
Robustness of Communication Networks in Complex Environments - A simulations using agent-based modelling

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Report Documentation Page

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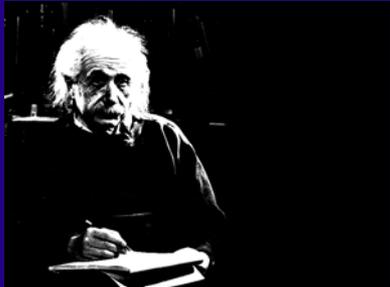
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Problem

- Communication which relies on direct line of sight is very difficult to achieve in complex environments
- This work takes a blue sky approach to consider methods that may overcome this problem

Communication in Complex Terrain

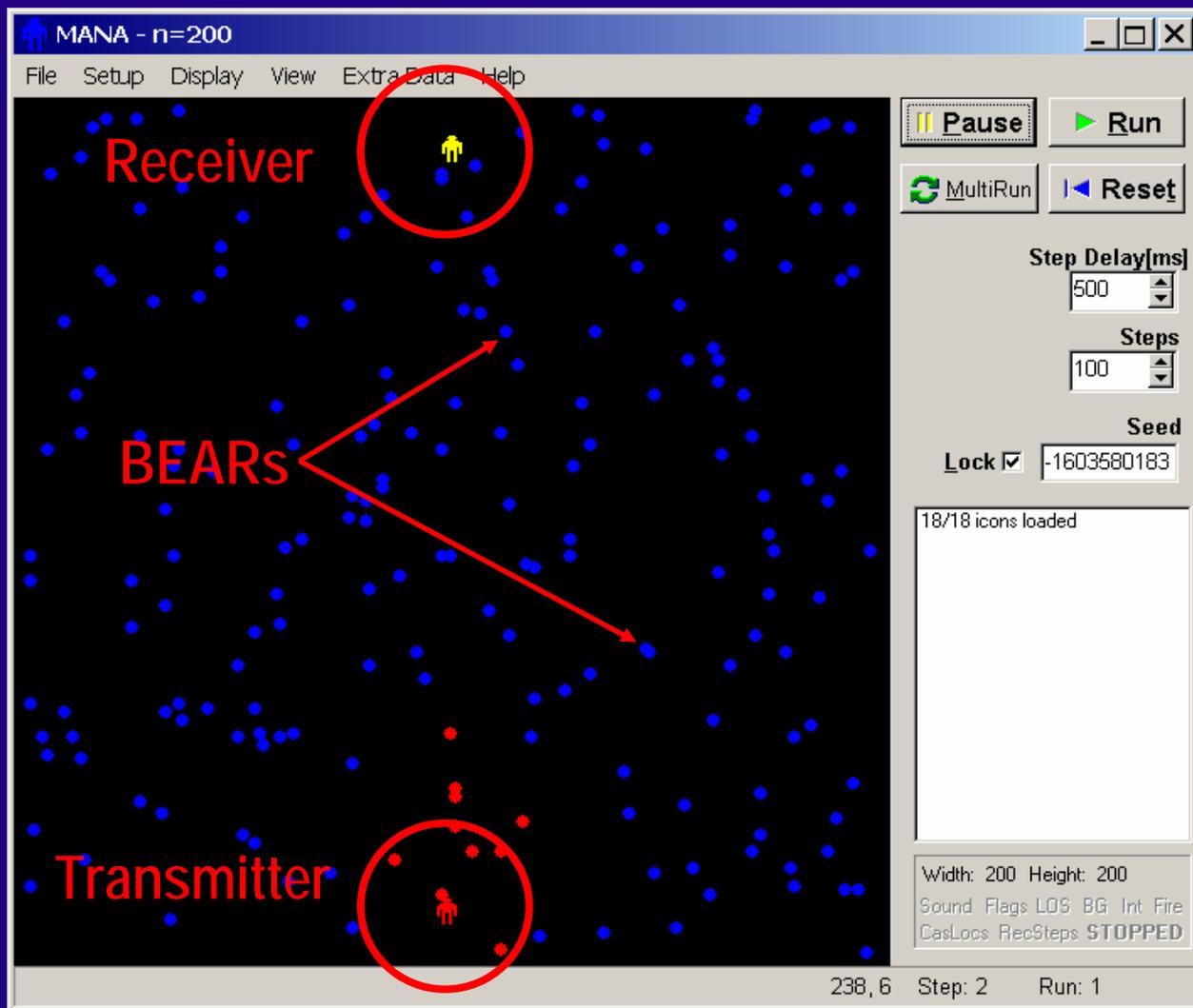


"You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat."

