The Equations the Simulation Uses

Thrust **Air Pressure in the bottle**	$PV^k = P_i V_i^k$	$k = C_p/C_v$ (the ratio of heat capacity at constant pressure to heat capacity at constant volume, 1.4 for air) P = the pressure of air in the bottle after the launch P_i = the initial pressure of air in the bottle V_i = the initial volume of air in the bottle V = the volume of air in the bottle	The air in the bottle expands so rapidly that it cools because it can not absorb heat from the surroundings. This equation that relates the pressure of the air in the bottle to the volume of air in the bottle is:
Thrust Velocity	$v_w = \sqrt{\frac{2(P - P_{atm})}{\rho}}$	P_{atm} = the pressure of the atmosphere (101 kPa or 14.7 psi) v_w = the velocity of the water relative to the bottle (a vector) ρ = the density of water (1000 kg/m^3 or 62.4 lbm/ft^3)	
Thrust Force	$F_w = \rho A v_w \lvert v_w \rvert$	F_w = the thrust from the water $\lvert v_w \rvert$ = the magnitude of the velocity v_w = the velocity of the water (a vector	The force of the expulsion of water pushes the rocket forward in the direction of the rocket is pointed.
Drag	$F_d = \frac{C_D A v_r^2}{2}$	A = the cross sectional area of the rocket C_D = the drag coefficient F_d = the drag force v_r = the velocity of the rocket	The drag coefficient is related to the aspect ratio of the nose cone (ratio of diameter of the base to height). It can be calculated and is typically in the range of 0.1 to 0.3 for water rockets.
Gravity	$F_g = mg$	F_g = the force of gravity m = the mass of the rocket and the water in it g = the gravitational constant (9.8 m/sec^2 or 32.2 ft/sec^2)	

Since the forces are changing with time, the equations are solved as a system of ordinary differential equations by the simulator.

http://www2.widener.edu/~crn0001/Bottle/images/BottleModel.htm