Signal Processing Environment For Analysis and Reduction (SPEAR)

Brian C. Smith[a] and Yasuhiro Kinashi[b]

[a] Coleman Research Corporation, 6820 Moquin Drive, Huntsville, Alabama 35806
[b] Nichols Research Corporation, Crystal Square 2, 1725 Jefferson Davis Highway, Suite 1103,
Arlington, VA 22202

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ABSTRACT

A need for a high-fidelity sensor design simulation model to accurately predict the envelope of the system performance and to offset the escalating cost of the system development and testing are widely accepted by the defense community. This paper presents one such example of the modeling capability developed for the Ballistic Missile Defense (BMD) application, called the Signal Processing Environment for Analysis and Reduction (SPEAR) simulation.

SPEAR has become a key IR sensor design and signal processing performance verification tool for the BMD Advanced Sensor Technology Program (ASTP), the Discriminating Interceptor Technology Program (DITP), and the Ground Based Interceptor (GBI) and , where it is used for sensitivity analyses, algorithm evaluations, and performance assessments. For these programs, SPEAR provides an algorithm testing simulation to evaluate candidate signal processing options, and implement and test performance of algorithms proposed through advanced technology programs. In addition, SPEAR is used to process real world data to provide assessments of sensor performance and provide preflight predictions. The simulation has been interfaced to the Synthetic Scene Generation Model (SSGM), a community standard background and target scene generation simulation. Through this interface sensor performance can be evaluated against realistically modeled backgrounds to evaluate filtering, detection, and false alarm performance.

SPEAR is a hi-fidelity passive infrared (IR) sensor and signal processing simulation for staring, scanning, and hybrid sensors. It allows the user to specify the IR sensor physics including the sensor, optics, focal plane array or scan chip assembly, analog signal processor, time dependent and object dependent processing parameters and specific noise sources such as optics, jitter, fixed pattern noise, dark current, and gamma spike noise. SPEAR is an Ada / PVWAVE combination. The sensor and signal processing is written in Ada and the execution, parameter input, and function analysis are controlled with the graphical user interface (GUI) written in PVWAVE. The signal processing techniques available as options include time dependent processing techniques such as adaptive threshold detection, background estimation and removal, morphological filtering, match filtering, target signature extraction and object dependent processing techniques such as centroiding and pulse matching. SPEAR has simulation control options to allow the user to execute and examine data per frame (mission mode) or in a statistical mode to investigate parametric sensitivities of the sensor performance. Documentation of SPEAR includes manuals on the GUI, the SPEAR application components, and guidelines for adding new algorithms and features.

This paper provides a summary of key algorithm and options in SPEAR. Examples of performance analysis results are provided. The paper includes stochastic analyses of both the above-the-horizon and below-the-horizon engagements of

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[a] B.C.S. Telephone: (205) 922 - 6010 x3108; Telefax: (205) 922 - 6053; E-Mail: brian_smith@mail.crc.com

[b] Y.K. Telephone: (703) 413 - 9200, ext. 4220; Telefax: (703) 416 - 1964; E-Mail: yas_kinashi@netqm.nichols.com

target and background generated scenes using SSGM. Also discussed are the evaluation of radiometric measurement precision, angular measurement precision, and detection of targets of varying intensities with respect to varying sensor signal processing techniques.

1. SPEAR OVERVIEW

SPEAR is both an environment for simulation of IR sensors and signal processors as well as a functional analysis tool, for characterizing deterministic signal processor performance. This dual nature allows the analyst to model and predict the behavior of a sensor/signal processor combination and thereby to optimize the system design. Just as important, it allows the analyst to process actual measurement data taken from a sensor system to perform data assessments. Having the ability to process data from the systems being modeled provides a high level of confidence in the accuracy and fidelity of the simulation.

The SPEAR application components are implemented as modular functional models of threat and background scenes, IR sensor components, and sensor processing algorithms written in Ada, approximately 50k lines of code (LOC). SPEAR is a mature simulation and has become a key sensor simulation which has evolved through the following programs: FAS / AOA / AST / GSTS / BP / BE / GBI / ASTP / DITP.

The Graphical User Interface (GUI) is written in PVWAVE, consisting of 40k LOC and is very easy to use. It controls the set up and maintains all inputs and allows data visualization at every level for simulation execution, sensor and signal processing parameter setup, and functional performance analysis.

The generic SPEAR simulation has the capability to model either a staring or scanning sensor system. The modularity of the SPEAR implementation allows for other types of sensor systems to be easily implemented. SPEAR provides hi-fidelity modeling of the effects of the targets and background at the aperture through the optical train to the Focal Plane Array (FPA) and then processed through the Analog Signal Processor (ASP), including the noise effects through the process. The data is then sent to the Time Dependent Processor (TDP), so named because its performance requirements are driven by the sample rate of the sensor, not by the characteristics of the target scene. The TDP, operating on all the FPA samples, contains algorithms to enhance the signal-to-noise ratio, isolate regions of interest in the scene and package the selected data to be sent to the Object Dependent Processor (ODP). The performance requirements of the ODP are driven by the number of possible objects that require processing. The job of the ODP is to determine the precise position and amplitude of the targets. The resulting data is packaged into object sighting messages on a frame-by-frame basis and entered into track files. In the case of an interceptor, the track files are used onboard to guide the vehicle to an intercept. The diagram below shows the flow of data from the threat / environment, through the signal generator, through the signal processor functions, and output to the data processor.

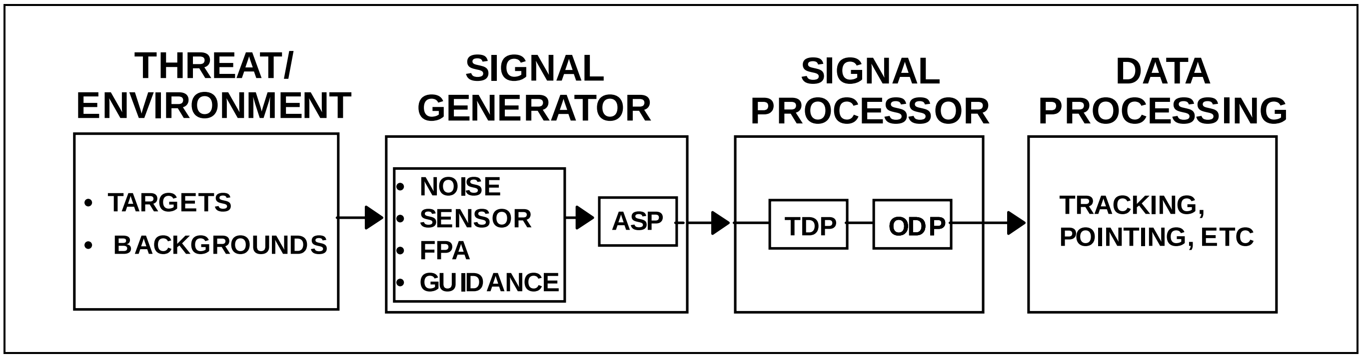


FIGURE 1. SPEAR FUNCTIONAL FLOW

SPEAR follows this functional flow, with emphasis on the signal processor. There are many processes within each major function that the analyst can set up to reflect the concept under study. If actual ground test or flight data is available, the data can be injected into the TDP or at the interface between the TDP and ODP, depending on the type of data available.