Model

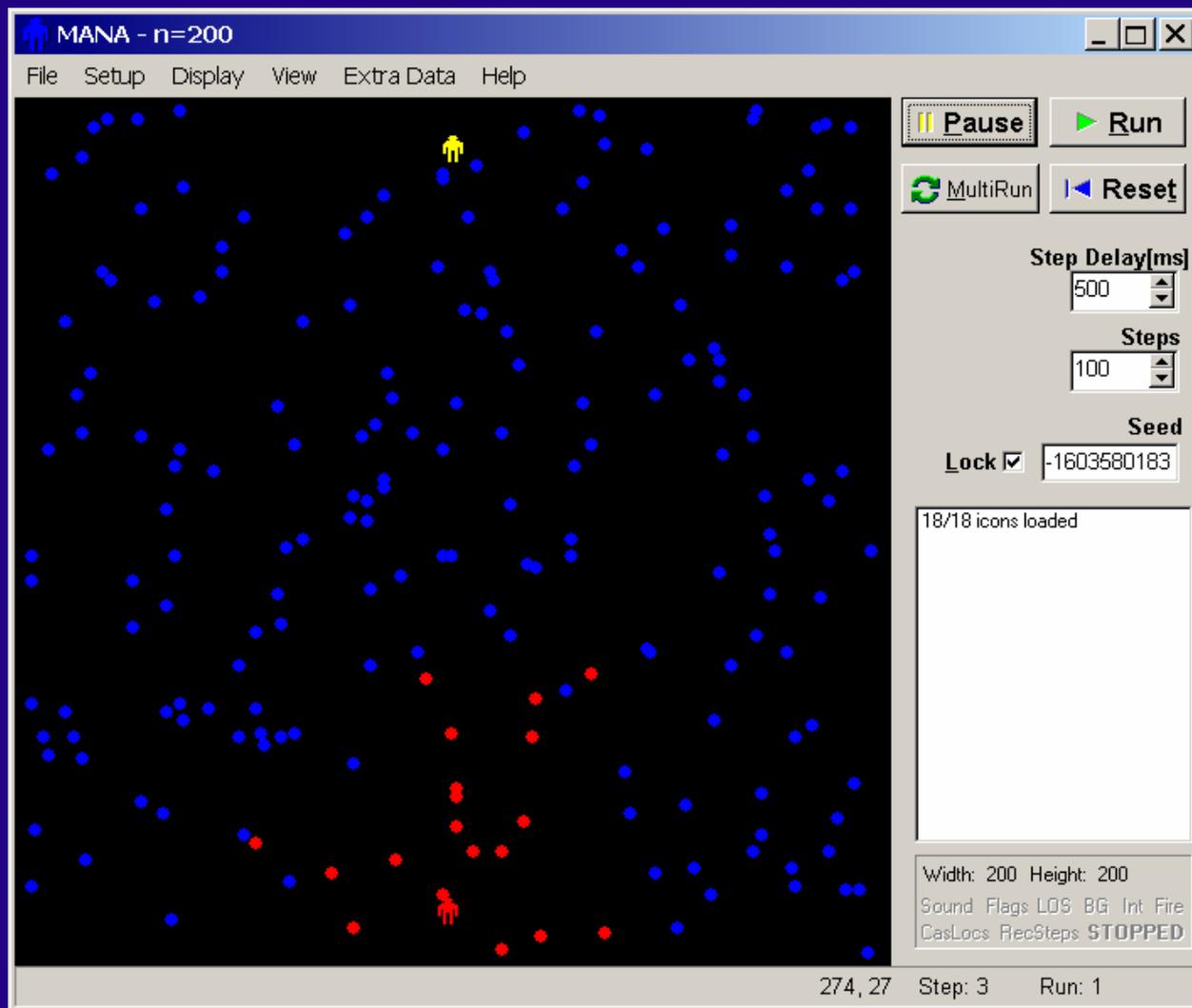
- The Army has named this communications method the BEAR
- Ballistic Expendable Air-delivered Retransmitter
- An extension of work on disease transmission
- Uses an agent-based distillation MANA

Communication in Open Terrain



The screenshot displays the MANA simulation software interface. The main window is titled "MANA - n=200" and contains a menu bar with "File", "Setup", "Display", "View", "Extra Data", and "Help". The central area is a black field representing terrain, populated with numerous blue dots. A yellow human icon, labeled "Receiver" in red text, is circled in red in the upper right. A red human icon, labeled "Transmitter" in red text, is circled in red in the lower right. A cluster of blue dots is labeled "BEARs" in red text, with two red arrows pointing from the label to the cluster. The right-hand side of the interface features a control panel with buttons for "Pause", "Run", "MultiRun", and "Reset". Below these are sliders for "Step Delay[ms]" (set to 500) and "Steps" (set to 100). A "Seed" field is set to "-1603580183" with a checked "Lock" option. A status box shows "18/18 icons loaded". At the bottom right, the status "Width: 200 Height: 200" and "Sound Flags LOS BG Int Fire CasLocs RecSteps STOPPED" is visible. The bottom status bar shows "238,6 Step: 2 Run: 1".

Communication in Open Terrain



The screenshot displays the MANA simulation software interface. The window title is "MANA - n=200". The menu bar includes "File", "Setup", "Display", "View", "Extra Data", and "Help". The main simulation area shows a 2D terrain with numerous blue and red agents. A yellow cursor is positioned over a blue agent. The control panel on the right includes buttons for "Pause", "Run", "MultiRun", and "Reset". It also features a "Step Delay[ms]" spinner set to 500, a "Steps" spinner set to 100, and a "Seed" field with the value -1603580183 and a checked "Lock" option. A status box shows "18/18 icons loaded". At the bottom, the status bar displays "274, 27", "Step: 3", and "Run: 1".

