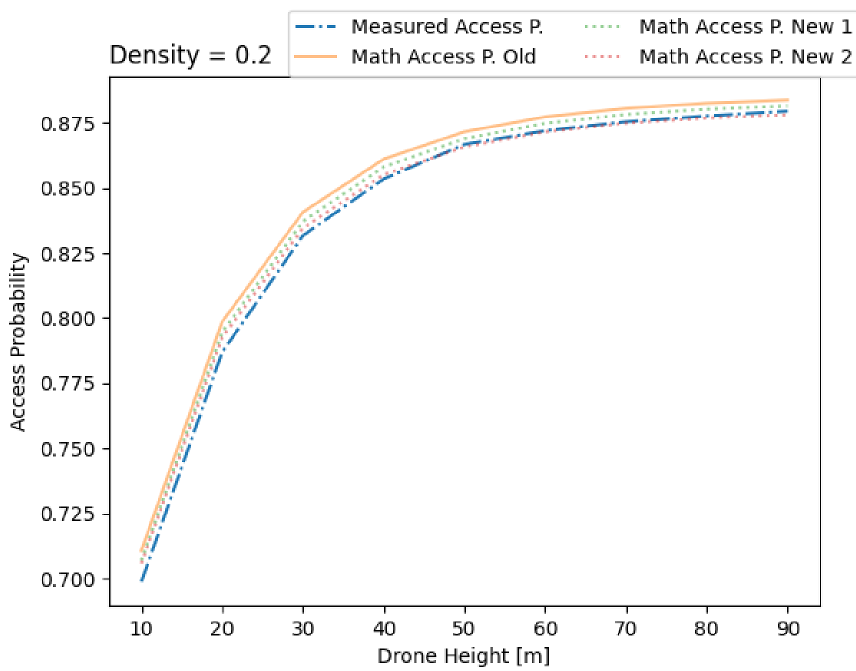
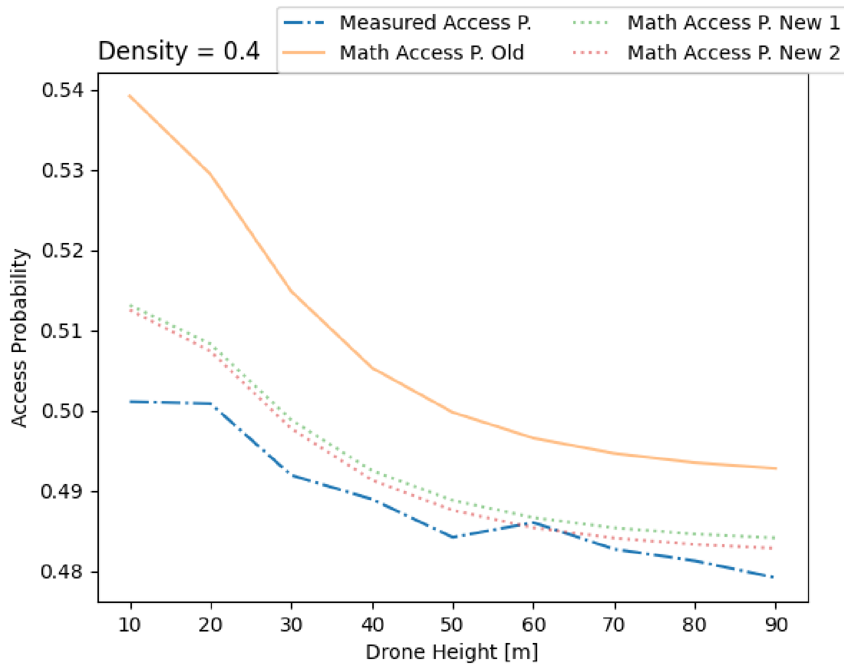
1 New Results

