Bandwidth and Capture Using the Multiray Model.

Michael A. Masleid
September 7, 1991

Inland Steel Company
3210 Watling St. MS 2-465
East Chicago, IN 46312
Tel: (219) 399-2454
Fax: (219) 399-5714

The Multiray program described previously is used to examine two issues: What is the effect of wide band signalling on field power profiles? To what extent might capture reduce handoff requirements in code division multiplexing?

The first color picture shows the power profiles for four antenna. Only the strongest antenna at a given receiver sight is displayed. Increasing brightness indicates increasing field strength. Four cases are examined. The first quadrant shows a 1 GHz CW carrier computed for the first 25 rays (all 1st and 2nd order reflections). The second quadrant shows a 1 GHz carrier with 20 MHz bandwidth. This is computed by summing power profiles at 20 equispaced wavelengths. Since the room dimensions are small compared to spatial coherence the first and second quadrants are virtually identical - 20 MHz bandwidth is not significant. The third quadrant shows a 1 GHz carrier with 100 MHz bandwidth. The fourth quadrant shows a 1 GHz carrier with 500 MHz bandwidth. Note that standing waves occur in all cases near walls. Note also that the beam guiding effect on the red antenna caused by corner of the room results in a pattern of peaks and nulls far removed from the walls. This is due to the near identical path lengths in this area.

The remaining four pictures show the power profiles for four antenna for the first 63 rays (all 1st, 2nd and 3rd order reflections). In each case three of the antenna are suppressed 9 dB to show the service area of the remaining antenna after signal capture. In some cases this is misleading since worst case interference is due to the sum of all three interferers together, not separately - this means that the service areas are not quite as large as shown.

The signal to interference ratio that can be obtained depends on length and choice of codes, whether or not the code is used for time compression to obtain path diversity, et cetera. Improving capture will increase service area, but there are many tradeoffs.

Referring back to the four pictures: the first shows the capture area of the green antenna, the second is blue, the third is white, the fourth is red. A roaming station captured by green remains with green until it leaves the green part of the green map. If it exits to blue it remains with blue until it leaves the blue part of the blue map - and so on. It is clear from the pictures that for some coverage areas the station will have to be nimble changing antenna.

The computer program has been described previously. To repeat basics: The computer program models propagation in a windowless room with no furnishings. The room measures 6 meters wide (x) by 5.1 meters depth (y) by 2.438 meters (8 feet) high (z). The receive antenna height is 0.4 meters from the floor at any location on an 81 x 69 point lattice. Lattice spacing is 1/4 wavelength, tests indicate that closer spacing is superfluous. The measurement system origin is the center of the floor. Transmit antenna identified by color are placed as follows:

```
green (0.4, 0.5, 1.1)
red   (-1.9, -1.7, 1.0)
blue  (-2.215, 2.385, 1.285)
white (1.3, -2.3, 1.145)
```

Transmit and receive antenna are infinitesimal[1] vertically polarized dipoles; antenna gain (voltage) varies with the cosine of the ascension angle. E field varies as 1/r. Near field is not used. Reflections are real (no imaginary component) no polarization effects are considered.

Transmitters are coherent at 1 GHz. The program computes the vertical E field at the receive antenna plane for each transmitter, and colors it appropriately. Hidden line removal is used so only the strongest E field at each point is shown.

The wall reflection coefficient is -0.8, for a voltage standing wave ratio of 9. This is appropriate for a poor conductor.

Conclusions:

Radio spectrum bandwidths available for data communication are two narrow in any single band to avoid standing wave effects in the indoor environment.

Capture reduces, but does not eliminate, the need for nimble "handoff" when using code diversity.

[1] Ramo, Whinnery, and Van Duzer. "Fields and Waves in Communication Electronics." John Wiley and Sons, Inc. 1965. p 648.

Bandwidth and Capture
Using the Multiray Model.

