Predicting the spin history of munitions

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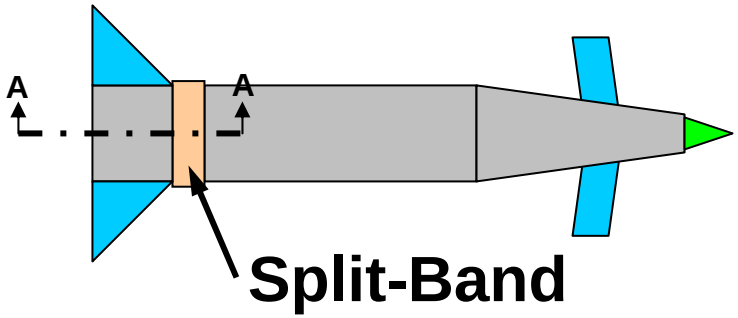
Motivation

Guided munitions spin much less than conventional munitions.

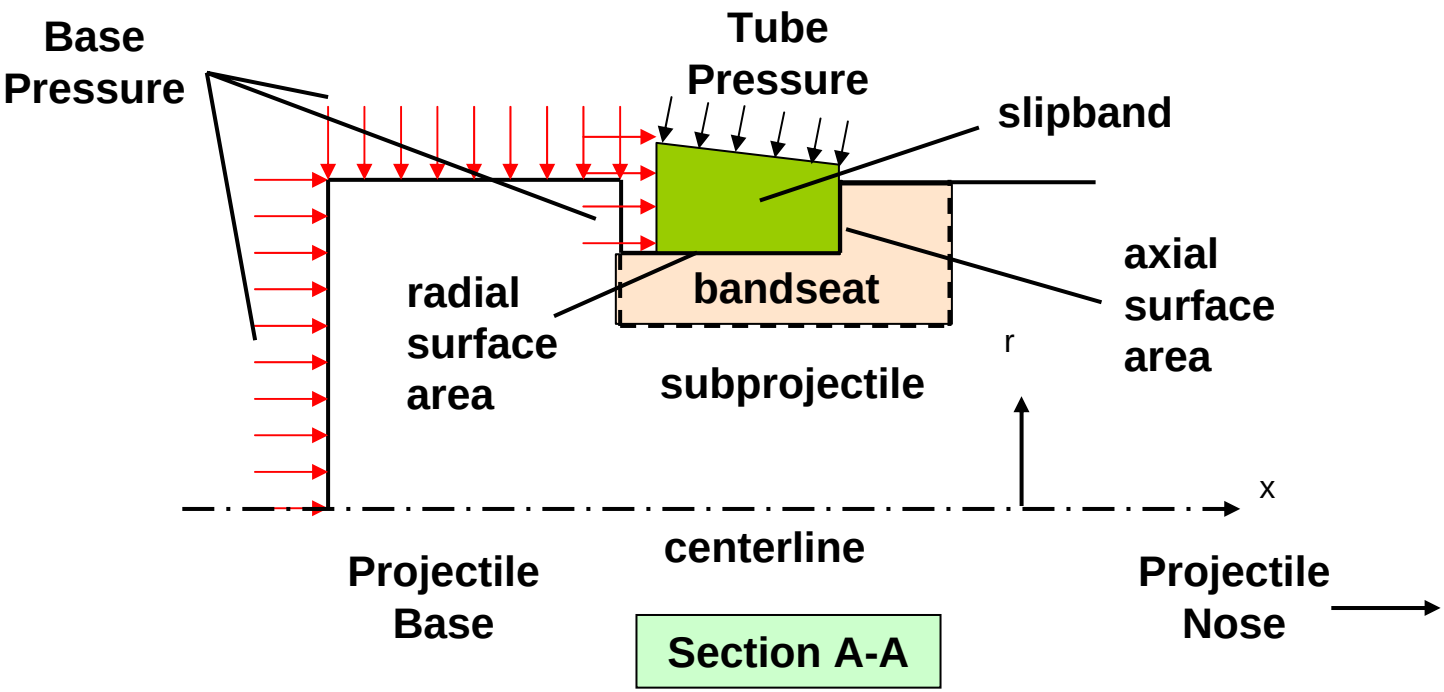
Guided munitions fired from rifled cannons need to be despun.

The guided munition is uncoupled from the cannon rifling by a two-piece band (aka split-band).

