

RADAR AND ATM PERFORMANCE ANALYSIS SUITE (RAPAS)

I2M Systems Inc. has a significant experience in developing ATC-related software. We have a proven record in developing software for Surveillance purposes (radar signal processing, ADS-C, ADS-B, CPDLC, multi-tracking, etc.).

The latest product that has been developed and tested in multiple radar installations is called "Radar and ATM Performance Analysis Suite" (RAPAS). The RAPAS can be run under Microsoft Windows or Linux based operating system and does not require any special hardware. The CPU and GPU requirements are minimal and the program can be installed and run on virtually any current hardware (desktop or laptop).

RAPAS is developed with the goal to assist Radars' and Air Traffic Management (ATM) Systems manufacturers and their users/client to be able to streamline installation and/or maintenance procedures by providing graphical views of various data of Radar installation and the performance of the Radar's processor and checking the accuracy of the ATM systems' displays. Provided graphics is viewed over the Earth surface image within the "Google Earth" minimizing uncertainties regarding the displayed elements' locations. It is also possible to over impose some map elements that the user may use with their ATM system (e.g. map elements represented via ".shp" files).

The RAPAS supports multiple configurations, one of which is a direct connection to the Radar processor, when the user is capable to connect directly to the radar and record the live data for any period of time. The recorded data can be analyzed with the use of the free version of the Google Earth software. There is no need for Internet connection to be able to use the RAPAS and/or view the data in Google Earth.

The information on a track that can be viewed at any reported position is configurable and can be selected while using the interface built for use within Google Earth.

It is also possible to configure, for display purposes, various elements of radar installation configuration (radar name, location, spd/hdg, radar reflector position, etc.).

The program may also be of help to Aviation Industry professionals in airspace utilization and planning as well as in creation of CNS/ATM requirements.

RAPAS consists of a set of modules, designed to tackle different features of the systems:

- Checking for the radar's reflection areas and other anomalies (e.g. effects of wind-farms on Radar's performance);
- Determining the accuracy of the multi-tracker's fusion, allowing the greater degree of Surveillance accuracy improvement.

VIEWING THE TRAJECTORIES AND ASSOCIATED DISPLAY ELEMENTS

One can see a sample screen of RAPAS output for one track in Figure 1 RAPAS screen shot below. To view the information on any reported position, one can simply click on the corresponding location on the screen.

Currently RAPAS decodes the following thirteen Asterix categories: 1, 2, 8, 10, 11, 19, 20, 21, 23, 34, 48, 63, 65, and we are in the process of developing additional formats. The processing requirements are minimal: while building the files for displaying within Google Earth, RAPAS processes hours worth of recorded data (in Asterix format) in under a minute.