Michael A. Masleid
September 7, 1991

Inland Steel Company
3210 Watling St. MS 2-465
East Chicago, IN 46312
Tel: (219) 399-2454
Fax: (219) 399-5714

The Multiray program described previously is used to examine two issues: What is the effect of wide band signalling on field power profiles? To what extent might capture reduce handoff requirements in code division multiplexing?

The first color picture shows the power profiles for four antenna. Only the strongest antenna at a given receiver sight is displayed. Increasing brightness indicates increasing field strength. Four cases are examined. The first quadrant shows a 1 GHz CW carrier computed for the first 25 rays (all 1st and 2nd order reflections). The second quadrant shows a 1 GHz carrier with 20 MHz bandwidth. This is computed by summing power profiles at 20 equispaced wavelengths. Since the room dimensions are small compared to spatial coherence the first and second quadrants are virtually identical - 20 MHz bandwidth is not significant. The third quadrant shows a 1 GHz carrier with 100 MHz bandwidth. The fourth quadrant shows a 1 GHz carrier with 500 MHz bandwidth. Note that standing waves occur in all cases near walls. Note also that the beam guiding effect on the red antenna caused by corner of the room results in a pattern of peaks and nulls far removed from the walls. This is due to the near identical path lengths in this area.

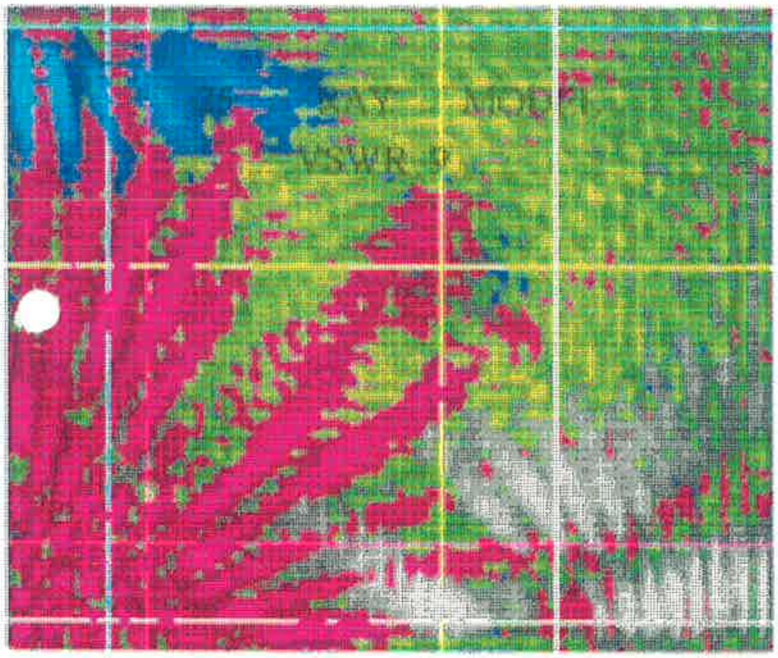
The remaining four pictures show the power profiles for four antenna for the first 63 rays (all 1st, 2nd and 3rd order reflections). In each case three of the antenna are suppressed 9 dB to show the service area of the remaining antenna after signal capture. In some cases this is misleading since worst case interference is due to the sum of all three interferers together, not separately - this means that the service areas are not quite as large as shown.

The signal to interference ratio that can be obtained depends on length and choice of codes, whether or not the code is used for time compression to obtain path diversity, et cetera. Improving capture will increase service area, but there are many tradeoffs.

