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Variable Acceleration Profiling and Characterization of S&A Escapement Mechanisms

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Rotary Tables

Standard tool in the measurement of escapement mechanism arming distance

- Capable of applying long duration acceleration loads
- Related to tactical performance through escapement theory
  - Devices assumed to be distance measurement mechanism
  - Distance = ½ at^2
- Commonly used as part of escapement device acceptance tests

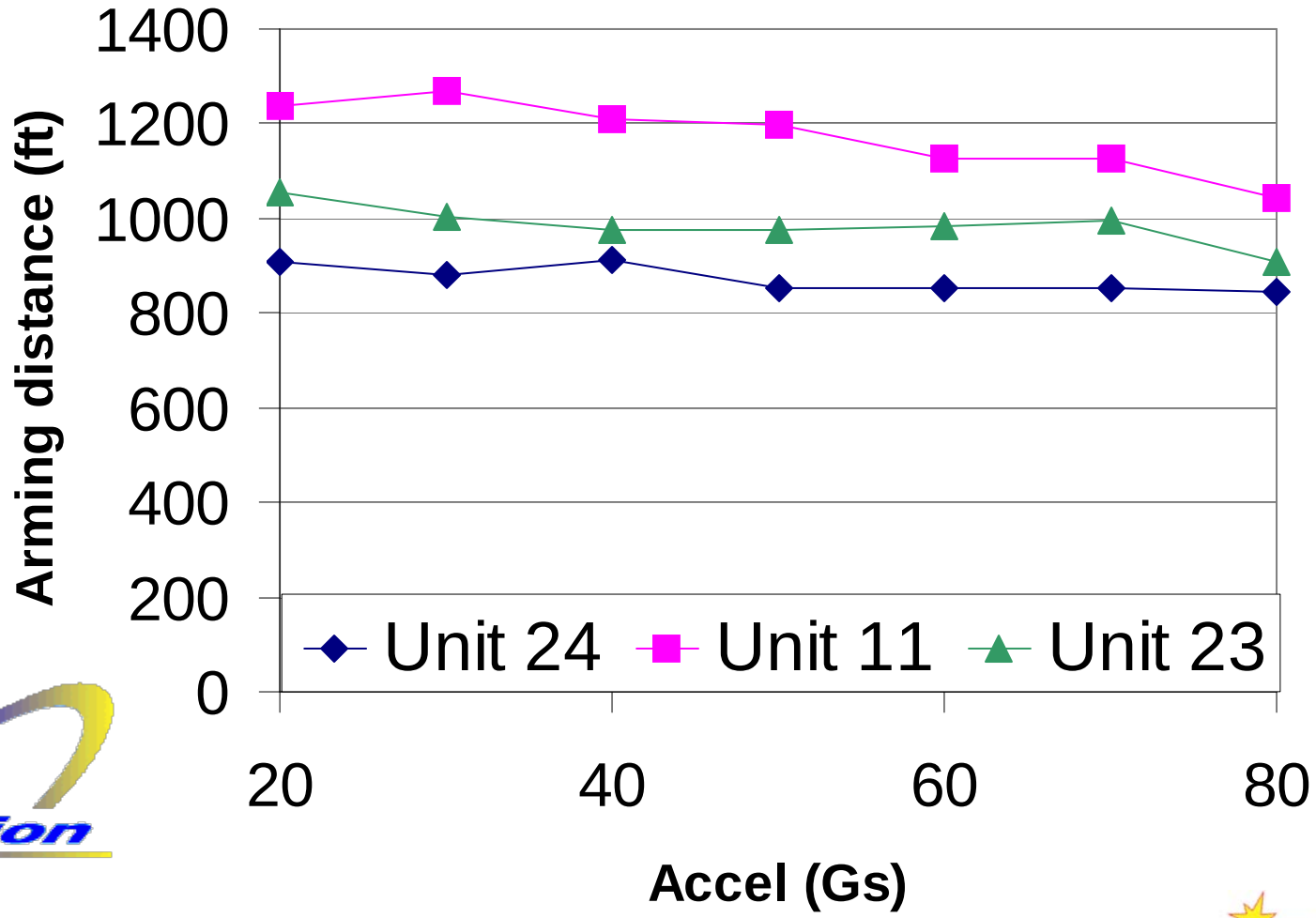
Standard Rotary Tables Limitations

- Not all devices follow escapement theory to the desired accuracy
- Fails to provide data on setback lock release
- Difficulty in indexing from specific event (e.g., setback lock release)
- For M427 family of devices, biases rotor towards the arm position
- Incapable of applying variable G loads