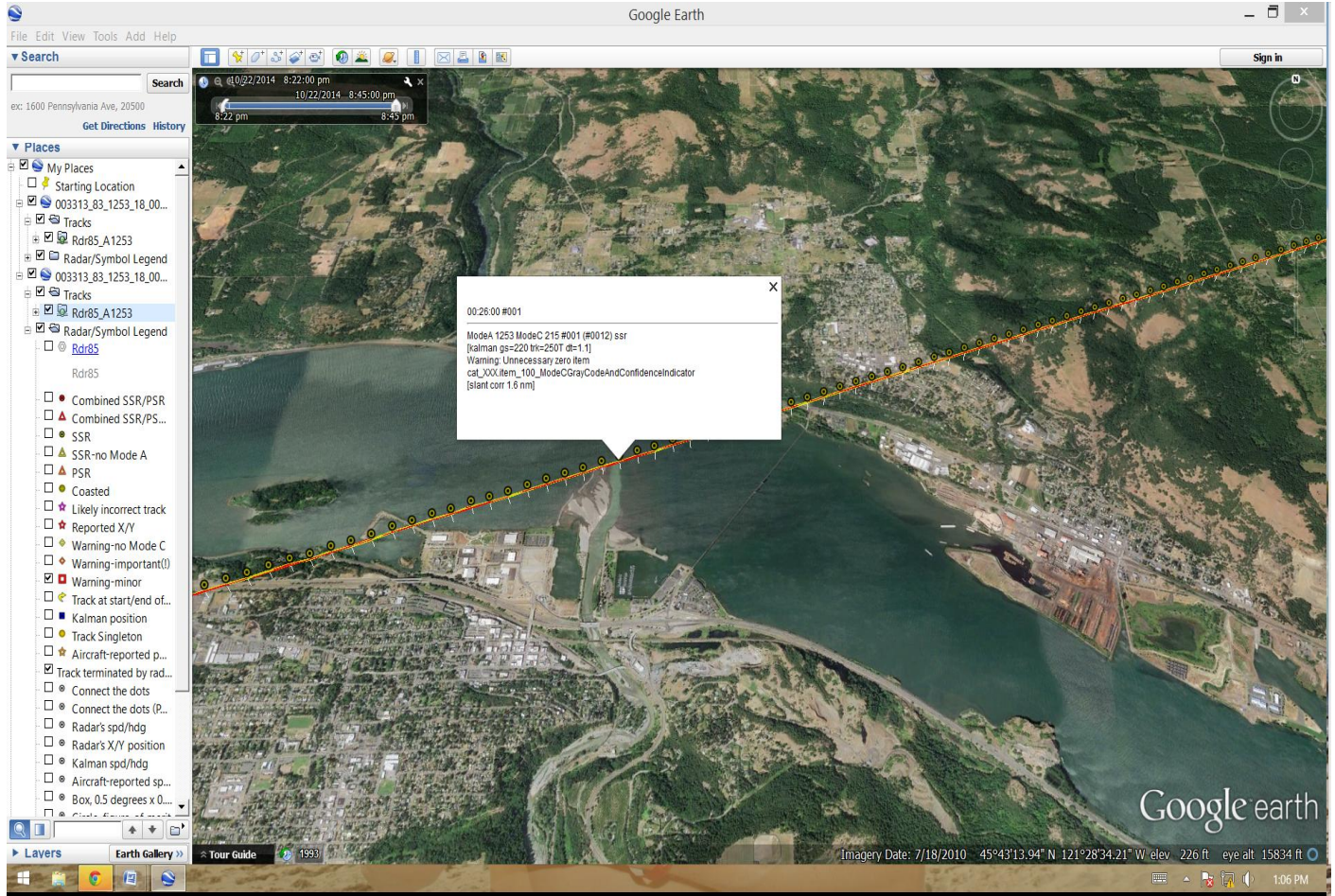


Figure 1 RAPAS screen shot

The recorded data may be played at different speeds and pause at any time for detailed analysis.

SENSOR FUSION ACCURACY ANALYSIS

This RAPAS' module is designed to analyzed the change in accuracy of sensor fusion.

When developing CNS requirements for a Flight Information Region, provided the accuracy in azimuth and range is given for each sensor in a set of sensors, the system will provide a graphical view of accuracy in Surveillance before and after the fusion is applied, as well as for different sensors' locations.

Please see below this analysis for recent CNS coverage study in the SAR.

This analyzes the improved accuracy for sensor fusion for a proposed set of WAM sensors across the SAR FIR. The model parameters for each sensor are:

azimuth accuracy: +/- 2 degrees

range accuracy: 0.08 nm to first 1.6 nm, the 5% of range thereafter

max range: 100 nm

Thus at the outer limit, the confidence ellipse will have major and minor semi axes of about:

5 nm in range

3 nm in azimuth

This is quite different from a normal radar, where the range error is constant with range, and much smaller, typically 0.2 nm or less. So its error ellipses at the outer limit are quite eccentric. In contrast, here the sensor's ellipses are virtually circles. This unfortunately eliminates one of the advantages of radar fusion, where a poor azimuth error from one radar can be compensated with a good range error from another radar.

But we can still get some advantage from fusion. If you have two independent estimates of a position with similar standard deviations, then the average of the two has a standard deviation reduced by a factor of $1 / \sqrt{2}$. Thus a 3 nm standard deviation will be reduced to 2.1 nm. And for n independent estimates, the standard deviation is reduced by a factor of $1 / \sqrt{n}$.

The first image gives the modeled accuracy *without* fusion. There are five colors:

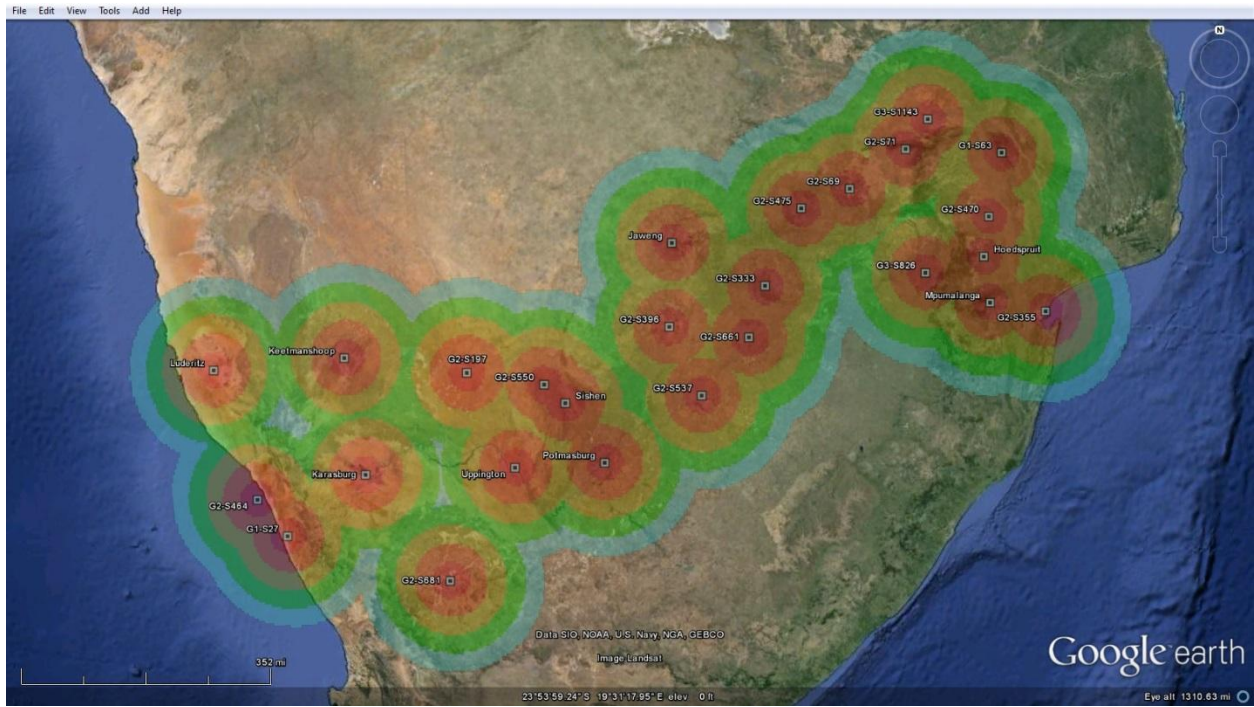
Red: 0-1 nm accuracy

Orange: 1-2 nm

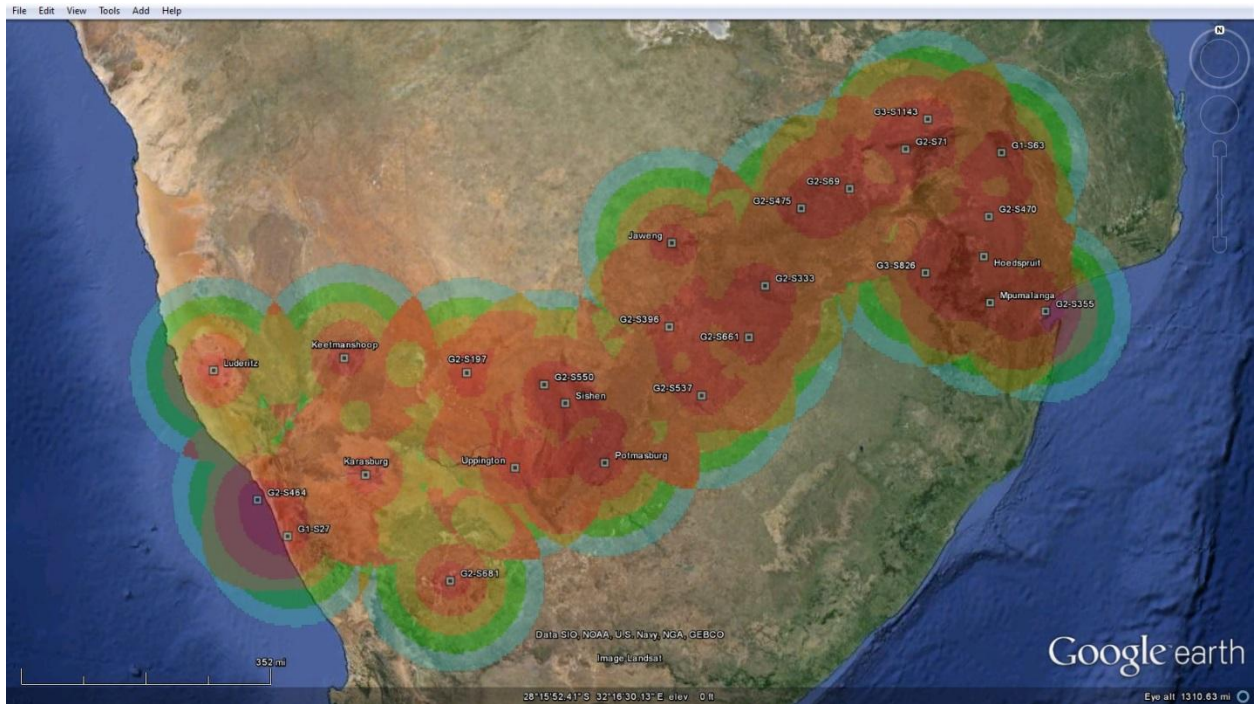
Yellow: 2-3 nm

Green: 3-4 nm

Light Blue: 4-5 nm



The next image gives the estimated accuracies *with fusion*. Many of the green spaces between sensors are now yellow or orange:



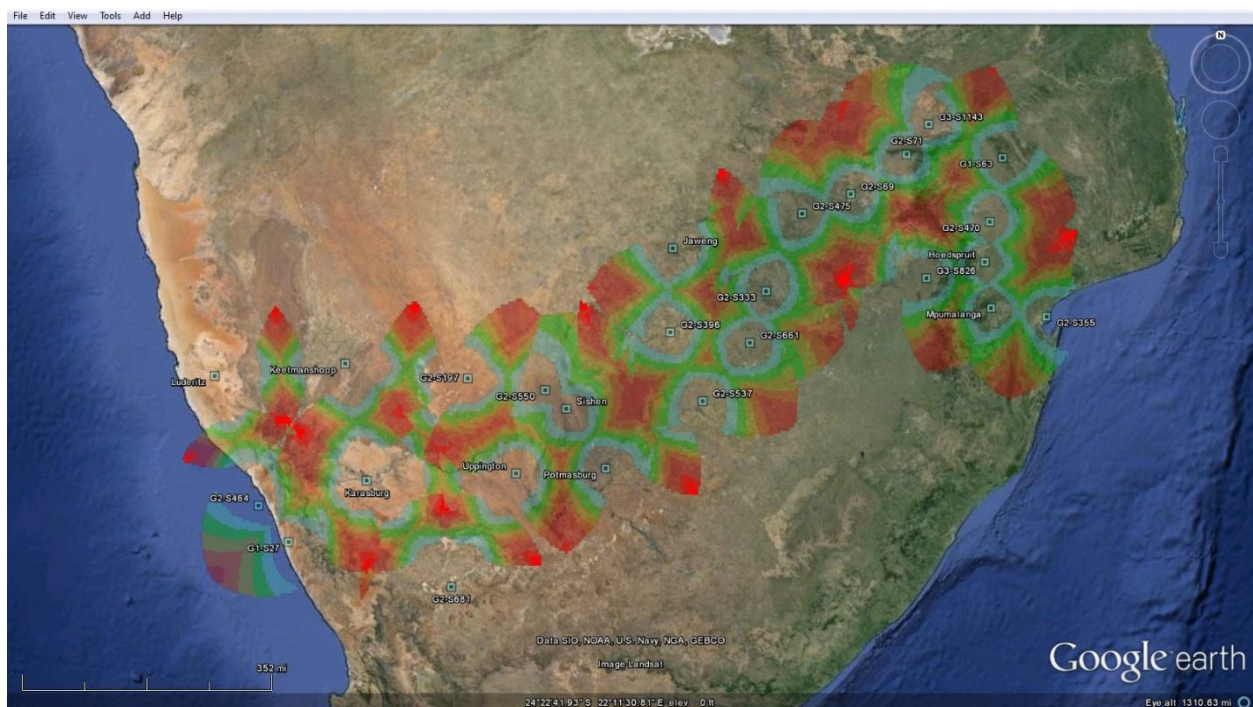
The third image gives the difference between the two.

Dark blue: 0.33 nm improvement

Light blue: 0.66 nm improvement

Green: 1 nm improvement

Etc.



RAPAS TRACKING ALGORITHM

The tracking algorithm used is based on a Kalman filter.

Optionally, it can include a turn-rate parameter, which improves response time for maneuvering targets. The turn rate is determined using heuristics using:

- The current reported position
- The previous reported position
- The expected (smoothed) positions and the heading, as given by the Kalman filter.
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The tracking is done for each sensor independently. The tracks for all sensors are then fused. Inconsistencies between sensors are flagged, especially if they are severe enough to cause safety issues.

RAPAS ALGORITHM FOR AUTOMATIC CALCULATION OF RADAR CALIBRATION VALUES

Every radar requires regular calibration and when the procedure is not performed at all or not done in the proper way, the accuracy of the radar output is compromised and to keep the radar processor working properly, the customer needs to know what the errors are (azimuth and range), so they may be adjusted by entering these offsets into the radar processor's data base. The feature's algorithm provides the user with the output consisting of two values - Range offset and Bearing offset. Given the available recording of the radar raw data, the algorithm uses the modified "least squares fitting" method to provide the necessary values. It should be stressed that developed algorithm does not require any knowledge of the hardware or the software and provides the required values automatically only by parsing the recorded data, therefore being applicable to essentially any radars' installation.

RADAR REGISTRATION

All radars have intrinsic biases. Two of the most common are a constant azimuth error and a constant range error. We can compare recorded data from two overlapping radars to determine the optimum correction for each of the two radars.

RADAR BEAM REFLECTION

Automatically detect the locations of radar reflectors such as building and bridges, and the elimination of ghost targets caused from these. Mostly useful for non-monopulse radars.

For further information please visit us at www.i2msystems.com.