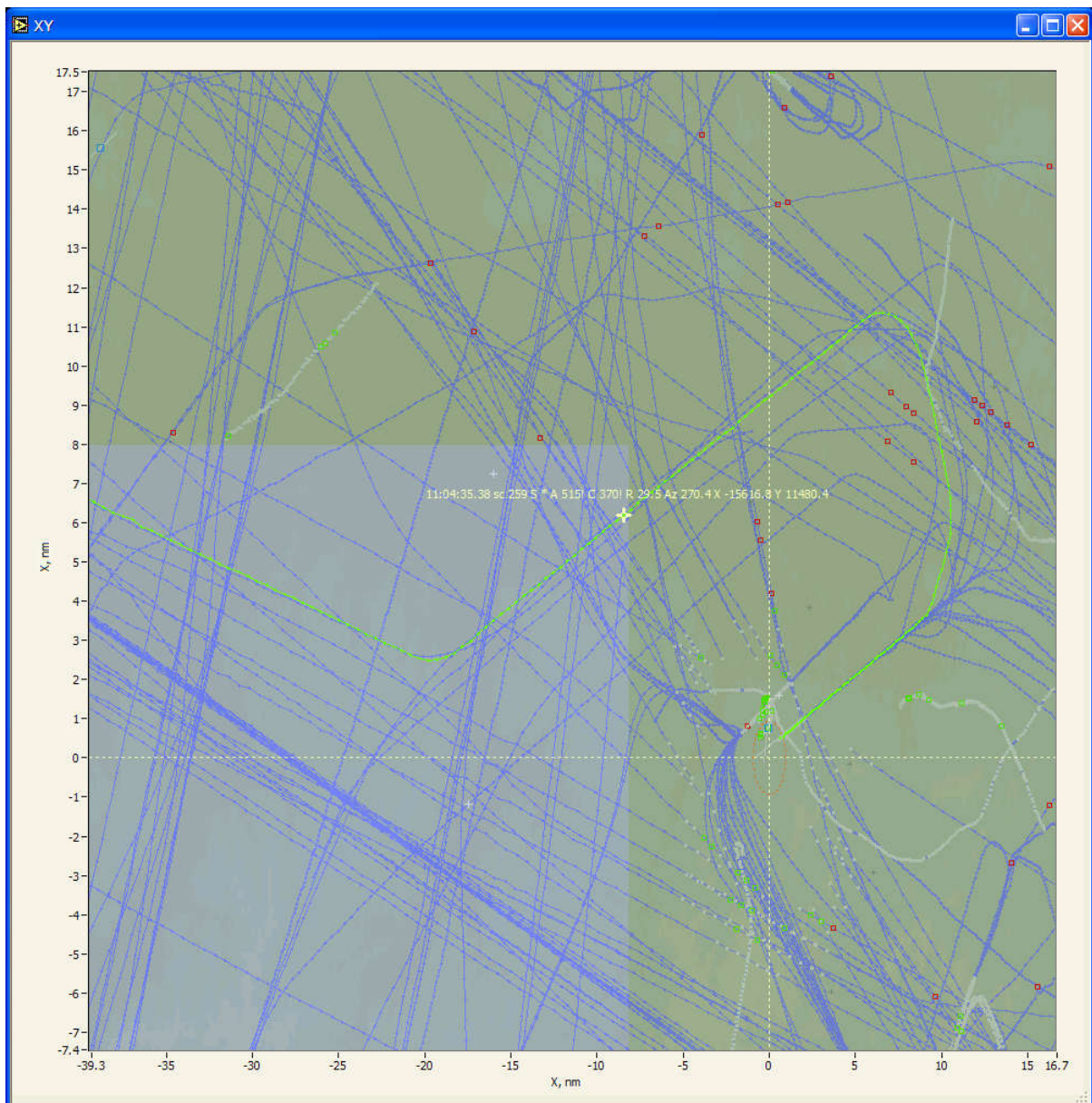


Figure 5-53: XY display

Let's come back on the setup of the XY screen. As explained in "5.1.2 Advanced display configuration", by right clicking in the XY display, you can open the following setup dialog:

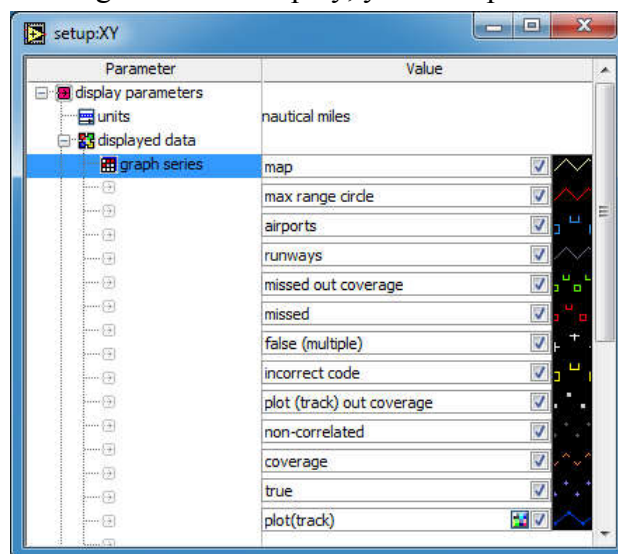


Figure 5-54: XY setup

After the processing, plots can have one of the following labels:

- Missed out of coverage: missed out of coverage calculated using the screening files and CMV parameters. Since the misses are reconstructed plots and aren't present in the radar recording (S4), the info window will only show calculated quantities: time, Range, Azimuth, 3/A-, C-code and/or S-address based on the established trajectory. Missed out of coverage *are not used* to calculate the statistics if the coverage parameter is set to ON. Missed out of coverage *are used* to calculate the statistics if the coverage parameter is set to OFF.
- Missed: missed in coverage calculated using the screening files and CMV parameters. Since the misses are reconstructed plots and aren't present in the radar recording (S4), the info window will only show calculated quantities: time, Range, Azimuth, 3/A-, C-code and/or S-address based on the established trajectory. Missed in coverage *are always used* to calculate the statistics independent of the coverage flag setting.
- False (multiple): False/multiple plots are detections present in the radar recording (S4), and classified as false/multiple based on the FPA (False Plot Analysis) parameters. FPA results are given in the statistics table and false plot table. Coverage is taken into account when computing the FPA result.
- Incorrect code: Incorrect 3/A- and C-codes are validated codes that do not match the current code expectations. For C-code correctness check, the following parameter is used: **C-code correct threshold**.
- Plot (track) out coverage: radar detections out of coverage calculated using the screening files and CMV parameters.
- Non-correlated: plots not associated with any trajectory.
- Plot(track): radar detections linked to a trajectory.



The missed plots (tracks) shown in XY display are “absolute” misses i.e. no detection was present for any PSR, SSR or MODES. For the combined plots (tracks) the partial misses are not shown here but are used for calculation of the statistics.

5.6.2 Accuracy display

The accuracy (random errors) display graphically presents the calculated random range errors vs. random azimuth errors. The display has a cursor which is linked to the XY display, plot info, track info and track statistics table. Use the cursor to query the specific error.

