Chemring Energetic Devices

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Test Fixture Influences on Pull Force of Mechanical Initiators
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Sensors & Electronics | Countermeasures | Pyrotechnics & Munitions | Energetic Sub-Systems

Purpose

- Demonstrate how pull force measurements characterizing the actuation force of mechanical initiators can be influenced by test methods
- Highlight need to define and control test method used to accept mechanical pull devices
  - Actuation forces are well defined per specification but method (fixture type, pull rate, etc.) are rarely specified

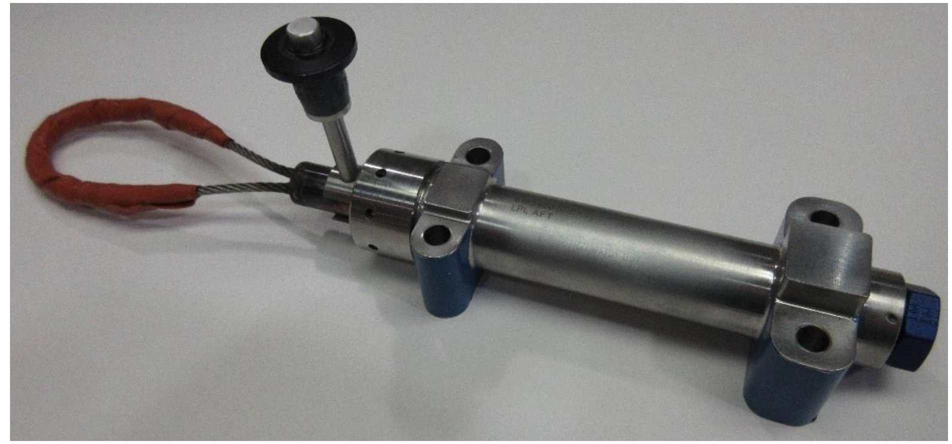
Outline

- Introduction
- Example mechanical initiators
- Review mechanical pull initiator operation
- Review quasi-static pull force FBD analysis
- Review dynamic model of typical pull test fixture
- Dynamic model case studies
- Conclusions

Introduction

- Mechanical pull mechanisms translate mechanical input to pyrotechnic output and are used in both aircraft and space systems
- Example uses
  - Escape systems
  - Destruct systems
  - Thermal Batteries
- Typical Mechanical Pull Requirements
  - “Unit shall be initiated with a pull force of – 40 lbs in any direction within the cone formed by the noted limits, and 22 – lbs by an inline force at ambient temperature ”
- Customer specifications generally do not define how the pull force is measured, or the rate at which the mechanism is pulled.
  - Many factors associated with test method may affect the measured pull force