Split-Band Theory and Design



Guided Projectile



VAPP Case Study

Very Affordable Precision Projectile (VAPP) Program

- Weight ~ 42 lbs
- Axial MOI ~ 108 lb-in^2
- Muzzle spin rate ~15 Hz
- Gun System = M119 105 mm Howitzer (M20 Tube)

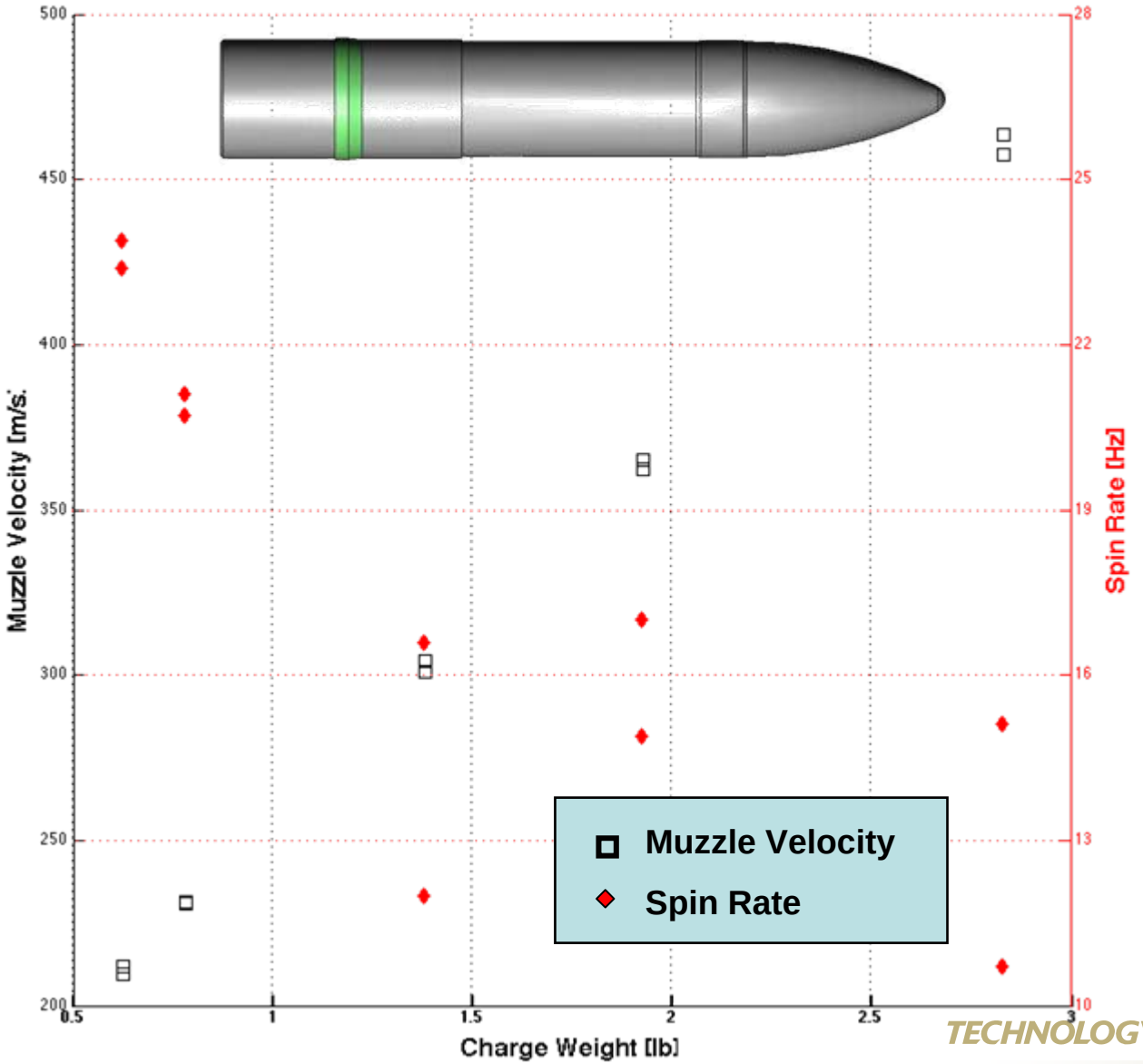
The M20 tube has a "gain-twist" rifling profile

- initial twist is 1:35 at the origin of rifling
- final twist is 1:18 near the muzzle

