

Extending the Arming Distance of MOFA

(MOFA & MOFN S&A Modeled in DADS & ABAQUS)

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Background

- MOFN proposes to use the MOFA S&A
- MOFA S&A will nominally arm at 250 ft
- MOFN needs a 400 ft minimum arming distance
- Previous work by Honeywell indicated that a MOFA S&A with a heavier pallet and lighter rotor would arm at 430 ft and would not arm at 375 ft



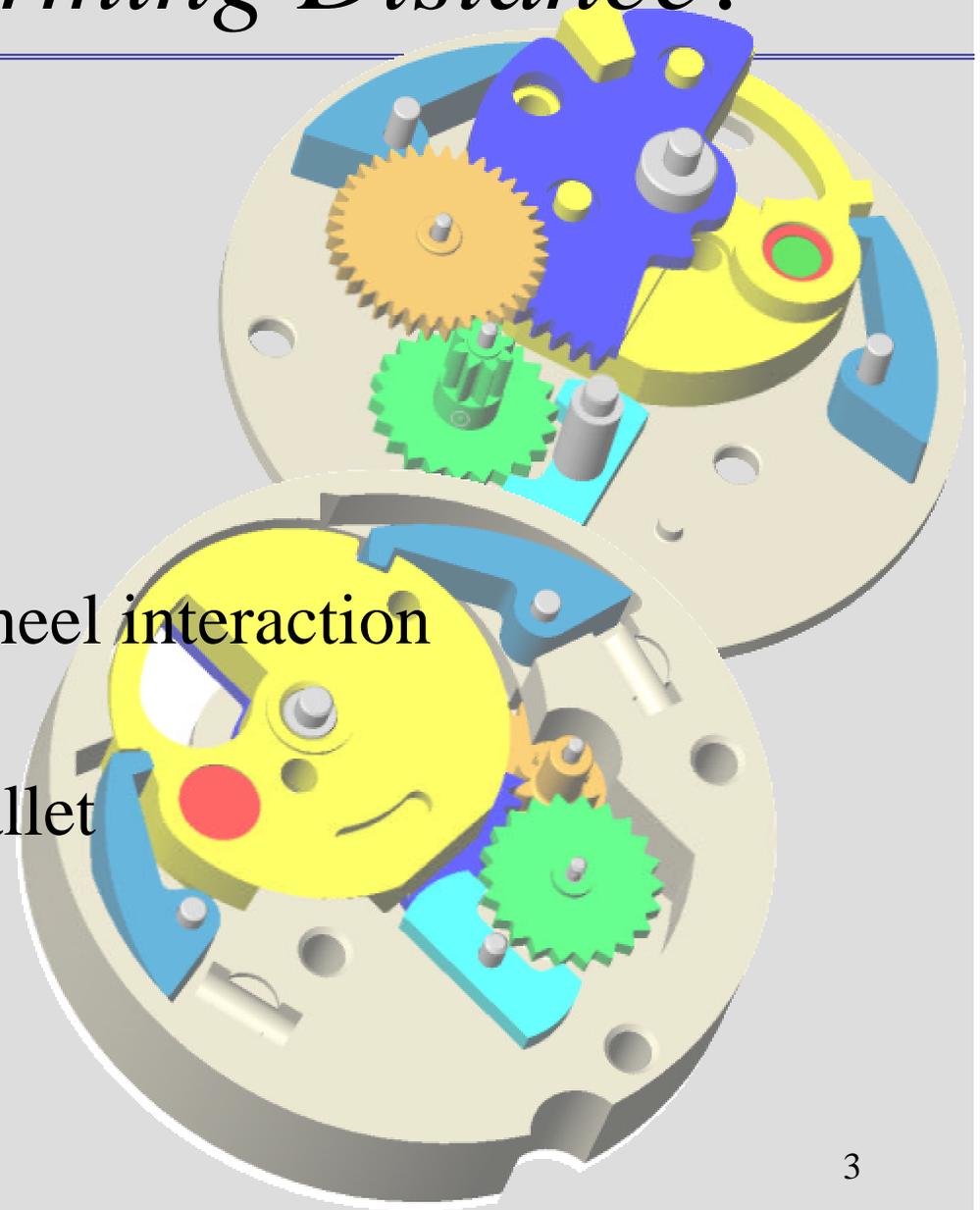
MOFA = 250'



MOFN >400'

Easy Arming Distance?

