

Magic Realm Probability for Beginners

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1. Introduction

Part of the reason why Magic Realm is such a puzzle to so many beginning players is that the probabilities behind the game are a mystery. They wander through the Realm, unclear where they have a good chance of accomplishing a goal and where their chances are impossibly remote. The popularity of Robin Warren's RealmSpeak computer realization of Magic Realm exacerbates the problem; one of the problems of computer games is that while you know what happens, you may have no idea why, or if it is likely to happen again.

This is unfortunate, because the probabilities in Magic Realm can be calculated, or at least estimated closely, and knowing what your chances are of getting a particular result opens up Magic Realm for what it is: a great risk/reward game. Die rolls play a huge role in Magic Realm, and without taking chances it is nearly impossible to gain any Victory Points. On the other hand, there are many encounters in the game which can be fatal, and a character who blithely ignores risks has a short life expectancy in the Realm.

The purpose of this article is to let players put some numbers on their risks so they can improve their decision-making and fully enter into the strategic depth of the game. I will assume that the reader has no training in probability. Those who have a nodding acquaintance with probability and statistics will find much of this familiar, but may find it useful to have the results reviewed and tabulated.

2. Die Rolling

Magic Realm is the only game I am aware of where most character die rolls are made with two dice and the higher of the two dice is used to find the result on a table. A 5 on one die and a 2 on the other is interpreted as a "5" result, for example. This creates an unusual non-uniform probability distribution (like the normal roll two-dice-and-add where the most probable result is "7" with "2" and "12" equally unlikely), but with the interesting twist that low numbers are harder to get and nearly always more desirable. Some special advantages or items can give a character the ability to roll only one die which makes it easier to roll low, but it is often unclear how much better this is - our intuition is often not a good guide for this unfamiliar system.

To put numbers on these chances, we invoke the fundamental theorem of probability: the probability of any outcome is proportional to the number of equally likely events that result in that outcome. So, if we consider that the roll of each die (the red die and the white die) are equally likely to come up with any number from 1 to 6, there are 36 equally likely outcomes of rolling two dice as shown in the table in Table 1 below. On the top row we show the result of the white die and in the left-hand column we show the result of the red die. The results in the table are

indicating both dice in the following format: (white die roll, red die roll). Assuming the dice are fair, all of the 36 results in the table (six white die possibilities time six red die possibilities = 36 total results) are equally probable.

		White Die					
		1	2	3	4	5	6
Red Die	1	(1,1)	(2,1)	(3,1)	(4,1)	(5,1)	(6,1)
	2	(1,2)	(2,2)	(3,2)	(4,2)	(5,2)	(6,2)
	3	(1,3)	(2,3)	(3,3)	(4,3)	(5,3)	(6,3)
	4	(1,4)	(2,4)	(3,4)	(4,4)	(5,4)	(6,4)
	5	(1,5)	(2,5)	(3,5)	(4,5)	(5,5)	(6,5)
	6	(1,6)	(2,6)	(3,6)	(4,6)	(5,6)	(6,6)

Table 1: An illustration of all possible results of rolling a red die and a white die simultaneously.

3. The Hide Table

If a character rolls on the Hide Table, any result except a 6 will result in him hiding successfully. Since only the highest number counts on each roll of the dice, all the results with a 6 on the red die in the bottom row and all the results with a 6 on the white die in the right-hand column give a game result of 6. The rolls that result in a 6 are high-lighted in blue on the following chart (Table 2).

		White Die					
		1	2	3	4	5	6
Red Die	1	(1,1)	(2,1)	(3,1)	(4,1)	(5,1)	(6,1)
	2	(1,2)	(2,2)	(3,2)	(4,2)	(5,2)	(6,2)
	3	(1,3)	(2,3)	(3,3)	(4,3)	(5,3)	(6,3)
	4	(1,4)	(2,4)	(3,4)	(4,4)	(5,4)	(6,4)
	5	(1,5)	(2,5)	(3,5)	(4,5)	(5,5)	(6,5)
	6	(1,6)	(2,6)	(3,6)	(4,6)	(5,6)	(6,6)

Table 2: The results of rolling two dice that give a 6 on the higher die ("No effect" on the Hide Table) are highlighted in blue.