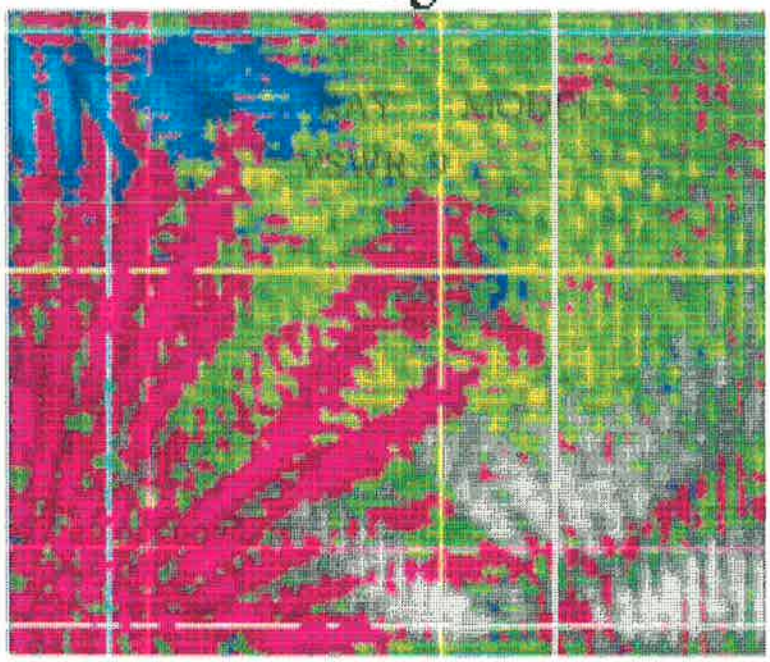
Referring back to the four pictures: the first shows the capture area of the green antenna, the second is blue, the third is white, the fourth is red. A roaming station captured by green remains with green until it leaves the green part of the green map. If it exits to blue it remains with blue until it leaves the blue part of the blue map - and so on. It is clear from the pictures that for some coverage areas the station will have to be nimble changing antenna.

The computer program has been described previously. To repeat basics: The computer program models propagation in a windowless room with no furnishings. The room measures 6 meters wide (x)