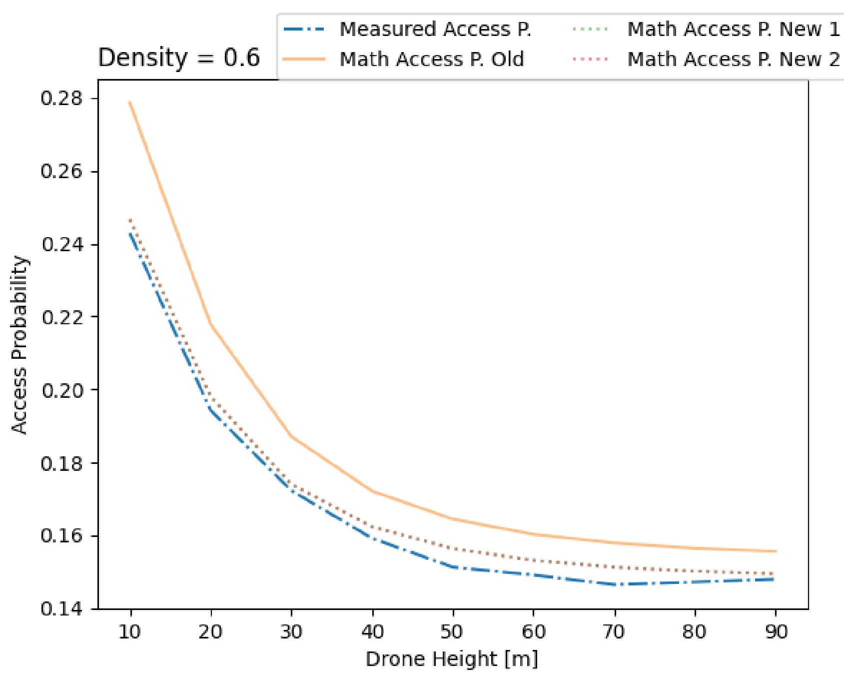
The results below show both the simulated access probability and the one obtained from mathematical models. We have three models:

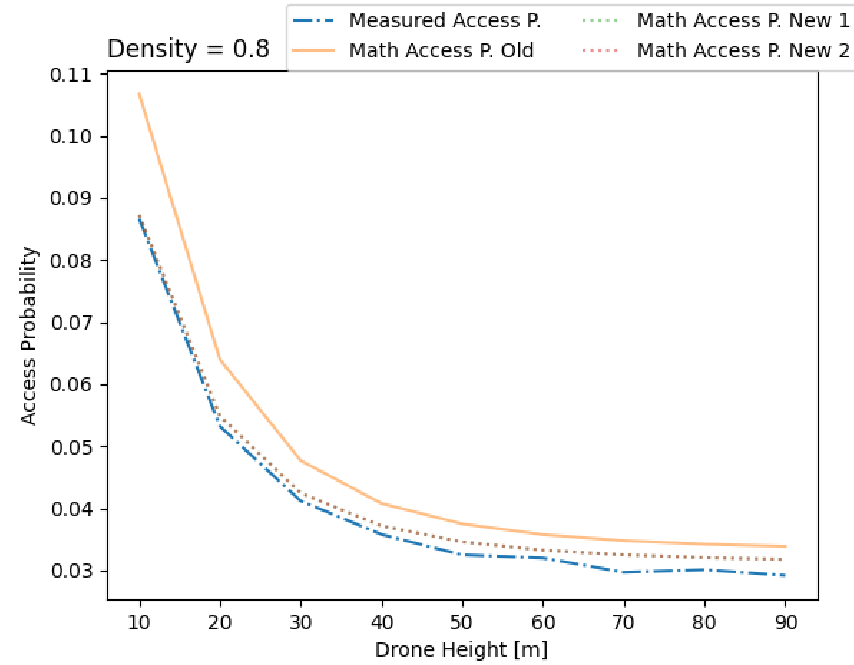
1. The old one,
2. Using (4), and
3. Using (7).