By simple counting, we see that there are 11 chances of getting a result of 6 on the highest die, and 25 (=36-11) chances of getting a result other than 6. Thus the chances of rolling a 6 result with one roll on the Hide Table (and not hiding) are $11/36=0.3056 = 30.6\%$. So there is nearly one chance in three of failing to hide on a single roll on the Hide Table - much too great a chance to take if failing to hide would result in your character's death!

In the second part of this tutorial we will look at how recording multiple Hide Phases increases your chances of hiding successfully. But first we will look at the probabilities of some other common rolls.

4. The Locate Table

In Magic Realm you need to discover a treasure site by using a Search Phase to roll on the Locate Table before you can roll on the Loot Table to take any treasure - which often entails a long and frustrating search requiring many Search Phases. If you are in a clearing with one or more treasure sites, you need a "Discover chits" result on the Locate Table to find the treasure site so that you can begin looting. "Discover chits" requires either a 4 on the Locate Table, or a 1, which gives a "Choice" result. The rolls which result in either 4 or 1 are highlighted in blue in Table 3 below.

		White Die					
		1	2	3	4	5	6
Red Die	1	(1,1)	(2,1)	(3,1)	(4,1)	(5,1)	(6,1)
	2	(1,2)	(2,2)	(3,2)	(4,2)	(5,2)	(6,2)
	3	(1,3)	(2,3)	(3,3)	(4,3)	(5,3)	(6,3)
	4	(1,4)	(2,4)	(3,4)	(4,4)	(5,4)	(6,4)
	5	(1,5)	(2,5)	(3,5)	(4,5)	(5,5)	(6,5)
	6	(1,6)	(2,6)	(3,6)	(4,6)	(5,6)	(6,6)

Table 3: The die roll results that give either a 4 or a 1 on the higher die (required to discover a treasure site) are highlighted in blue.

Again, simple counting give the probability of discovering a treasure site in one roll on the Search Table = $8/36=22.2\%$, about one chance in five. This relatively low probability is the reason that in multi-player games treasure locations are often transferred by gift or sale from one character to another or discovered by "spying" on another character who is looting a site.

To discover a secret passage requires a roll of 3 ("Passages"), 2 ("Passages and clues"), or 1 ("Choice") on the Locate Table. The rolls that result in a 3, 2, or 1 on the higher of two dice are highlighted in Table 4 below.

		White Die					
		1	2	3	4	5	6
Red Die	1	(1,1)	(2,1)	(3,1)	(4,1)	(5,1)	(6,1)
	2	(1,2)	(2,2)	(3,2)	(4,2)	(5,2)	(6,2)
	3	(1,3)	(2,3)	(3,3)	(4,3)	(5,3)	(6,3)
	4	(1,4)	(2,4)	(3,4)	(4,4)	(5,4)	(6,4)
	5	(1,5)	(2,5)	(3,5)	(4,5)	(5,5)	(6,5)
	6	(1,6)	(2,6)	(3,6)	(4,6)	(5,6)	(6,6)

Table 4: Die rolls that would result in finding a secret passage or hidden path on the Locate Table or Peer Table, respectively, are highlighted in blue.

There are nine rolls out of 36 possible that give a 1, 2, or 3 on the higher of two dice, so your chances of finding a secret passage in Search Phase roll on the Locate Table is $9/36=25\%$, one chance in four. (This is also the chance of finding a hidden path in one roll on the Peer Table.)

The probabilities of various results on other tables can be calculated from the data in Table 6 below; they are explicitly listed in Scott DeMers and Vittorio Alinari's "MagicRealmOdds" Excel table which can be found on the Magic Realm Keep site at: <http://www.geocities.com/finiasjynx/>

5. Rolling One Die

Character special advantages, like the Dwarf's "Cave Knowledge," or items like the Lucky Charm that allow a character to roll only one die, offer a huge advantage in using the tables. To illustrate how this works, consider the Druid who rolls only one die on Hide rolls. There are only six possible results of rolling one die, and only one result (die roll = 6) that would prevent the Druid from hiding, as shown in Table 5 below. The probability of missing a Hide roll is clearly $1/6=16.7\%$, about half as great as the character who rolls two dice.