Twist = the number of calibers for a fully spun munition to make one revolution

Goal: Develop a split-band that results in a reduced spun projectile at all firing zones

Test Projectile Shot Results



Muzzle velocity is linear with WRT charge weight

Scatter evident in the spin rate data

Largest spin rate is ~24 Hz

"Bandslip" Prediction Software

Originally developed by SNL for constant twist gun tubes

Rewritten to enable the simulation of gain-twist gun tubes

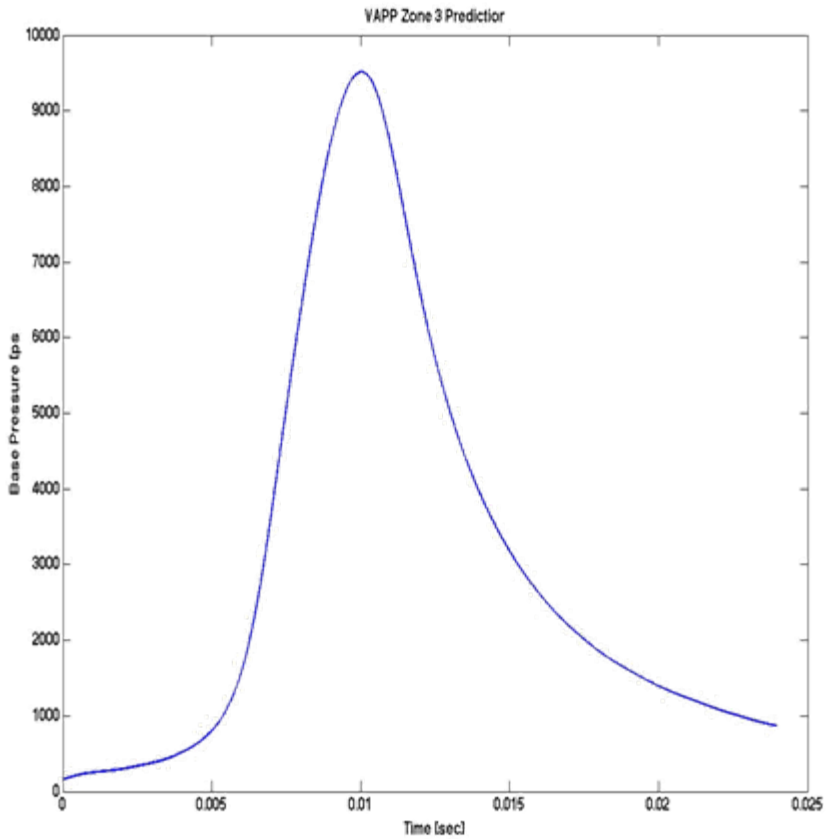
Input to software includes
- **projectile inertial properties**
- **Split-Band geometry**
- **Split-Band material properties**
- **gun tube characteristics**
- **base pressure-time history**
- **estimate of the "tube pressure" and slipband-bandseat friction**

The *slipband* angular quanities are kinematically constrained to the projectile's linear quantities through the rifling profile

The bandseat/projectile's angular velocity and position are calculated from first differences

