RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #14

Validation of TASC Simulation

Presented by William Harman

SUMMARY

During the work of the TLAT, efforts were made to validate the TASC Simulation by comparing simulated results with measured results. By the time the TLAT process came to an end in March 2001, this validation work had not converged. Subsequently, Lincoln Laboratory continued working with TASC to complete the validation study. By February 2002, a comparison had been set up to determine whether simulated fruit rates would agree with airborne fruit rate measurements. The results exhibited reasonable agreement. These results and the formulation of the comparison were documented in February 2002. The remainder of this Working Paper presents the documentation of this analysis and its conclusions.

In summary, when terrain was included in the simulation, and the TLAT model was used for aircraft antenna gains (for both the vertical patterns and the stochastic horizontal patterns), then the simulated fruit rates agreed with the airborne measurements of fruit rate, showing agreement in the absolute fruit rates, and also agreement in the power distribution of received fruit rates for power level from about -80 dBm to –60 dBm.

Validation of TASC Simulation

8 February 2002, W. Harman

As the TASC simulation became operational for determining fruit rates received airborne and their power distributions, the main initial question was whether the simulated fruit rates agree with measurements. We set up a comparison, using the maximum ATCRBS fruit measured on 17 June 1999. SSR data are available for that same time showing the number of aircraft and their locations. The SSR data came from the LAX terminal radar, whose coverage extends to about 60 nmi in range.

Measurements. The fruit measurement were made on N40, flying near LAX (about 10 nmi north of LAX), and using the 1090 MHz Testbed for fruit measurements. The measured fruit rates can be summarized as follows.

For powers > -70	Fruit rate = 1400 / sec. (top antenna)
For powers > -75	Fruit rate = 5700 / sec. (top antenna)
For powers > -80	Fruit rate = 12,200 /sec. (top antenna)

The accompanying plot shows the full distribution.

Aircraft Antenna Model. Initial TASC simulations used a model for aircraft antenna gains that was significantly different from the model used by TLAT. This special model did not have an elevation pattern, whereas the TLAT model does. Also the special model has a substantially lower average gain than the TLAT model, lower by about 3 dB when considering both a transmitting aircraft and a receiving aircraft.

A meeting on this subject was held on 16 November at Lincoln Laboratory, with Al Cameron, Jackie Schaefer, Bill Harman, and Loren Wood. We agreed on the following specifics for a simulation run to compare with the LA fruit measurements.

- Vertical-Receiving. The receiving aircraft uses a top antenna, and the TLAT model is used for the vertical pattern of this antenna (defined in the TLAT report, page J-7).
- Vertical-Transmitting. All transmitting aircraft use bottom antennas, and the TLAT model is used for the vertical pattern of this antenna.
- Stochastic Component. For the stochastic component of antenna gain, the simulation uses the TLAT model (ibid.) for each of the aircraft. To put this in the simulation, I generated random values, using the TLAT model, and sent these values to TASC. TASC assigned one of these to each aircraft, and kept it constant for the duration of the simulation run, which was 20 seconds.
- Aircraft. The aircraft model was taken directly from the recorded SSR data, sampled at the time of the maximum fruit.

Al Cameron was somewhat uncomfortable with the assignment of a constant antenna gain over the 20 second period, but I was also uncomfortable with a model that would vary this for every signal. Al agreed to run it my way (constant).

Transmitter Powers. The simulation also includes deviations in transmitter powers. The model uses a random distribution, uniform over +/-3 dB for each transmitter, held constant for the duration of the simulation.

Simulation Results. The simulation results can be summarized as follows.

For powers > -70	Fruit rate = 1600 / sec. (top antenna)
For powers > -75	Fruit rate = 5840 / sec. (top antenna)
For powers > -80	Fruit rate = 10,240 /sec. (top antenna)