One Die					
1	2	3	4	5	6
(1)	(2)	(3)	(4)	(5)	(6)

Table 5: Illustrating the probability of the Druid failing to hide by rolling a 6 on one die.

Similarly the Dwarf in a cave has two chances out of six (33.3%) to roll a 4 or a 1 and locate a treasure site, and three chances out of six (50%) to roll a 3, 2, or 1 to find a secret passage. Compared with a character without a roll-one-die advantage, the Dwarf is about 1.5 times as likely to find a treasure site - and twice as likely to find a hidden passage - with one roll on the Locate Table in the caves.

In summary, the probability of rolling any result when rolling one die or rolling two dice and taking the higher number is given in Table 6 below. The probability of rolling one result OR another result is the sum of the two probabilities. Using this table you can predict the probability of any Magic Realm die roll with one die or two dice. For example, the probability of rolling a 4 or a 1 with two dice is 19.4% + 2.8% = 22.2% as we saw in our discussion above.

Result	Probability (Higher of two dice)	Probability (One die)
1	1/36 = 2.8%	1/6 = 16.7%
2	3/36 = 8.3%	1/6 = 16.7%
3	5/36 = 13.9%	1/6 = 16.7%
4	7/36 = 19.4%	1/6 = 16.7%
5	9/36 = 25.0%	1/6 = 16.7%
6	11/36 = 30.6%	1/6 = 16.7%

Table 6: Probability of getting any one result by rolling one die or by rolling two dice and taking the highest die.

5. The Loot Table

Once you have discovered a treasure site, you can use a Search Phase to roll on the Loot Table to try to draw treasure out of the site. A roll of 1 on the higher of the

two dice (1,1) permits you to take the top treasure in the site, a roll of 2 takes the second treasure from the top, a roll of 3 the third treasure from the top, and so forth. So, if there are only three treasures left in a treasure site, you need to roll either a 1, 2, or 3 on the higher of two dice to take a treasure; otherwise you take nothing. The rolls of two dice that give you a 3 or less are exactly the same as the rolls required to find a secret passage or hidden path illustrated in Table 4: $9/36=25\%$.

The probability of looting a treasure from a site with any number of treasures left can be found from Table 6 by adding the probabilities of all numbers less than the number of treasures remaining, as shown in Table 7 below.

Number of Treasures in Site	Probability of Taking Treasure Card (2 Dice)	Probability of Taking Treasure Card (1 Die)
1	2.8%	16.7%
2	11.1%	33.3%
3	25.0%	50.0%
4	44.4%	66.7%
5	69.4%	83.3%
6 or more	100%	100%

Table 7: Probability of taking a treasure from a treasure site (or an item from a pile of abandoned items) with one roll on the Loot Table, as a function of the number of treasures in the site (or items in the pile).

6. Rolling More Than Once

The probabilities we have calculated so far make Magic Realm seem a rather dismal game: only one chance in five of finding a treasure site and one chance in three of failing a Hide roll. No wonder it seems easier for your character to die than to fulfill his Victory Requirements! Fortunately things do get better when we consider the effect of recording multiple phases.

To understand the effect of multiple rolls, we have to advance to the next lesson in probability, as given in the two theorems below:

1. If P1 is the probability of Event 1 and P2 is the probability of Event 2, the probability of Event 1 happening OR Event 2 happening is $P(1+2) = P1 \text{ plus } P2$.

2. If P_1 is the probability of Event 1 and P_2 is the probability of an independent Event 2, the probability of Event 1 AND Event 2 both happening is $P(1 \cdot 2) = P_1$ times P_2 .

For example, we have seen that the probability of rolling a 1 with one die is 16.7% (P_1) and the probability of rolling a 2 with one die is also 16.7% (P_2). The probability of rolling either a 1 OR a 2 is $P_1 + P_2 = 16.7\% + 16.7\% = 33.3\%$ (rounded off). On the other hand, since the red die roll and the white die roll are independent events, the probability of the red die result being 1 AND the white die result also being 1 is $P_1 \times P_2 = 16.7\% \times 16.7\% = 2.8\%$, which is what we found in Table 6.