Example Mechanical Initiators

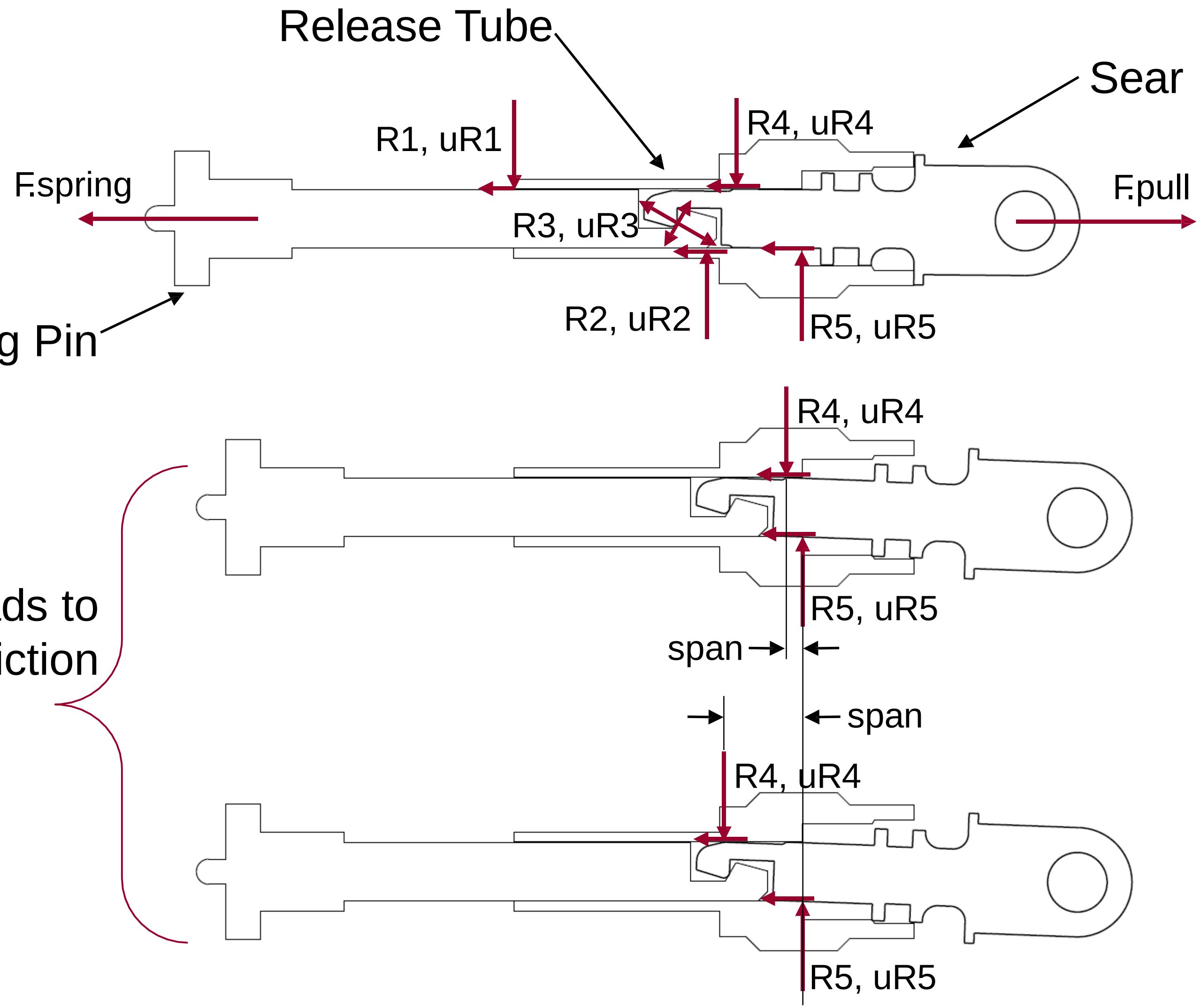


Mechanical Pull Initiator Operation

- Initiator consists of a firing mechanism and a detonating output (typically)
- Firing mechanism comprised of a firing pin, sear, retaining tube, and spring
  - Mechanism is spring loaded and may be held in place using a shear pin
  - Sear connected to firing pin with a disconnect mechanism (hook, balls, etc).
  - As sear is mechanically pulled internal spring is compressed, storing energy, until a release point in release tube is reached, allowing sear to disengage firing pin.
  - Spring drives firing pin into a percussion primer, initiating a detonating output
  - Detonation transferred to a receptor tip