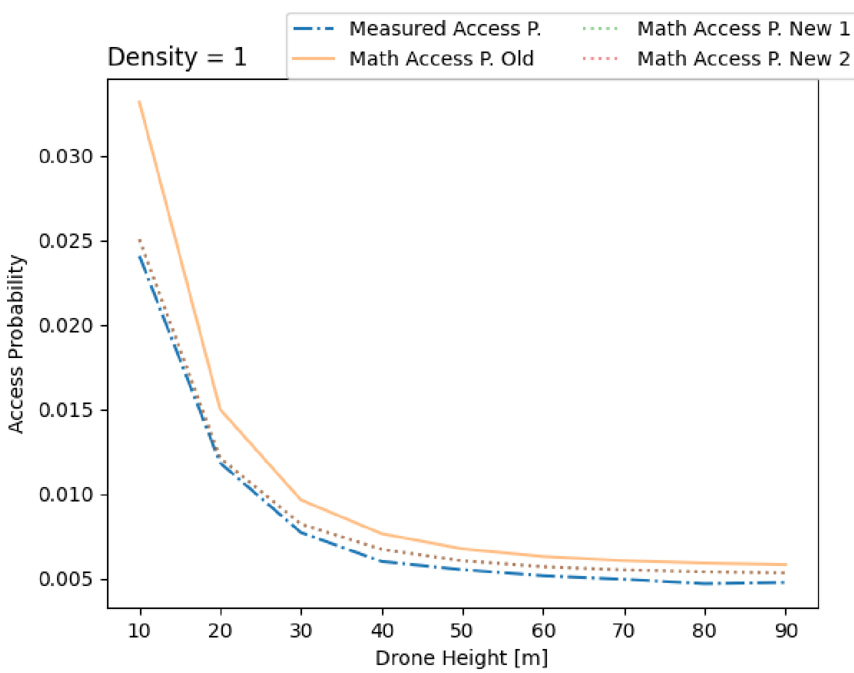
Different figures correspond to simulations with different density parameter value λ which is annotated at the top left. Each simulation is run across various drone heights.




Density = 0.4
Measured Access P.
Math Access P. Old
Math Access P. New 1
Math Access P. New 2
Access Probability
0.54
0.53
0.52
0.51
0.50
0.49
0.48
10
20
30
40
50
60
70
80
90
Drone Height [m]


Density = 0.6
Measured Access P.
Math Access P. Old
Math Access P. New 1
Math Access P. New 2
Access Probability
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
10
20
30
40
50
60
70
80
90
Drone Height [m]


Density = 0.8
Measured Access P.
Math Access P. Old
Math Access P. New 1
Math Access P. New 2
Access Probability
Drone Height [m]
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
10
20
30
40
50
60
70
80
90


Density = 1
Measured Access P.
Math Access P. Old
Math Access P. New 1
Math Access P. New 2
Access Probability
Drone Height [m]
0.030
0.025
0.020
0.015
0.010
0.005
10
20
30
40
50
60
70
80
90

2 Binomial distribution of outaged users

If we consider k users, each with a probability of success equal to P_{out}, then the probability of having n users that have sufficient SNR is given by the binomial distribution:

$$P(X = n) = \binom{k}{n} P_{\text{out}}^{k-n}(1 - P_{\text{out}})^n \tag{1}$$

3 Probability of insufficient resources $P_{\overline{\textbf{acc}}}$

Assuming that the maximum number of served users is limited by K_0, then whenever we have a $k > K_0$ users, and when we are looking for the probability that a given user will have sufficient SNR and **NOT** sufficient resources, then this probability can be obtained as

$$P_N(k) = \sum_{n=\lfloor K_0+1 \rfloor}^{k} \binom{k-1}{n-1} P_{\text{out}}^{k-n}(1 - P_{\text{out}})^n \tag{2}$$

where $\binom{k-1}{n-1}$ highlights that one user should receive sufficient SNR, and therefore we don't need to consider it when calculating the total number of combinations.

Then, if we know that the total number of users belongs to a poisson process with given λ, the probability for a user to have sufficient SNR and not receive sufficient resources is

$$P_{\overline{\text{acc}}} = \sum_{k=\lfloor K_0+1 \rfloor}^{\infty} P_N(k) \times \frac{\lambda^k e^{-\lambda}}{k!} \tag{3}$$

4 New model 1

Given, (3), the probability of a user being served is given by subtracting the probability of it not having sufficient resources despite sufficient SNR and not having sufficient SNR. That is,

$$P_{\text{served}} = 1 - P_{\overline{\text{acc}}} - P_{\text{out}} \tag{4}$$

5 New model with scaling (conditional probability)

When we are considering a specific user, this already indicates that we have at least one user present in the road. The probability of having at least one user is given by

$$P_1 = 1 - \frac{\lambda^0 e^{-\lambda}}{0!}. \tag{5}$$

Then, $P_{\overline{\text{acc}}}$ can be replaced by

$$\hat{P}_{\overline{\text{acc}}}(\cdot|\text{at least one user exists}) = \frac{P_{\overline{\text{acc}}}}{P_1} \tag{6}$$

and so the second version of the new model is

$$P_{\text{served}} = 1 - \hat{P}_{\overline{\text{acc}}} - P_{\text{out}} \tag{7}$$