These theorems need to be applied carefully; it is important to consider completely all the possible results. For example, in Section 3 above we learned that the probability of not hiding in a single Hide roll was $11/36 = 30.6\%$, which means the probability of hiding in one phase is $100\% - 30.6\% = 69.4\%$. What if we record two Hide phases in a day? At first thought, we might think that our chances of hiding are equal to the probability of hiding in Phase 1 plus the probability of hiding in Phase 2, but this is clearly wrong because $69.4\% + 69.4\% = 138.8\%$ and we can't have a probability of greater than 100%.

7. Multiple Phases to Hide

So how do we find our chances of successfully hiding if we record more than one Hide phase per day? If we record two Hide phase, we have to add the probability of:

- a. *hiding on the first phase AND not hiding on the second phase ($69.4\% * 30.6\%$),*
OR
- b. *not hiding on the first phase AND hiding on the second phase ($30.6\% * 69.4\%$),*
OR
- c. *hiding on both the first phase AND the second phase ($69.4\% * 69.4\%$).*

Each of these three cases will result in our character being hidden at the end of two Hide phases. So the total probability of successfully hiding in two Hide phases is: $(69.4\% * 30.6\%) + (30.6\% * 69.4\%) + (69.4\% * 69.4\%) = 90.6\%$. The probability of not hiding is the probability of not hiding on the first phase times the probability of not hiding in second phase = $(30.6\% * 30.6\%) = 9.4\%$. Note that the probability of hiding (90.6%) plus the probability of not hiding (9.4%) sum to 100%, which has to be correct because they are the only two possible results – either the character is hidden or he is not hidden.

Obviously the calculation for the probability of hiding can quickly get out of hand if we try to generalize to more than two rolls. If H =probability of hiding (69.4%) and N =probability of not hiding (30.6%), for three rolls we would have to add the probabilities of $HNN + NHN + NNH + HNH + HHN + NHH + HHH$ – not an easy

calculation! On the other hand, the only way that we could fail to be hidden is if we failed to hide in the first phase AND failed to hide in the second phase AND failed to hide in the third phase, so the probability of failing to hide = 30.4% * 30.4% * 30.4% = 2.9%. Since the probability of hiding OR not hiding is 100%, the probability of hiding in three phases is 100% - 2.9% = 97.1%. These results are tabulated in Table 8 below.

Number of Hide Phases	Probability of Successfully Hiding (two dice)	Probability of Successfully Hiding (one die)
1	$1 - 11/36 = 69.4\%$	$1 - 1/6 = 83.3\%$
2	$1 - (11/36)^2 = 90.6\%$	$1 - (1/6)^2 = 97.2\%$
3	$1 - (11/36)^3 = 97.2\%$	$1 - (1/6)^3 = 99.5\%$
4	$1 - (11/36)^4 = 99.1\%$	$1 - (1/6)^4 = 99.9\%$

Table 8: Probability of successfully hiding in multiple Hide phases using one or two dice.

Finally, let us compare the probability for hiding in multiple phases for a character who rolls two dice (taking the higher result) with the character who, because of some item or special advantage (the Druid, the Dwarf in the caves, a character with the Lucky Charm or Elusive Cloak) only rolls one die. These results are also included in Table 8. In two Hide rolls with one die, a character has a 97.2% chance of being successfully hidden, equal to the probability of a character who has three Hide phases but needs to roll two dice.

8. Multiple Search Phases

Let's look at another example where a single roll yields discouragingly poor probabilities: searching for a treasure site. As we have seen, the probability of discovering a treasure site is the probability of rolling a 4 ("Discover chits") or a 1 ("Choice") on the Locate Table. Using the higher of two dice rolled, this happens $8/36 = 22.2\%$ of the time. How do your chances of locating a treasure site increase in multiple rolls?

Again, there are many ways to successfully roll a "Discover chits" result in N rolls: you could roll a "4" on the first roll and be unsuccessful for the remaining (N-1) rolls OR you could roll successfully on the second roll OR you could Discover chits on all N rolls, etc. To find the probability of success in this way you would need to sum the probabilities of all of these ways of being successful. But, there is only one way that you could be unsuccessful in N roll: you would have to roll unsuccessfully

the first time AND roll unsuccessfully the second time AND roll unsuccessfully the third time, etc. The easier way to find the probability of success, therefore, is to calculate the probability of failure and subtract from 100%.