FBD Analysis

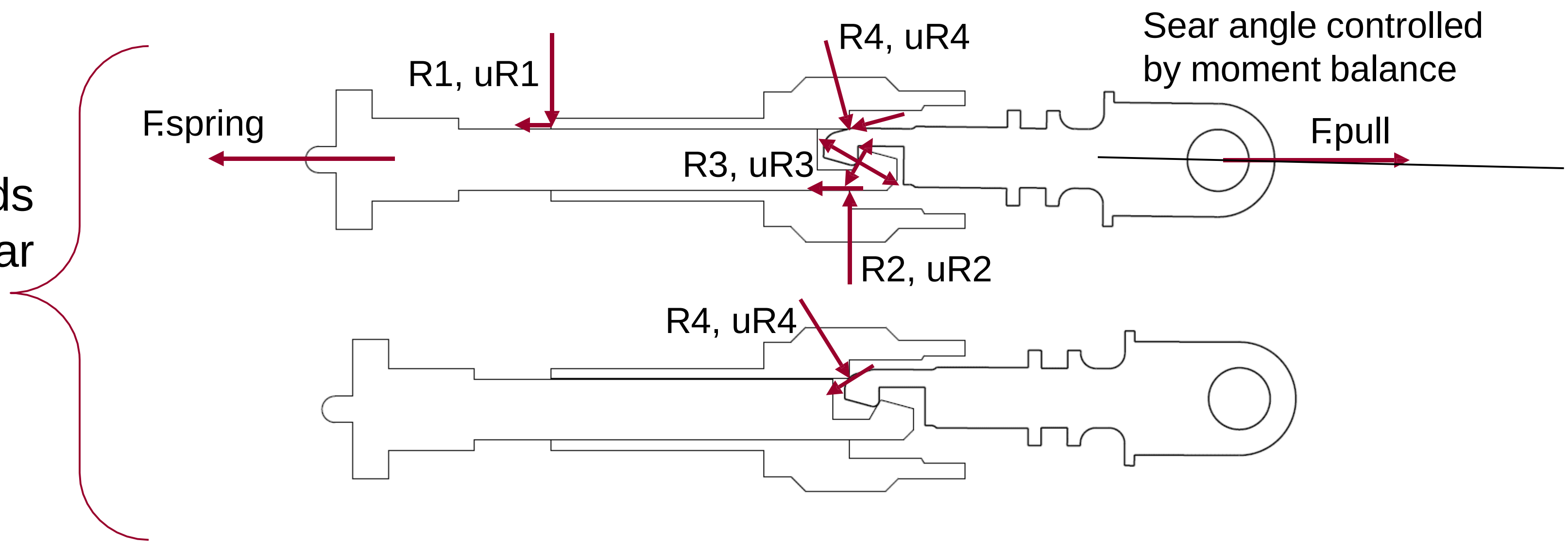
Initial Position



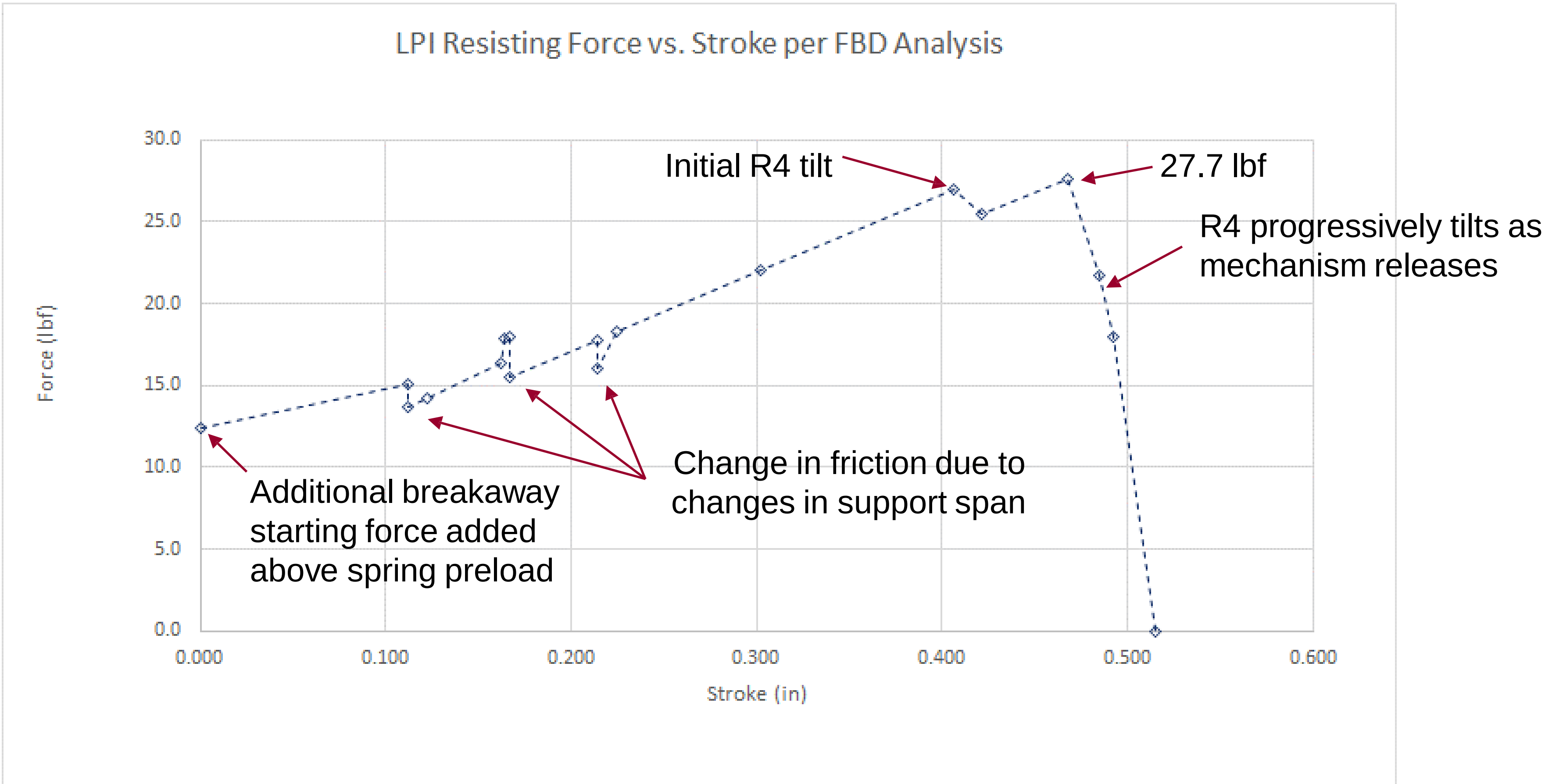
Change in reaction span leads to decreased contact forces and friction