- Options:
 - Different S&Aor
 - More gears
 - More teeth
 - Modify Pallet/Star-wheel interaction
 - Mass properties
 - Rotor Body and Pallet



Analysis Tools

- Rule-of Thumb Calculations:

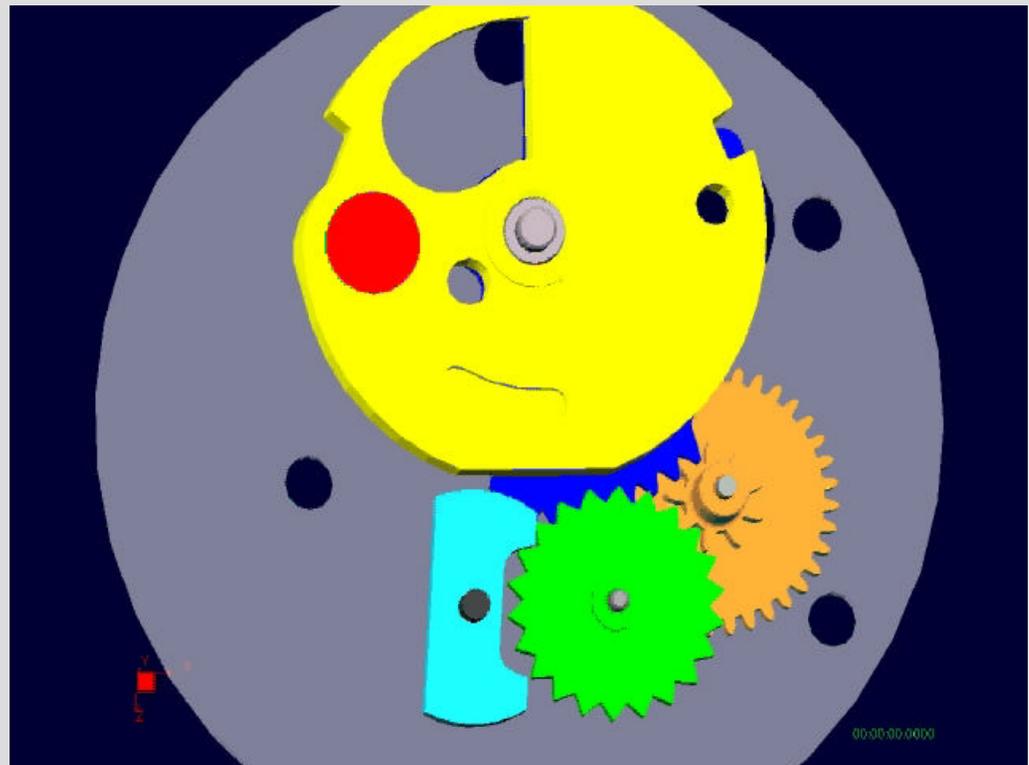
$$\frac{Speed_{Rotor1}}{Speed_{Rotor2}} = \sqrt{\frac{Mass_{Rotor1}}{Mass_{Rotor2}}} \sqrt{\frac{Inertia_{Pallet2} + Inertia_{Starwheel2} \times \left(\frac{N_2}{q_2}\right)^2}{Inertia_{Pallet1} + Inertia_{Starwheel1} \times \left(\frac{N_1}{q_1}\right)^2}}$$

- DADS (Dynamic Analysis and Design System) from LMS International
 - Rigid Body Dynamics
- ABAQUS from ABAQUS, Inc.
 - Finite Element Analysis

Analysis with DADS

- Analyze MOFA S&A with Dynamic Analysis and Design System
- Feature of DADS Model
 - Rigid Bodies
 - Implicit Solver
 - Limited contact capability
 - Ideal constraints such as journals and gears
 - Coefficient of restitution