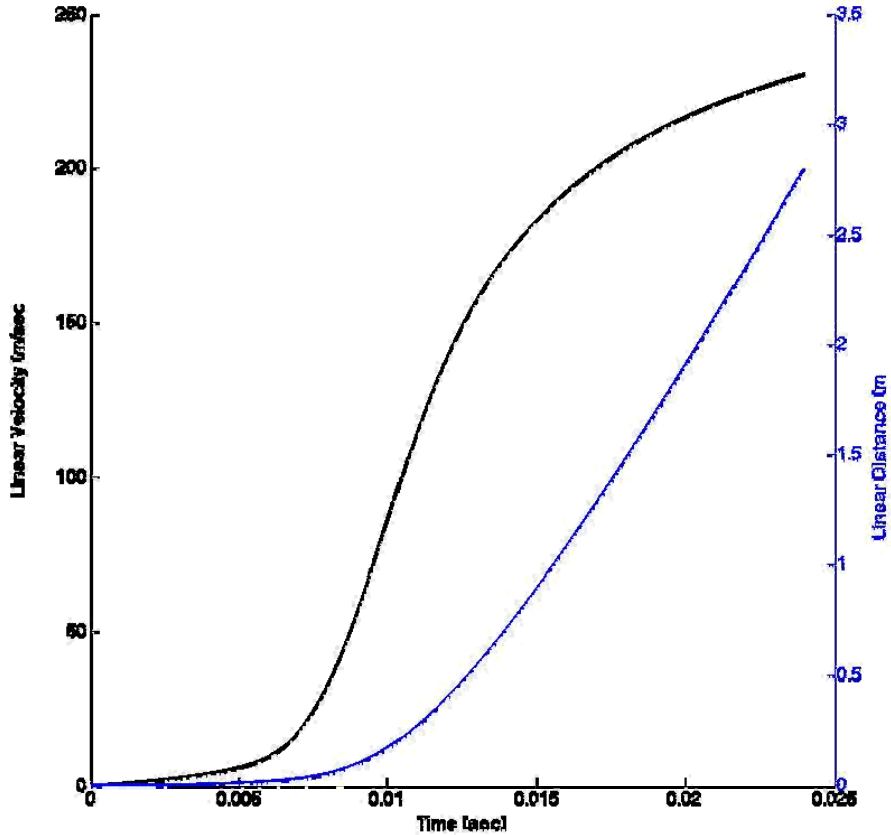
VAPP Zone 3 Simulation

Input



Zone 3 Pressure-Time Data

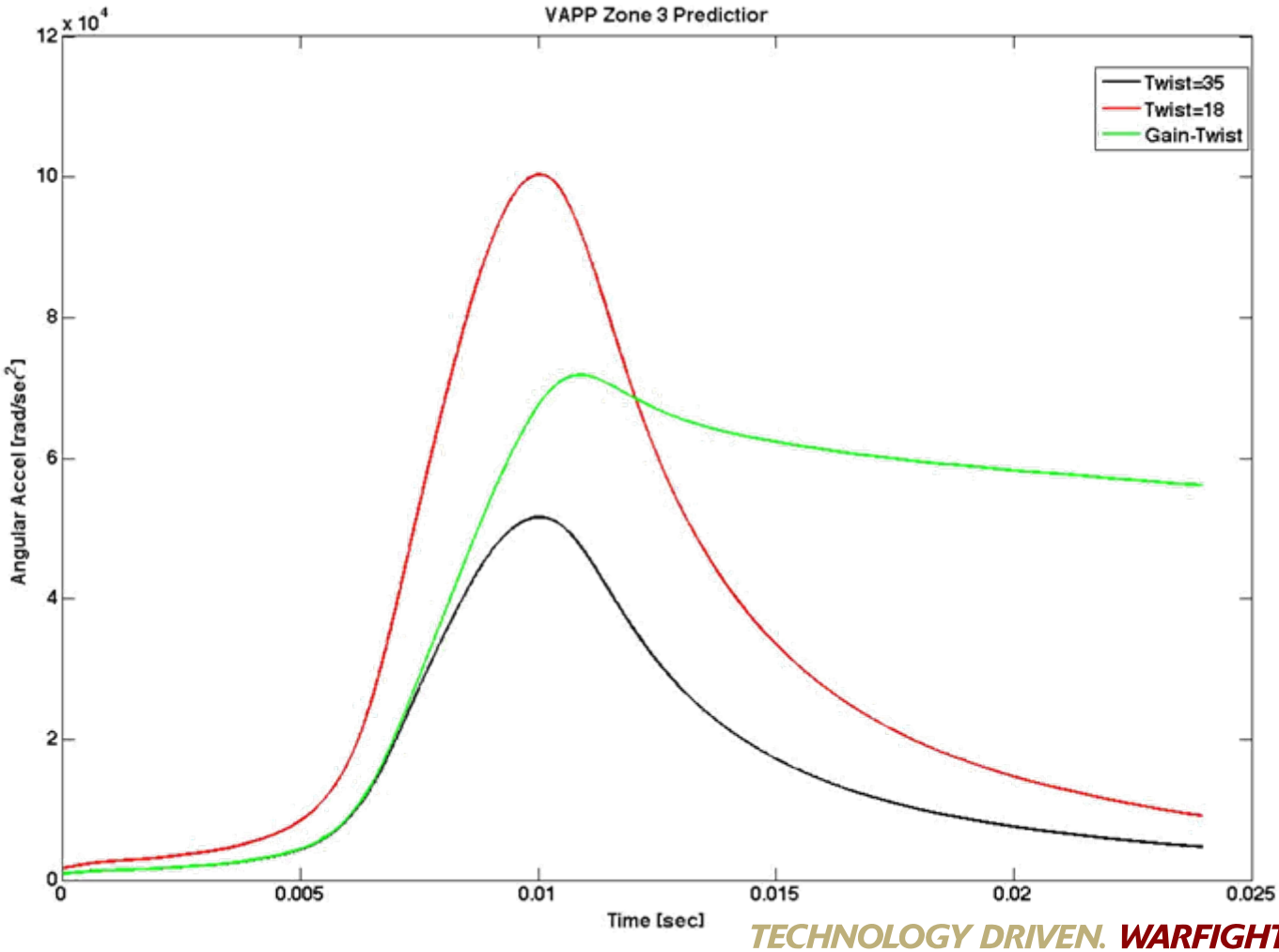
Output



Resulting linear displacement and velocity histories