FBD Analysis con'd

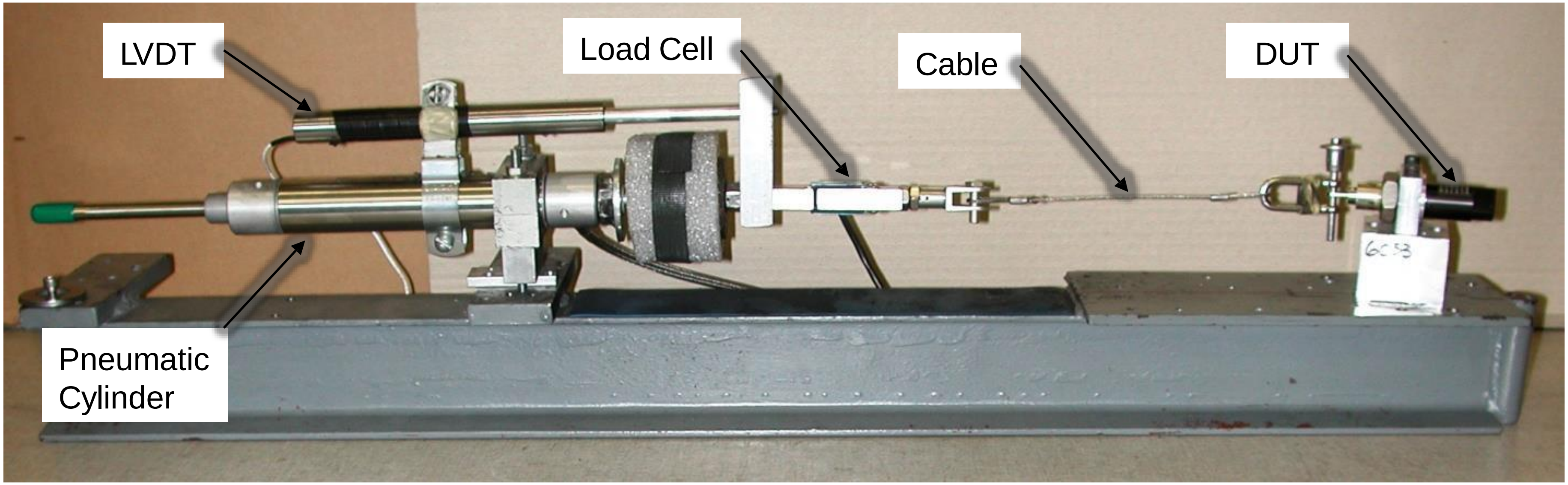
R4 tilts and adds assisting force to sear