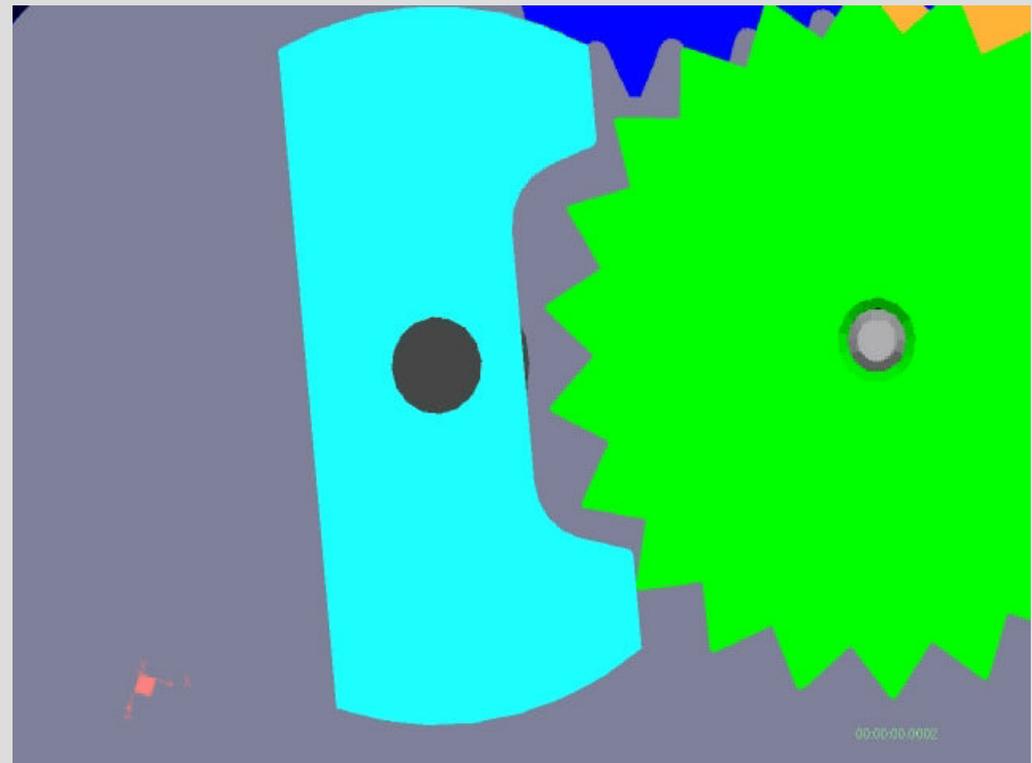
View Rotates with S&A



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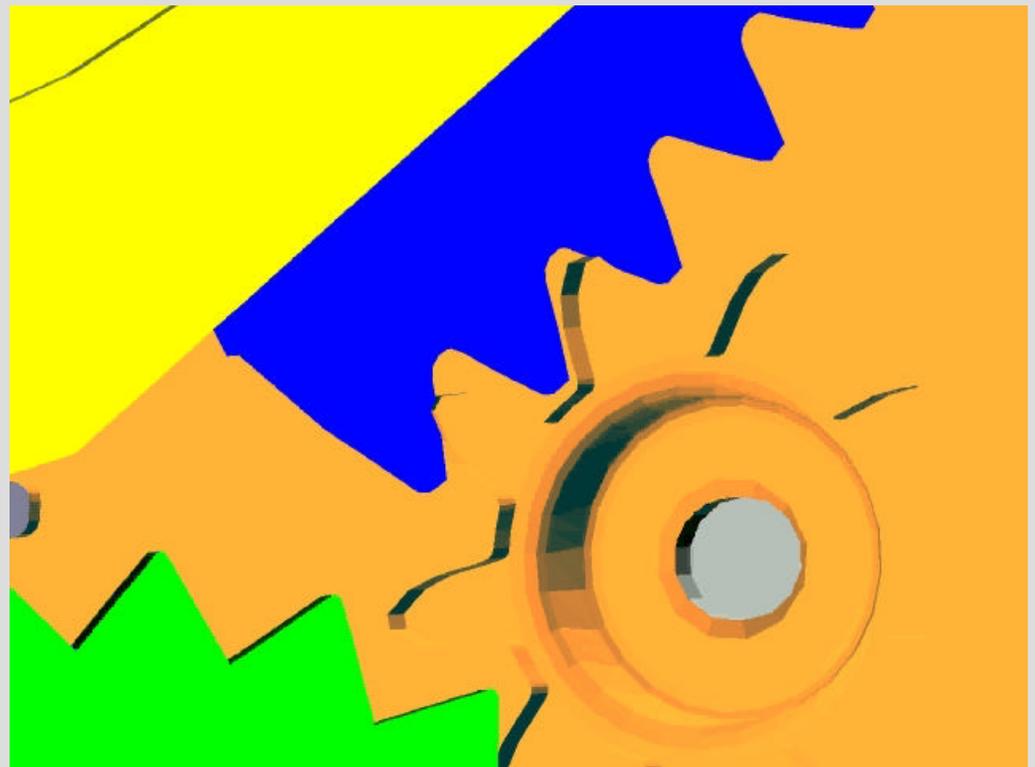
Ideal Pallet Pivot