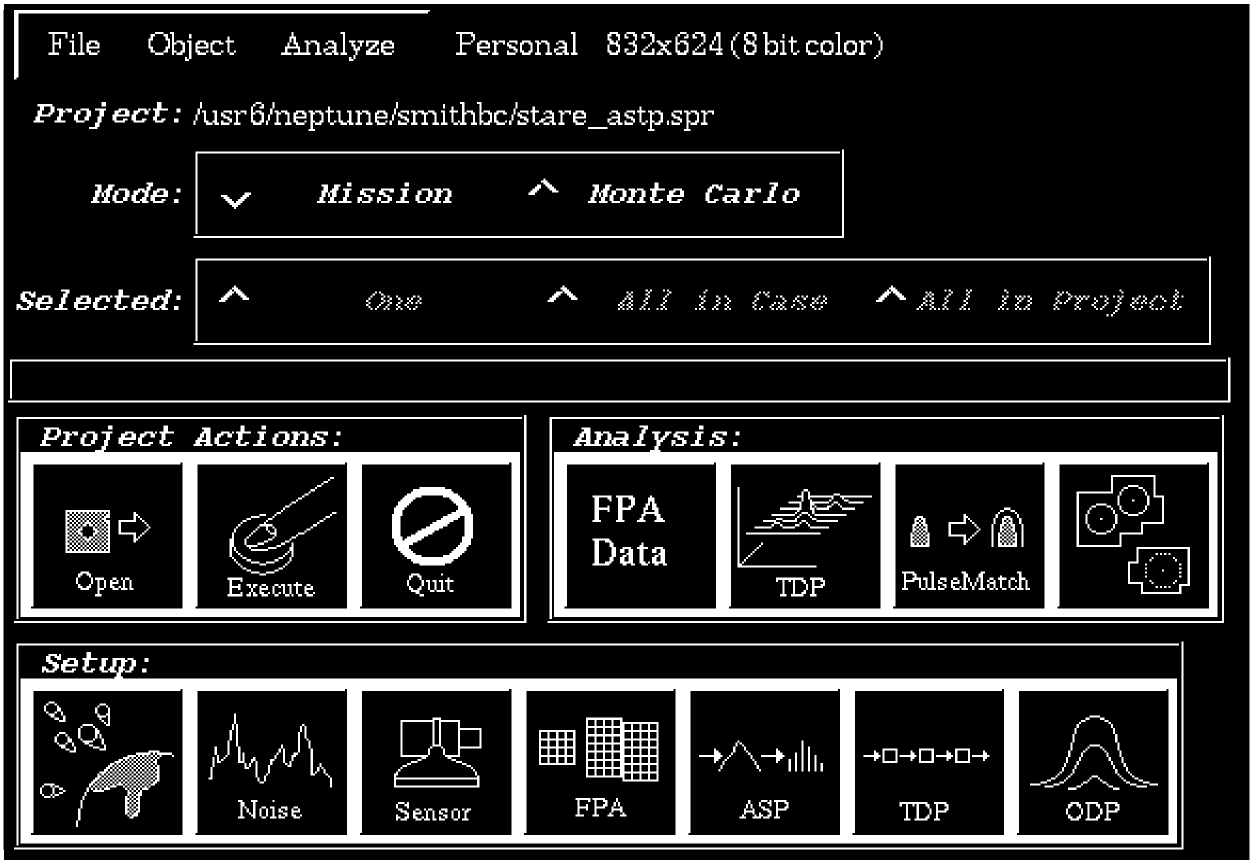
SPEAR provides a flexible model of a sensor system to drive the signal processor when controlled, simulated data is desired. When using simulated sensor data, Monte Carlo runs can be made, varying noise draws on each trial and accumulating statistics on performance. Typical performance measurements include Probability of Detection, Probability of False Alarm, Radiometric Measurement Precision (RMP), Angular Measurement Precision (AMP), and probability of resolution for Closely Spaced Objects (CSOs).

A fundamental strength of SPEAR is that the analyst can change the sensor parameters or the signal processor setup without re-compiling. All changes are made through the GUI with mouse clicks and minimal typing. Extensive plotting capabilities are included and these also are controlled by the GUI. These attributes have led to a tremendous increase in productivity. The analyst, who needs very little computer expertise, can study more concepts in a shorter period of time with much less opportunity for error.

2. SPEAR EXECUTION

The SPEAR GUI main window shown in Figure 1, displays the top level user options. The user operates within a Project, which groups all the inputs and outputs. The Project can be saved, new ones can be created, and existing Projects can be modified, all using the GUI. This method of controlling the setup and execution has two important benefits: reducing the likelihood of user error, and reducing the time required to setup and document results.

SPEAR can be run in two basic modes: Mission and Monte Carlo. In the Mission mode, one or more frames of target data is set up (or read in from an external source) and each frame is processed once. In the Monte Carlo mode, a single frame is executed many times while varying noise parameters for each frame which allows for the accumulation of statistics for algorithm performance.



Project: /usr6/neptune/smithbc/stare_astp.spr

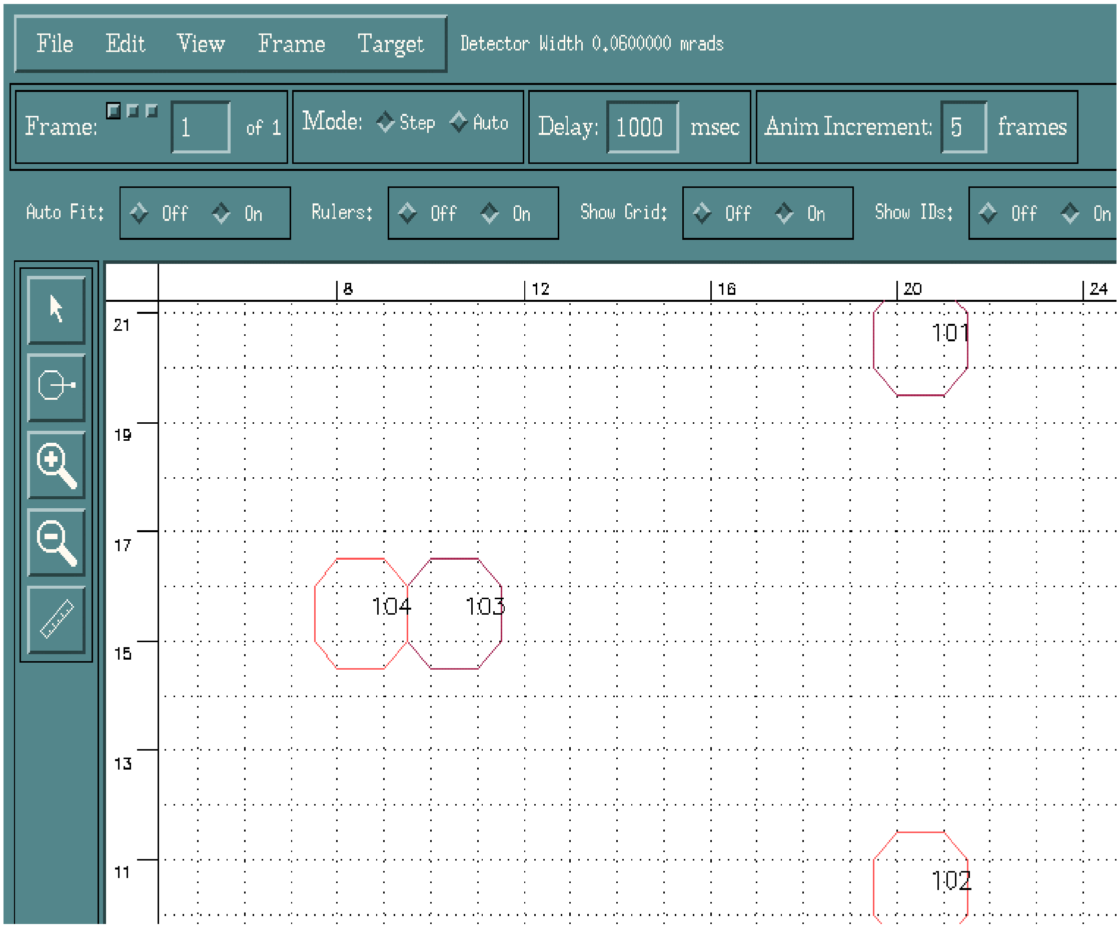
Mode: Mission

FIGURE 2. SPEAR MAIN WINDOW

The Project is composed of seven “objects” that contain the setup parameters. To edit the objects, the user clicks on the object icon, creating new screens and dialog boxes for setting up the parameters. The setup objects are described below:

2.1 Threat Definition

The threat definition window represents the sensor field of view with a representation of virtual pixel locations where the position, amplitude, and velocity of point source targets and extended source targets can be can be easily created, moved, duplicated, and deleted with a graphical interface. The user also has the option to setup multiple frames of target data to perform mission mode analyses. The target amplitudes can be input in units of irradiance (W/cm^2) or a signal-to-noise ratio (SNR), based upon the noise equivalent input, for up to 3 wavebands. The last option of the threat model is to allow the user to specify the exact locations of the targets and their mappings to the FPA or the user can specify to bound the specified targets in the field of view and map them to the center of the FPA.



