This is document discusses the differences between the STARS unsteady solver and the newer Euler3d flow solver. This document arose from a discussion how to compare the two solvers. It is not an instruction manual.

I have an example of a working CFD model solution using euler3d. I ran the old agard solution using euler3d and compared to the same solution using the unsteady flow solver of STARS, (referred to as "STARS" within this document). The attached spreadsheet has a summary of my results. Here is a description of what I did:

1. Agard solution at Mach 0.96 using ainf = 12571.08, rhoinf = 6.04186E-09, dt = 15.71, and refdim = 1.0. These are the original parameters used for our old agard model tests with STARS.

2. The Overview tab of the spreadsheet has the conu and scalars files used with STARS as well as the con file used with euler3d. These are the files used for the 3211 multistep solution for the agard. I had to hack euler3d to allow me to specify the equivalent of STARS rbcx so that both solvers would run the exact same multistep. By default, euler3d picks an rbcx such that the max displacement is one, which is a little more user friendly but not as flexible. This could cause problems if the scaling of your mode shapes was such that one unit is a large displacement (we want small displacements).

3. The STARS tab contains the time history data output by STARS for the 3211 multistep solution. Columns A-G contain the dimensional values normally output by STARS. columns H-N contain the dimensionless values for comparison with euler3d, and columns O-P contain the de-trended dimensionless forces.

4. The E3D tab contains the time history data output by euler3d for the 3211 multistep solution. Columns A-H contain the dimensionless values normally output by euler3d. Columns I-J contain the de-trended dimensionless forces, and columns K-Q contain the dimensional values for comparison with STARS.

5. The Plots tab contains a comparison of the dimensionless time history data from each solver. The generalized displacement and velocity match exactly for both, so the input signal for each is identical. The de-trended forces match-up fairly well with some small differences. There is a big difference between the static offset for force 1, but we would expect the offset to be zero for this symmetric wing so the euler3d solution is "better" in that respect.

6. The differences between the two solutions comes from (in no particular order):

   a. algorithmic differences in the flux integration, dissipation, etc.

   b. normals: STARS uses parametric normals from the sur file, but euler3d uses averaged normals computed from the surface triangulation. This means the normals used by STARS will be smoother than those used by euler3d in regions where the surface tringulation came out poorly.

   c. STARS = single precision, euler3d = double precision

d. Symmetry boundary condition is implemented slightly different in euler3d.

e. The STARS solution for this problem used residual smoothing. This is an additional form of junk artificial dissipation that was needed to further stabilize the solution.

These differences add up to small discrepancies between the two time force time histories, but they ended up matching even better than I would have expected...

7. The Models tab shows a comparison between the ARMA models for these solutions. Columns A-C have the model generated by cfdmdl for the dimensional STARS time history data. Columns E-G have the model generated by the new cfdmdl3d (which is used with euler3d) for the dimensionless STARS time history data. I added a percent difference column (italicized) to compare the two models. When comparing models, the first na parameters do not have to be converted at all since they are scaling factors for forces (dimensional or dimensionless). The last nb parameters do have to be converted though. In this case I converted the dimensional nb parameters from cfdmdl to dimensionless parameters (columns A-B). Notice that the percent difference between the two models is at most 0.4%. This demonstrates that the two modeling programs (cfdmdl and cfdmdl3d) produce consistent models given the proper input files.

8. The same process is completed using the time history data from euler3d. Again, I use the dimensionless data with cfdmdl3d (columns K-M) and the dimensional data with cfdmdl (columns O-Q). In this example we actually end up with one parameter that differs by a little over 20%, but it is very close to zero and should not influence the solution very much. All other parameters are with 0.5% of each other or better.

9. As a last step, we can run asemdl3d using either of the dimensionless models. The first dynamic instability occurs at approximately 0.2335 psi using the STARS model or 0.2444 psi using the euler3d model. This is consistent with results originally reported for the agard instability. I tried to do the same thing with asemdl (and the dimensional models), but the results were all wrong. I seem to recall that asemdl was broken at some point. I am not sure what is wrong with it, but asemdl3d is generating the correct results.