MANA - n=200

File Setup Display View Extra Data Help

Pause Run

MultiRun Reset

Step Delay[ms]
500

Steps
100

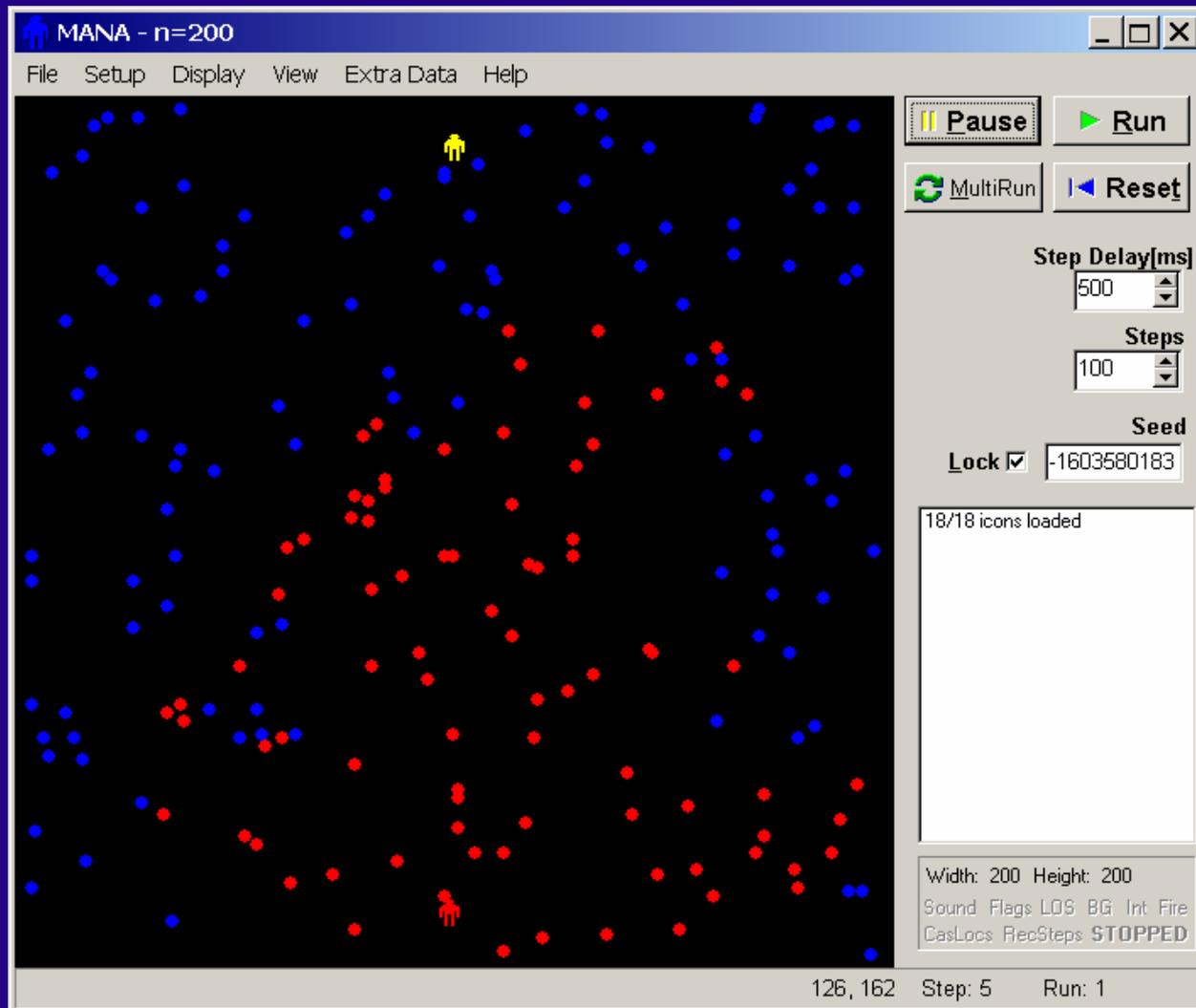
Seed
Lock -1603580183

18/18 icons loaded

Width: 200 Height: 200
Sound Flags LOS BG Int Fire
CasLocs RecSteps STOPPED

274, 27 Step: 3 Run: 1

Communication in Open Terrain



MANA - n=200

File Setup Display View Extra Data Help

Pause Run

MultiRun Reset

Step Delay[ms] 500

Steps 100

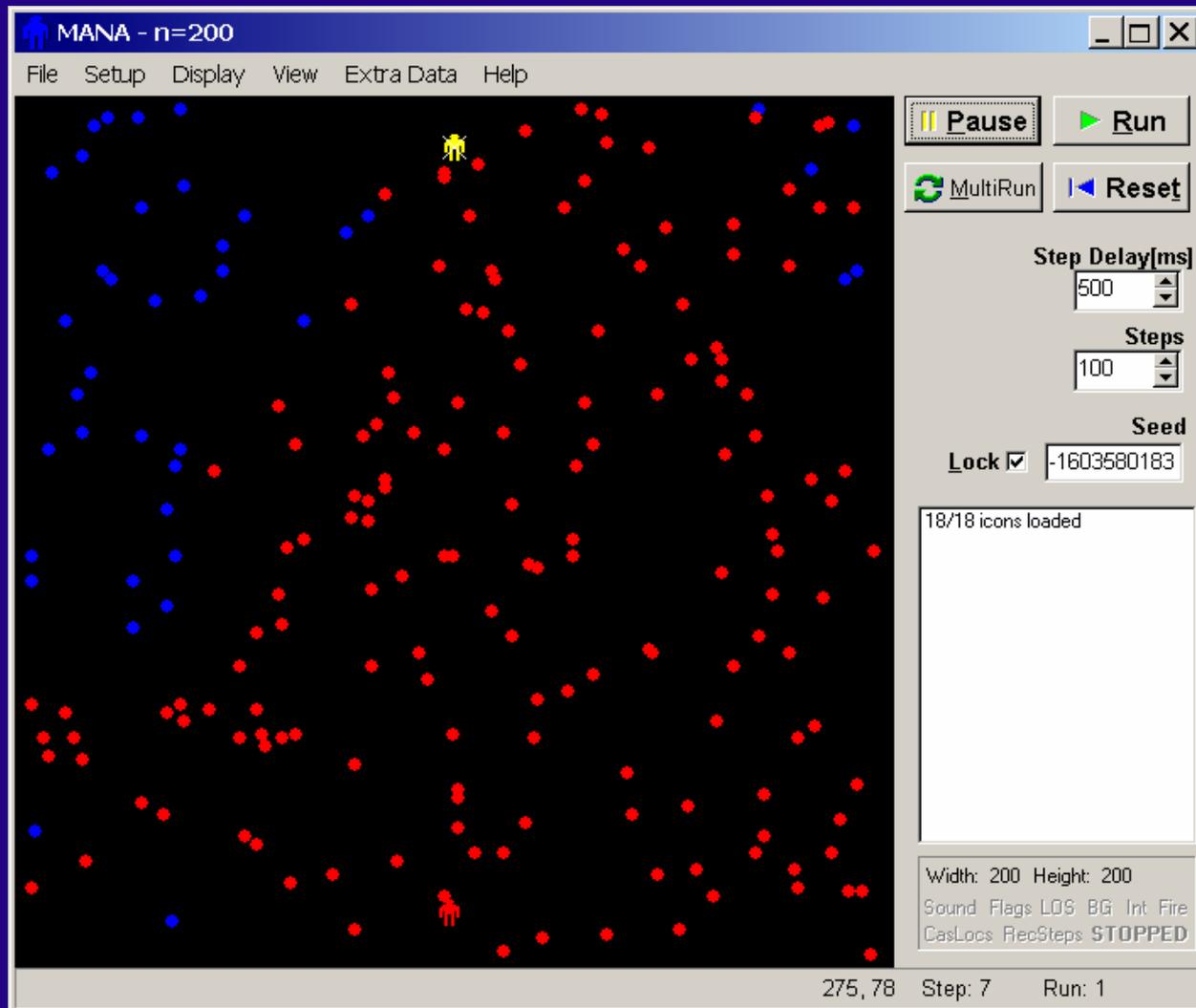