When selecting a target report with the cursor, that report and all target reports linked to the same trajectory will be selected and thus change to the display settings linked to the “selection” settings (click with right mouse button to change the display settings).

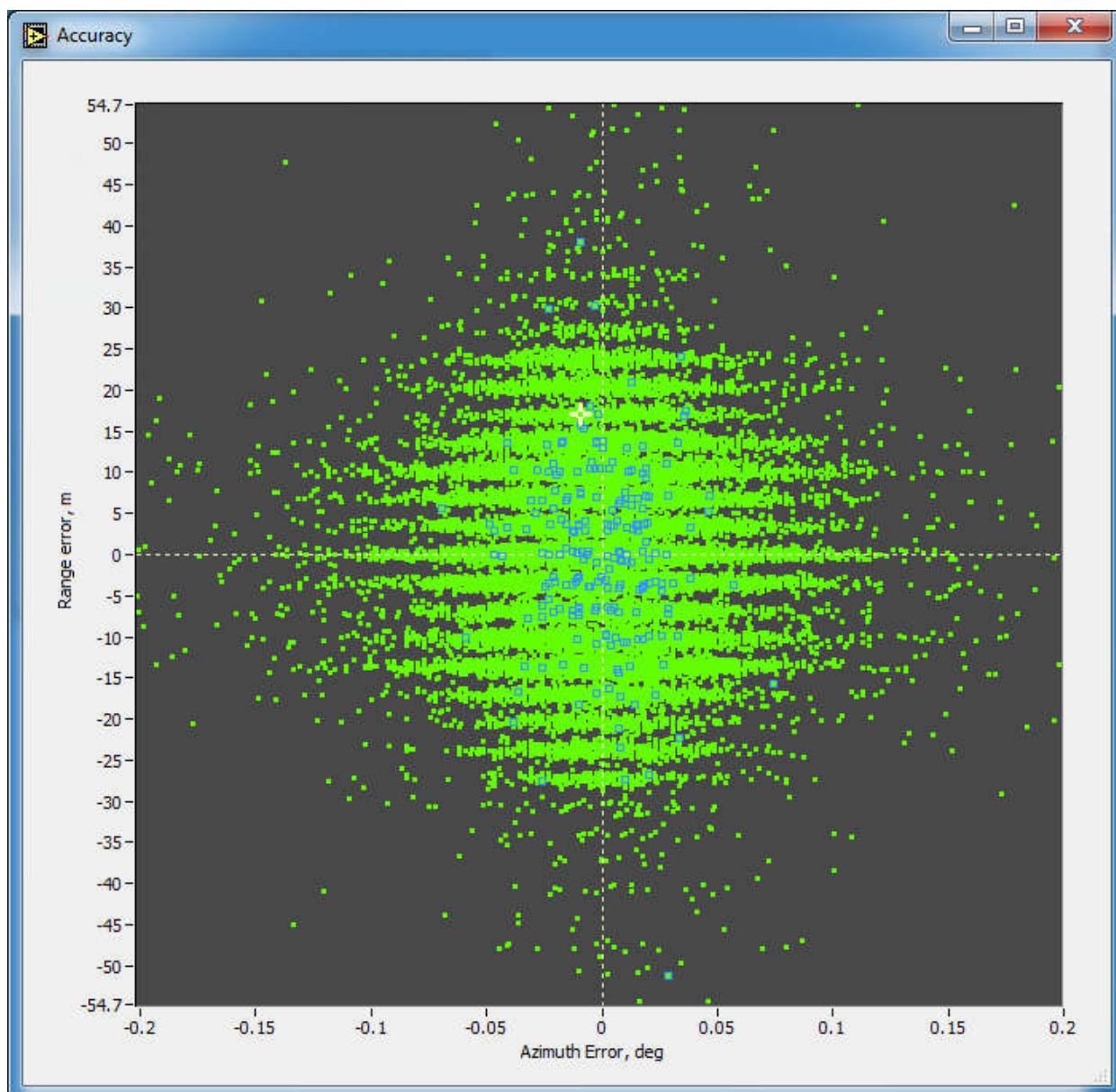


Figure 5-55: Accuracy display

5.6.3 Coverage display

The coverage (screening angles) display shows the theoretical coverage diagram of the radar site expressed using equipotential FL lines (these show the XY extent of the theoretical coverage for a specific flight level. The actual coverage might differ from the theoretical due to the barometric height errors, anomalous propagation etc. Colour scales can be adjusted by changing the tabular colours. The plots are displayed as in the original dataset, i.e. before processing by the RCM and without CMV parameters applied, but upon the filter conditions.

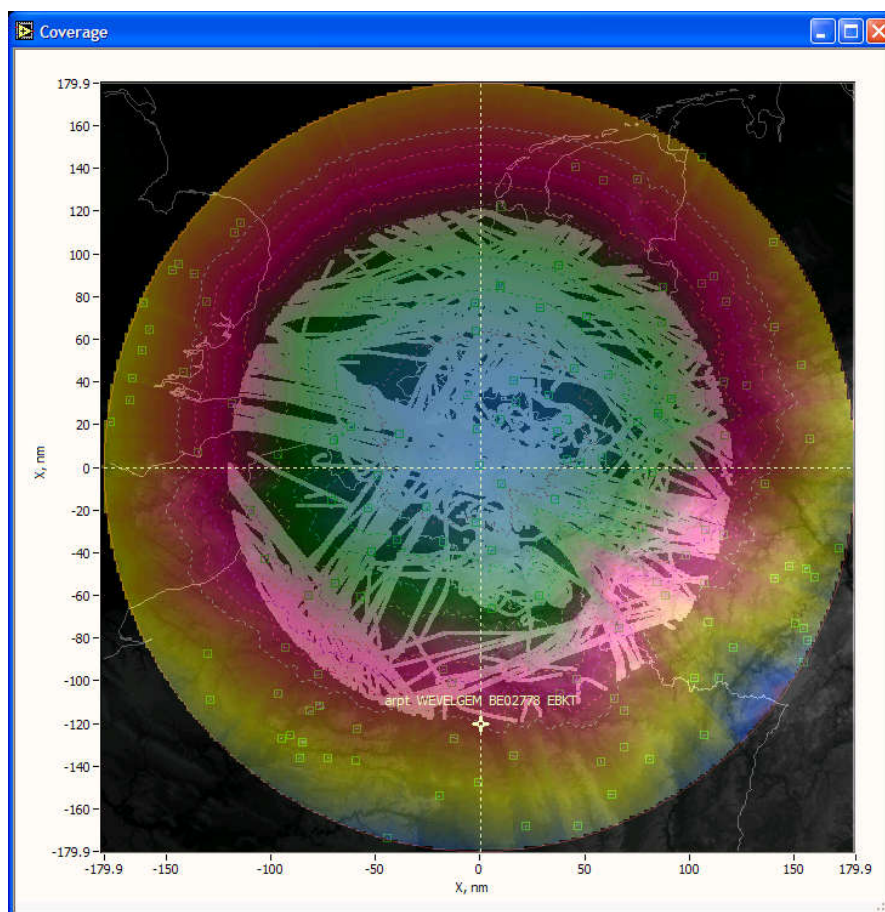


Figure 5-56: Coverage display

The figure above is based on the following tabular colours (click right mouse button on screen to change these):