40G Acceptance Testing
Constant Acceleration Acceptance

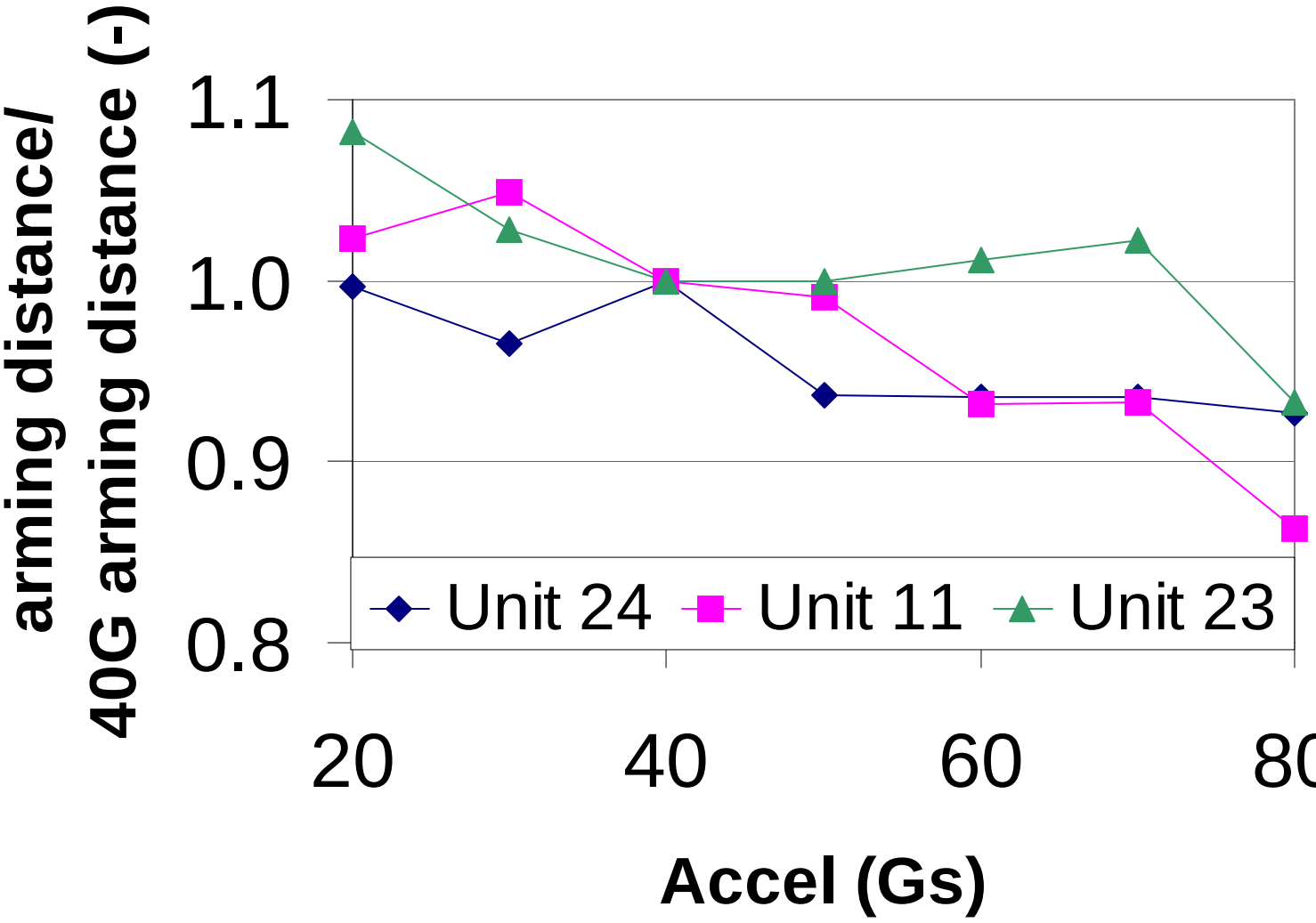
- Acceptance test calls for a constant 40G stimulus be applied to the mechanism
- Setback weight is held until rotary table is at speed
- Weight is released and the mechanism is timed
- Acceptance determined via times in specification