Seed Lock -1603580183

18/18 icons loaded

Width: 200 Height: 200
Sound Flags LOS BG Int Fire
CasLocs RecSteps STOPPED

126, 162 Step: 5 Run: 1

Communication in Open Terrain



MANA - n=200

File Setup Display View Extra Data Help

Pause Run

MultiRun Reset

Step Delay[ms]
500

Steps
100

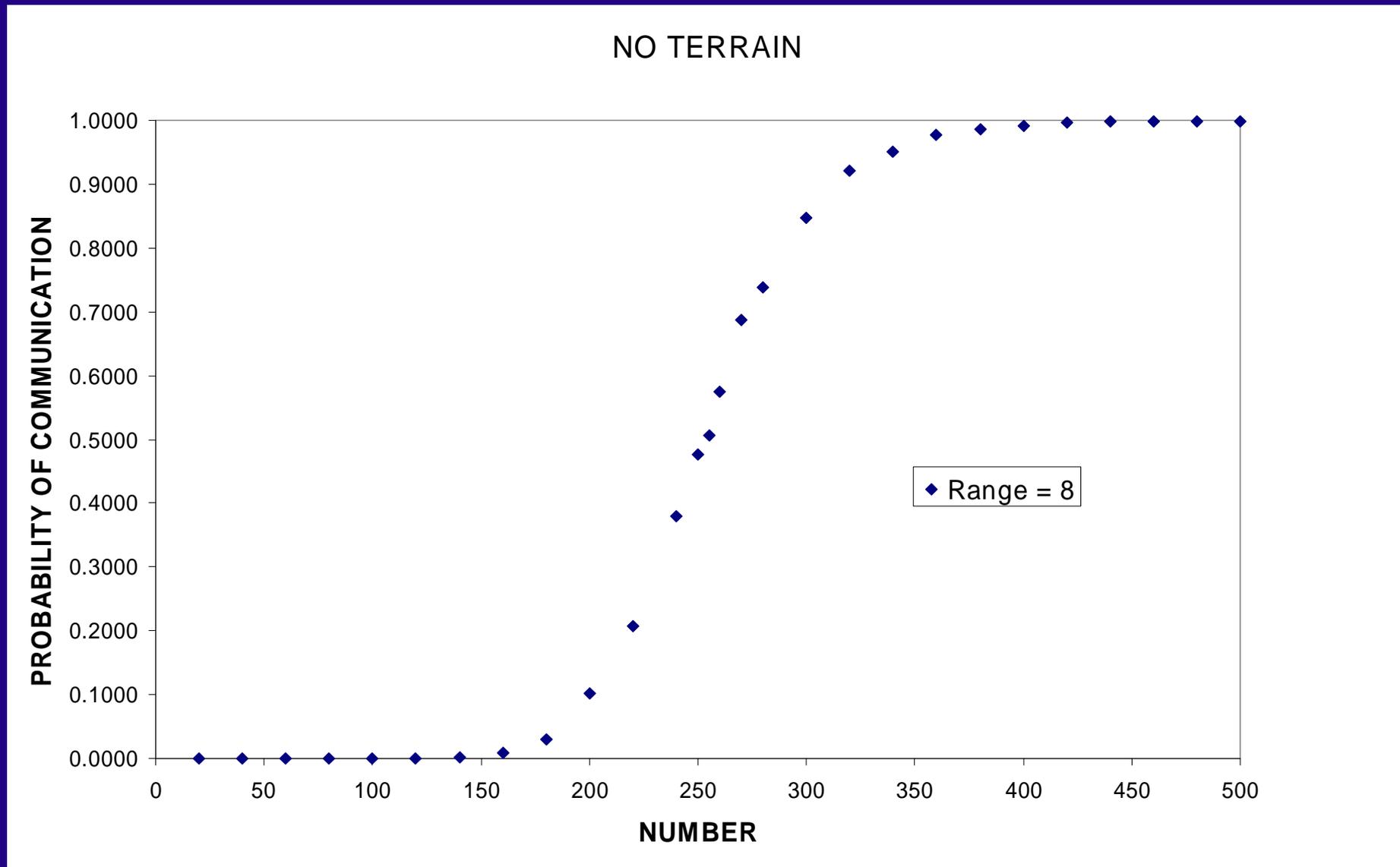
Seed
Lock -1603580183

18/18 icons loaded

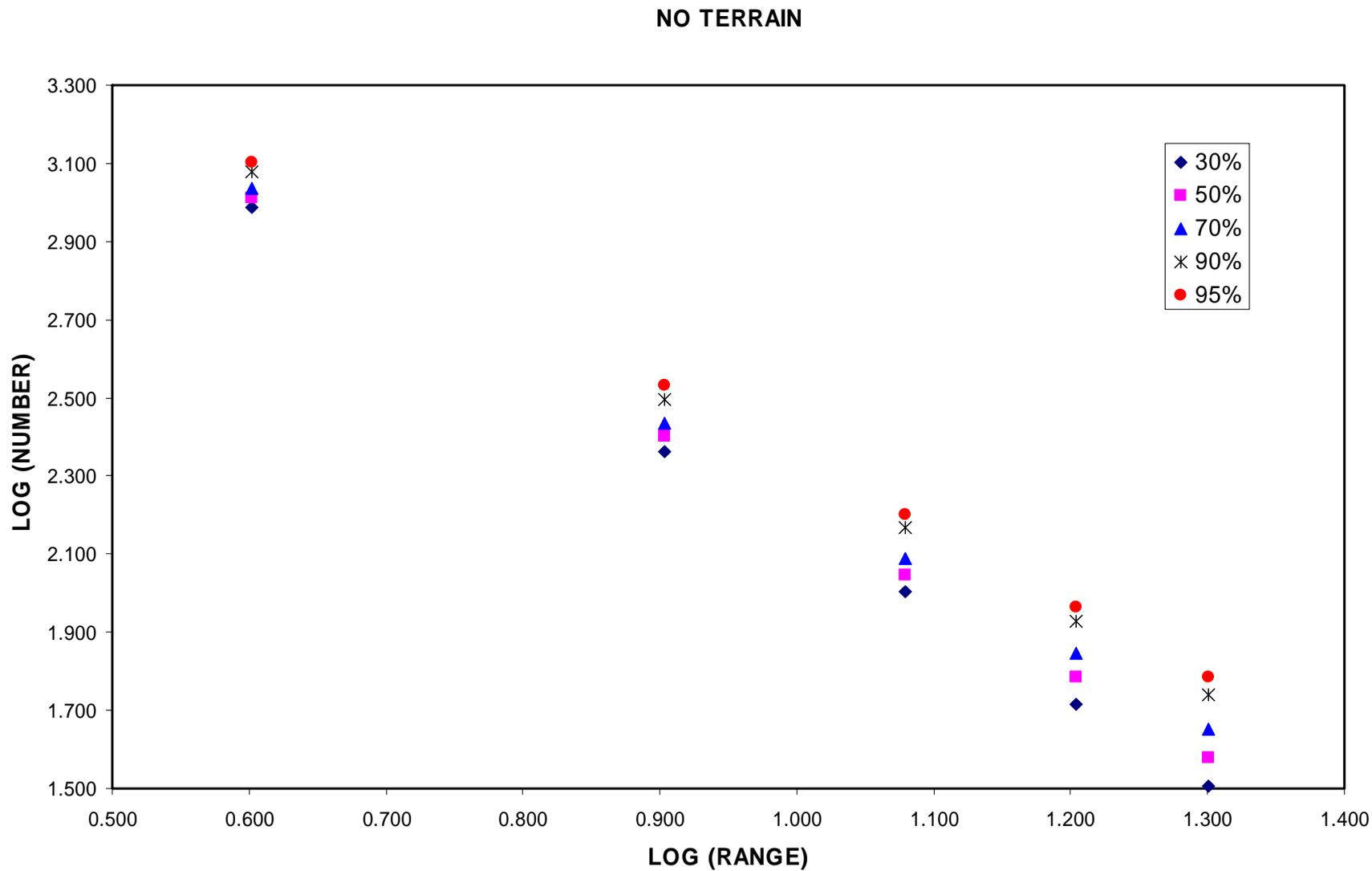
Width: 200 Height: 200
Sound Flags LOS BG Int Fire