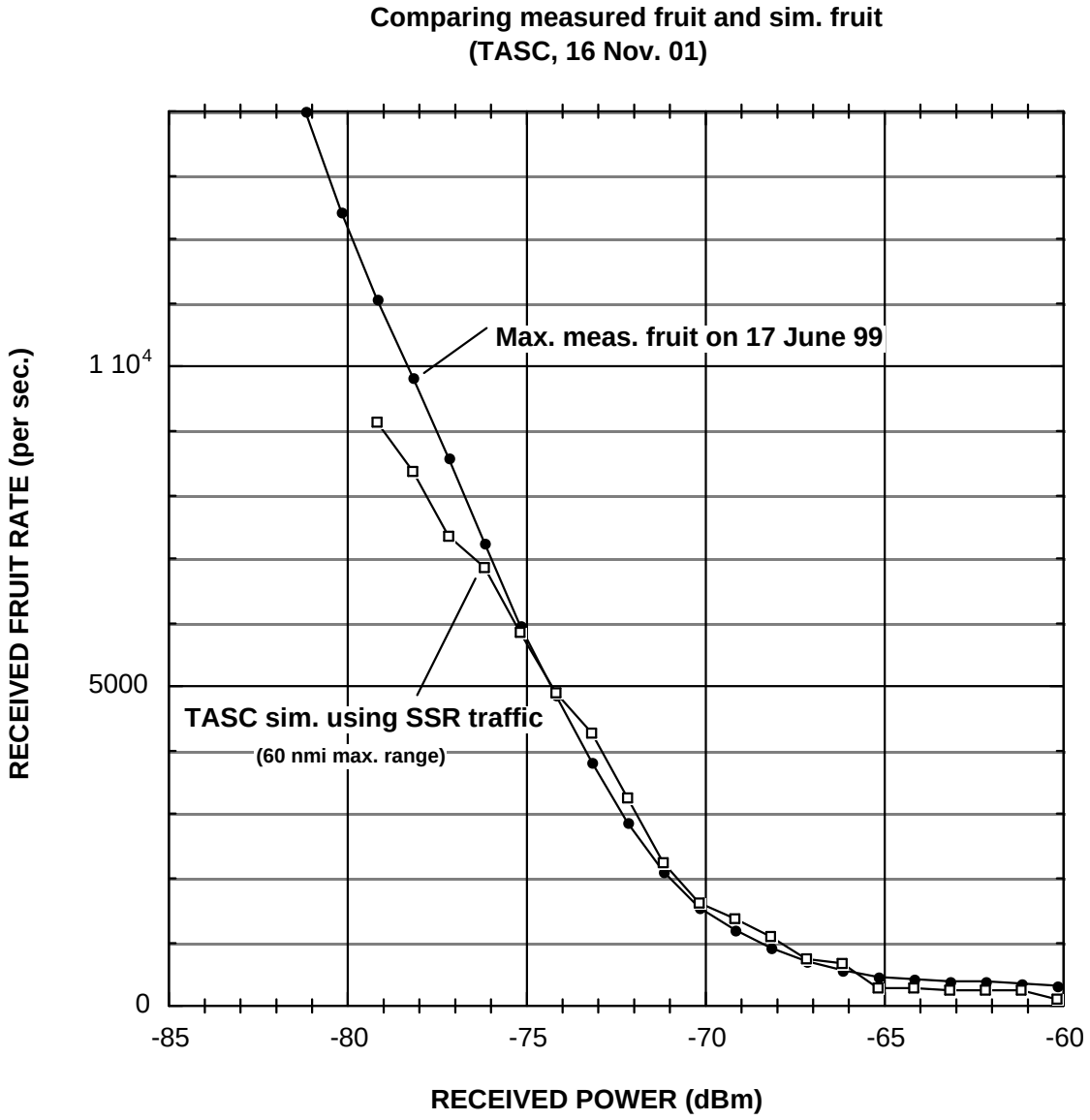
The accompanying plot shows the data in more detail.

Comparison. I believe this constitutes good agreement between the simulation and the LA measurements. The most noticeable difference is a trend in which the simulated fruit becomes less than the measurements going toward the left side of the plot. This behavior is in agreement with what would be expected as a result of the limited range of the radar data.

Seeing such good agreement may give an impression that this was easy to accomplish. In reality, a number of major steps were needed to reach this result. It was necessary to add the mountainous terrain, a major change that was found to cause a significant change in the simulated fruit. A substantial amount of work was also required to represent the ground based interrogators realistically. It was also necessary to include the vertical patterns of aircraft antennas, as described above. I think Volpe and TASC are to be commended for a major accomplishment.

Conclusion. I believe that the simulation can be considered to be validated for calculating fruit from a scenario of aircraft. I think it's important to include the top-antenna, bottom-antenna conditions specifically for each aircraft, and to include the TLAT antenna model in each case.

Validation


Comparing measured fruit and sim. fruit
(TASC, 16 Nov. 01)
RECEIVED FRUIT RATE (per sec.)
1 10^4
5000
0
Max. meas. fruit on 17 June 99
TASC sim. using SSR traffic
(60 nmi max. range)
-85
-80
-75
-70
-65
-60
RECEIVED POWER (dBm)