APPLIED BALLISTICS™

Marketing Hype in Ballistics - The Hornady 4 DOF Ballistics Calculator

By: Bryan Litz

Applied Ballistics' mission[i] is to be the complete and unbiased source of external ballistics information for long range shooters. Gaining the knowledge required to master long range shooting is very difficult, even when you have good information. Unfortunately the hyper-marketing/advertising culture we live in is constantly pushing out misleading or outright false information to promote products with genuine truth as a distant afterthought.

In addition to exploring the unknown areas of ballistics and publishing original information, it's also part of our mission at Applied Ballistics to address the many questions which arise from the overwhelming marketing hype.

The Hornady 4 DOF Ballistic Solver

If you were a long range shooter in the summer of 2016, you were probably been touched by Hornady's extensive marketing campaign promoting their Doppler Radar, melting tip bullets, ELD bullets, and the latest big thing which is the 4 DOF online ballistic solver. You may have seen a video, read an article, and maybe even ran the program and wondered if there really is anything special about it. The goal of this article is to examine these questions about the Hornady 4 DOF ballistic solver.

As the Hornady literature explains, DOF stands for Degrees Of Freedom. Each direction something can move or rotate is a degree of freedom. Many ballistic solvers model 3 degrees of freedom: X, Y, and Z. In shooter speak that means: range, windage and elevation; basically what you need to hit a target at long range. A more complex approach to simulating the flight dynamics of projectiles is with 6 Degrees Of Freedom which includes the angles: Pitch, Roll and Yaw.

Both 3 DOF and 6 DOF simulations are common and have their applications. Hornady claims that the Degrees Of Freedom modeled by their 4 DOF solver are: X, Y, Z and *angle of attack.* Angle of attack is the total angle made by the bullets axis and its velocity vector (flight path). Hornady's technical manual[1] describes their solver as being a *modified point mass* (MPM) solver, and there are references to MPM solvers being referred to as 4-DOF solvers. These particular MPM solvers approximate yaw of repose as the 4th degree of freedom. The inclusion of yaw of repose allows the solver to account for spin drift and yaw induced drag, but not limit cycle yaw or aerodynamic jump; which are two effects that Hornady claims to model with their MPM solution but require additional degrees of freedom not modeled by 4 DOF MPM solutions.

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[1] http://www.hornady.com/assets/files/4dof/Hornady_4DOF_Technical_Paper.pdf

Hornady states that their 4 DOF solver is patent pending. This is particularly shocking since MPM solvers have been around since the 1960's and goes beyond marketing hype to a new level. Why is Hornady trying to establish ownership of something that was invented decades ago? This paragraph isn't so much about marketing hype as it is the overall tactics being employed. Hornady isn't just making false claims about being the first to offer a ballistics solver with advanced capabilities when others have had it for years; they're also attempting to secure ownership of the solver so they can disallow others from using it.

Getting past the title and patent tactics, let's explore what a modified point mass (MPM) simulation is and what information it requires to work properly.

A properly written MPM solver requires vast tables of obscure and hard to get aerodynamic coefficients for each bullet which characterize the forces and moments on a projectile as it flies thru the air. This data is very difficult to calculate with any accuracy. *It doesn't come from radar testing which only measures the projectiles velocity decay*. Generally speaking, these aerodynamic coefficients are estimated using prediction software such as PRODAS. In Hornady's case, out of the many different tables of aerodynamic coefficients used to drive the MPM solver, the drag coefficient is the only one that was directly measured with the rest being estimated. This puts their claim into perspective and reveals the marketing twist that's in play. *It's true that a MPM solver simulates more details than a standard solver, however, the data being used to model the additional details is all estimated, not measured*. So when the Hornady marketing message says their stability calculations are more accurate than conventional approximations, what they're not saying is that their own complex stability calculations are based on data that is *estimated* and not verified with live fire. It's a good position to spin up marketing hype, but a poor position to support under scrutiny.

For example, what happens when you calculate spin drift with Hornady's solver is the MPM equations are being solved based on the *estimated* aerodynamic tables. By contrast, when you run the Applied Ballistics solver, a different approach is used to calculate spin drift: a formula which was developed years ago and has been verified with live fire measurements of actual measured spin drift[2] is used. In other words, the Hornady MPM approach does *extensive calculations* using *estimated data*, and the Applied Ballistics solver applies a *basic formula* using *measured data*. If you wonder which is more accurate, you can read about the live fire verification of the Applied Ballistics method in Modern Advancements In Long Range Shooting – Volume I, which was published in 2014.

Aerodynamic jump is another similar example where the AB solver applies a simple and robust formula which has proven accurate in the field, and the Hornady supplied data is based on a different approximation which is not verified, and it's questionable how AJ is even being calculated in a 4 DOF MPM solver.