Device Arming Under Constant Load
Effect of Load on Arming Distance



Data courtesy of Action Manufacturing

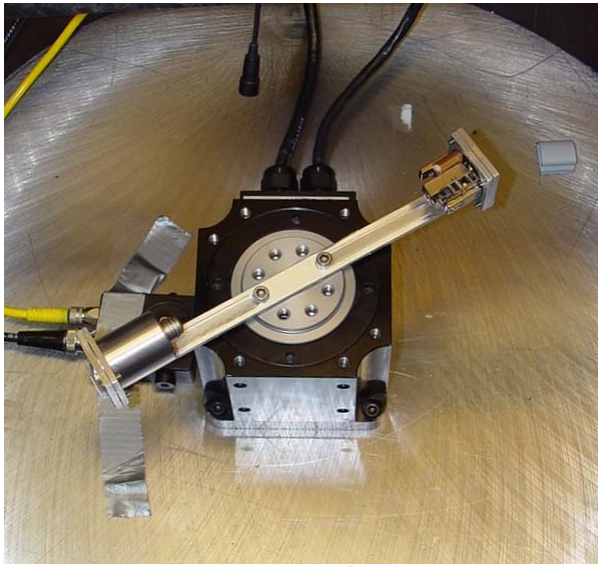
Device Arming Under Constant Load
Effect of Load on Arming Distance



Load affects arming distance by as much as 10%

Programmable Rotary Tables

- Allow the user to input desired positional coordinates and time history
- Resulting program can more accurately reproduce the tactical environment acceleration history

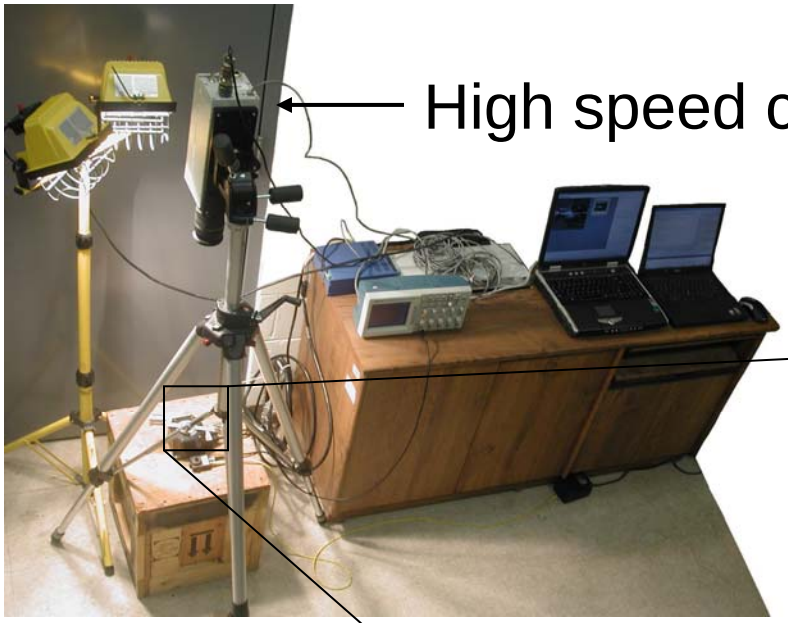


- Microphone allows for timing of critical events, such as environmental lock release