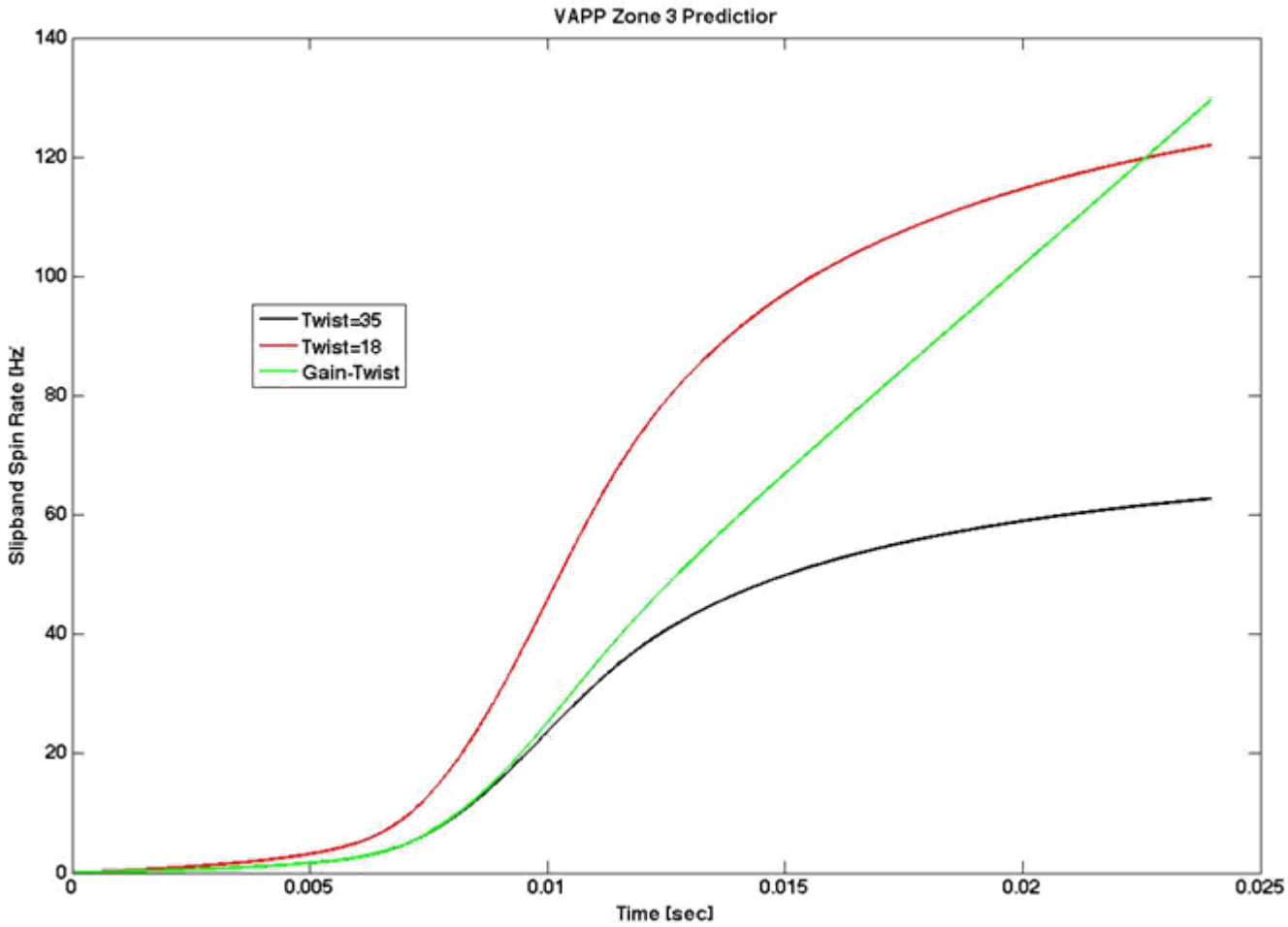
Slipband Angular Acceleration

The slipband's angular acceleration remains large due to the gain-twist rifling profile