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Ideal Gear

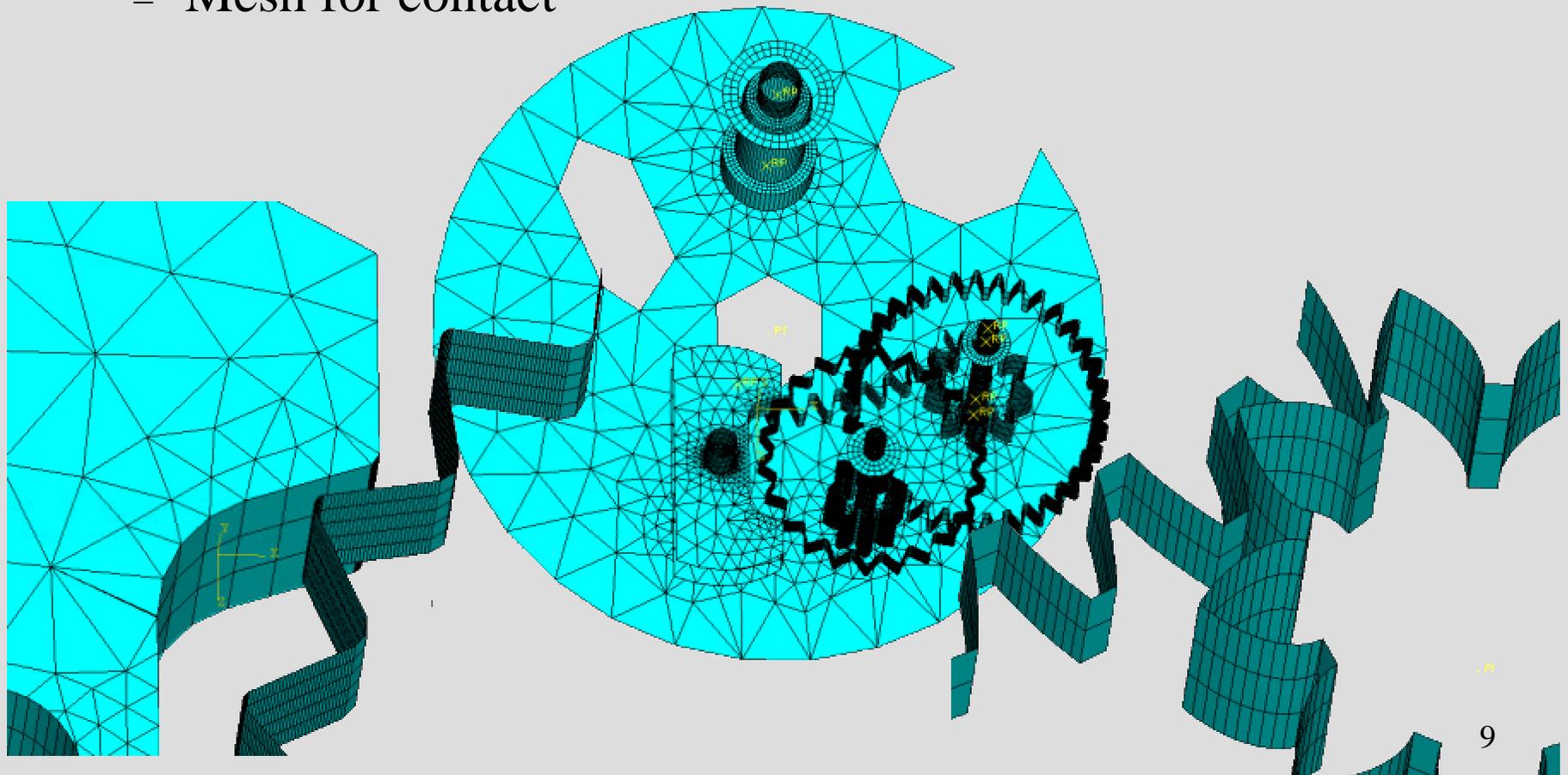


Results with DADS

- MOFA Nominal Arming – 280ft
 - Fast MOFA – 234ft
 - Slow MOFA – 400ft Huh?
- MOFN w/ Aluminum Rotor Body and Double-Thick Pallet – 427 ft
- Concern about friction model and gears in DADS

Modeling with ABAQUS