Programmable Rotary Tables Limitations

- Inertia of device under test must be sufficiently small to allow table to track desired profile
- A tangential load is imparted to the device as table changes velocity
- Longer arm length is desirable for reduced error, but is limited by motor torque

Programmable Rotary Table



High speed camera

Device under test

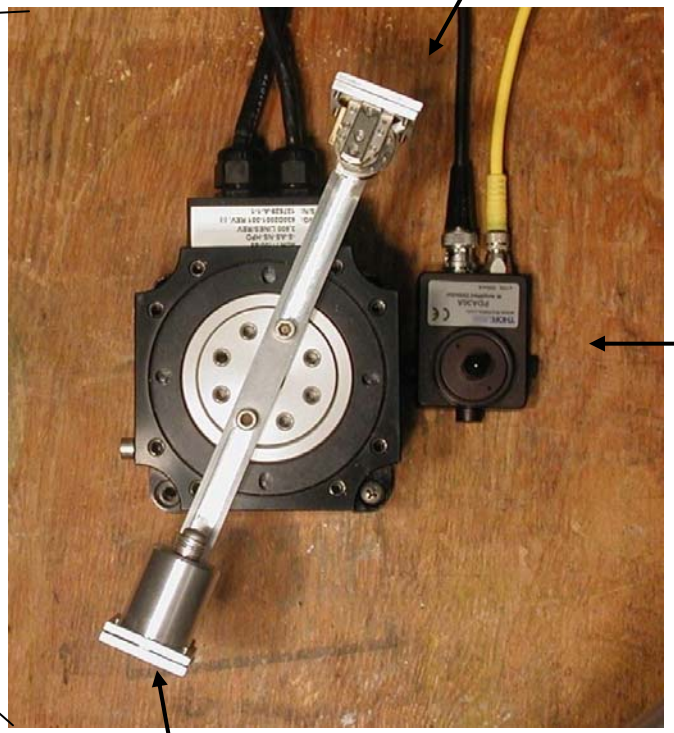


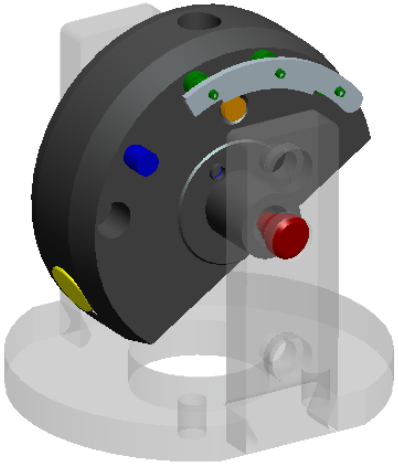
Photo detector

Table: ADRT-100-85’
Arm length: ~3.5”
Test item weight: ~.11lbs

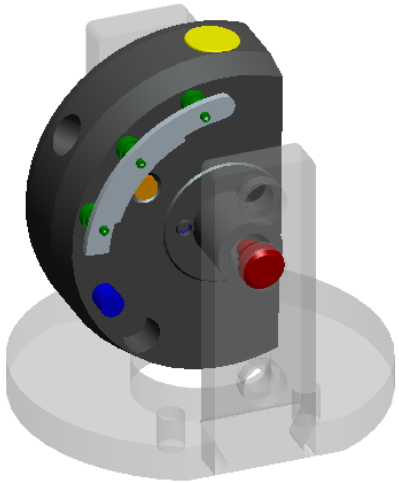
Ballast

Device Under Test

- Testing was conducted on the M427 S&A
- Part of Navy's 2.75 inch rocket system
- Setback Weight extracts around 15 to 20Gs
- Mechanism arms: 1.13 to 1.37 sec (or 817-1218 feet of rocket thrust)