Detector Width 0.0600000 mrads

Frame: 1 of 1

Mode: ◆ Step ◆ Auto

Delay: 1000 msec

Anim Increment: 5 frames

Auto Fit: ◆ Off ◆ On

Rulers: ◆ Off ◆ On

Show Grid: ◆ Off ◆ On

Show IDs: ◆ Off ◆ On

FIGURE 3. THREAT SETUP WINDOW

2.2 Noise Source Models

The noise module includes seven types of noise sources which consist of white noise, background noise, jitter, optical noise, fixed pattern noise, dark current, and gamma noise. The noise sources are calculated for each detector in the user specified FPA. There are other noise terms which may be important to consider based upon the sensor the user is evaluating and these models can be easily implemented into the modular architecture of SPEAR.

White Noise. The white noise model is modeled as random draws from a gaussian distribution with the mean of zero and the standard deviation equal to the noise equivalent input in units of W/cm^2. The user can set the noise seed for the random number generator and can choose to specify the random numbers used in each calculation to be read in from an external file, which is useful for execution, repeatability, and verification of large mission analyses where many frames of data are processed in subsets.

Background Noise. The background noise model consists of specifying a previously generated scene utilizing the Synthetic Scene Generation Model (SSGM), a government supplied model, sponsored by the Ballistic Missile Defense Organization, and developed by the Naval Research Laboratory. For analysis requiring an SSGM background scene as input requires the user to specify the sensor model parameters, target parameters (whether in boost phase with plume effects or post boost phase), time of day, viewing geometry, and the corresponding terrain, cloud, or celestial backgrounds (in some cases the scenes may contain all three, for a sensor viewing both below the horizon and above the horizon). SSGM generates the background scene in radiance units of $W/cm^2/sr$ at the sensor aperture. SPEAR converts the input background scene radiance at the aperture into irradiance at the aperture. The user has the option to generate a background scene without embedded targets so that the targets can be placed in specified regions of interest by using the threat model specified above. This option allows the user to either use the entire background scene as an input or specify a specific sub-region of interest or randomly select regions to generate performance statistics.

Jitter. The jitter model is used to model the telescope jitter by combining user defined sine waves imposed on the line of sight. The user specifies the number of sine waves, their amplitudes, and their frequencies.

Optical Noise. The effective optical photon flux from the telescope components is set up here by specifying the waveband, temperature, and emissivity of the elements. Calculation of the exitance of the optical elements is performed by integrating the Plank blackbody equation over the waveband(s) of interest for the specified temperature. The specified emissivity is used to calculate the radiant intensity of the optical elements. The mean optical background flux level is converted from radiant intensity to electrons and the standard deviation is calculated as the square root of the mean electron flux level. The user specifies the random number seed for the noise fluctuation which is modeled as random draws from a gaussian distribution with the specified mean and standard deviation.

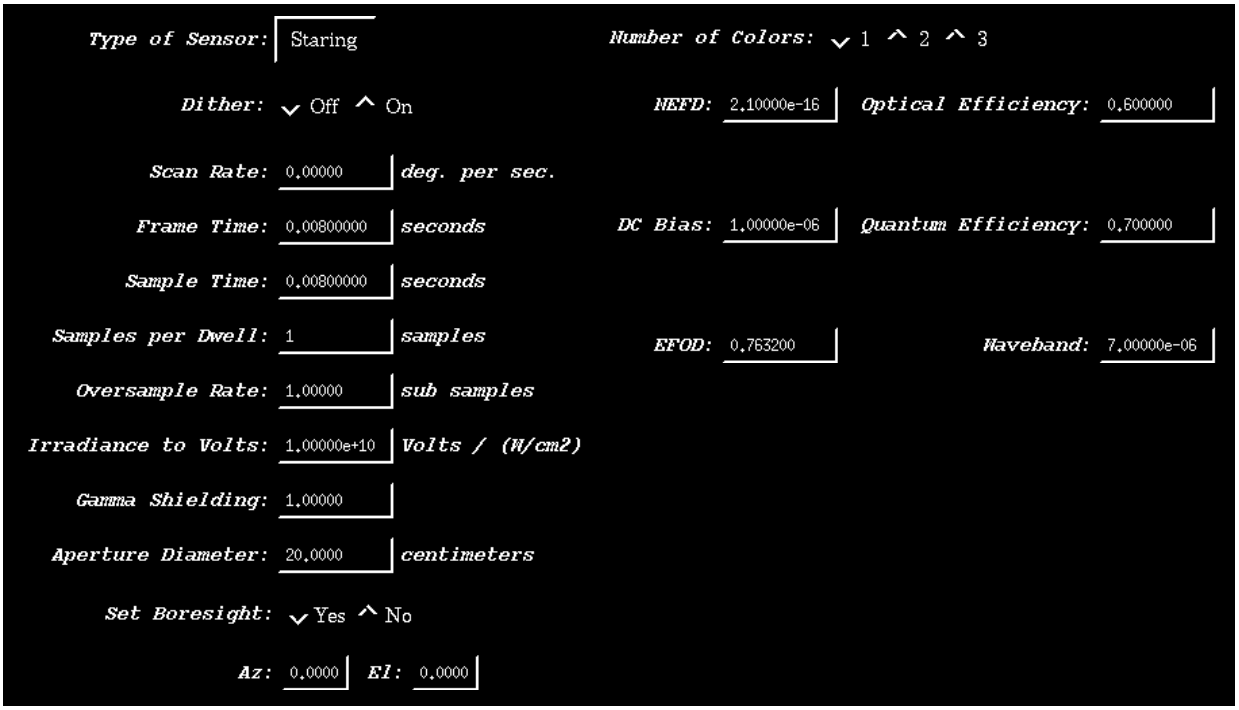
Fixed Pattern Noise. The fixed pattern noise model models the detector non-uniformity for each detector in the array. Here the user specifies the percent non-uniformity across the array which is modeled as random draws from a gaussian distribution with the mean equal to the specified effective offset value and the standard deviation equal to the percent non-uniformity times the mean value. The modeling of the responsivity (gain) of the detectors is in progress.

Dark Current. Dark current is the current generated from the detector when it is non-illuminated. The user can specify the effective dark current and the noise seed value. For each pixel in the array the model calculates the effective dark current by random draws on a gaussian distribution with the mean equal to the dark current and the standard deviation calculated within the model.

Gamma Noise. The gamma noise model is used for simulating the effects of natural space (Van Allen belt) environment or nuclear bursts on the sensor and signal processor. The user can select the pulse height distribution file to be used and the random number seed.

2.3 Sensor Design Parameters

In this dialog box, the basic sensor parameters are defined. The type of sensor is defined, along with the aperture diameter, the frame time, the sample time, number of samples per dwell, the over-sample rate, the degree of gamma shielding, the energy focused on detector, the noise equivalent input, the optics transmission, the quantum efficiency, and the waveband(s) of interest.



Type of Sensor: Staring

Number of Colors: ✓ 1 ^ 2 ^ 3

Dither: ✓ Off ^ On

NEFD: 2.10000e-16

Optical Efficiency: 0.600000

Scan Rate: 0.00000 deg. per sec.