If the probability of success in a single roll is $8/36$, the probability of failure in one roll is $(36-8)/36 = 28/36$. The probability of failure in two rolls (the probability of failing in the first roll AND in the second roll) is $(28/36) * (28/36)$. The probability of failing in each roll for N rolls is $(28/36)$ to the Nth power $= (28/36)^N$. The probability of success is therefore $[1 - (28/36)^N]$.

Table 9 below shows the probability of finding a treasure site as a function of the number of Search Phases, rolling with either one die or two dice. The probability of discovering a treasure site in a day (four phases) of searching is over 63% if rolling with two dice and over 80% if a special advantage (the Woods Girl's "Tracking Skills") or an item (the Lucky Charm or Deft Gloves) allows the character to roll with only one die. Even if a Hide Phase is advisable, there is a better than even chance that a character can find a treasure site in one day of searching.

Number of Search Phases	Probability of Discovering Site (two dice)	Probability of Discovering Site (one die)
1	$1 - 28/36 = 22.2\%$	$1 - 4/6 = 33.3\%$
2	$1 - (28/36)^2 = 39.5\%$	$1 - (4/6)^2 = 55.6\%$
3	$1 - (28/36)^3 = 52.9\%$	$1 - (4/6)^3 = 70.4\%$
4	$1 - (28/36)^4 = 63.5\%$	$1 - (4/6)^4 = 80.3\%$

Table 9: Chance of character getting "Discover chits" or "Choice" result on Locate Table to discover a treasure site in multiple phases - rolling either one or two dice.

In a cave where characters get only two phases, on the other hand, one day of searching gives less than 40% chance of discovering a treasure site. The roll-one-die advantage of the Dwarf makes him the only character who has a greater-than-even chance of finding a site in the caves without the assistance of any special item.

The Map of the Lost City and Map of the Lost Castle treasures give the owner a -1 on any roll on the Locate Table in the tiles that contain the "Lost City" or "Lost Castle" chit. This creates three results (5, 2, and 1) instead of two that will result in discovering chits, in addition to the greater chance of rolling a 5 ($=9/36$) as opposed to rolling a 4 ($=7/36$). The net result is that a given probability of discovering a site can be achieved in between one and three fewer Search Phases than without the Map: 2 phases rather than 3 to have a probability greater than 50%, 3 phases rather than 5 for a probability greater than 70%, and 4 phases

rather than 7 to achieve a probability greater than 80%. There is a similar savings of Search Phases spent for the character who only rolls one die, but the probabilities are correspondingly higher: 4 rolls with the Map as opposed to 7 rolls without the Map result in a probability greater than 90% of discovering the site.

This suggests that three phases is an upper limit on the number of Trade Phases that a character should spend in attempting to buy the Map of the Lost City or Map of the Lost Castle from a native group, but reducing the number of days spent making Search rolls in the Lost City or Lost Castle tile has the advantage of significantly reducing the number of monsters drawn. The reduction in the number of rolls with the maps is especially valuable in the caves where phases are precious. Spending phases to buy a map in a valley tile where you have four phases per day to save time searching in a cave clearing where you only have two phases would be a greater advantage than saving the same number of phases in a mountain or woods clearing. This implies that the Map of the Lost City is more valuable than the Map of the Lost Castle because the Lost City is always located in a tile with cave clearing.

To show one more example, consider the probability of finding a hidden path (on the Peer Table) or a secret passage (on the Locate Table). In both cases, the character has to roll a 1, 2, or 3 to discover the path or passage. The probability of achieving this successfully in one, two, three, or four Search Phases is shown in Table 10 below. Note in comparison with Table 9 that the two-dice probability is similar to the probability of discovering a treasure site, but the one-die probability is much higher. The Dwarf, rolling one die in the caves, has a 75% chance of finding a secret passage in two Search Phases!