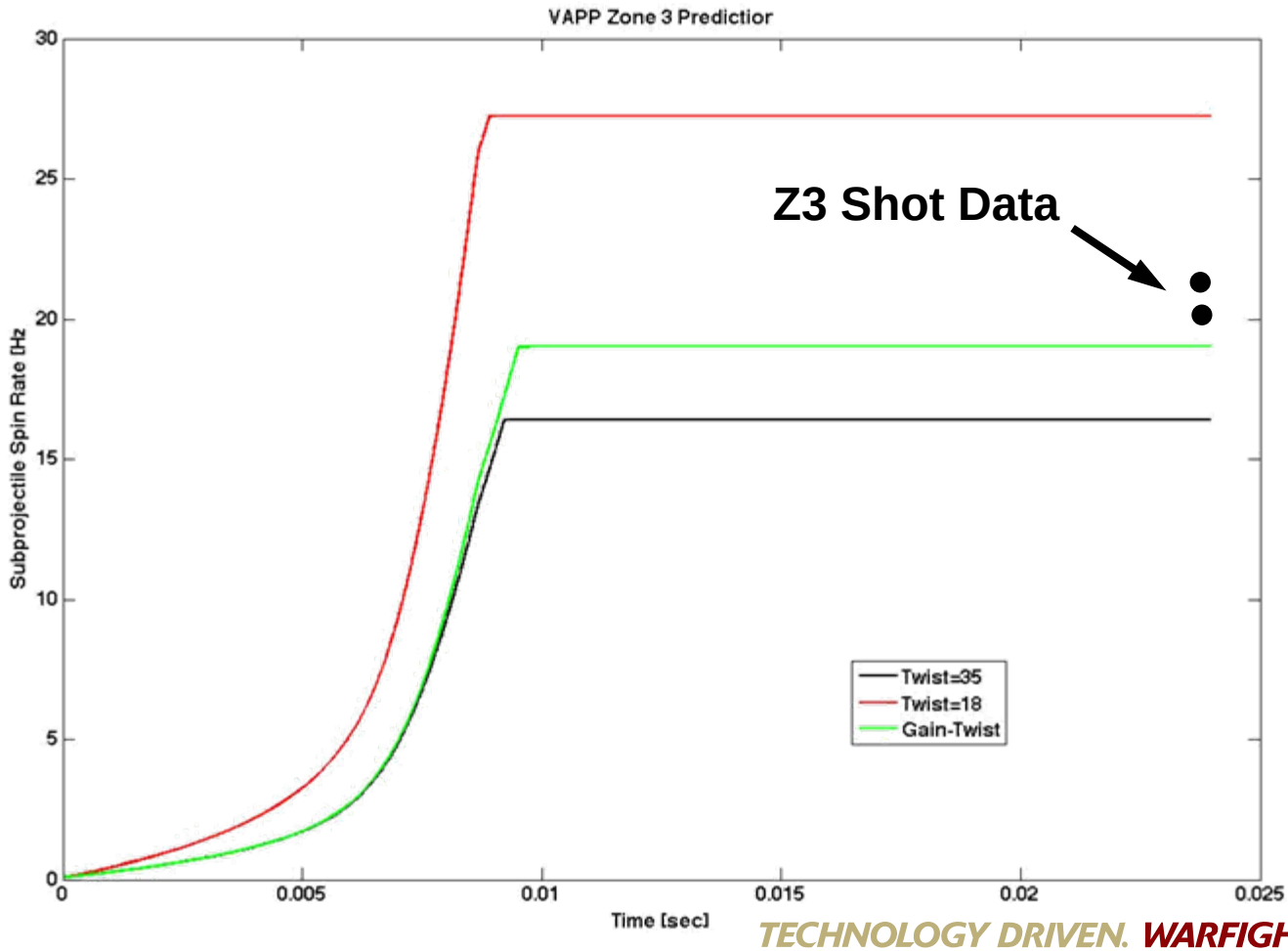
Slipband Angular Velocity

The slipband's angular spin rate $f = {}^{v}/_{(D*twist)}$



Projectile Spin Rate Prediction

The projectile spin history depends significantly on the initial twist rate



Summary

- **Split-Band theory and design features are understood**
- **A numerical predictive capability is demonstrated**
- **A projectile spin rate of ~19 Hz (21 Hz actual) was predicted for the VAPP shot at Zone 3**
- **24 Hz was the largest spin rate recorded for the VAPP**