Frame Time: 0.00800000 seconds

DC Bias: 1.00000e-06

Quantum Efficiency: 0.700000

Sample Time: 0.00800000 seconds

Samples per Dwell: 1 samples

EFOD: 0.763200

Waveband: 7.00000e-06

Oversample Rate: 1.00000 sub samples

Irradiance to Volts: 1.00000e+10 Volts / (W/cm2)

Gamma Shielding: 1.00000

Aperture Diameter: 20.0000 centimeters

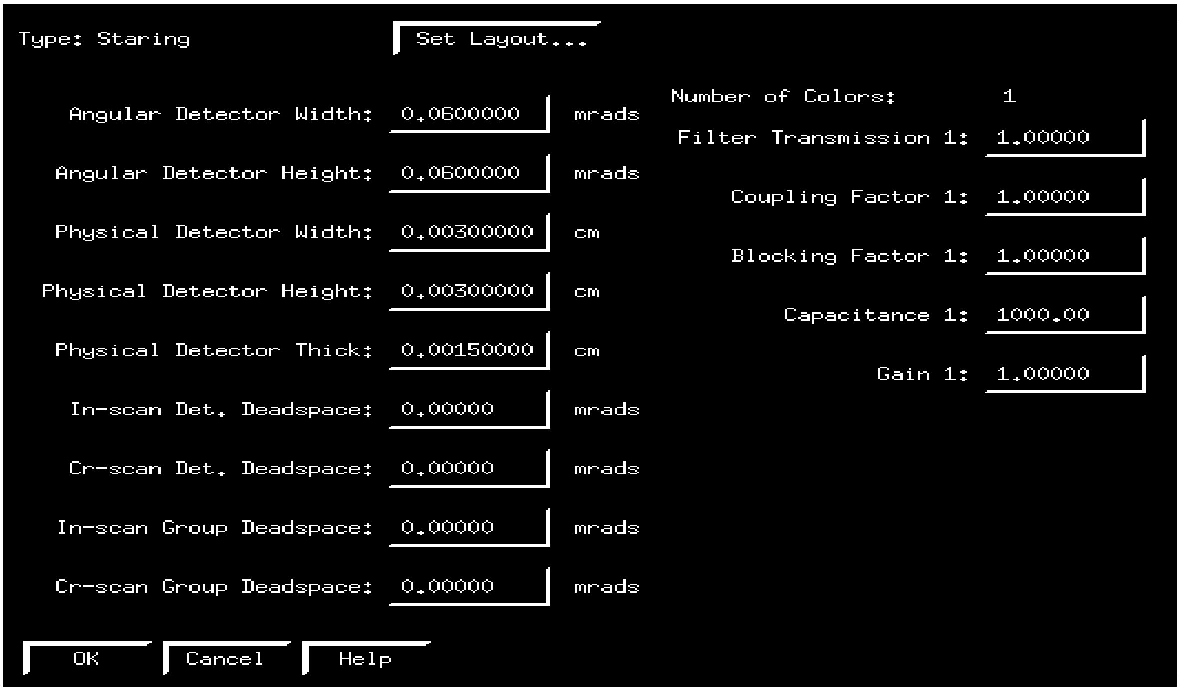
Set Boresight: ✓ Yes ^ No

Az: 0.0000 El: 0.0000

FIGURE 4. SENSOR SETUP WINDOW

2.4 Focal Plane Array (FPA) Design Parameters

Here the user sets up the focal plane array design parameters. The dialog box changes to reflect the type of sensor defined in the sensor dialog box. If the sensor is staring, the user selects the number of rows and columns of the mosaic. The number of columns defines a Time Delay and Integration (TDI) set for a scanning sensor. The relative sensitivity of each detector column is set here. For either type of sensor, the user specifies the physical and angular dimensions of each detector, the “deadspace” between detectors and groups, detector filter transmission, coupling factor, blocking factor, capacitance, and the gain term. SPEAR calculates the amount of energy reaching each pixel in each waveband and maps it to the FPA using the internally generated gaussian detector response function or an externally generated response function from an optics model like CODE - V.



Type: Staring

Angular Detector Width: 0.0600000 mrads
Angular Detector Height: 0.0600000 mrads
Physical Detector Width: 0.00300000 cm
Physical Detector Height: 0.00300000 cm
Physical Detector Thick: 0.00150000 cm
In-scan Det. Deadspace: 0.00000 mrads
Cr-scan Det. Deadspace: 0.00000 mrads
In-scan Group Deadspace: 0.00000 mrads
Cr-scan Group Deadspace: 0.00000 mrads

Number of Colors: 1
Filter Transmission 1: 1.00000
Coupling Factor 1: 1.00000
Blocking Factor 1: 1.00000
Capacitance 1: 1000.00
Gain 1: 1.00000

FIGURE 5. FPA SETUP WINDOW

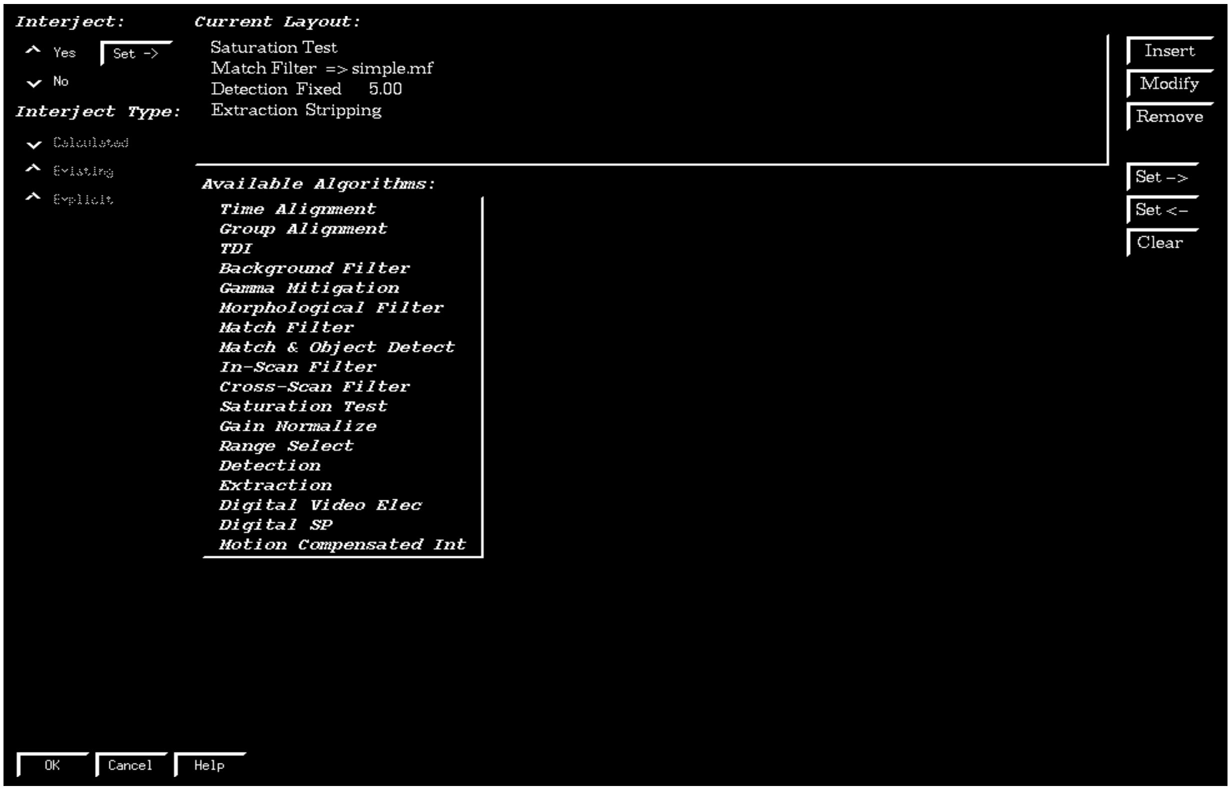
2.5 Analog Signal Processor (ASP) Modules

Inside the ASP dialog box the user can select from a list of functions performed in the ASP. These functions include analog-to-digital conversion (A/D), background filtering, gamma mitigation, Nyquist rate restore, and sum oversamples. For the A/D conversion the user specifies the maximum range of the A/D (e.g. for a 12 bit A/D the maximum range is calculated as $2^{12} - 1 = 4095$ counts), and the user specifies the voltage range across the A/D.

2.6 Time Dependent Processor (TDP) Modules

This is the dialog box most frequently used by the SPEAR analyst (see Figure 6). Here the user defines the sequence of functions for the TDP. The user selects from the “Available Functions” list and inserts it in the processing chain by pointing and clicking. SPEAR does a considerable amount of work behind the scenes to ensure that the algorithms will work together properly even with the changes in the sequence.

