TOP GUN MAVERICK

Mission ChanceOmeter
With BayesOmatic

User's Guide

Interactive Excel simulation available at

ProbabilityManagement.org and the Military Operations Research Society

Probability Management

MORS
Military Operations Research Society

Blog on the development of this model

TOP GUN MAVERICK

TOP GUN: MAVERICK
A WALK IN THE PARK OR MISSION IMPOSSIBLE?
By John Button, Connor McLemore, and Sam Savage

"Maverick" has been authorized by the President, and tasked by the Pentagon, to lead a specialized a strike team to take out the enemy's illegal uranium enrichment plant before it is fully operational and make it back safely to tell the story.

The plant sits in an underground bunker, surrounded by two mountains, at the end of an incredibly steep valley. The strike mission in the movie is four complicating factors:

- Hitting a very small target (three meters wide,) two consecutive times
- at a very precise angle,
- in a very steep valley,
- in a GPS-jammed environment.

The attack strategy calls for two sections (a.k.a, '2-ships'), with F/A-18E flight leads (Maverick and Rooster) and F/A-18F wingmen (Phoenix w/ Bob and Payback w/ Fanboy). Each aircraft pair will fly in a welded wing formation with one plane aiming the targeting laser and the other plane delivering the weapon. Each pair must accomplish one of two dependent actions:

- **F-18 Pair 1**: The first pair will breach the reactor by dropping a targeting laser-guided bomb on an exposed ventilation hatch. (This will create an opening for the second pair.)
- **F-18 Pair 2**: The second team will deliver the kill shot.

Using the Model

1. In our **Chance**Calc model the first attack is designated as black, and the second as blue. There are three sources of uncertainty that may be individually adjusted.
   a. The Azimuth (left/right) error and Range (fore/aft) error of the targeting laser guided weapons. These are measured in in terms of the standard deviation away from the target and are the same for both attacks.
   b. The chance of malfunction of the targeting laser in each attack. These may be adjusted separately.
   c. The Azimuth and Range errors for each attack in the event that the targeting laser malfunctions. These depend on pilot skill and might be quite different for each attack.

Attack 1

Plane 1		Plane 2		Errors
Chance of Laser		Errors w/o Laser		SD in m.
Failure	10%		Sd in meters	w/Laser
		Azimuth	1.8	1
Target Designated		Range	2.4	1
		Chance	96%	
Laser Disabled ▪		HIT		

(callouts: **c**, **a**, **b**)

Attack 2

Plane 1		Plane 2	
Chance of Laser		Errors w/o Laser	
Failure	10%	SD in meters	
		Azimuth	2.1
...esignated		Range	3.6
		Chance	93%
Laser Disabled ▪		HIT	

(callouts: **c**, **b**)

2. For plane 1 of each attack, disable the targeting laser and specify the range and azimuth dimensions of the 95% dispersion ellipse in the event of targeting laser failure.
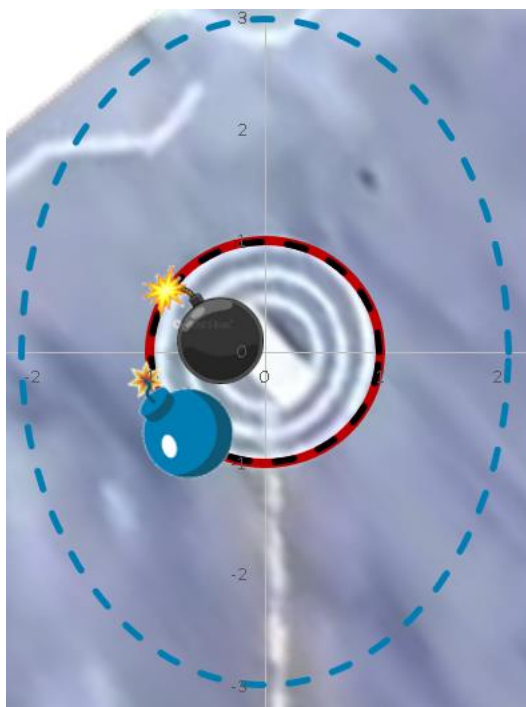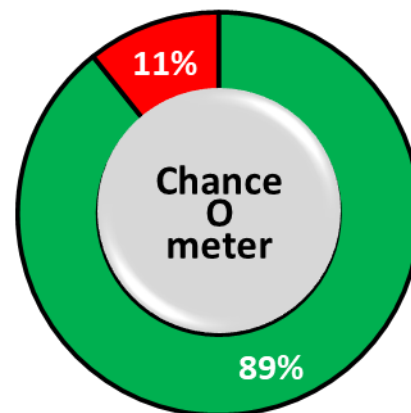
Attack 2