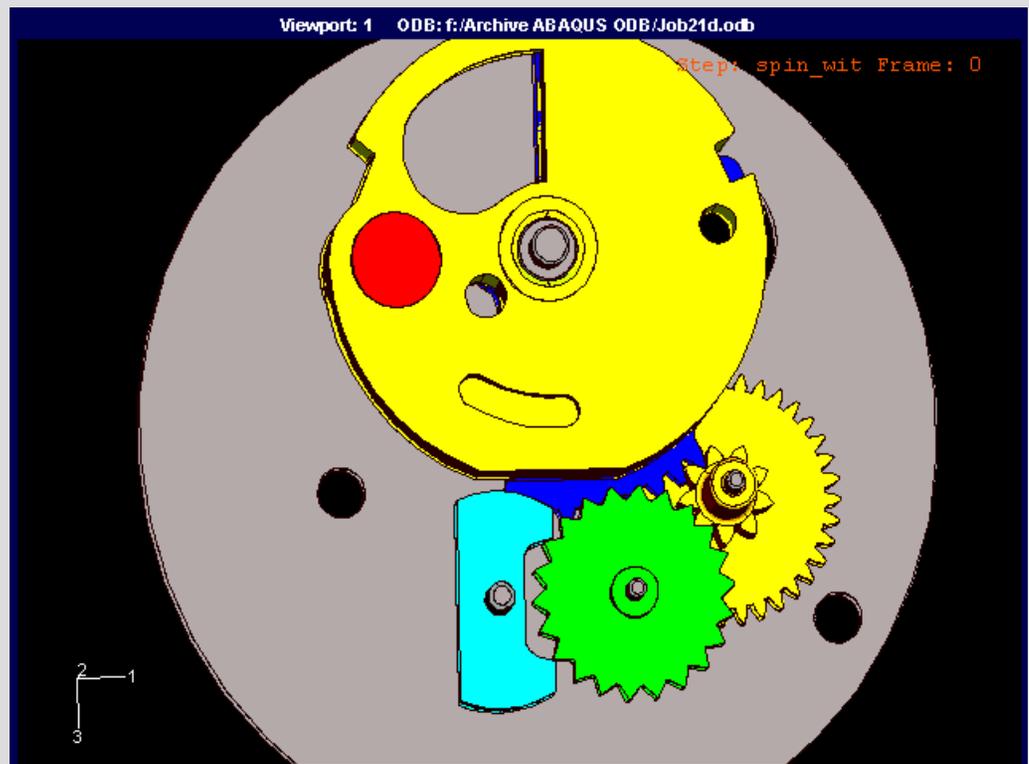
- Based on FEA, but
 - No Deformable bodies - Rigid Bodies only
 - Mesh for contact



Analysis with ABAQUS

- Analyze MOFA S&A with ABAQUS
- Features of ABAQUS Model
 - Rigid bodies – no Deformable bodies
 - Explicit solver
 - General contact capability for journals and gears
 - Contact damping coefficient