If the analyst is using data imported from another source (e.g. sensor test or flight data), the “interject data” button is selected and the arrow is placed to show at what point in the chain the data is to be inserted. In some concepts, data is filtered to improve signal to noise ratio for detection purposes, but unfiltered data is used for accurate determination of target position and amplitude. SPEAR allows the user to specify at what point the unfiltered data is to be saved for position and amplitude determination. The data is then processed by extraction stripping to extract the regions above threshold.



Saturation Test
Match Filter => simple.mf
Detection Fixed 5.00
Extraction Stripping

FIGURE 6. TDP SETUP WINDOW

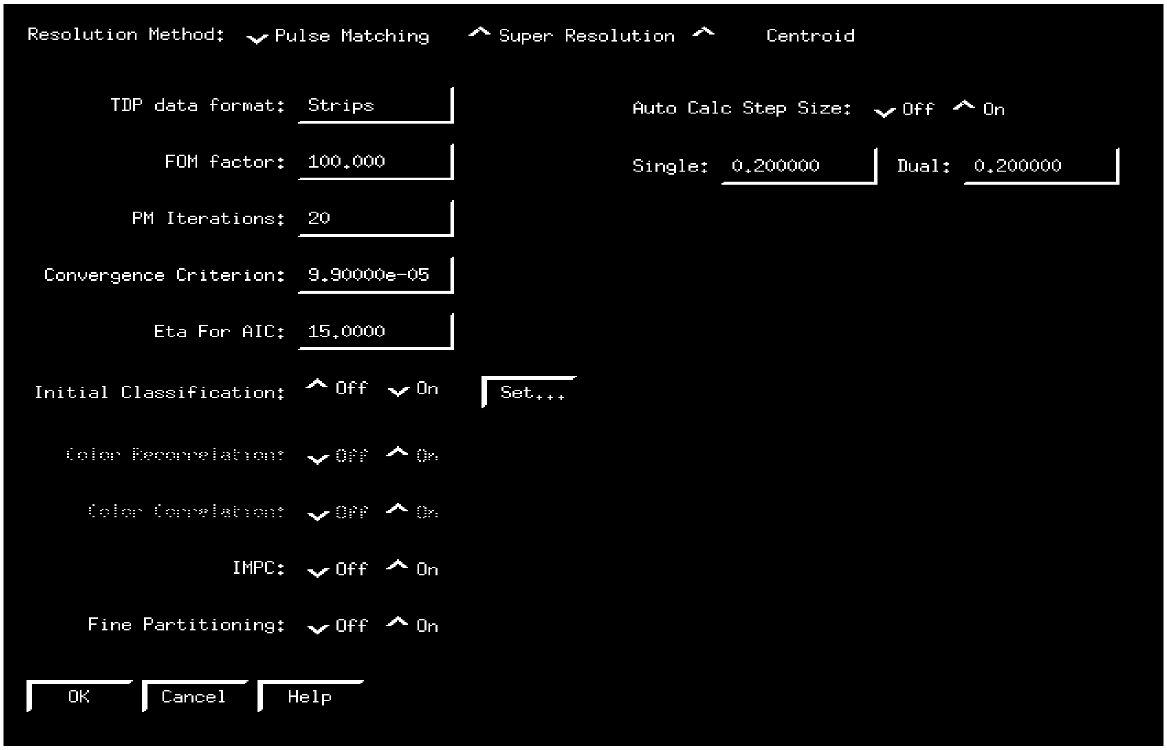
The TDP setup dialog box is where the modular structure of SPEAR is most apparent and where the benefits of the Ada language are demonstrated. The functions can be inserted, deleted, modified, or re-ordered, mostly by pointing and clicking. Typically this can be done in only a few seconds and the case can be re-run without having to re-compile the simulation. For example, if the processor appears to be passing too many false alarms or low-amplitude targets, the detection threshold can be raised as desired. Or a background filter can be selected that provides more clutter suppression. This allows very rapid turnaround in evaluating algorithm performance or in analyzing data. If the user is interested in evaluating a signal processing algorithm which is currently not implemented into the TDP, the modular design of the TDP allows for easy implementation and testing.

2.7 Object Dependent Processing (ODP) Modules

The dialog box for the ODP (see Figure 7) is where the analyst determines how the position and amplitude are estimated. The basic choices are Pulse Matching, Centroiding, and Super Resolution with choices for parameters appearing (or being hidden) in the box based on which method is selected.

The example in Figure 7 shows the Pulse Matcher selected. The Figure of Merit (FOM) factor determines how “target-like” a detection has to be for it to be declared a true target. The initial classification button brings up a sub-window where the analyst can select a screening method: second moments or a simple size check. The buttons for color correlation and re-correlation are dimmed because only one waveband is being processed in the current setup. If multiple wavebands had been selected, this option would direct SPEAR to attempt to associate target sightings from individual bands, thus reducing the false alarm rate. The Image Motion Parameter Compensation (IMPC) is a method for mitigating the effects of target motion across the focal plane. Clump processing and fine partitioning are two methods for dealing with multiple targets that are so closely spaced that they extend across many detectors. Additional choices appear when these options are selected for setting sup-parameters.

The Aikaike Information Criteria (AIC) is used in the decision process of classifying the pulse matcher fit of the extracted data packet as either containing one or two targets. The Eta parameter in the AIC equation is a weighting factor in the decision process and provides a method of fine tuning the pulse matcher performance.



Resolution Method: [✓ Pulse Matching] Super Resolution Centroid

TDP data format: Strips

FOM factor: 100.000

PM Iterations: 20

Convergence Criterion: 9.90000e-05

Eta For AIC: 15.0000

Initial Classification: Off [✓ On]