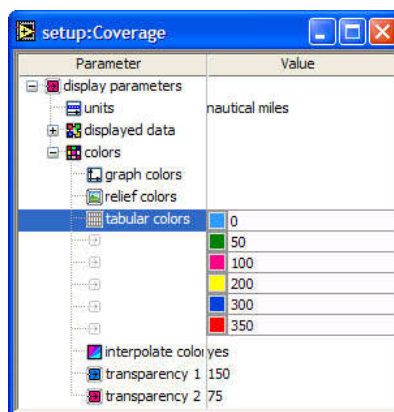


Figure 5-57: Tabular colours for coverage display

5.6.4 Cell based display

The cell based (tabular result) display shows the statistical quantities for a radar based on graph type, selected cell size and other parameters defined in the cell statistics parameter list. (See paragraph 4.1.3). As the statistical quantities the Pd, range or azimuth accuracy can be displayed. The colour represents the specific levels of the parameter and configurable using the general display configuration interfaces (right mouse click).

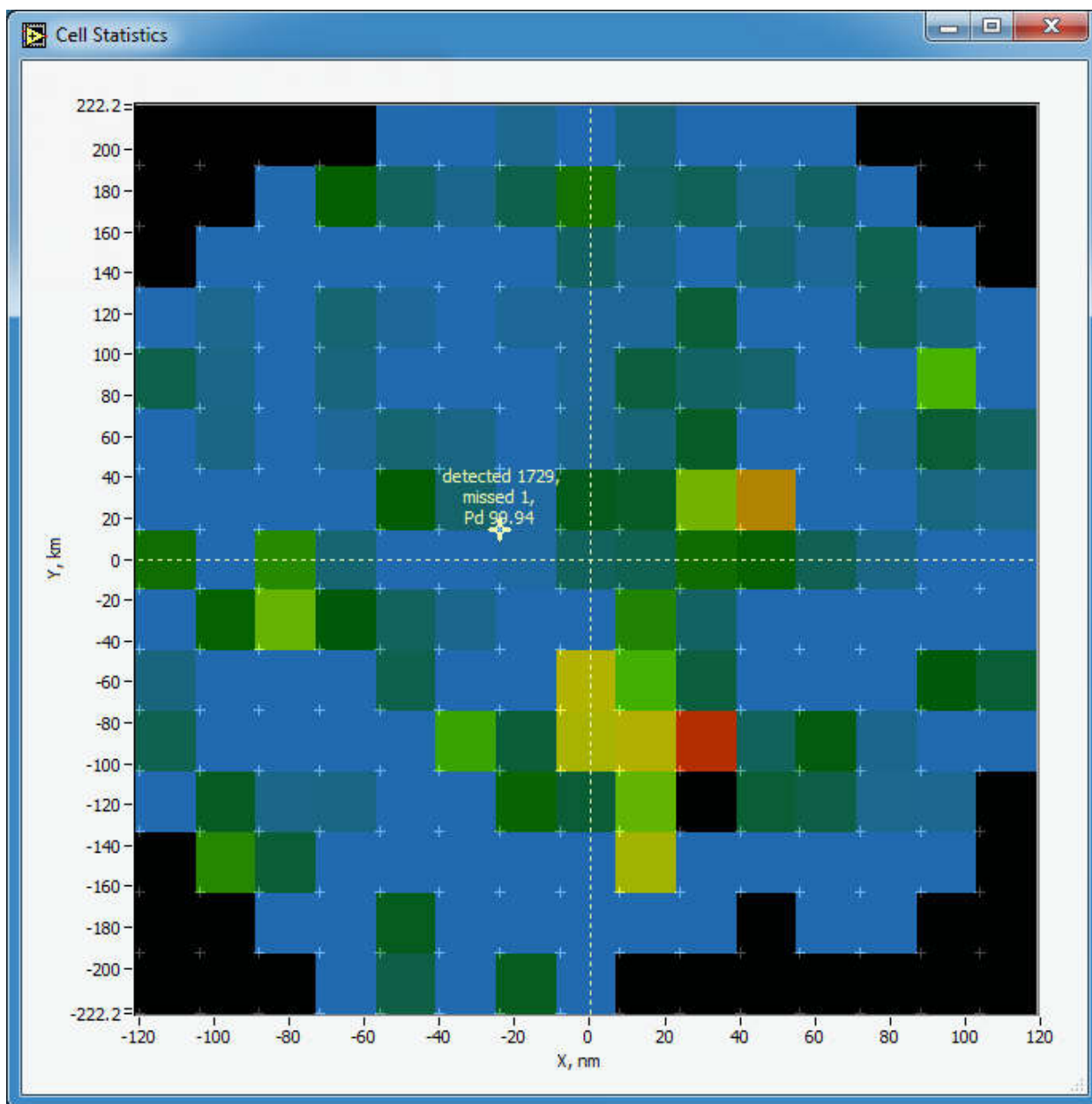
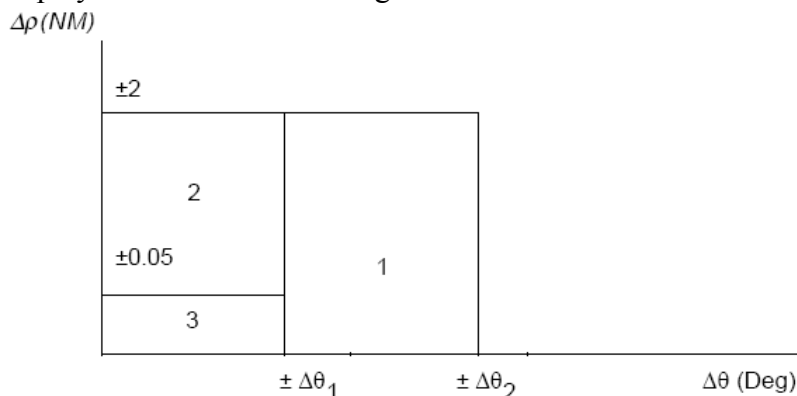


Figure 5-58: Cell based display

5.6.5 Resolution Analysis (RA) Display

Provides a graphical representation, dR versus dAz , of all observed resolution cases divided in 3 resolution areas as defined by EUROCONTROL standards *SUR.ET1.ST01.1000-STD-01-01* and *SUR.ET1.ST03.1000-STD-01-01*. Edges of the areas are set by the RA parameters (see 4.1.3) For a SSR the display is divided in following 3 areas:



$\Delta\rho$, $\Delta\theta$ are the differences of the two aircraft true positions in slant range and azimuth.