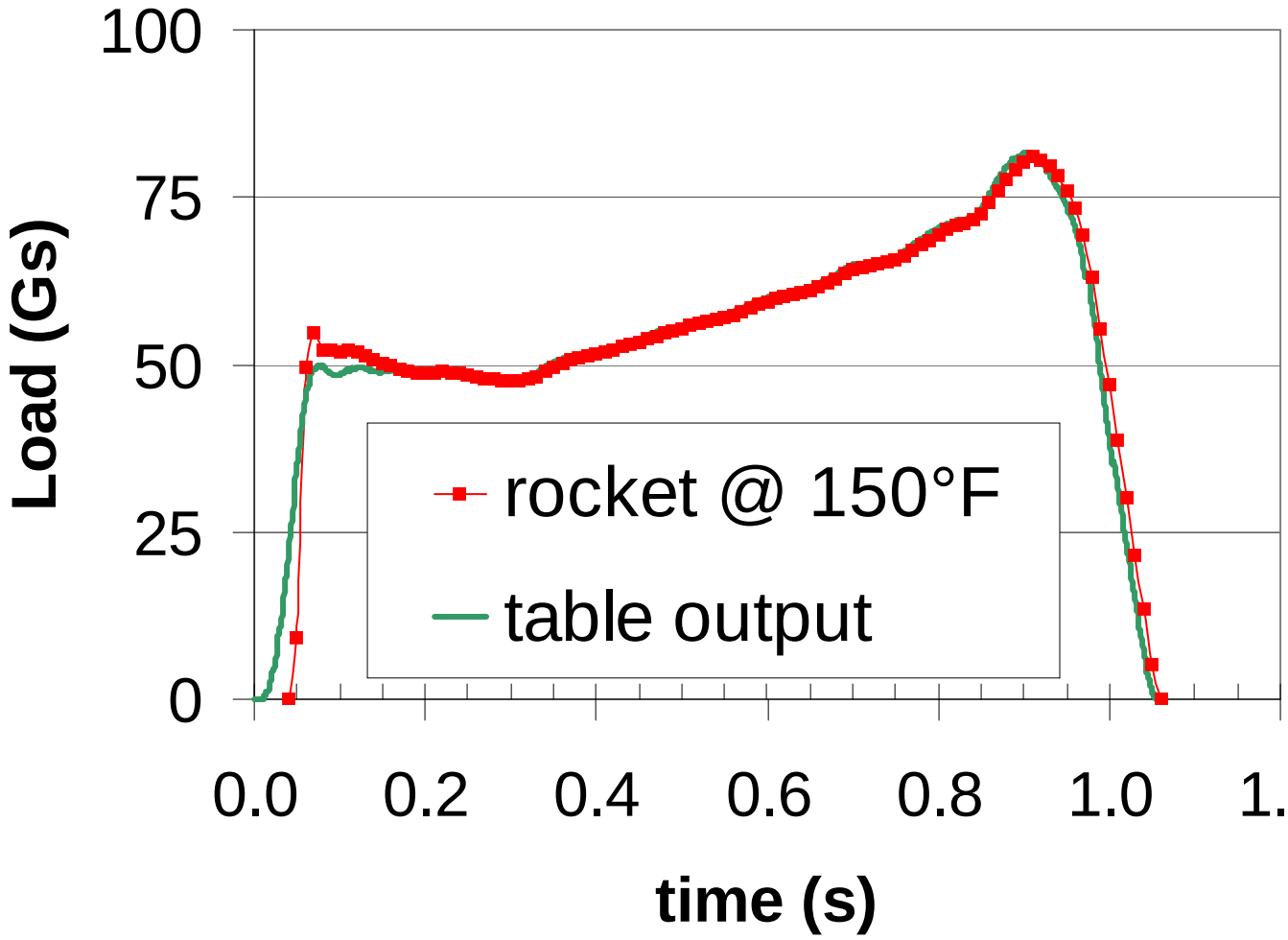


Safe



Armed

Programmable Table Replication of Tactical Acceleration Environment