CasLocs RecSteps STOPPED

275, 78 Step: 7 Run: 1

Probability of Successful Communication



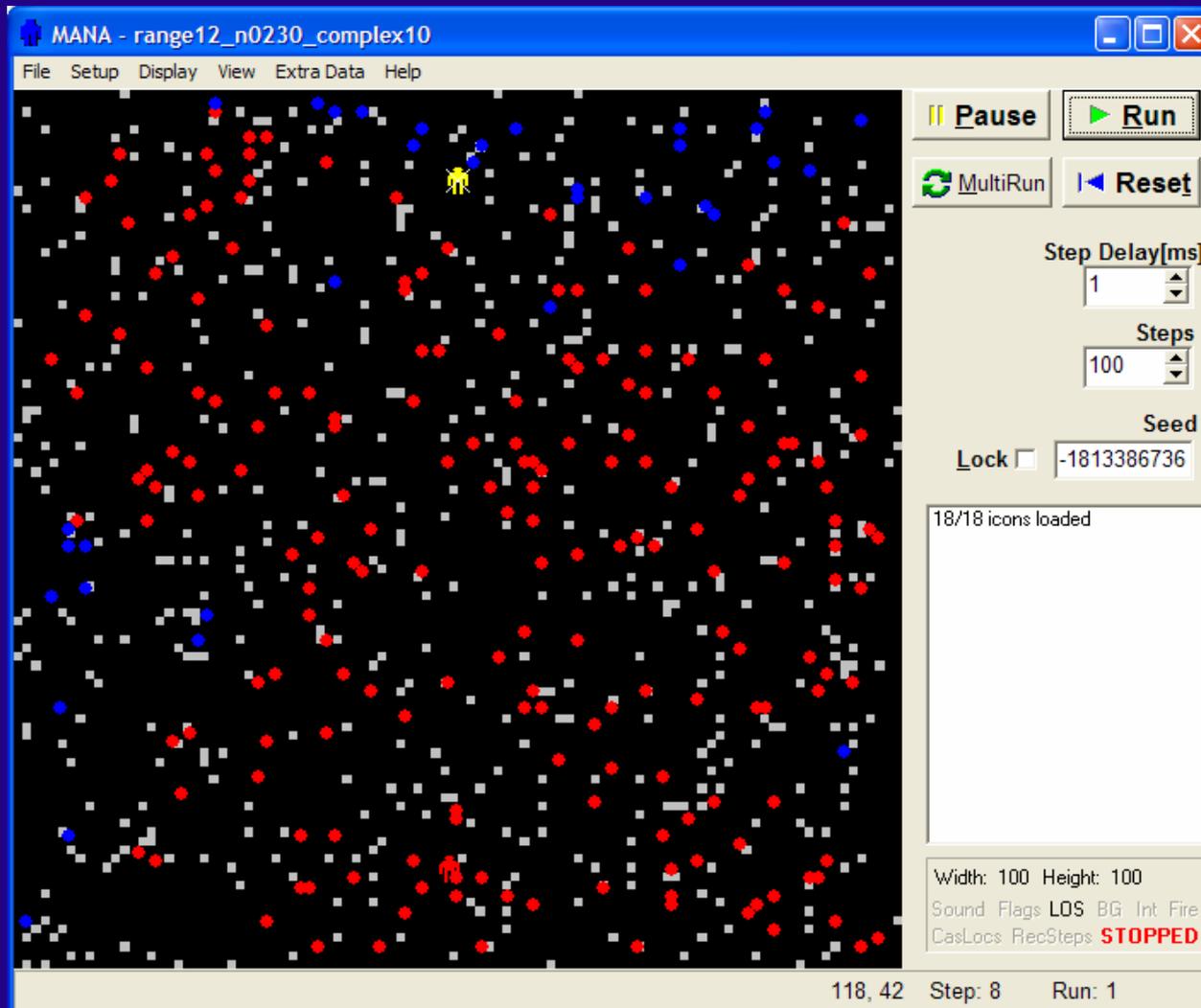
Results with No Terrain



Terrain

- We now introduce “Terrain” to block signal
- Terrain is represented by blocks in the grid through which a signal cannot be passed
- Terrain is randomly generated
- We examine how the relationship between range of the BEARs and number required varies as environment complexity is increased

