

## Why Displacement Matters: A Green/Purple Debate

1 Hex = 10 km, 1 turn = 64 seconds. (DV scale, VMS/FT have no specified scale)  
 Velocity= $a \cdot t$ , displacement= $0.5 \cdot a \cdot t^2$ . A velocity change of 2 hexes/turn is 0.5 g of thrust.

Black circles show position at the end of a turn assuming constant thrust. Gray circles show position assuming the engines are cut off at the beginning of the turn and the target drifts at its new velocity.

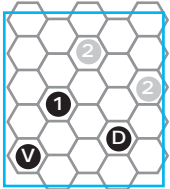
The green bounding box is VMS, the standard we're comparing to. VMS assumes that thrust is either instantaneous, or that the displacement on the first turn of thrust is equal to the velocity change.

The first purple bounding box is thrust 1 in DV scale, where thrust 1 equates to one additional hex of movement (displacement) on the turn of thrust; it results in a velocity change of 2 hexes per turn, and is closest to the VMS model.

The second purple bounding box is thrust 2 in DV scale. This matches the initial displacement of turn 1 thrust (and the only example where both VMS and DV will put the ship into the same position). As can be seen, the velocities are twice the values as would be derived in the VMS system.

This graphic understates the discrepancy, because it's measuring it from a fixed point. Spaceships aren't fixed points when calculating movement and firing ranges. Assuming that the first purple box is the correct interpretation of the discrepancy (thrust measures change in velocity, and everything is instant) two units approaching each other at a continuous thrust of 2 via VMS would be 8 hexes closer to one another than where they would be with correct movement after turn 4.

The error increases linearly with thrust rate. Going to thrust 4 results in double the error above; two units thrusting towards each other at thrust 4 in VMS would have a combined positional error of 16 hexes, which is significant in most games that can be played on a hex grid -- and a thrust rate of 4 is fairly modest for most VMS systems. This positional error also expands at the rate of  $(n^2 - n)$  where  $n$  is the number of units in a combat. If you have four units all with different vectors and varying degrees of discrepancy in four different directions, you really have no basis for figuring out ranges in a game.



At left is a blue bounding box that shows what happens when facing changes are allowed in the middle of a burn; assuming the turn took place at the exact midpoint of the burn, there would be no displacement on the hex grid in correct Newtonian movement. Assuming vector change always equals displacement as VMS does, you get a significant positional error; as the number of facing changes during a burn increases, the rate of error also increases. This may be why VMS does not allow facing changes during the burn.

To illustrate the cumulative effects of these positional errors, see the graphic below. Stars indicate where the unit started from; green circles show where the unit would be with VMS, and purple circles indicate where the unit would be with actual Newtonian movement. The labels indicate the duration of the burn and the rate of thrust where thrust 1 = 0.5 g, and thrust 1 means the units change position by 1 hex during the turn of thrust. For this example, unit A has initial vectors of 4 in D, 2 in C and does not thrust on turn 1, then thrusts for 4 in F on turn 2. Unit B starts at rest, and thrusts at 7 in C on turn 1, and thrusts at 4 in A on turn 2. Unit C has an initial vector of 3 in E, and thrusts at 5 in B on turn 1, and has no thrust on turn 2. All three ships drift on turn 3. Lighter colored circles indicate positions obtained solely by drifting on an existing vector.