Figure 5-59: Resolution areas for SSR as defined in *SUR.ET1.ST01.1000-STD-01-01*

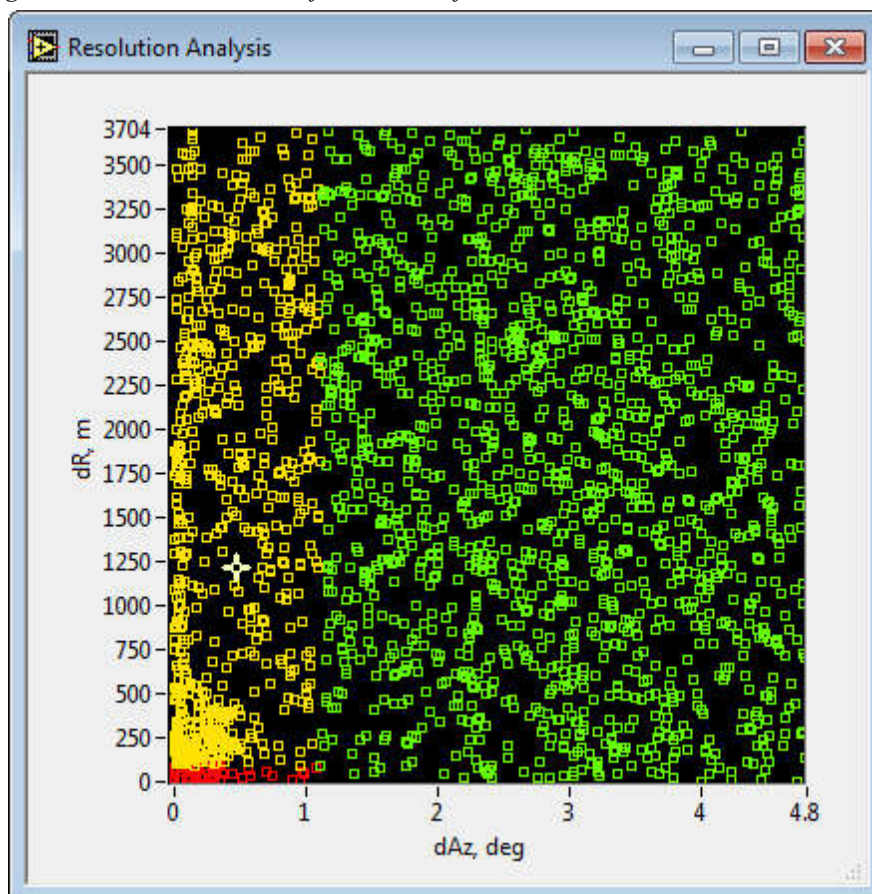


Figure 5-60: RA display for SSR (area1=green; area2=yellow; area3=red)

The RA display and statistics will represent the SSR resolution unless the reference type parameter (see 4.2.1) is set to PSR.

For a PSR following 3 resolution areas apply:

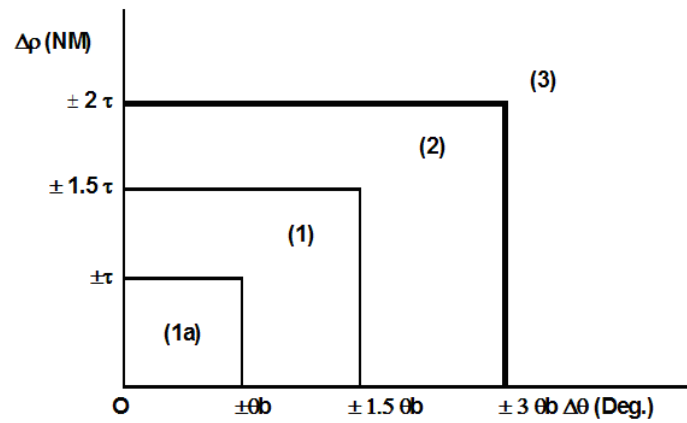


Figure 5-61: Resolution areas for PSR as defined in SUR.ET1.ST03.1000-STD-01-01 (page A/22)

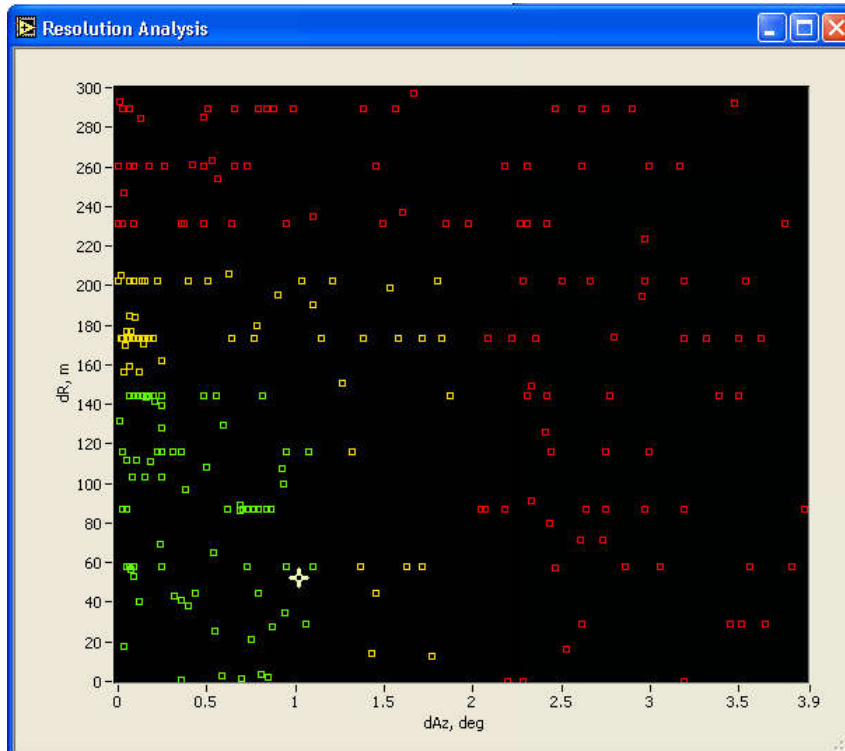


Figure 5-62: RA display for PSR (area1a=green; area1=yellow; area2=red)

5.7 Export to SMS (Surveillance Monitoring System)

The Export to SMS feature is relevant only when RCM and RCD are used in combination with the automated Surveillance Monitoring System (SMS). When selecting Export from the main menu a subset of the parameters and active filter will be exported to extension less files formatted to compatibility with the SMS database. First you will be asked to save the RCM parameter subset (see Figure 5-63: export RCM to DB). Type in a file name and press OK. Next you will be asked to save the active filter, give it a name and press OK. *To import these files in a SMS refer to [9 - SEAMP user manual].*