Impulse error: 0%

Distance error: 0.3%

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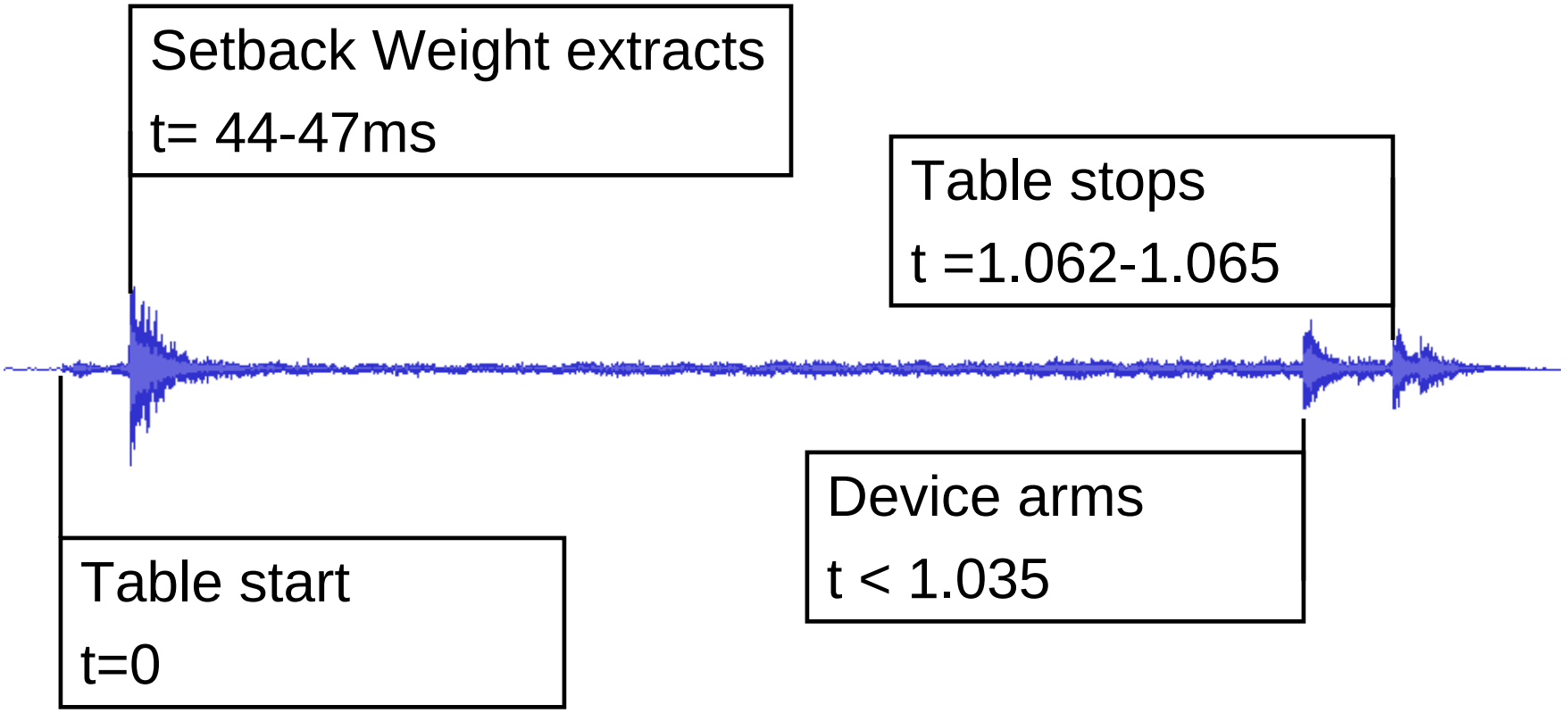
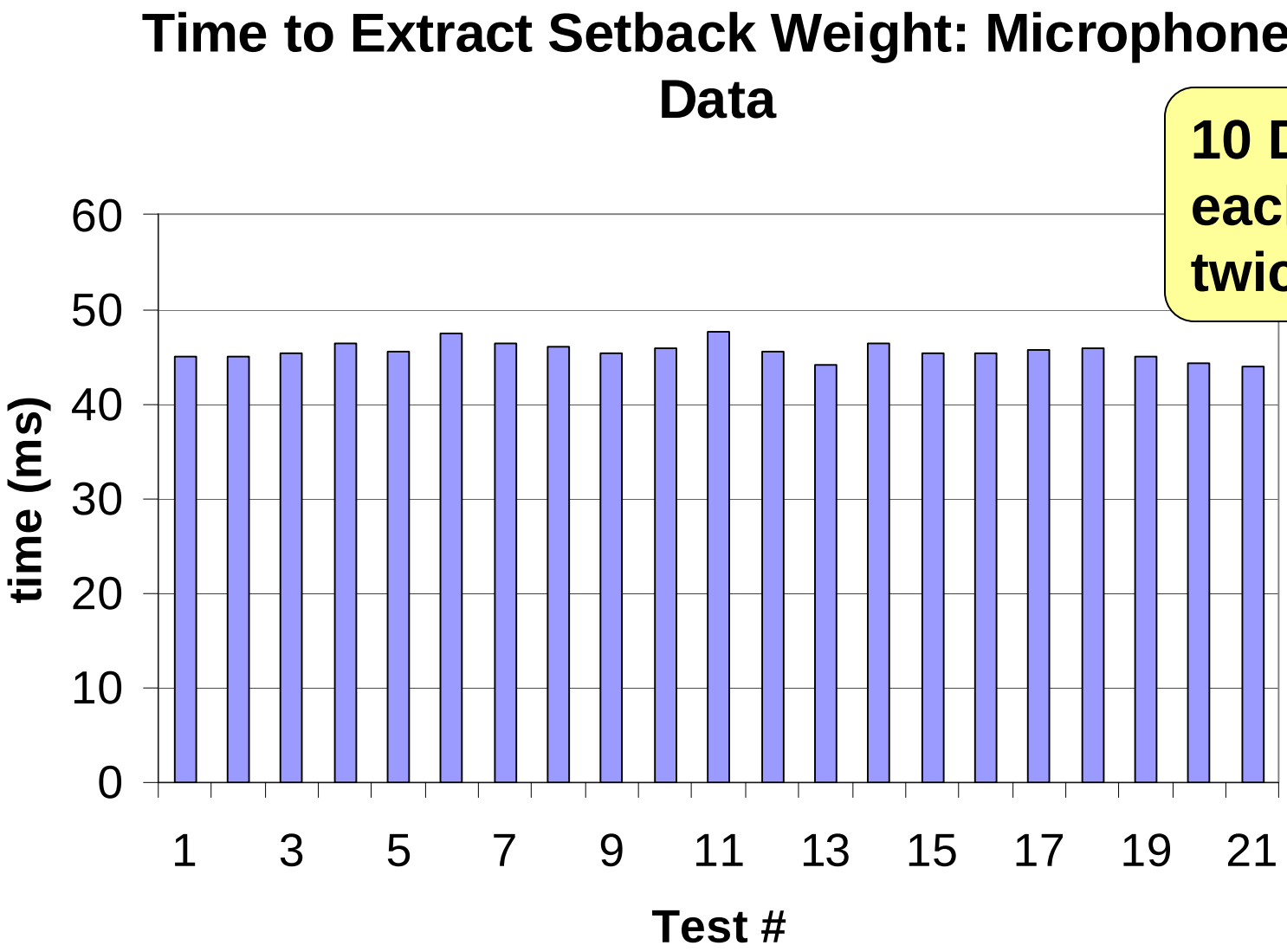
Acoustic Trace from Device Armed on Rotary Table