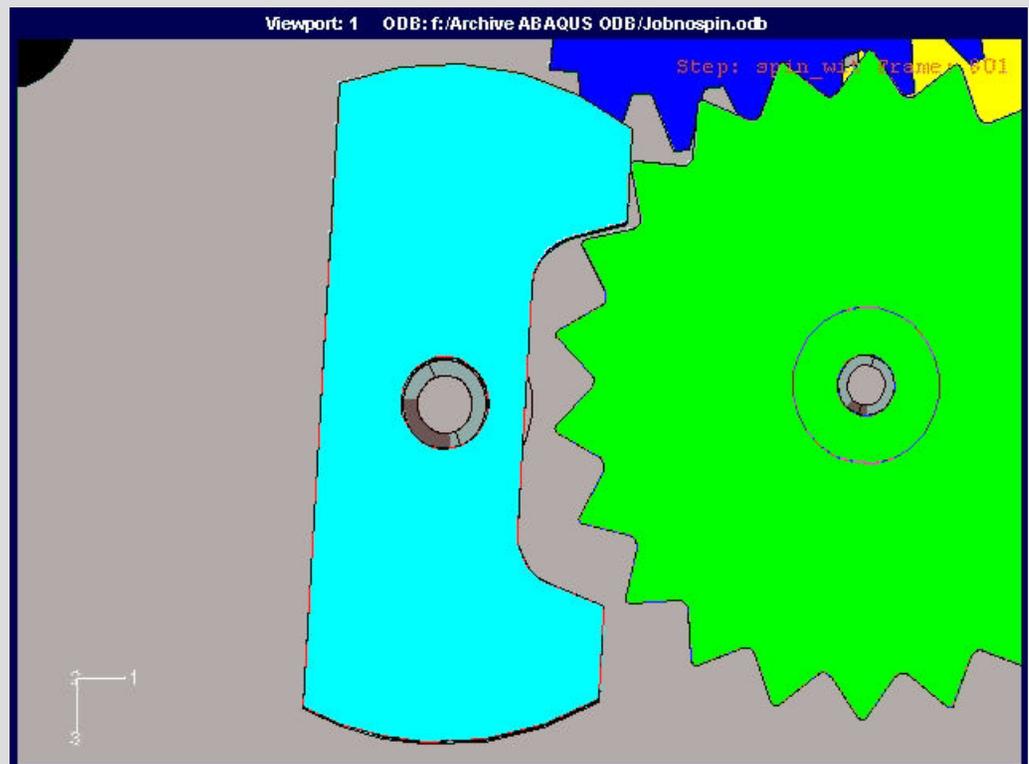
View Does Not Rotate with S&A



Analysis with ABAQUS

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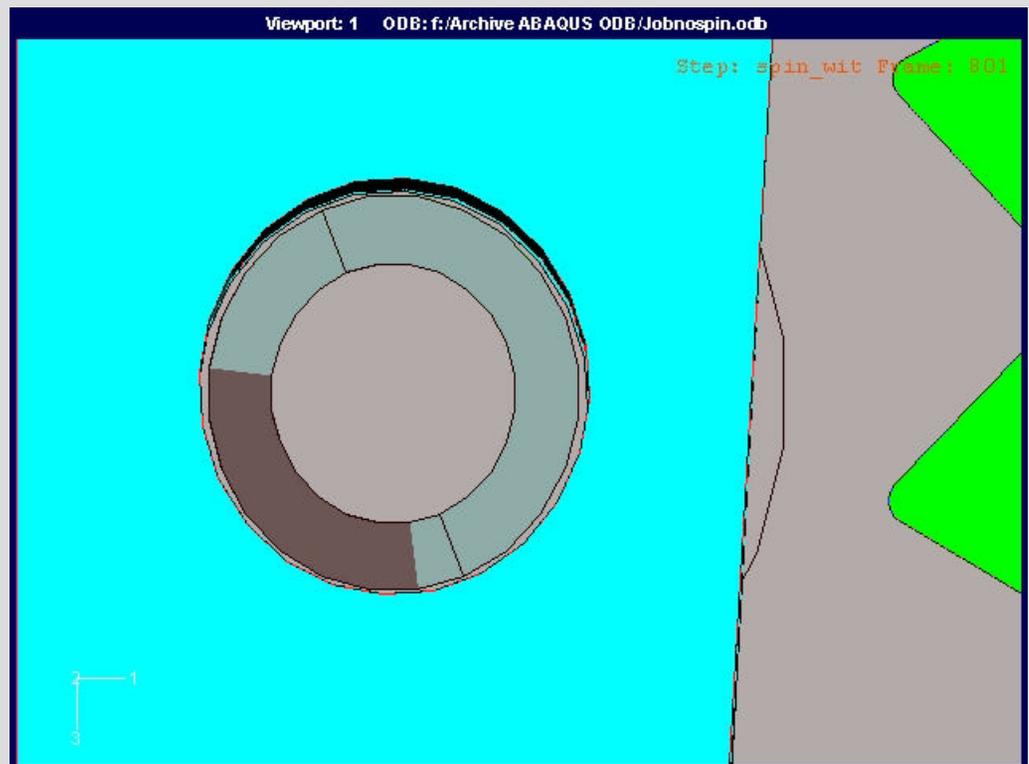
Realistic Pallet Pivot