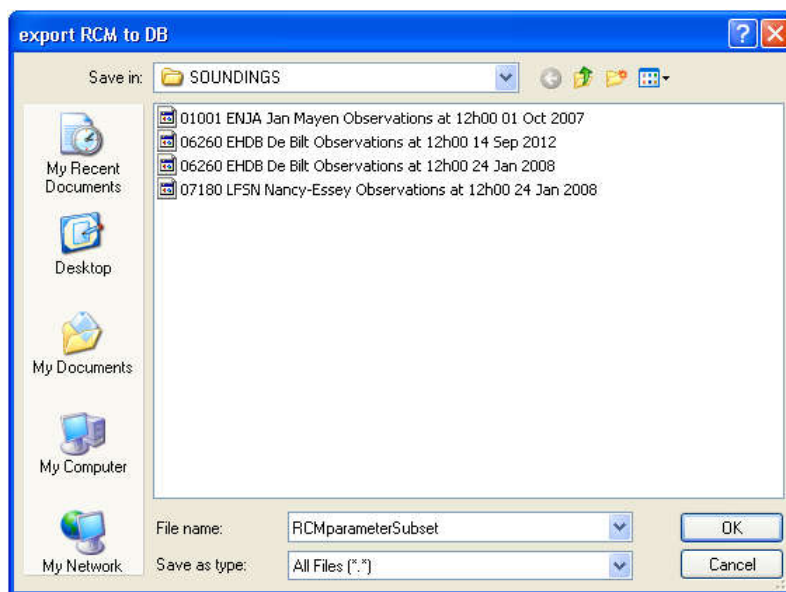


Figure 5-63: export RCM to DB

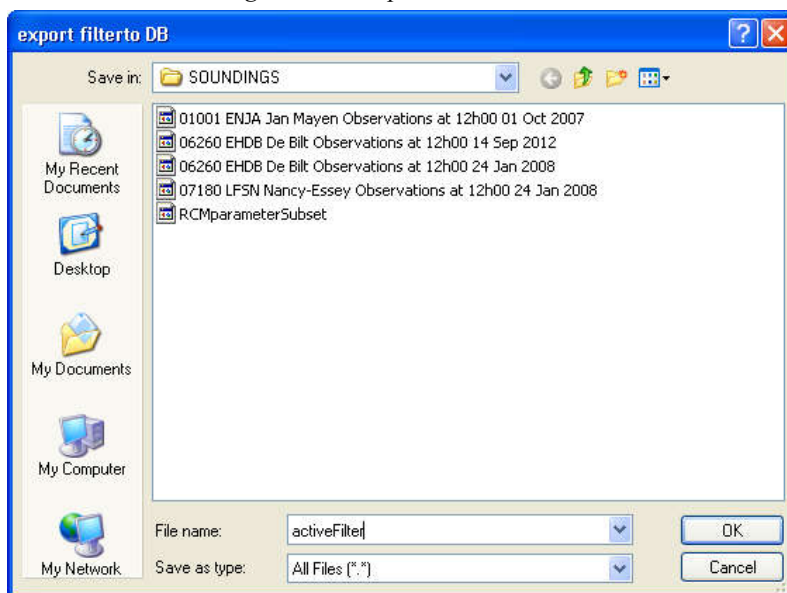


Figure 5-64: export filter to DB

6. Statistics

Open the tabular displays using the **tool & displays** menu button  in the main window. All the statistics tables are handled in the same way.

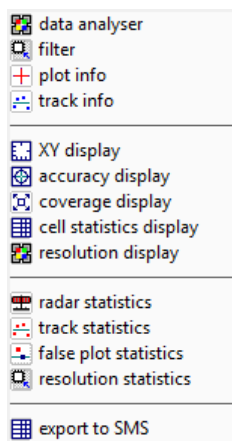
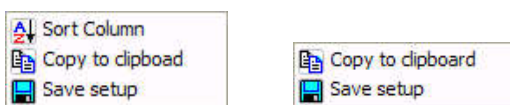


Figure 6-65: General utilities and display menu

The user can adjust window sizes, column widths, number of rows and columns etc. Should you make a right mouse click in the window, one of the following menus will appear:



The popup menu entries have the following meaning and functionality:

- **Sort Column:** used to sort the table according to the contents of the selected column
- **Copy to clipboard:** used to copy the table data to the clipboard. From here, it can be pasted into for example a spreadsheet. (e.g. Microsoft Excel)
- **Save setup:** used to save the layout of the statistics table

The typical outlook of the tables **radar statistics**, **track statistics** and **false plot statistics** are given below in Figure 6-66 through Figure 6-71.

In plot or track based tables (**statistics**, **track data** and **false plot statistics**) a selected row is linked to the XY display allowing visual inspection of the corresponding plot (track). For user convenience **false plot statistics** table contains pairs of plots true-false improving the visibility and user friendliness.

6.1 General Statistics

Parameters:	rad3	Count	%	EUROCONTROL
Start Time		11:00:03		
Length		00:59:55		
Plot		118972		
Track		0		
PSR		38470		
SSR		110777		
CMB		38470		
MODES		0		
MODES intervals				
Linked		110777		
< min track length [mm:ss] OR < max NC length [scan]		6424		
Unused		0		
Detection Analysis				
Number of chains		499	200	
Minimum track length, mm:ss		05:00	05:00	
Number of chains with Pd < P _{dmin}		2		
Number of detections with a > a _{max}		3295		
Valid A-code		109723	99.049	
Valid and Correct A-code		109666	98.997	98.0%
Valid and Incorrect A-code		57	0.051	0.1%
Valid C-code		109601	98.938	
Valid and Correct C-code		109351	98.713	96.0%
Valid and Incorrect C-code		250	0.226	0.1%
Overall false A/C-codes		305	0.275	0.2%
SSR/PSR probability of association			85.544	95%
Missed PSR		6842		
Missed SSR		581		
Missed SSR & PSR		581		
Missed MODES		0		
Missed MODES & SSR & PSR		0		
Detection probability PSR			84.900	90.0%
Detection probability SSR			99.478	97.0%
Detection probability SSR V PSR				
Detection probability MODES				97.0%
Detection probability MODES V SSR V PSR				97.0%
False Plot Analysis (FPA)				
max NC length [scan]				
False PSR	0.0			20 p/scan
Multiple SSR target reports	9	0.008		0.3%
reflections	2	0.002		0.2%
sidelobes	5	0.005		0.1%
splits	2	0.002		0.1%
Accuracy Analysis				
SSR range accuracy, m	11.830			70.0
SSR azimuth accuracy, deg	0.033			0.08
SSR ratio of jumps (>1deg or >700m)			0.00	0.05%
PSR range accuracy, m				120.0
PSR azimuth accuracy, deg				0.15
MODES range accuracy, m				15.0
MODES azimuth accuracy, deg				0.068
X accuracy, m				
Y accuracy, m				
SSR average gap size	1.236			
Probability (>2 gaps)			4.681	%

Selected standard

Figure 6-66: Statistics table window

The following table explains the different meanings:

Table 6-6: Statistics explanation

Parameter	Count	%	Standard	Explanation
Start time	11:00:03			Lowest timestamp of used target reports
Length	00:59:55			Length in time of the used dataset
Plot	118972			Number of detected plots in the filtered dataset
Track	0			Number of detected tracks in the filtered dataset
PSR	38470			Number of used PSR detected reports in horizontal coverage
SSR	110777			Number of used SSR detected reports in CMV coverage volume
CMB	38470			Number of used combined PSR/SSR detected reports in CMV coverage volume
MODES	0			Number of used Mode-S detected reports in CMV coverage volume
Linked	110777			Number of used detection reports in CMV coverage volume
< minimum track length [mm:ss]&max NC length [scan]	6424			Number of disregarded detection reports because of short track length or NC length
Unused	0			Unprocessed reports because of other reasons
Detection Analysis				
Number of chains	495		200	Is the number of tracks after the tracking algorithm in the RCM.
Minimum track length, mm:ss	05:00		05:00	Set parameter (see 4.1.4)
Number of chains with Pd< Padmin	2			Count of chains with Pd below the set threshold (see 4.1.4)
Number of detections with a>amax	3295			Count of target reports with excessive acceleration (see 4.1.4)
Valid A-code	109723	99.049		Number of valid A-codes equals number of correct + incorrect
Valid and Correct A-code	109666	98.997	98.00%	Number of valid and correct A-codes as assigned by the RCM
Valid and Incorrect A-code **	57	0.051	0.10%	Number of valid and incorrect A-codes as assigned by the RCM
Valid C-code	109601	98.938		Number of valid C-codes equals number of correct + incorrect
Valid and Correct C-code	109351	98.713	96.00%	Number of valid and correct C-codes as assigned by the RCM
Valid and Incorrect C-code **	250	0.226	0.10%	Number of valid and incorrect C-codes as assigned by the RCM
Overall false A/C-codes	305	0.275	0.20%	
SSR/PSR probability of association		85.544	95%	
Missed PSR	6842			Number of missed PSR targets (only in coverage if ON) after performing the tracking algorithm. (Depending on plot-to-track association parameters)
Missed SSR	581			Number of missed SSR targets (only in coverage if ON) after performing the tracking algorithm. (Depending on plot-to-track association parameters)
Missed SSR & PSR	581			Missed PSR AND SSR plots/tracks
Missed MODES	0			Number of missed Mode-S plots/tracks
Missed MODES & SSR & PSR	0			Missed PSR AND SSR AND MODES plots/tracks
Detection probability PSR		84.900	90.00%	Pd PSR with reference to EUROCONTROL or ICAO
Detection probability SSR		99.478	97.00%	Pd SSR with reference to EUROCONTROL or ICAO
Detection probability SSR V PSR *				PSR OR SSR probability of detection (overall performance indicator) See Note.
Detection probability MODES			97.00%	Pd Mode-S with reference to EUROCONTROL or ICAO
Detection probability MODES V SSR V PSR *			97.00%	Mode-S OR SSR OR PSR probability of detection (overall performance indicator) See Note.
False Plot Analysis (FPA)				
max NC length [scan]	5			Set parameter (see 4.1.2)
False PSR	0		20 p/scan	Average PSR false plot rate per scan
Multiple SSR target reports	9	0.008	0.30%	Total of all multiple SSR target reports. Because classes partially overlap might the total not equal the sum of below 3 subgroups.
reflections	2	0.002	0.20%	Multipaths and reflections
sidelobes	5	0.005	0.10%	Sidelobe, backlobe and ringaround detections
splits	2	0.002	0.10%	Splits

Accuracy Analysis				
SSR range accuracy, m	11.830		70	Compared against the selected standard in the Statistics
SSR azimuth accuracy, deg	0.033		0.08	Compared against the selected standard in the Statistics
SSR ratio of jumps (>1deg or >700m)		0	0.05%	
PSR range accuracy, m			120	Compared against the selected standard in the Statistics
PSR azimuth accuracy, deg			0.15	Compared against the selected standard in the Statistics
MODES range accuracy, m			15	Compared against the selected standard in the Statistics
MODES azimuth accuracy, deg			0.068	Compared against the selected standard in the Statistics
X accuracy, m				Random X error when evaluating ADS-B source
Y accuracy, m				Random Y error when evaluating ADS-B source
SSR average gap size	1.236			
Probability (>2 gaps)		4.681	%	Probability that a gap is larger than 2 misses
Average update rate, s				Average rotation time of the radar
Update rate stdev, s				Standard deviation on the average rotation time of the radar

* the existing references [2], [3] do not specify how to calculate the probability of detection for operation in mixed modes. However it is extremely important to analyze overall performance of the radar independent of the interrogation type. That is why the probability of detection for the SSR-Mode-S mixed mode was determined as follows:

$$Pd_{mixed} = \frac{N_{SSR} + N_{MODES}}{N_{expected\ SSR\ v\ MODES}} \quad (1)$$

Where N_{SSR} is the count of SSR detections, N_{MODES} is the count of Mode-S detections (roll-call or all-call), $N_{expected\ SSR\ v\ MODES}$ is the count of expected detections independent Mode-S or SSR. The partial probabilities for each mode are also evaluated.

$$Pd_{SSR} = \frac{N_{SSR}}{N_{expected\ SSR\ v\ MODES}} \quad (2)$$

$$Pd_{MODES} = \frac{N_{MODES}}{N_{expected\ SSR\ v\ MODES}} \quad (3)$$

Thus the partial probabilities of detection demonstrate only the ratio of Mode-S capable transponders vs. the total number of transponders at a given time period. The overall Pd of PSR-SSR is evaluated using a similar method.

** How to calculate the valid and incorrect A and C codes are explained in ICAO DOC 8071 vol. 3 and EUROCONTROL standards (see references on last page).

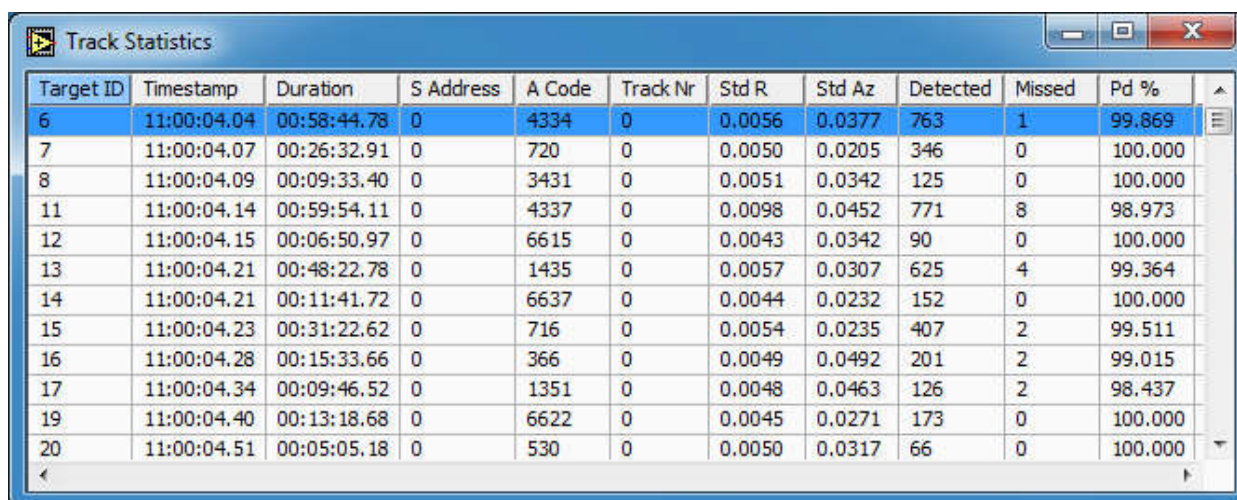
Unfortunately they all merely state the reported value has to be compared against the “true” value. These standards do not indicate how the software should know what the true value is.