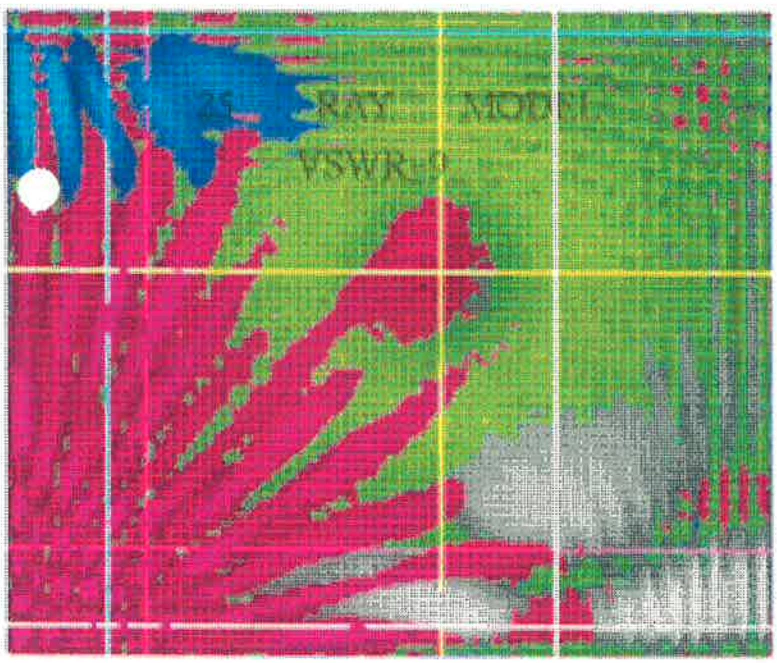
Effect of Bandwidth on Fading



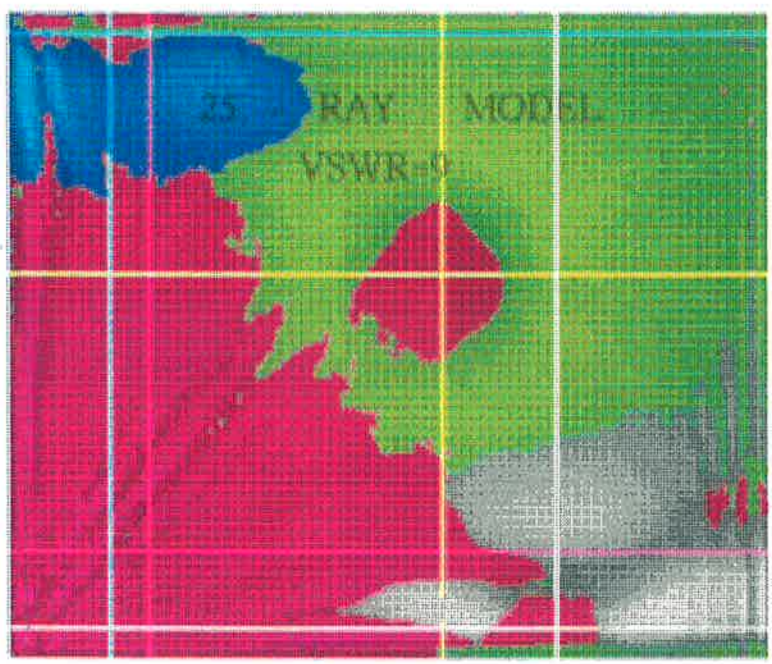
20 MHz / 1 GHz



0 MHz / 1 GHz

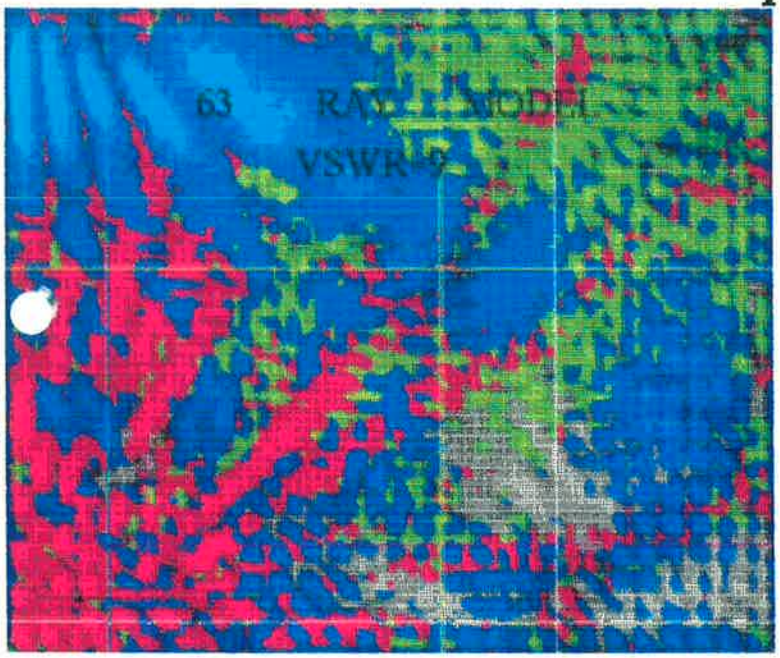


100 MHz / 1 GHz