Number of Search Phases	Probability of Discovering Path/Passage (two dice)	Probability of Discovering Path/Passage (one die)
1	$1 - 27/36 = 25.0\%$	$1 - 3/6 = 50.0\%$
2	$1 - (27/36)^2 = 43.7\%$	$1 - (3/6)^2 = 75.0\%$
3	$1 - (27/36)^3 = 57.8\%$	$1 - (3/6)^3 = 87.5\%$
4	$1 - (27/36)^4 = 68.4\%$	$1 - (3/6)^4 = 93.7\%$

Table 10: Probability of discovering hidden path or secret passage in multiple rolls on the Peer Table or Locate Table, using one or two dice.

9. Generalized Probability for Multiple Rolls

To express the effect of multiple rolls in another way, let us consider the number of rolls that one must make to have a 10%, 30%, 50%, 70%, or 90% chance of a successful outcome as a function of the probability of success in one roll. This is compiled in Table 11 below.

Only single-roll probabilities involving an odd numerator over 36 ($1/36$, $3/36$, $5/36$, ...) are listed in the table. The results for intermediate single-roll probabilities can be estimated by interpolating between columns. The position in the table of single-die roll probabilities of $1/6$, $2/6$, and $3/6$ are indicated by the thick vertical lines near $6/36$ ($=1/6$), $12/36$ ($=2/6$), and $18/36$ ($=3/6$). If the given probability of success would be achieved in one roll or less, the table contains a dash (-).

Number of Rolls to Achieve Given Probability of Success											
Prob. Success	Probability of Success in One Roll										
	1/ 36	3/ 36	5/ 36	7/ 36	9/ 36	11/ 36	13/ 36	15/ 36	17/ 36	19/ 36	21/ 36
10%	3.7	1.2	-	-	-	-	-	-	-	-	-
30%	13	4.1	2.3	1.6	1.2	-	-	-	-	-	-
50%	25	8.0	4.6	3.2	2.4	1.9	1.5	1.3	1.1	-	-
70%	43	14	8.1	5.6	4.1	3.3	2.7	2.2	1.9	1.6	1.3
90%	82	26	15	11	8.0	6.3	5.1	4.3	3.6	3.1	2.6

Table 11: Number of rolls required to achieve a 10%, 30%, 50%, 70%, or 90% probability of success as a function of the probability of success on one roll.

So, for example, consider the probability of locating a secret passage by on the Locate Table with two dice. From Table 4 (in Part I of this series), the probability of rolling a 1, 2, or 3 on the higher of two dice is $9/36=1/4$. Looking at Table 11, we see that it would require 1.2 rolls to have a probability of success of 30%, 2.4 rolls to have a probability of 50%, and 4.1 rolls to have a probability of 70%. We see that this is consistent with the results in Table 10: one roll gives a probability slightly less than 30%, a 50% probability of success corresponds to between two

and three rolls. and four rolls gives a probability slightly less than 70%.

Table 11 along with Table 1 allows us to extend our analysis to any other case that we may consider. Consider the case where a two items remain to be looted in a treasure site or pile of abandoned items. From Table 1, the probability of rolling a 1 or 2 with the higher of two dice is $4/36$. From Table 11, to have a 50% chance of success in rolling a 1 or 2 with two die would require approximately 6 (between 4.6 and 8) Search Phases. If a character and his hired leader were both searching - recording a total 8 Search Phases per day - their chances of finding one of the remaining treasures in one day would be between 50% (8 phases at $3/36$) and 70% (8.1 phases at $5/36$), or about 60%. If they searched for two days - a total of 16 Search phases - their probability of finding one of the treasures would be between 70% and 90%.

The Dwarf, rolling one die to loot the last treasure from a site in a cave clearing ($1/6=6/36$ chance of success per roll), would need about 4 Search phases (halfway between 3.2 and 4.6) to have a 50% chance of getting the last treasure. As always, these results are subject to the usual vagaries of probability: after the Dwarf had taken 4 Search phases over two days and hadn't looted the last treasure, he could only expect that he would need an additional 4 Search phases to have a 50% probability of success. If he were lucky, on the other hand, he could find the last treasure on his first roll!

Next: Probabilities in Combat