The assessment in RCM works the following:

- The A code of a target report is considered invalid when the code differs from the median of the 3 preceding and 3 following target report from the trajectory the report under investigation is linked to, and is unique in this subset of 7. If the A-code was flagged valid than it is counted as a “valid and incorrect A-code.
- Valid and Incorrect C-code: In this case the C-code is considered invalid if it deviates from the expected (“true”) value with more than the set threshold – see 4.1.4.

With MODE-S no false codes should exist however the software still calculates them using the same method (upon popular request).

6.2 Track statistics



Target ID	Timestamp	Duration	S Address	A Code	Track Nr	Std R	Std Az	Detected	Missed	Pd %
6	11:00:04.04	00:58:44.78	0	4334	0	0.0056	0.0377	763	1	99.869
7	11:00:04.07	00:26:32.91	0	720	0	0.0050	0.0205	346	0	100.000
8	11:00:04.09	00:09:33.40	0	3431	0	0.0051	0.0342	125	0	100.000
11	11:00:04.14	00:59:54.11	0	4337	0	0.0098	0.0452	771	8	98.973
12	11:00:04.15	00:06:50.97	0	6615	0	0.0043	0.0342	90	0	100.000
13	11:00:04.21	00:48:22.78	0	1435	0	0.0057	0.0307	625	4	99.364
14	11:00:04.21	00:11:41.72	0	6637	0	0.0044	0.0232	152	0	100.000
15	11:00:04.23	00:31:22.62	0	716	0	0.0054	0.0235	407	2	99.511
16	11:00:04.28	00:15:33.66	0	366	0	0.0049	0.0492	201	2	99.015
17	11:00:04.34	00:09:46.52	0	1351	0	0.0048	0.0463	126	2	98.437
19	11:00:04.40	00:13:18.68	0	6622	0	0.0045	0.0271	173	0	100.000
20	11:00:04.51	00:05:05.18	0	530	0	0.0050	0.0317	66	0	100.000

Figure 6-67: Track statistics table

The track statistics table (trajectory based info) may be very useful to detect aircraft with anomalous Pd, code probabilities, and/or accuracy. This kind of anomalies may have nothing to do with the radar performance, and solely reflect the transponder problems. Trajectories with abnormal statistics in common airspace with the other trajectories with “normal” statistics must be carefully handled and might be filtered out to obtain objective radar performance figures. However this type of the filtering must be performed with caution without compromising the measurement objectivity and trustworthiness. The track statistics can be sorted according to the column contents and has cross-cursor links with the XY display. When scrolling in the track statistics table, the plot number is cross linked with the XY display and the accuracy display.



The unit of the reported Range and Azimuth accuracy depend on the units set in the parameters section of the main setup window (see 4.1.4 . In above screenshot this was set to NM for range accuracy (Std R) and degrees for azimuth accuracy (Std Az).

6.3 Multiple (False) target report statistics

The RCM software performs plot-to-track correlation and as result misses are calculated along with a number of plots that could not be correlated with the existing tracks: non-correlated (NC) plots. Non-correlated plots are analysed for trajectories shorter than the **maximum number of NC plots** (subgroup FPA, see 4.1.2). The RCM processes NC plots and compares them with existing tracks using the range, azimuth windows defined in FPA subgroup. After comparison, the target can be given one or multiple labels according to the FPA classification parameters as defined in the EUROCONTROL standards.

When scrolling in the multiple (false) target report statistics table, the target ID is cross linked with the XY display. Two lines per each multiple plot are present, the first corresponding to the true plot and the second to the false (multiple) plot. The false plots typically cannot be determined by mono-radar evaluation software, except for some cases of FRUIT.

Figure 6-68: False plot statistics table

New from RCM version 3.4.2 is that the user can add any field, available in the S4 data, to the track data table. By right clicking in the False plot statistics table, the following options are possible:

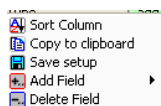


Figure 6-69: Right click in the False plot statistics table

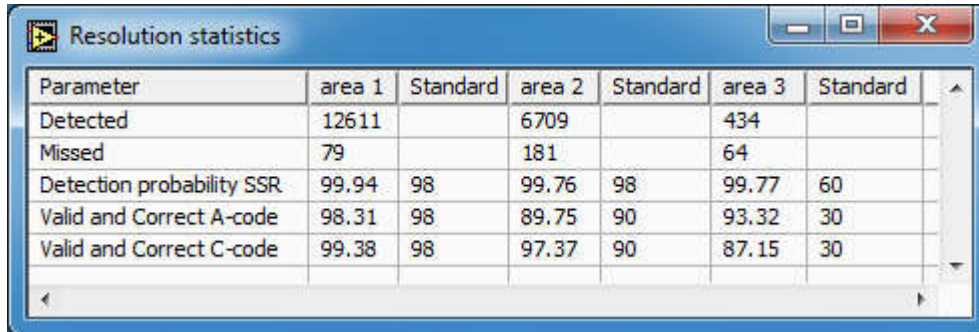
Adding a field invokes the same table as in Table 5-5: Info window explanation.



The unit of the reported Range and Azimuth difference depend on the units set in the parameters section of the main setup window (see 4.1.4). In above screenshot this was set to NM for range (dR) and degrees for azimuth (dAz).

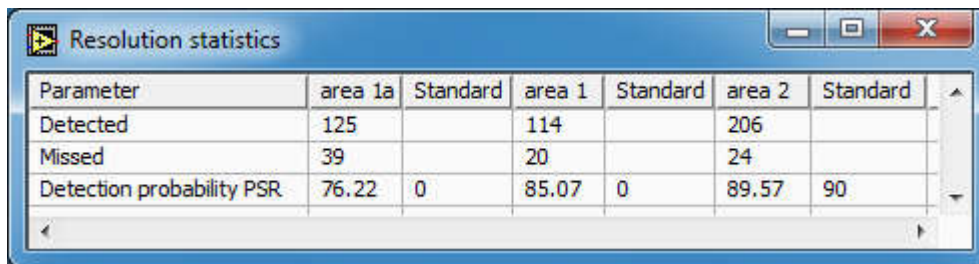
6.4 Resolution statistics

For rotating radars resolution statistics as defined by EUROCONTROL standards *SUR.ET1.ST01.1000-STD-01-01* and *SUR.ET1.ST03.1000-STD-01-01* are calculated (see also 5.6.5).