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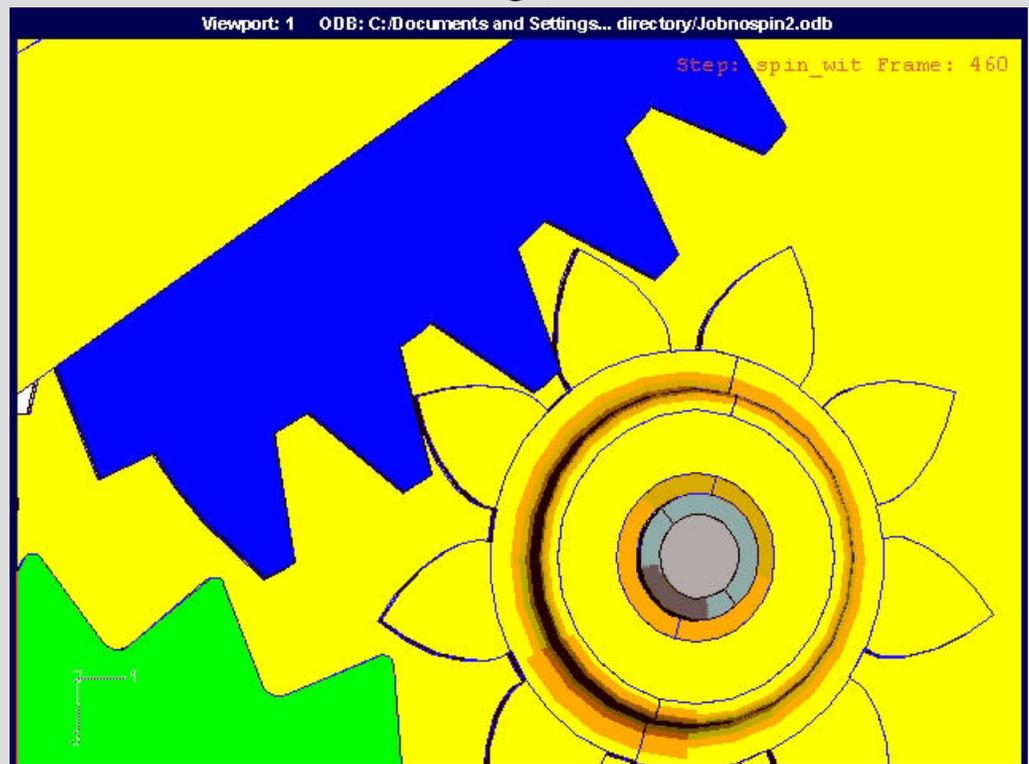
Realistic Pallet Pivot