Plane 1		Plane 2	
Chance of Laser		Errors w/o Laser	
Failure	10%	SD in meters	
		Azimuth	2.1
Laser Malfunction		Range	3.6
		Chance	44%
Laser Disabled ☑		MISS	

Dispersion – – – –

3. Enable both targeting lasers and read off the chance of mission success as well as the individual chances of success for each attack.

■ Success   ■ Failure

11%

Chance O meter

89%

10,000 trials are run instantly with each keystroke with the results reflected in the ChanceOmeter. The state of the screen reflects just a single trial. Use the Trial Control to scroll through trials or view any particular trials, such as 8,268, on which both targeting lasers fail, but for which the mission succeeded anyway. This model was created using **Chance**Calc from nonprofit ProbabilityManagement.org and performs its simulations using the Excel Data Table without macros or add-ins.

BayesOmatic

The model can also calculate the chance of various outcomes of the mission given specified conditions. For example, we can calculate the chance that mission would succeed given the malfunction of both targeting lasers.

Bayes O matic		Mission	Attack 1	Attack 2	Laser 1	Laser 2
22.8%	Chance that this happens given that	Success ▼	-------- ▼	-------- ▼	-------- ▼	-------- ▼
	This has happened	-------- ▼	-------- ▼	-------- ▼	Down ▼	Down ▼

How it works

Bayes Theorem states that

Probability of event A given event B = Probability of events A and B ÷ Probability of event B

This can be viewed geometrically as the chance that a dart is in region A given that you know it has already hit B as shown. This is elementary to do in a SIPmath model by creating Boolean (0/1) variables that signify that A has occurred, B has occurred, and that A and B have both occurred. This creates three ranges on the PMTable sheet, let's call them A, B, and A_and_B. Because the results of the 10,000 trials are always live in the Data Table, it is easy to perform Bayesian analysis on the fly and the formula above is simply
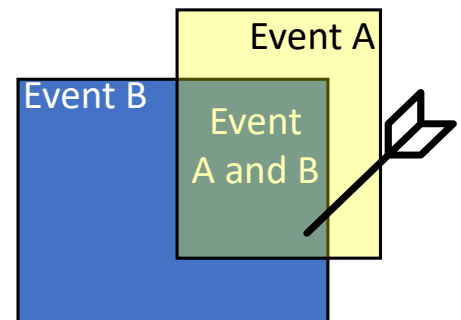
Probability of event A given event B = SUM(A_and_B)/SUM(B)

This model sets up the Boolean variables using user forms on the Calculations sheet. The Data Table is shown below. Note that targeting laser 2 failed on trial 9.

Index	Hit_1	Hit_2	Mission	Laser_1	Laser_2	Condition1	Condition 1 and 2
Values	1	1	1	1	1	0	0
1	1	1	1	1	1	0	0
2	1	1	1	1	1	0	0
3	1	1	1	1	1	0	0
4	1	1	1	1	1	0	0
5	1	1	1	1	1	0	0
6	1	1	1	1	1	0	0
7	1	1	1	1	1	0	0
8	1	1	1	1	1	0	0
9	1	1	1	1	0	0	0

It is also easy to do what is known as Bayesian inversion. Suppose you're back on the deck of the carrier after a successful mission, and the Maintenance Chief says: "Did you realize that both targeting lasers malfunctioned?" "Impossible," you say. Well not exactly. There is a 2 tenths% chance as shown below. To understand the difference, return to the figure with the dart. It should be clear that the chance of hitting in blue given that you hit in yellow is greater than the chance of hitting in yellow given that you hit in blue.

Free Excel Simulation and User's Guide available at
ProbabilityManagement.org and the Military Operations Research Society

Probability Management

MORS Military Operations Research Society

References

1. https://en.wikipedia.org/wiki/Top_Gun:_Maverick
2. There are many sources for computing dispersion patterns. We used the following reference.
   https://www1.udel.edu/biology/rosewc/kaap686/reserve/cop/center%20of%20position%20conf95.pdf
3. Plotting ellipses in Excel are well covered on YouTube, for example at
   https://youtu.be/xVoFVVcx2oQ