Parameter	area 1	Standard	area 2	Standard	area 3	Standard
Detected	12611		6709		434	
Missed	79		181		64	
Detection probability SSR	99.94	98	99.76	98	99.77	60
Valid and Correct A-code	98.31	98	89.75	90	93.32	30
Valid and Correct C-code	99.38	98	97.37	90	87.15	30

Figure 6-70: SSR resolution statistics



Parameter	area 1a	Standard	area 1	Standard	area 2	Standard
Detected	125		114		206	
Missed	39		20		24	
Detection probability PSR	76.22	0	85.07	0	89.57	90

Figure 6-71: PSR resolution statistics

7. Troubleshooting/Q&A

A. Problem:

When starting up the RCM, it loads blank line as campaign folder.

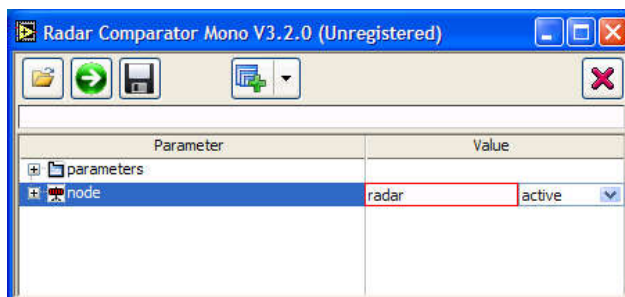


Figure 7-72: No campaign loaded

Reason:

by default, the RCM reads the path to a campaign folder that is saved in the following registry key: HKEY_LOCAL_MACHINE\SOFTWARE\Intersoft Electronics\RASS\Campaign

Solution:

This registry key can be filled in by selecting existing or creating a new campaign in the RASS-R toolbox or RCM.

B. Problem:

I need assistance from Intersoft Electronics and want to upload a campaign folder to the IE ftp-site ([ftp.inventive-engineering.com](ftp://ftp.inventive-engineering.com))

Solution:

Upload the complete folder, with the correct screening file and relief file in the GENERAL folder. Make sure that the RCM setup file is in the campaign folder, so that the campaign can be correctly loaded in the RCM. (See Chapter 2 RASS-R toolbox).

Mention the following things by email:

- Software version of the RCM
- Type of data
- If you have questions about a particular track: report the A-code or Mode-S address.

C. Problem:

The coverage display shows **circular** lines of equipotential flight level.

Reason:

It is possible that the screening file could not be found by the RCM or that the screening information is incorrect.

Solution:

make sure that the screening file is in the correct location (See Chapter 2 RASS-R toolbox). In the Coverage Map Calculator: make sure you calculate the screening map with the correct settings for longitude, latitude and height.

D. Problem: When you start processing, you see the following message:

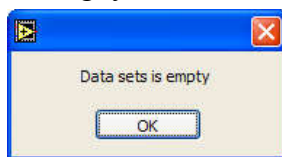


Figure 7-73: Data set empty

Reason: The RCM cannot find the source file data (.S4) or the applied filter removes all data.

Solution: Make sure you have selected the proper .S4 file. Switch off or alter the set filter. Check the reference type mono as well, it might be associated with a wrong type.

E. Problem: When you want to do timestamp analysis, you see the following message:

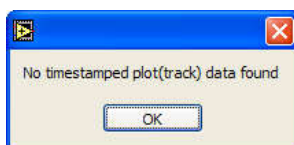


Figure 7-74: Data analyser error dialog

Reason: The RCM cannot find the source file data (.S4) to perform the timestamp analysis on.

Solution: Make sure you have selected the proper .S4 file.

F. Problem: When you want to run the RCM with barometric correction set to ON, the following window appears:

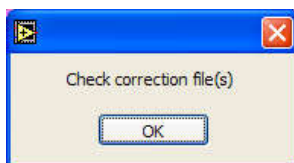


Figure 7-75: No barometric sounding file selected

Reason: there is no sounding file selected.

Solution: make sure you have selected a sounding file:

Figure 7-76: Selection of the proper barometric sounding file

G. Problem: When performing the plot-to-track analysis in the RCM, the following dialog appears:

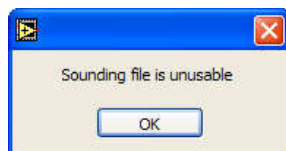


Figure 7-77: Unusable sounding file

Reason: An erroneous barometric sounding file is loaded

Solution: select the correct barometric sounding file.

H. Problem: You see the error dialog: “Data set exceeds 3,000,000 plot/tracks”.

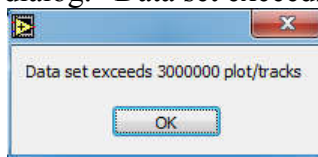


Figure 7-78: Data set exceeds 3000000 plot/tracks

Solution: RCM can process and display a maximum of 3 million target reports. Processing will terminate without result when this maximum is exceeded. Try to select a smaller file (size), a smaller group of files or limit the dataset by applying a filter.

I. Problem: when I paste a copy from the statistics tables in Open Office Writer, only the heading is pasted.

Reason: the copy to clipboard is a table copy

Solution: paste into an Open Office Calc spreadsheet and insert the spreadsheet into Writer.

J. Problem: When running data analyser in timestamp type, following dialog opens:

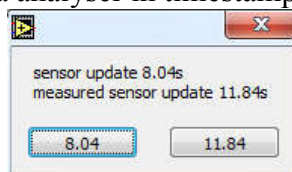


Figure 7-79: sensor update difference

Reason: The average rotation/update time measured by the data analyser significantly differs from the revolution period set in the node parameters.

Solution: Select what update period you want the data analyser to use for his time error computation. In most cases the data analyser will correctly calculate the rotation time and it is probably the set revolution period that is wrong. However, when the used dataset has large gaps or the timestamps in the data are inaccurate, the measured update period might be off.

K. Question: I have a PSR with a short and long pulse and want to perform resolution analysis on both. The RA parameters only allow a single pulse width.

Solution: Run the RCM twice, first time you fill in the PSR RA parameters for the short pulse and limit the range in the CMV parameter group to the range the short pulse is valid. The RA statistics will thus be relevant to the short pulse. The second time fill in the PSR RA parameters as applicable for long pulse and set the minimum range for CMV to the range were long pulse processing becomes active.

REFERENCES

Reference	Document
[1]	RASS-R User Manual, Intersoft Electronics 2005
[2]	ICAO Document 8071 Volume III Manual on Testing of Radio Navigation Aids , Testing of Surveillance Radar Systems
[3]	EUROCONTROL Standard Document for Radar Surveillance in En-Route Airspace and Major Terminal Areas
[4]	SASS-C Study on MURATREC Multi Radar Trajectory Reconstruction Toolbox. Part Two, Intersoft Electronics 2003
[5]	Radar Alignment and Accuracy Tool, RASS-R Radar Comparator Dual, Intersoft Electronics 2009 (published at ATCA 2009), see website
[6]	User manual of the Radar Comparator Dual (IE-UM-00028-xxx RCD.pdf)
[7]	S4 ICD, IE-DD-00273-002 ICD S4.pdf
[8]	D6 ICD, IE-DD-00272-001 ICD D6.pdf
[9]	IE-UM-00423-007 SMS SEAMP.pdf