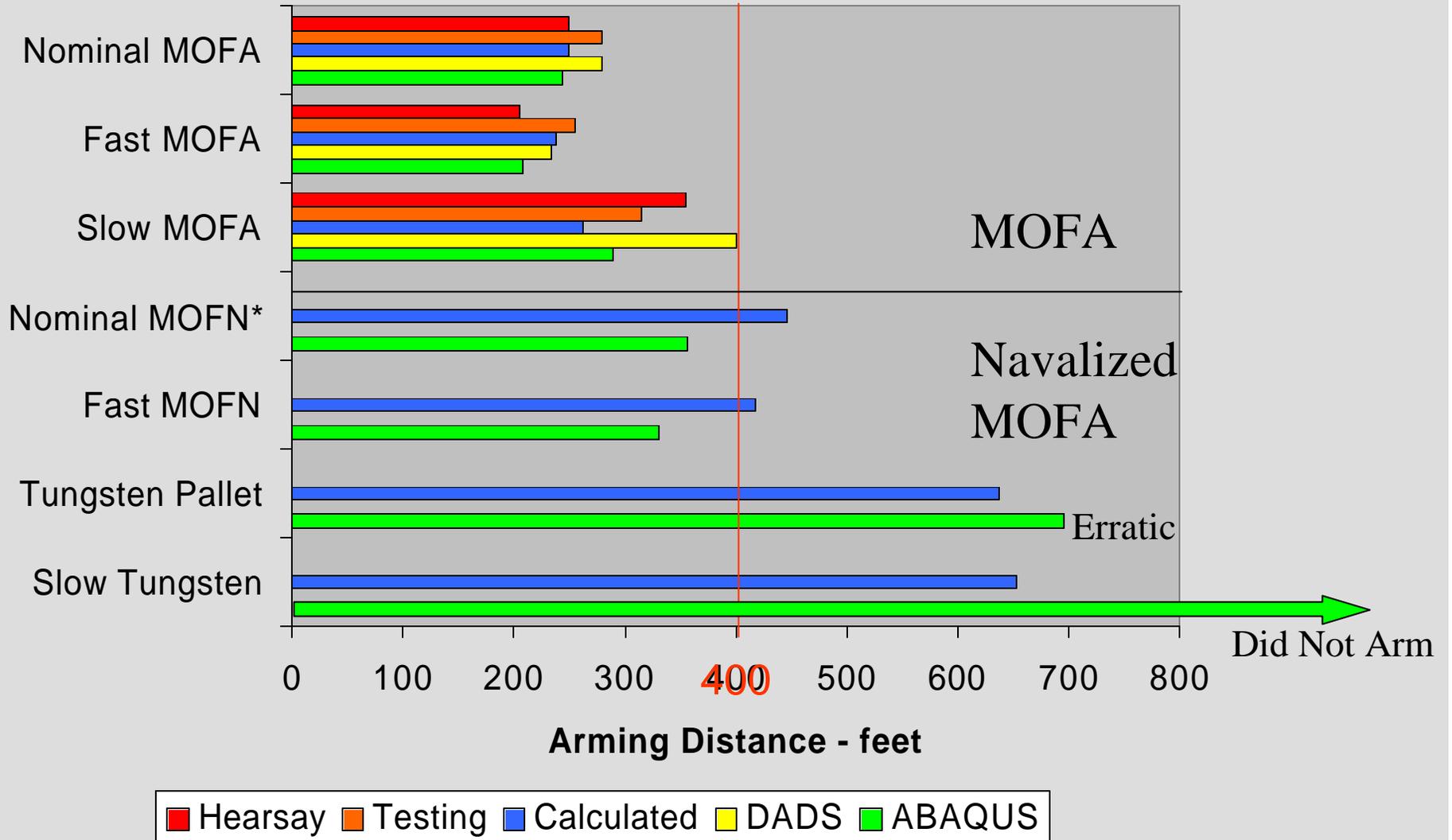
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Contacting Gear Teeth



Results



* aluminum rotor body & double-thick pallet

Conclusions

- Increasing the *Nominal* Arming Distance to 400' Possible
- Increasing the *Minimum* Arming Distance to 400' May be Risky Due to Friction
- Longer Arming Distances Through Pallet and Rotor Modifications Very Risky
- Analysis Tools Need More Validation
 - Especially Friction

Comparison

	Testing	Hand Calculation	DADS	ABAQUS
Initial model development	4 weeks	10 minutes	2 weeks	4 weeks
Revised case setup	2 weeks	10 seconds	10 minutes	10 minutes
Run times	15 minutes	0 sec each	5 minutes	3 hours
Accuracy	Very accurate	No friction effects Limited to small changes	Excellent track record in industry, but gear friction not modeled	Excellent Track record for FEA. TBD for rigid bodies, but all relevant physics modeled