Color Decorrelation: [✓ Off] On

Color Correlation: [✓ Off] On

IMPC: [✓ Off] On

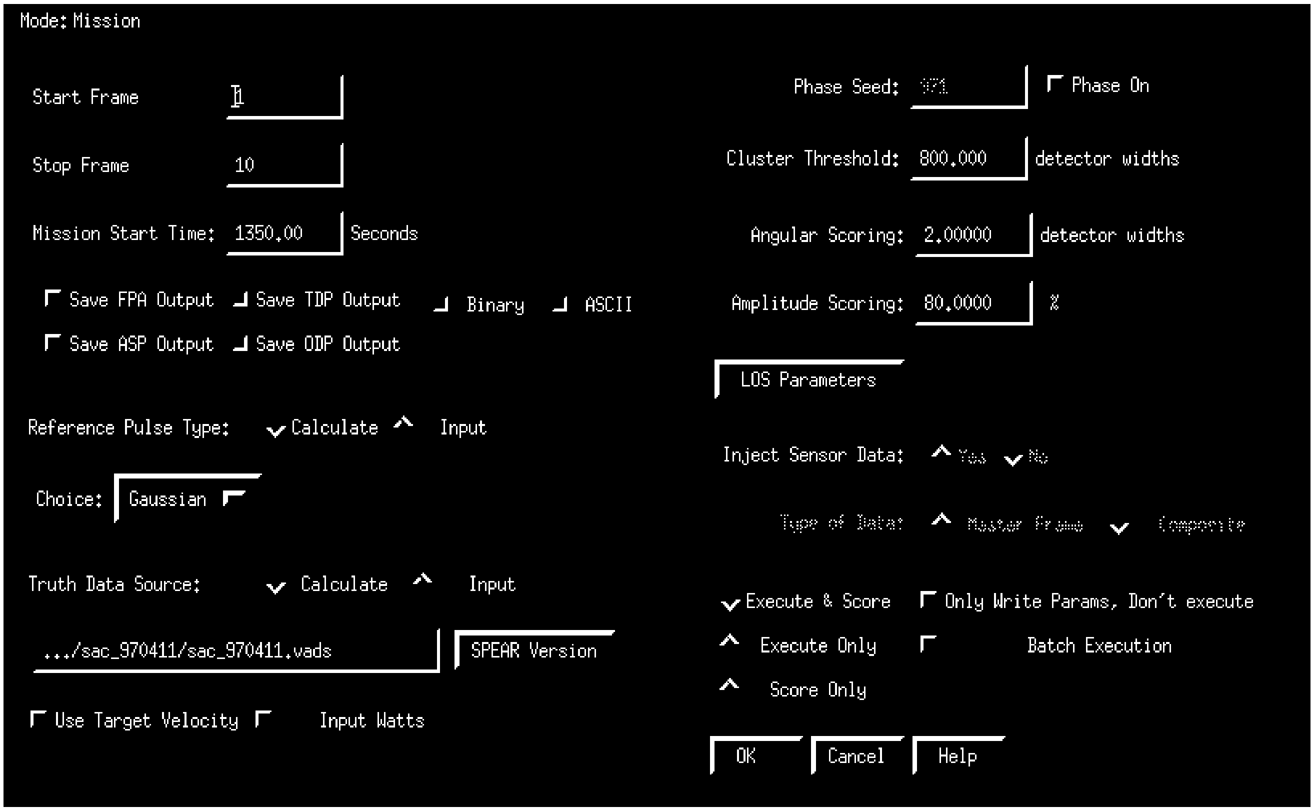
Fine Partitioning: [✓ Off] On

Auto Calc Step Size: [✓ Off] On

Single: 0.200000

Dual: 0.200000

FIGURE 7. ODP SETUP WINDOW



Mode: Mission

Start Frame: 1

Stop Frame: 10

Mission Start Time: 1350.00 Seconds

☐ Save FPA Output ☑ Save TDP Output ☑ Binary ☑ ASCII

☐ Save ASP Output ☑ Save ODP Output

Reference Pulse Type: [✓ Calculate] Input

Choice: Gaussian

Truth Data Source: [✓ Calculate] Input

.../sac_970411/sac_970411.vads

☐ Use Target Velocity ☐ Input Watts

Phase Seed: 971

☐ Phase On

Cluster Threshold: 800.000 detector widths

Angular Scoring: 2.00000 detector widths

Amplitude Scoring: 80.0000 %

Inject Sensor Data: Yes [✓ No]

Type of Data: Master Frame [✓ Composite]

[✓ Execute & Score] ☐ Only Write Params, Don't execute

Execute Only ☐ Batch Execution

Score Only

FIGURE 8. EXECUTION SETUP WINDOW

2.8 Execution Modes

Once the setup is completed, the user pushes the "Execute" button and the execute dialog box shown in Figure 8 appears. If in the mission mode, the execute window will allow the user to pick a range of frames for processing, what intermediate data to save, whether to use the default Gaussian reference pulse or an externally supplied reference pulse from CODE - V for the detector response function and pulse matching, whether to use or ignore the target velocity, and whether to vary the target-to-detector phasing. The execute dialog box is also where the options for injecting data are chosen and where the execution options for execution and scoring are chosen.

If the user selects the Monte Carlo mode in the SPEAR main window prior to execution, a list of parameters appears that will be the "independent variable" in the Monte Carlo analysis. Items are added and deleted in a manner similar to the TDP setup window. When the "Execute" button is pressed, the user selects the number of trials, along with the normal settings described above.

3. FUNCTIONAL PERFORMANCE ANALYSIS

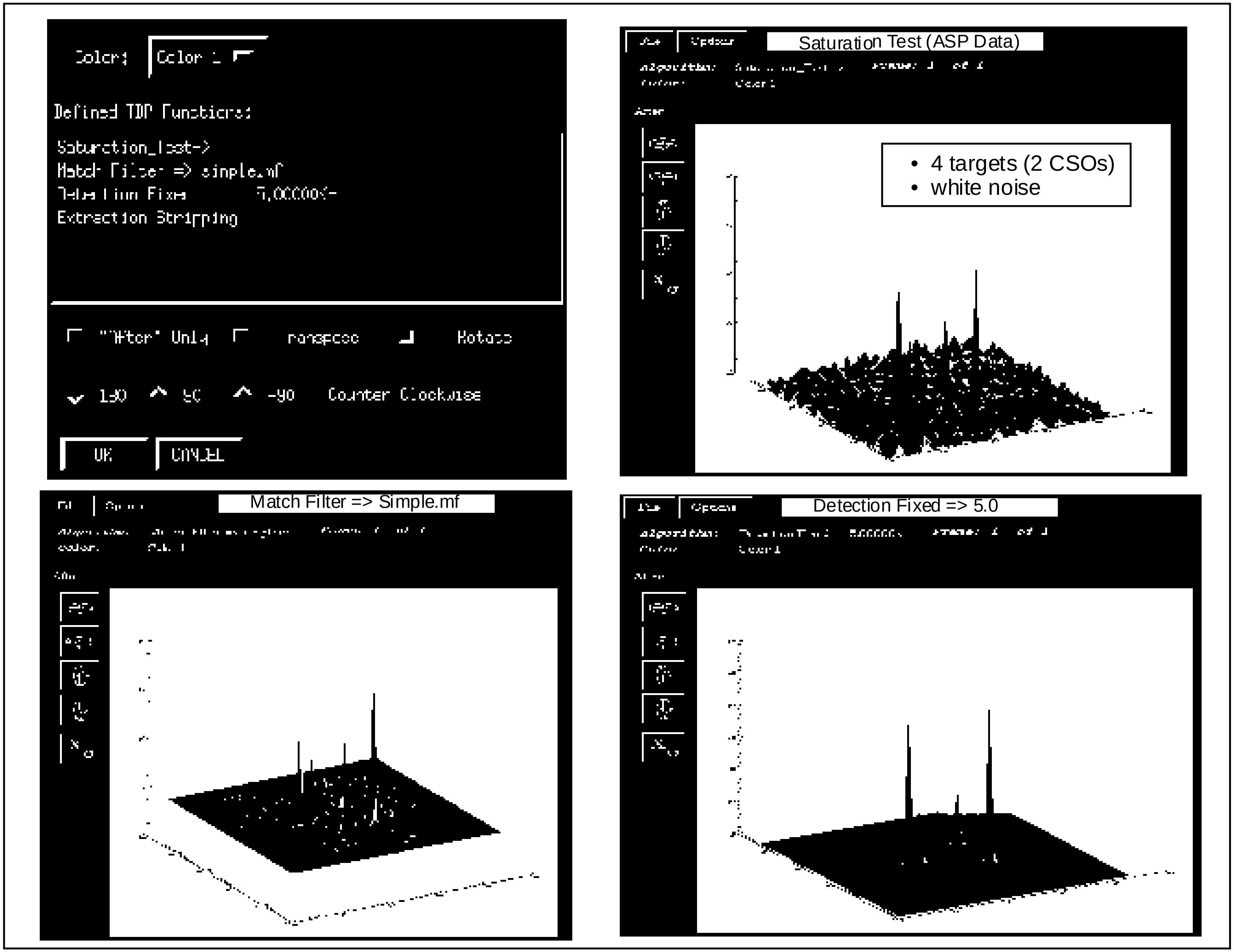
The user may perform two types of analyses: 1) Mission Mode, or 2) Statistical Analyses Mode. The first, Mission Mode, is used for assessment of signal processor performance per frame of data. Processing algorithm options, including background filtering techniques can be applied to, for instance, assess the ability of the signal processor to detect and extract the target. Operation in the mission mode is well suited for predicting sensor preflight performance over the multiple frames during the mission and for evaluating the sensor postflight data to verify and validate SPEAR modules. The second type of analyses, Statistical Analyses, is used to obtain a statistical evaluation of sensor measurement performance. In this mode, a Monte Carlo approach is used to generate a large number of realizations of a target against the defined background to provide evaluation of sensor figures of merit, including probability of detection and probability of false alarm.

3.1 Mission Mode Analysis

Example results for Mission Mode analyses cases are shown in Figures 9, 10, 11. When the user clicks the "TDP Analysis" button the user sees the algorithm chain defined in the TDP setup window which SPEAR has executed is displayed. SPEAR provides the analyst with a useful feature to display data before and after each selected function through a simple selected function through a simple selection of the processing option from the algorithm list. The TDP graphical results for a staring sensor are shown in Figures 9, 10, 11. In Figure 9 the results of the TDP processing chain of a sensor viewing 4 targets (two of which are CSOs) with white noise background modeled. For this case the TDP algorithm chain consists of a saturation test (monitoring for pixels out of range, essentially the virtual FPA in counts, output from the ASP), the Matched Filter (3x3 convolution mask), and the detection thresholding. Similar TDP results are shown in Figure 10 for a IR staring sensor viewing the a similar set of targets against a SSGM background scene (terrain plus cloud). In this case the analyst can choose to generate the targets within SSGM for the specific viewing geometry or can use SPEAR to splice the targets into regions of interest within the SSGM background scene. The TDP plots can be rotated for optimum viewing and the color palette can be modified with a slider bar to enhance details. The ability to see the effects of each function is another key benefit to productivity that SPEAR brings to data analysis.