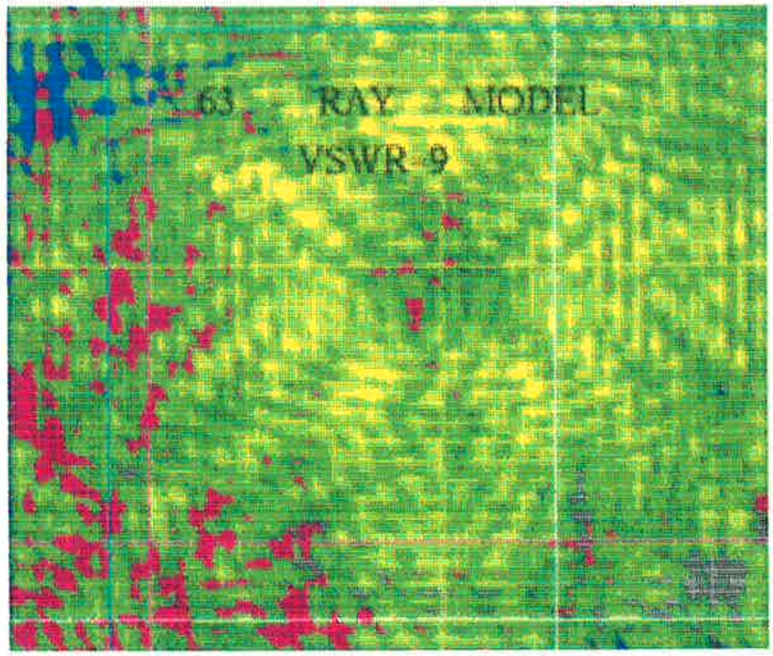


500 MHz / 1GHz

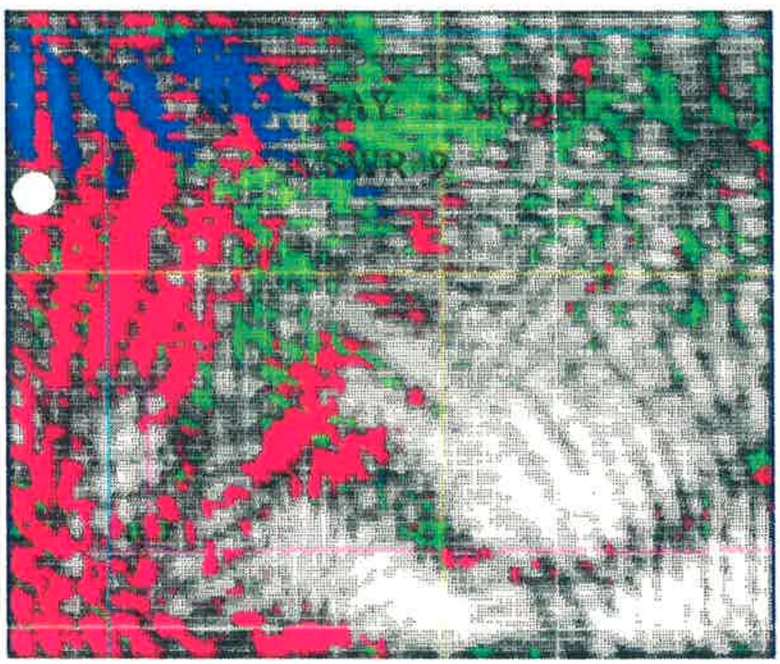
Effect of 9 dB Capture on Interference



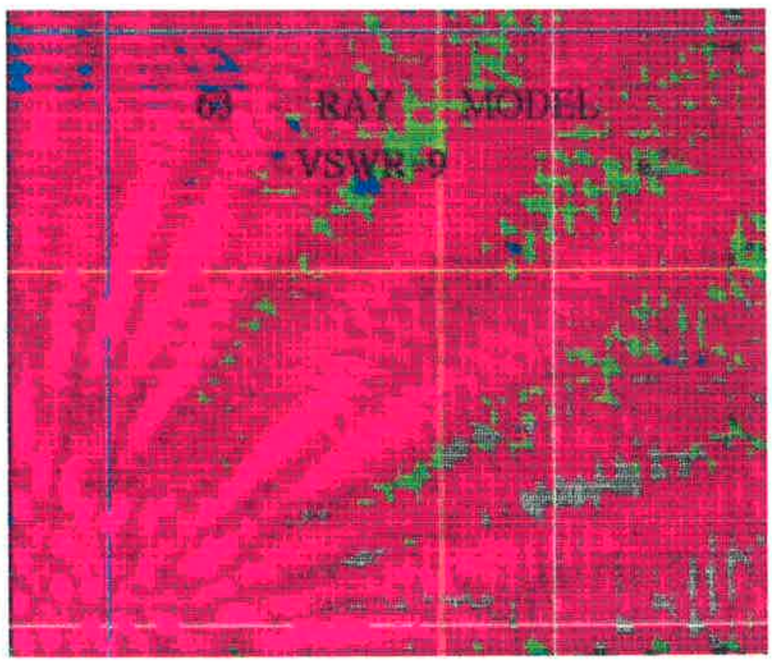
Blue captured



Green captured



White captured



Red captured