Setback weight and arming events can be timed via a microphone

Setback Weight Instrumentation



Device and test method repeatable

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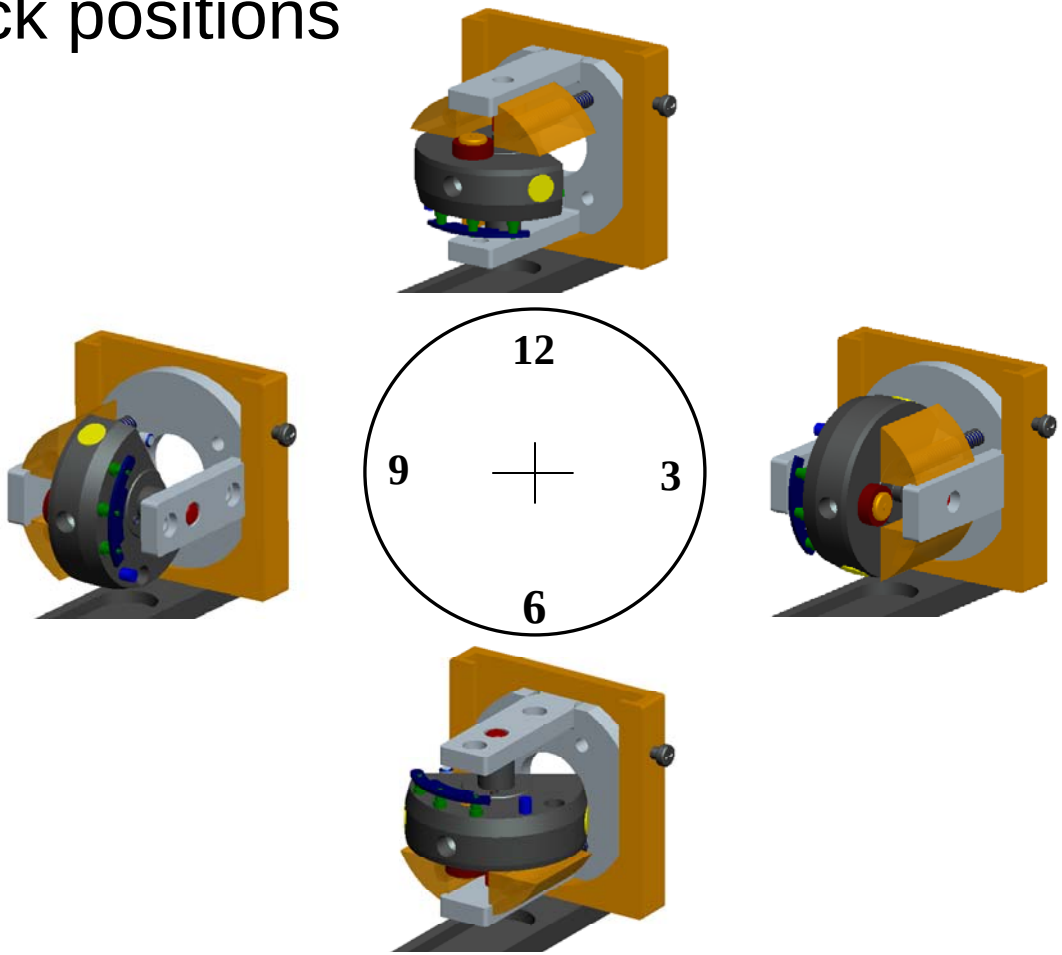
Tangential Acceleration Effects

- Device static position in fixture was adjusted such that timing test was performed with setback weight at 12, 3, 6, and 9 o'clock positions



Tangential Acceleration Effects

- Device timing consistent for a given orientation: <20ms (36’)
- Device timing varied based on change in initial orientation: <53ms (95’)
- Devices in 12 o’ clock armed 30 – 60ft faster than in 6 o’clock position (44’ expected from inertial effects)
- Devices in 3 and 9 o’clock distances varied depending on device, up to 70’ (0’ expected from inertial effects)

Instrumented Rocket Tests

- Device to be spun in the lab using constant 40G and programmable rotary table tests
- Devices will be flown on instrumented rocket tests
  - Record arming time during flight
  - Record rocket acceleration history
- Provide correlation between field and lab simulation

Summary

- Programmable rotary table has sufficient frequency response to replicate acceleration environment for fuzing applications
- Provide additional insight into mechanism status during deployment
- Alternative acceptance test, and in some cases more accurate, compared to the constant 40G test