[2] Modern Advancements in Long Range Shooting: Volume I by Bryan Litz

The use of MPM and even 6 DOF solvers is something that was considered by Applied Ballistics years ago for public availability. It was decided, after weighing all options, that it wouldn't make sense to offer a 6 DOF or MPM solver which relied on such extensive data tables that could only be approximated. It's not difficult to make and offer higher order solvers like MPM and 6 DOF, it just doesn't make sense from an application perspective.

It's strange that Hornady omitted the Coriolis effect in their solver. Depending on your location and azimuth, Coriolis can have an effect comparable in magnitude to aerodynamic jump, and the difference between BC based solutions and their custom drag models.

Hornady's exclusive use of drag coefficients instead of BC's in their 4 DOF solver will be the subject of another article. For now I will just point out that they claim the solver to be highly accurate out to 2000 yards, and that the radar derived drag coefficients are so very accurate that no *truing* is required. However, the Hornady solver requires an *axial form factor* input; which allows you to scale the radar measured drag tables up or down up to +/-10% from what's in the library to match your data. This is the same thing as truing, which Hornady claims is not necessary with their solver.

Much of Hornady's hype centers around their 4 DOF solver being the first to offer some advanced features like spin drift and aerodynamic jump. Of course this is completely false as the Applied Ballistics solver has refined these features thru live fire and incorporated them into our solver many years ago. Hornady is very much following, not leading, in ballistic science.

The previous paragraph clears up some of the misleading hype in which Hornady attempts to take credit as leaders. However the average shooter probably doesn't care much about who did it first. The average shooter cares more about how accurate the ballistic predictions are. Perhaps one way to approach the accuracy question is to consider real world results. What sort of accuracy have the different solver/data combinations produced thru verified live fire testing?

For the Applied Ballistics combination of solver/CDM, the most recent public demonstration of accuracy was at the 2016 King of 2 Mile (KO2M) Extended Long Range (ELR) shooting event in Raton, NM. The KO2M event is an official competition sanctioned by the 50 caliber shooters association and shot under time constraints, rules, and scored with many observers. In this event, the Applied Ballistics team achieved *first round hits on targets out to 2488 yards*. This was accomplished with two different rifles and bullet combinations. In order to achieve first round hits on such distant targets, every element of the ballistic prediction has to be right, especially the bullet drag model. In summary, the Applied Ballistics solver results in first round hits with multiple rifles and bullets at over 1.4 miles. 1.4 miles is further than Hornady's radar is even capable of tracking bullets, and further than their online 4 DOF solver is capable of running. Yet Hornady's marketing claim is that their approach is better.

For now I leave you with the following facts regarding the Hornady 4 DOF solver:

1) The Hornady solver is not a 4 Degree Of Freedom solver. It is a modified point mass solver; something which has been around since the 1960's[3]. It's not actually possible to model spin drift and aerodynamic jump with 4 degrees of freedom.
2) The angular calculations of Hornady's solver are based on *estimated* aerodynamic coefficients. By contrast, the formulas published by Applied Ballistics have been proven accurate thru *live fire* over the years by thousands of users.
3) The Hornady solver does not account for the Coriolis affect; something which is of comparable importance as the difference between G7 BC's and custom drag models which Hornady cites as being one of the main advantages of their solver.
4) Hornady's solver is an easily accessible online tool but the accuracy of even the basic drop and wind drift calculations are difficult to verify for sure since their drag data is hidden and prevents a direct comparison to established solvers.
5) Since the solver is limited to only those bullets in the library, it's useless for anything but those particular bullets which don't even include Hornady's own full line.
6) Hornady's claim of being the first to introduce advanced ballistic modeling effects such as spin drift and aerodynamic jump is completely false. In reality, Hornady is years behind the curve when it comes to ballistic modeling.
7) Hornady's claim of superior accuracy is not supported with live fire results like the Applied Ballistics solver is.

In conclusion, Hornady's 4 DOF solver may be reasonably accurate. However, regardless of the extensive marketing hype, there's actually nothing novel about it. There are no facts which support their statements of it being more capable or more accurate than what has been available for many years.

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[i] **Our Mission:** Applied Ballistics' mission is to be the complete and unbiased source of external ballistics information for long range shooters. We're highly active in R&D, constantly testing new claims, products and ideas for potential merit and dispensing with themarketing hype which can make it so difficult for shooters to master the challenging discipline of long range shooting. We believe in the scientific method and promote mastery thru unders tanding of the fundamentals. Our work is passed on to the shooting community in the form of instructional materials which are easy to understand, and products such as ballistic software which runs on many platforms. If you're a long range shooter who's eager to learn about the science of your craft, we're here for you.

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[3] Modern Exterior Ballistics 2nd edition by Robert L. McCoy