Another valuable graphical analysis tool is the Pulse Matcher window. The raw extracted data and the best fit to the 3-D data that was achieved is displayed in Figure 11, for the two CSO targets in this case. Also displayed within the pulse matcher window are the extracted packet statistics such as size, sum squared fit errors for singles and duals, the Aikaike Information Criterion (AIC) results for singles and duals, the number of targets determined per packet, and finally the pulse matcher FOM. These analysis features help in separating data quality issues from algorithm performance issues.

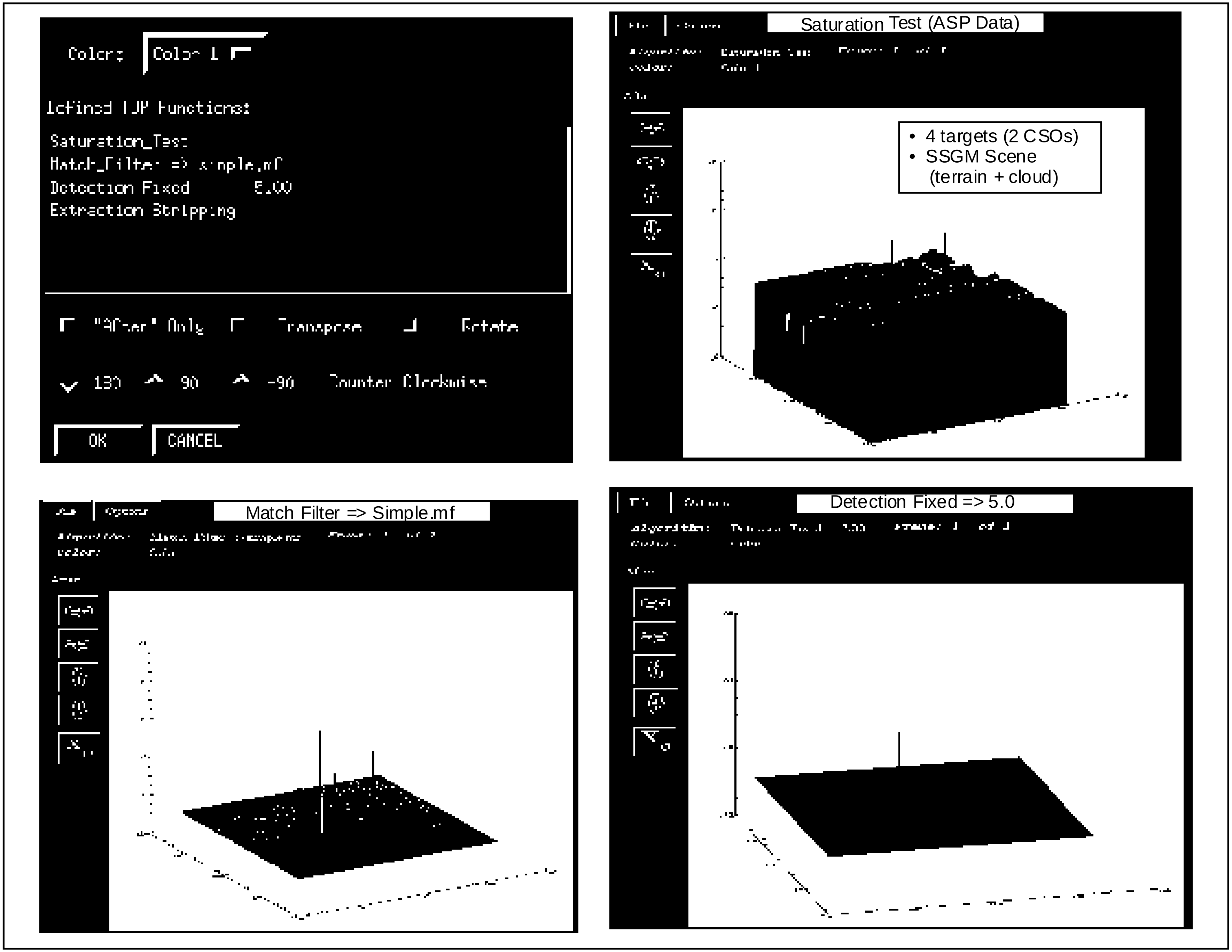
The last tool in the Mission Mode analysis toolbox is the OSM window. Plotted in this window are the true positions of each target, SPEAR's estimated position, and the physical boundaries of the extracted data. Any spatial biases introduced by the signal processor are readily apparent. A quick assessment of CSO resolution can be performed. From this plot, the analyst quickly sees the overall estimation performance of the algorithm chain.


Colors: Color 1

Defined TDP Functions:

Saturation_Test->
Match Filter => simple.mf
Detection Fixed 5.00000
Extraction Stripping

FIGURE 9. TDP FUNCTIONAL ANALYSIS (STARING SENSOR)



Color: Color 1

Defined TDP Functions:

Saturation_Test
Match_Filter => simple.mf
Detection Fixed 5.00
Extraction Stripping

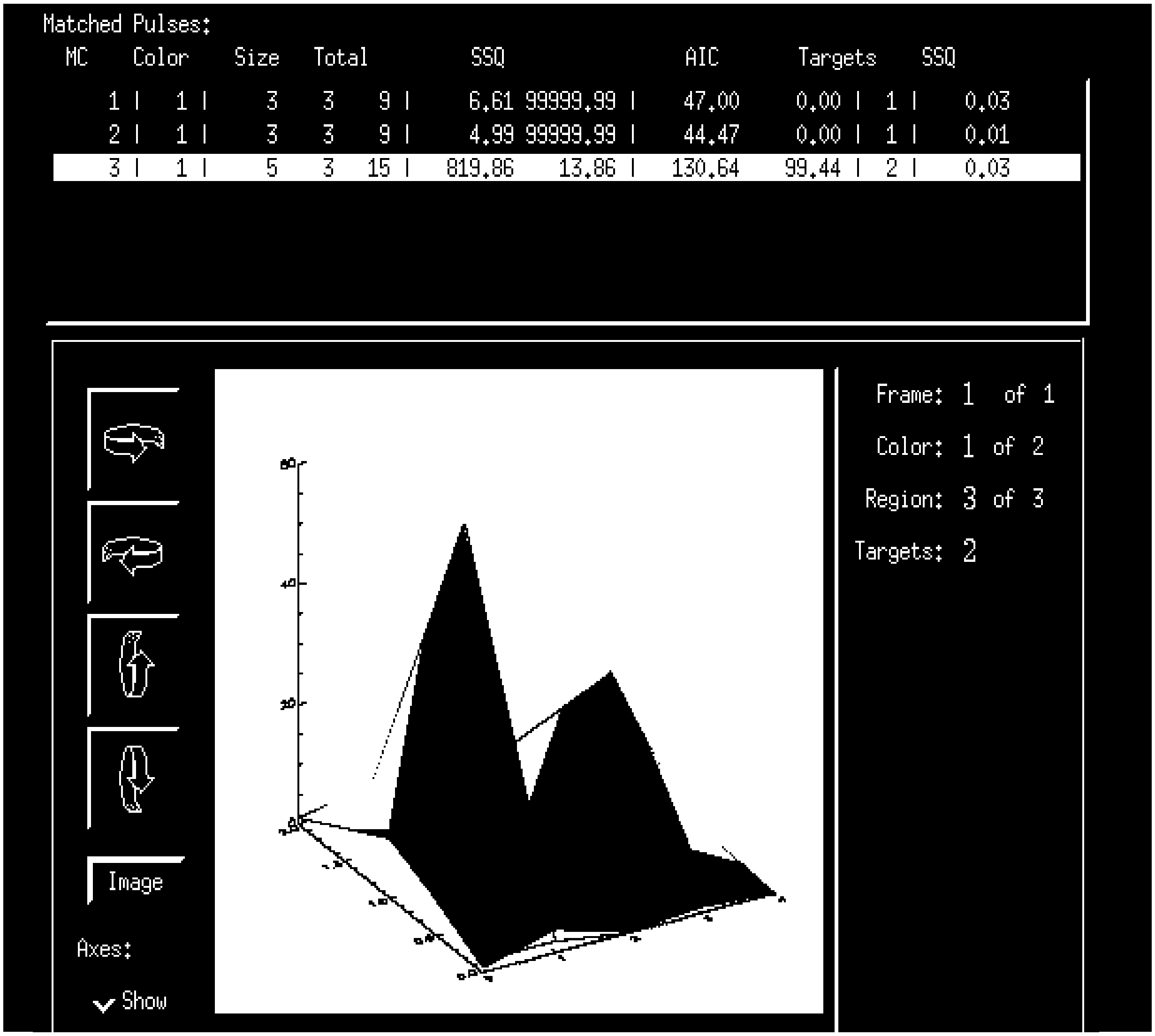
Saturation Test (ASP Data)