Communication in Complex Terrain



MANA - range12_n0230_complex10

File Setup Display View Extra Data Help

Pause Run

MultiRun Reset

Step Delay[ms]
1

Steps
100

Seed
-1813386736

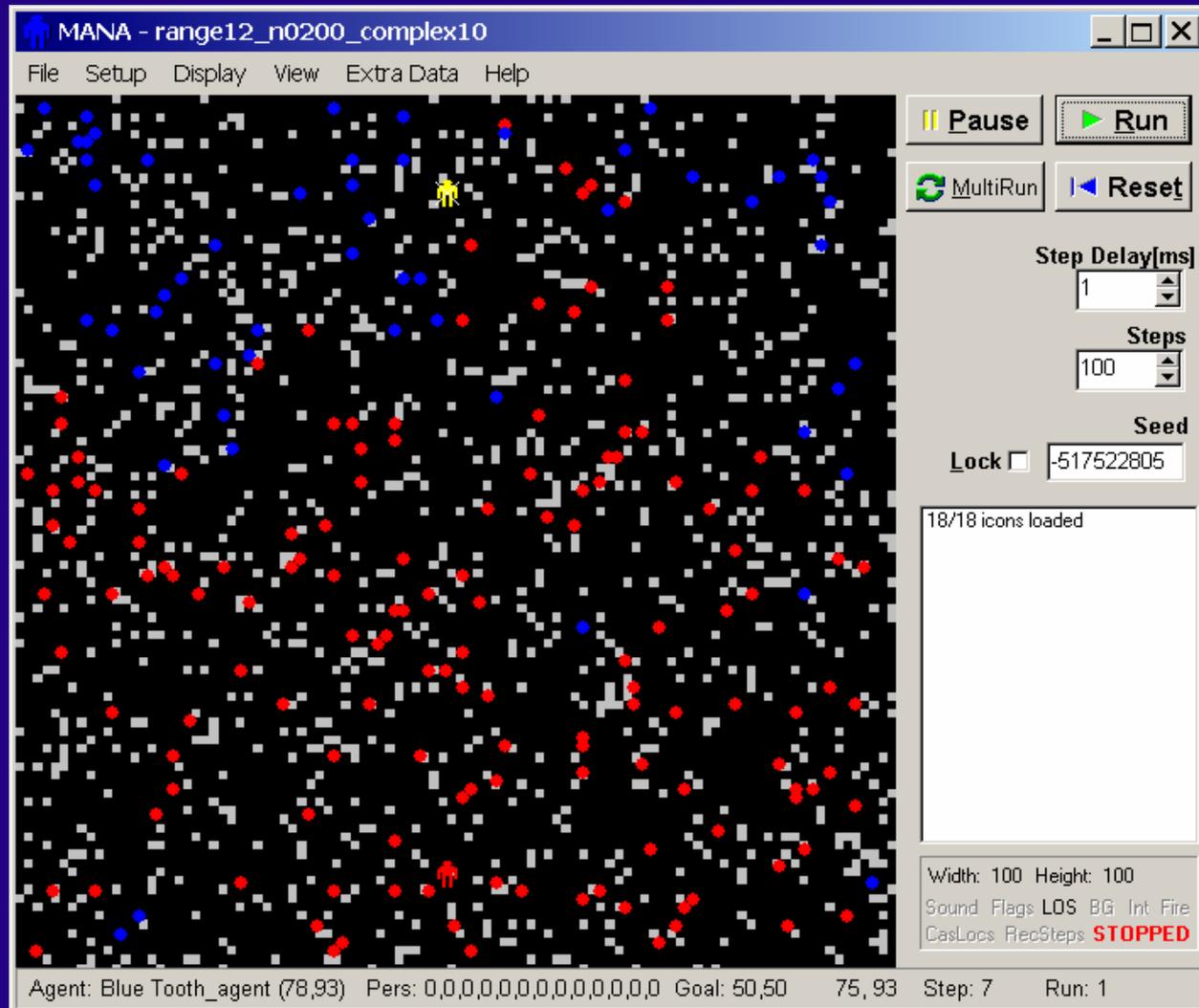
Lock

18/18 icons loaded

Width: 100 Height: 100
Sound Flags LOS BG Int Fire
CasLocs RecSteps **STOPPED**

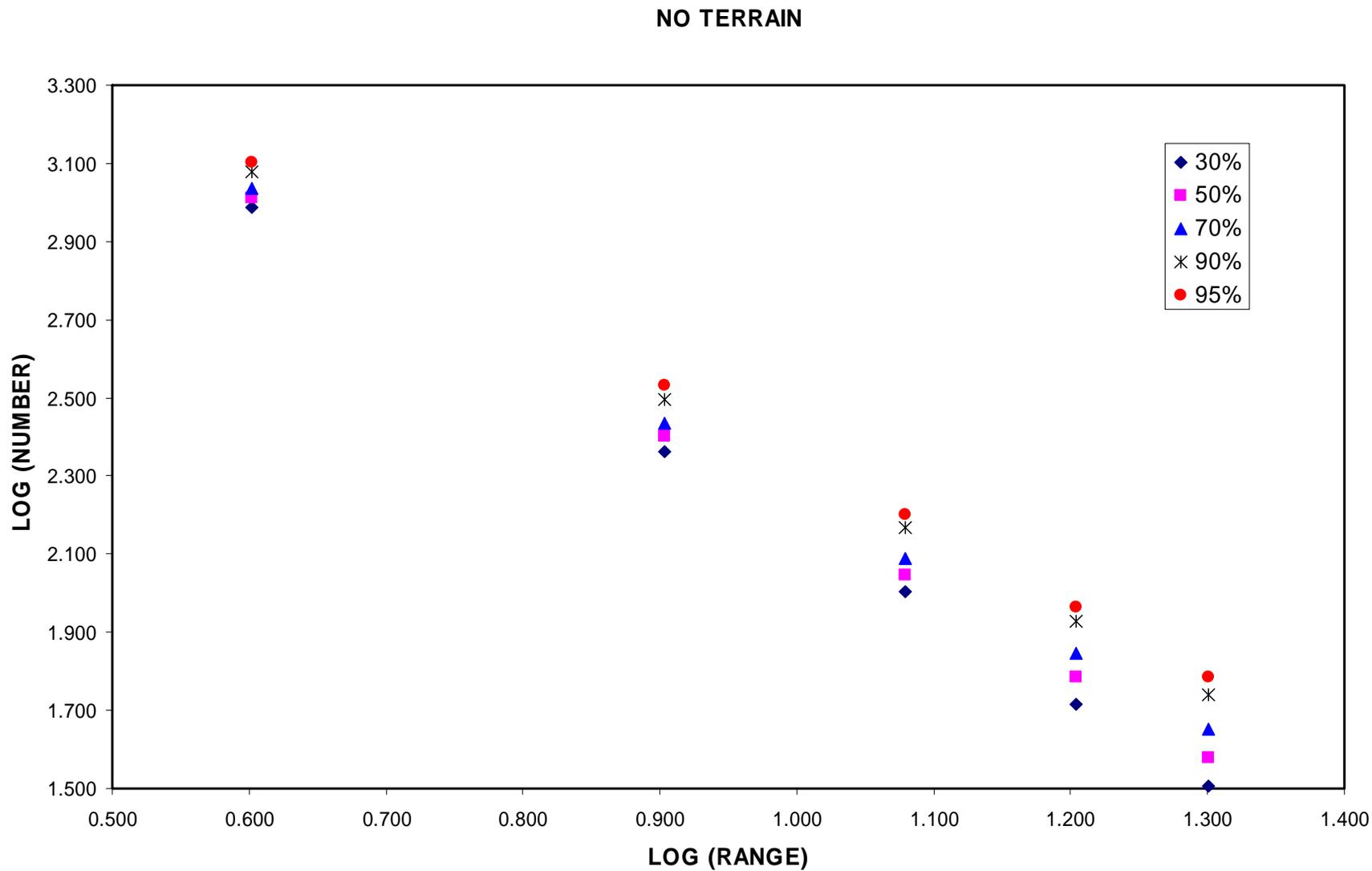
118, 42 Step: 8 Run: 1

Communication in Very Complex Terrain

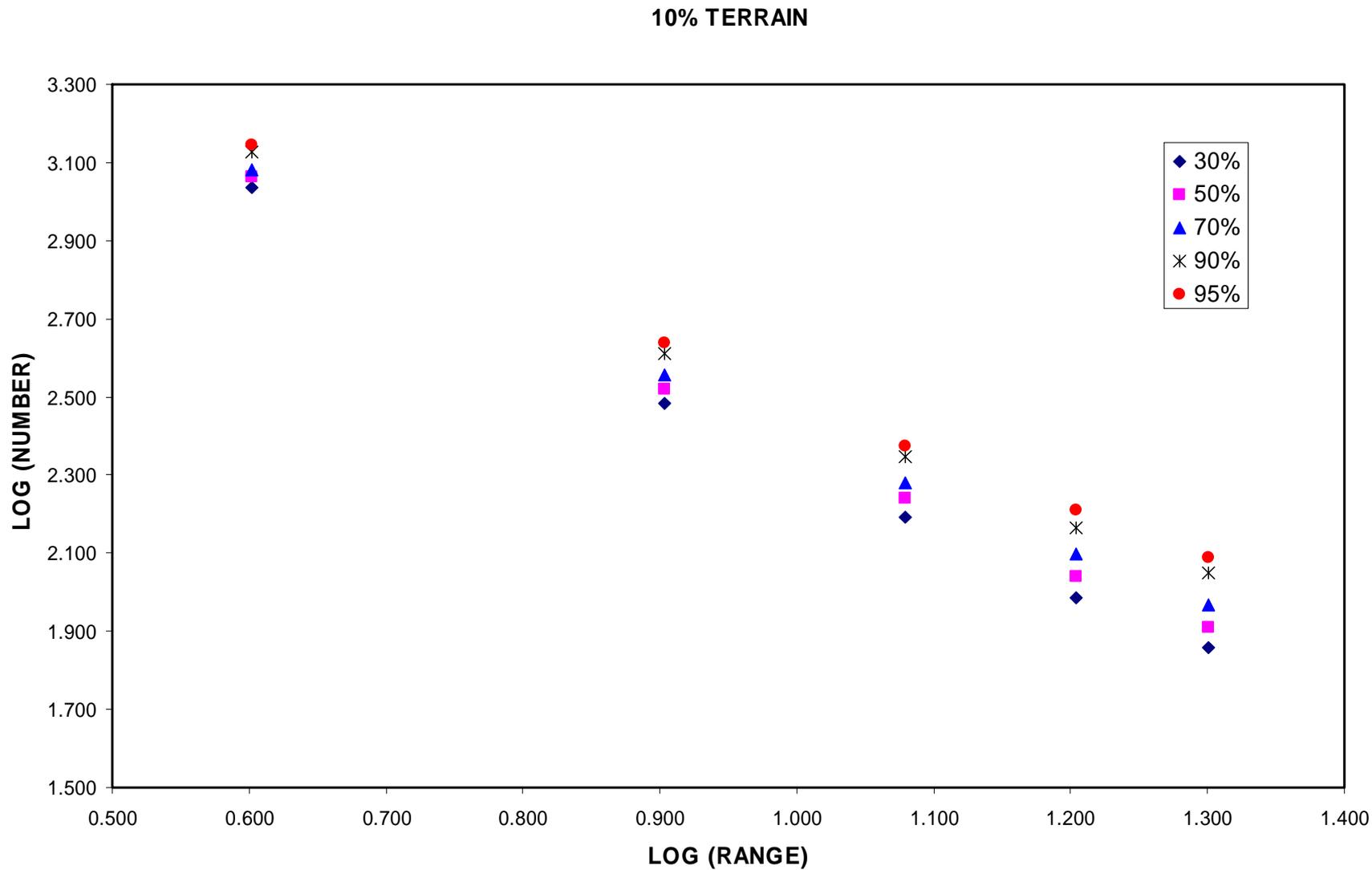


The screenshot displays the MANA simulation window titled "MANA - range12_n0200_complex10". The interface includes a menu bar (File, Setup, Display, View, Extra Data, Help) and a main simulation area showing a complex terrain with numerous red and blue agents. A yellow agent is visible near the top center. The right-hand side features a control panel with buttons for "Pause", "Run", "MultiRun", and "Reset". Below these are input fields for "Step Delay[ms]" (set to 1), "Steps" (set to 100), and "Seed" (set to -517522805). A "Lock" checkbox is present. A status box indicates "18/18 icons loaded". At the bottom, a status bar shows: "Agent: Blue Tooth_agent (78,93) Pers: 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0 Goal: 50,50 75, 93 Step: 7 Run: 1". The "STOPPED" status is highlighted in red.

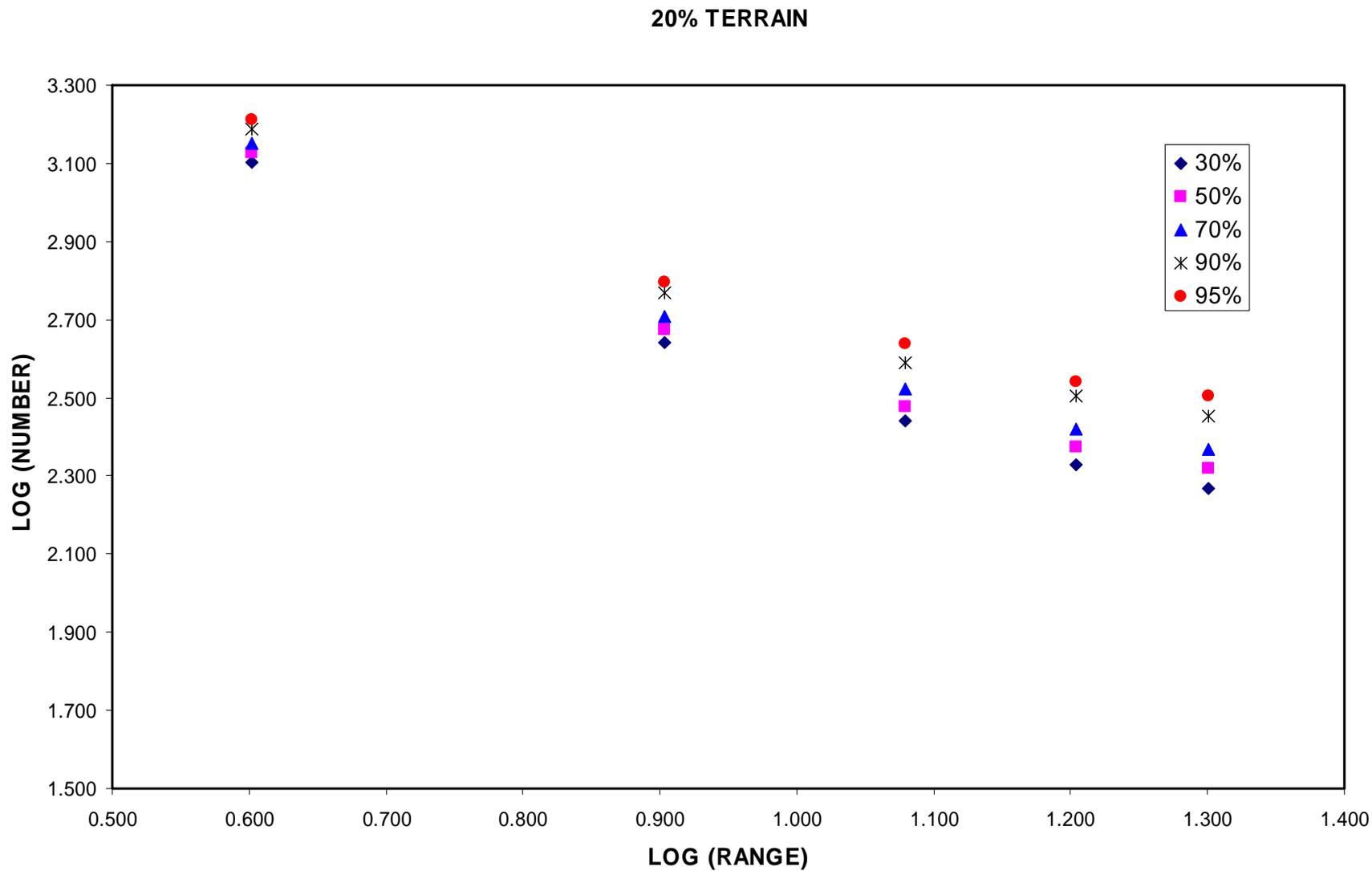
Results with No Terrain



Results with 10% Impassable Terrain



Results with 20% Impassable Terrain



Communication in Complex Terrain

- Insights
 - There is a trade-off between range of retransmitters and number of retransmitters
 - The relationship is a simple power law when there is no terrain
 - Number of re-transmitters required drops off more slowly with increasing range than a power law when terrain is present
 - A larger number of shorter range retransmitters is more robust

QUESTIONS?