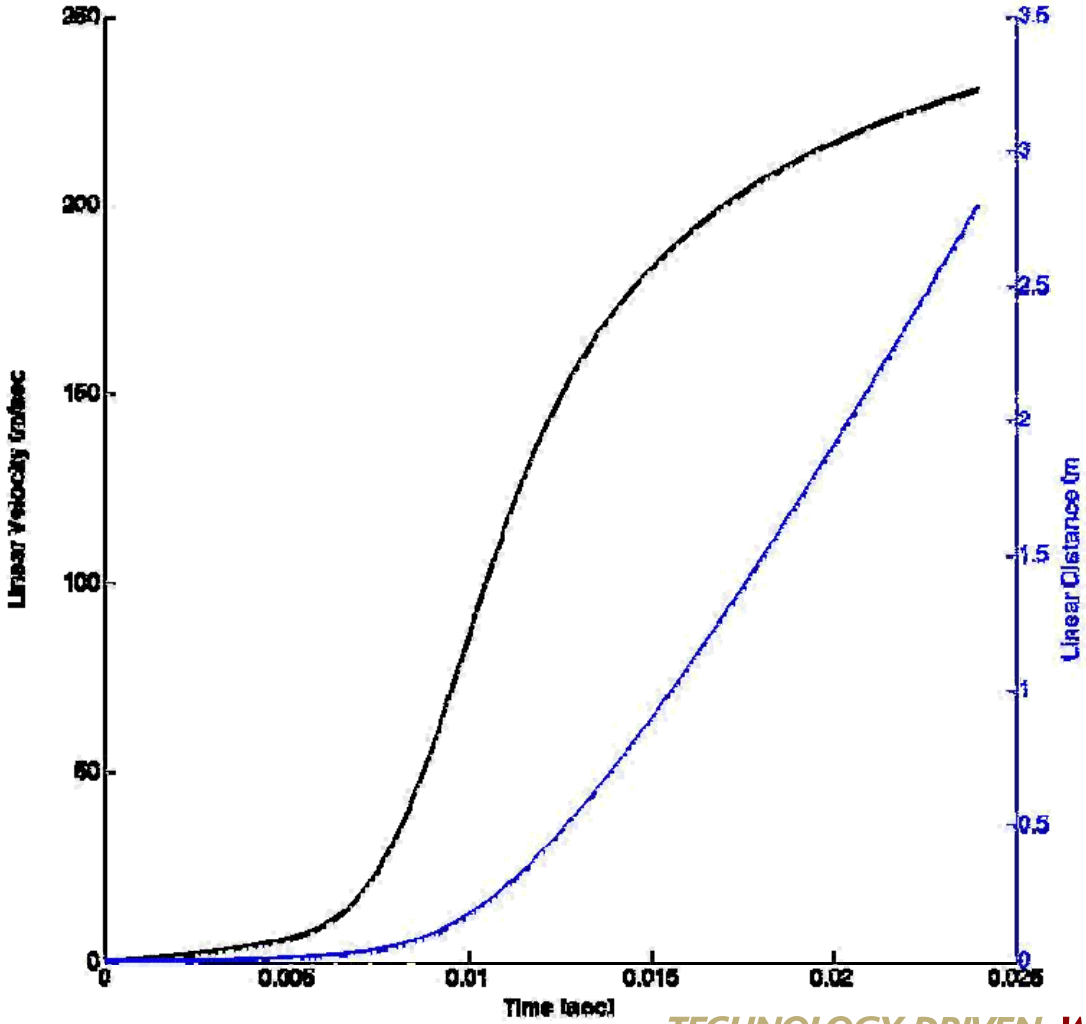
Questions

More slides

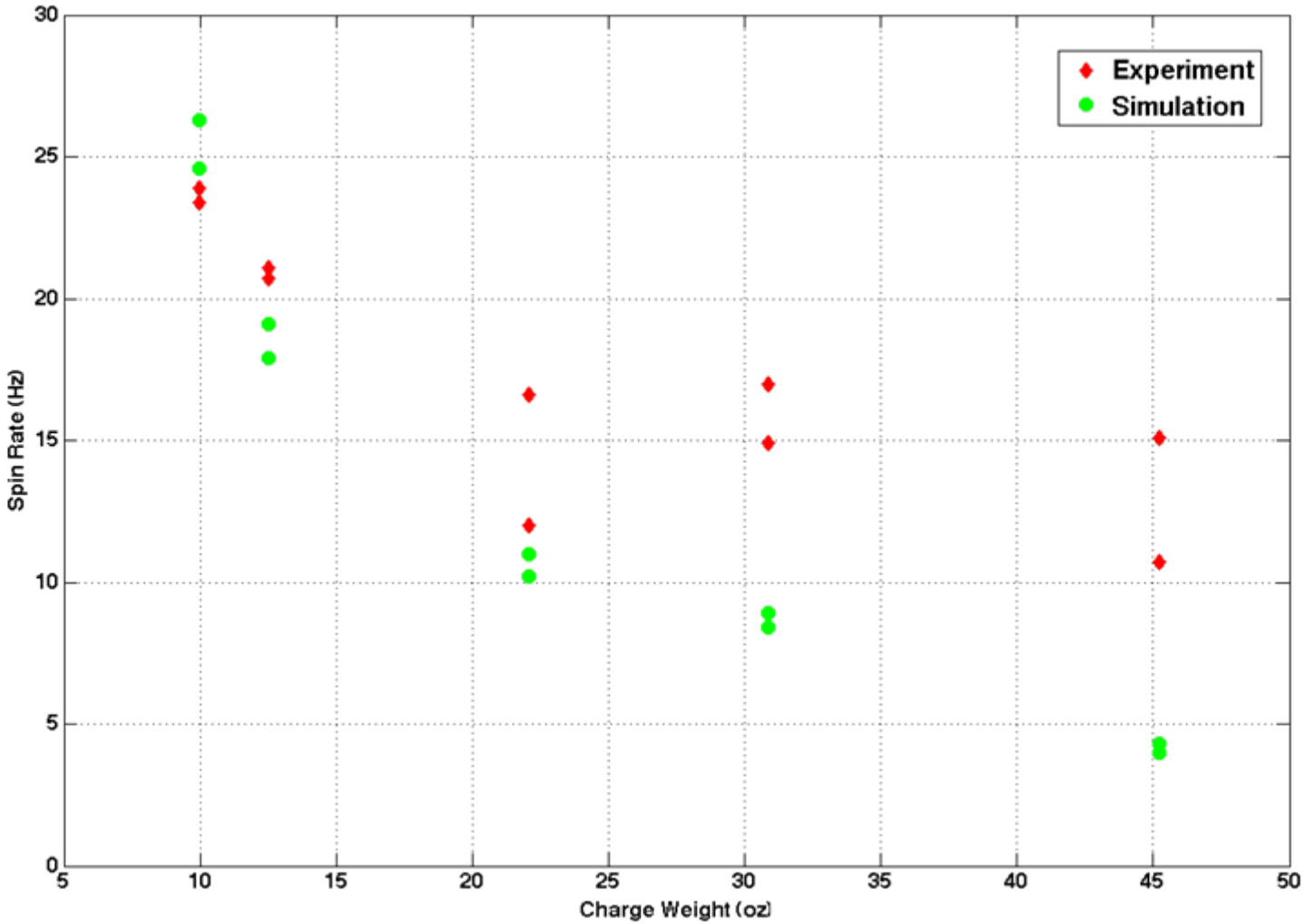
Split-Band

- **Geometry and thermal material properties are used in determining slipband behavior**
- **Base pressure and “Tube pressure are used to determine slipband “lift” time, i.e., when the base pressure is greater than the effective Tube pressure**
- **Constant twist rate is used to determine required torque needed to spin subprojectile at same rate as slipband**

Linear (Axial) Velocity and Travel



Summary


Experiment
Simulation
Spin Rate (Hz)
Charge Weight (oz)
0
5
10
15
20
25
30
5
10
15
20
25
30
35
40
45
50