- 4 targets (2 CSOs)
- SSGM Scene (terrain + cloud)

Match Filter => Simple.mf

Detection Fixed => 5.0

FIGURE 10. TDP FUNCTIONAL ANALYSIS (STARING SENSOR w/ SSGM BACKGROUND)



```
Matched Pulses:
 MC    Color    Size  Total       SSQ                AIC       Targets   SSQ

      1 |   1 |     3    3    9 |     6.61 99999.99 |     47.00     0.00 |  1 |    0.03
      2 |   1 |     3    3    9 |     4.99 99999.99 |     44.47     0.00 |  1 |    0.01
      3 |   1 |     5    3   15 |   819.86    13.86 |    130.64    99.44 |  2 |    0.03
```

Frame: 1 of 1

Color: 1 of 2

Region: 3 of 3

Targets: 2

FIGURE 11. PULSE MATCHER ANALYSIS WINDOW

3.2 Statistical Analysis Mode

In the Statistical Analysis Mode the analyst accesses to the Monte Carlo analysis window. In this window the user organizes the data to summarize the performance. The analyst selects from a list the data sets to plot and the measurement type desired. The list of measurements includes radiometric error, angular error, pulse matcher figure of merit, and detection / false alarm performance. The data can include all detection’s or only those SPEAR classified as Singles or CSOs. After the desired data is chosen, the analyst sets the plot parameters: plot title, axis titles, and automatic user scaling. SPEAR then plots the data to the screen. The analyst can then send the plots to a printer, to an encapsulated PostScript file (EPSF) or save it as a Graphics Interchange Format (GIF) file for later use.

Example Statistical Analysis Mode results are shown in Figure 12. These results were generated by modeling a staring sensor viewing 6 targets varying in SNR from 2 to 64 with the noise term "white noise" and the target-to-detector phasing options turned "on", with the signal processing chain consisting of a matched filter and detection thresholding. The results show the percent targets detected, RMP, and AMP as a function of the SNR. As the SNR gets smaller the percent detected drops off until no targets are detected at SNR of 2, and the corresponding precisions (RMP and AMP) get larger as expected. The analyst can investigate ways to improve the performance of the sensor and signal processor by modifying sensor parameters or by applying other signal processing filtering and thresholding functions.

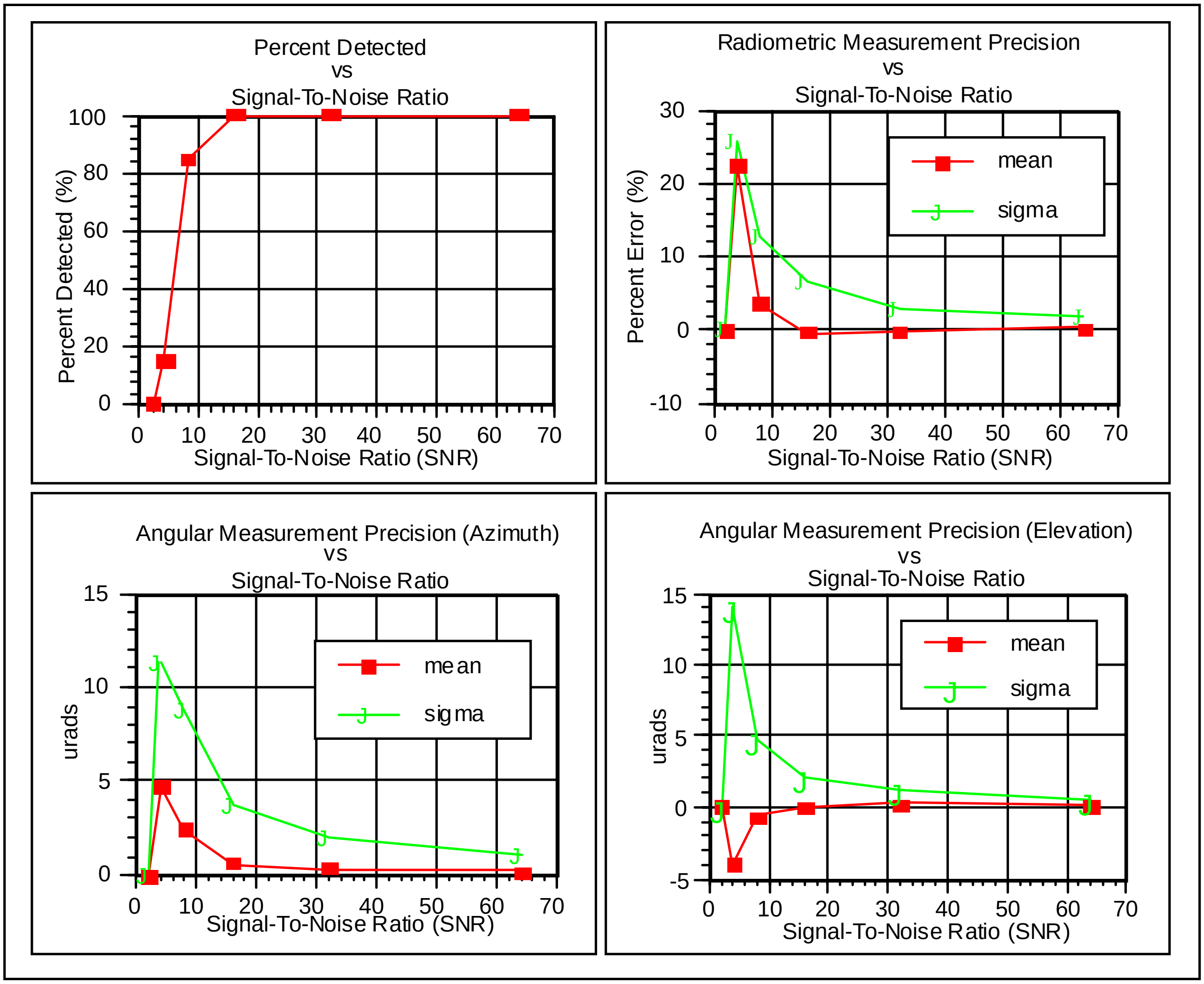


FIGURE 12. MONTE CARLO ANALYSIS RESULTS

4. SUMMARY

This brief paper can only highlight some of SPEAR's capabilities. SPEAR has been carefully designed to fulfill its dual roles of IR sensor model / signal processing testbed and data analysis tool. Extensive documentation has been produced covering the User Interface and the Application Components, including guidelines for adding new algorithms and features.

SPEAR has been used to analyze IR sensor test / flight data and simulated data for several actual and proposed optical systems. Its output has been carefully compared to laboratory data and was found to agree within the uncertainties of the lab setup. Its development and use is continuing under support and guidance from ASTP, DITP, and GBI program offices.

Current efforts include preflight predictions and processing of actual sensor flight data. Another major emphasis is the continued capability to interface to the Synthetic Scene Generation Model (SSGM), to support technology assessments against realistic backgrounds and targets. Through this interface SPEAR will provide sensor modeling for the ASTP and DITP Modeling and Simulation Testbeds being used to evaluate advanced sensor technologies and data fusion algorithms.

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