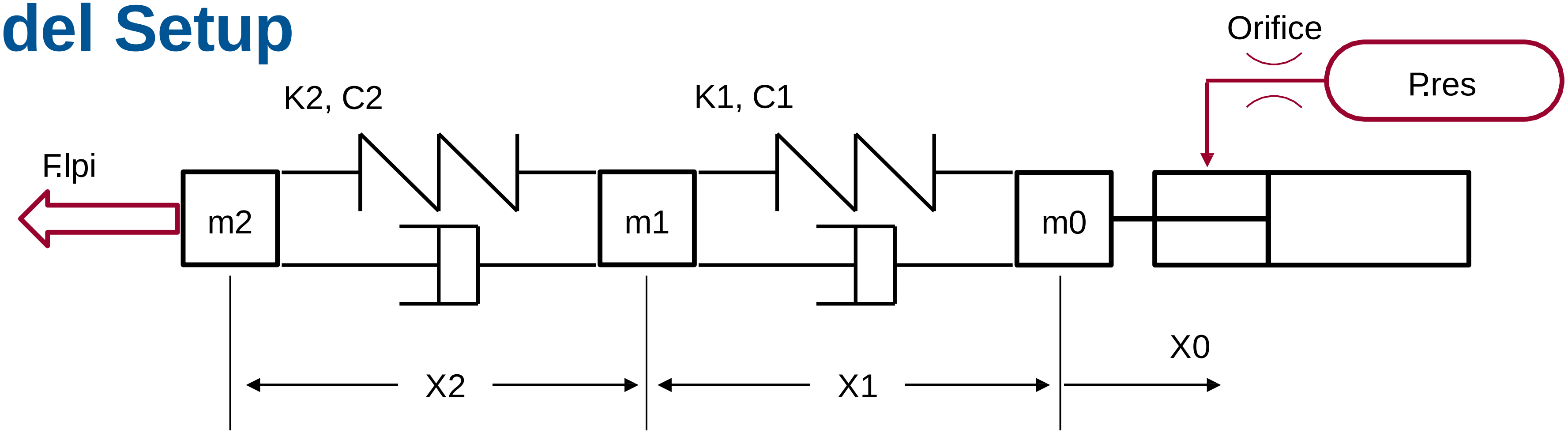
Pull Force vs. Stroke



Typical Mechanical Pull Test Setup

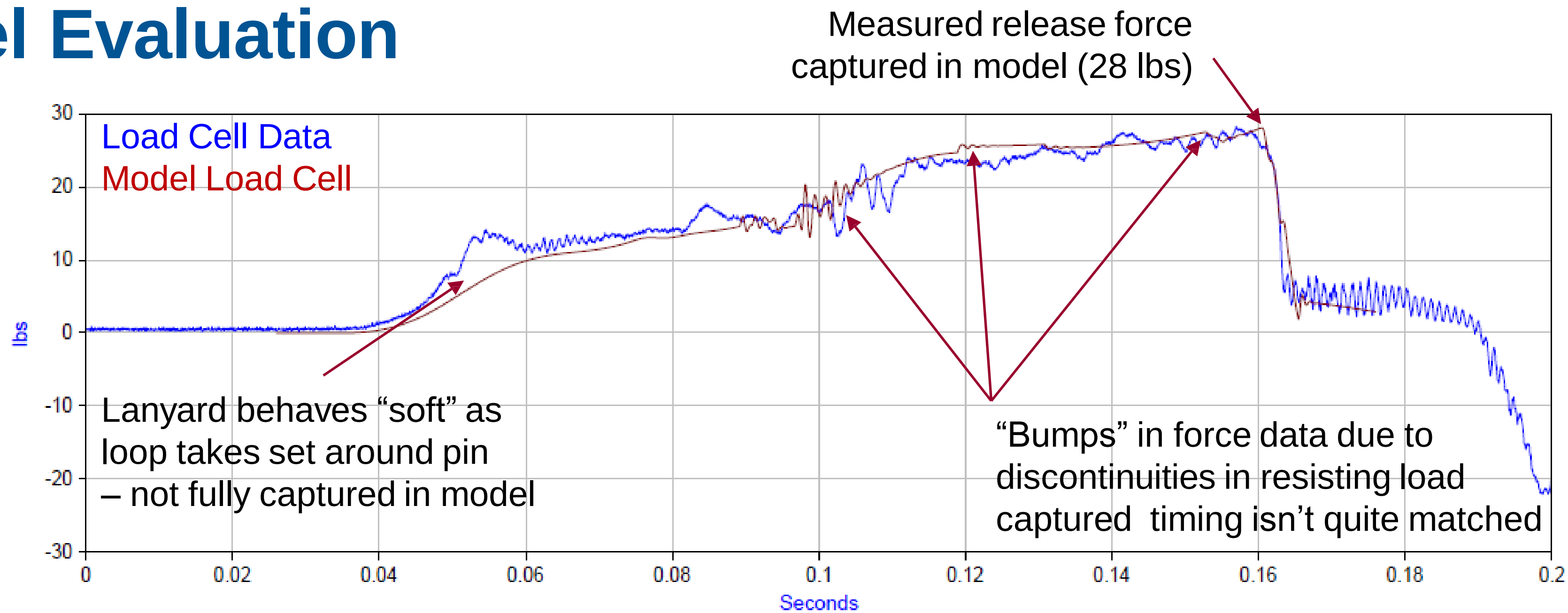


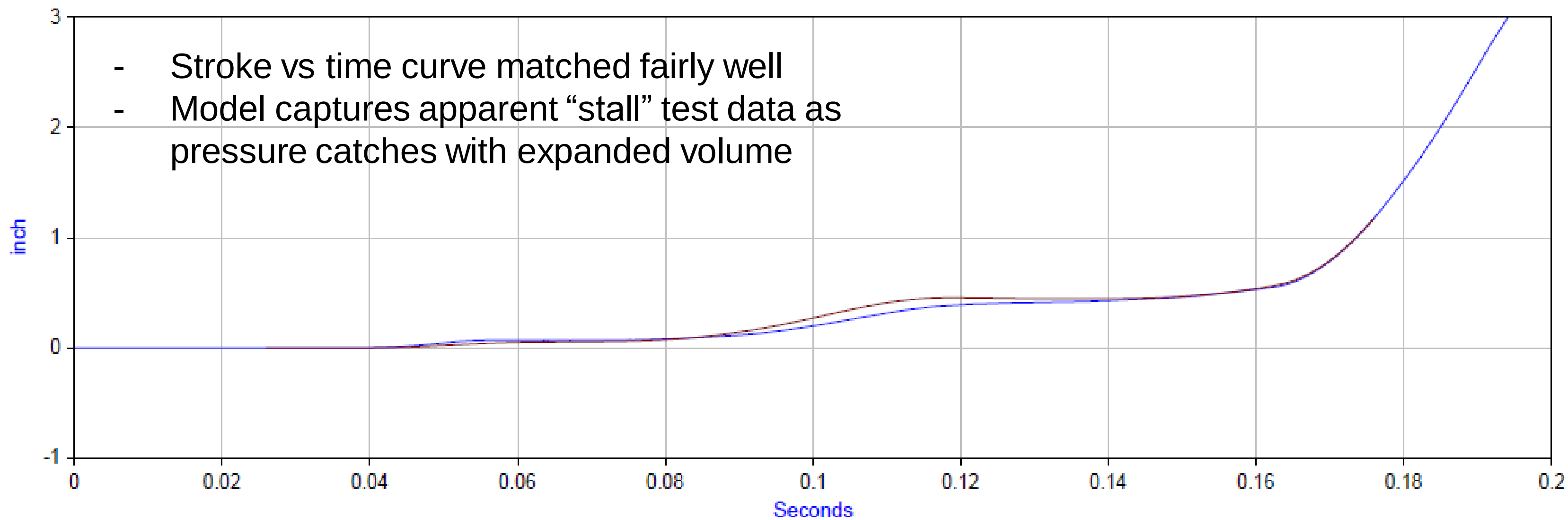
Model Setup



Parameter	Description	Notes
F.lpi	LPI pull force	
m0	Piston mass + ½ load cell	
m1	½ Load cell + ½ lanyard	
m2	Firing mech + ½ lanyard	
X0	Piston stroke	
X1	Load cell stretch	
X2	Lanyard stretch	Supports tension only
K1, C1	Load cell stiffness and damping	Stiffness derived from X ” dia cable damping factor Q = 5
K2, C2	Lanyard stiffness and damping	Damping factor Q = 5, supports tension only
P.res	Reservoir pressure	
Orifice	Chock orifice	Opens over 10 ms

Model Evaluation

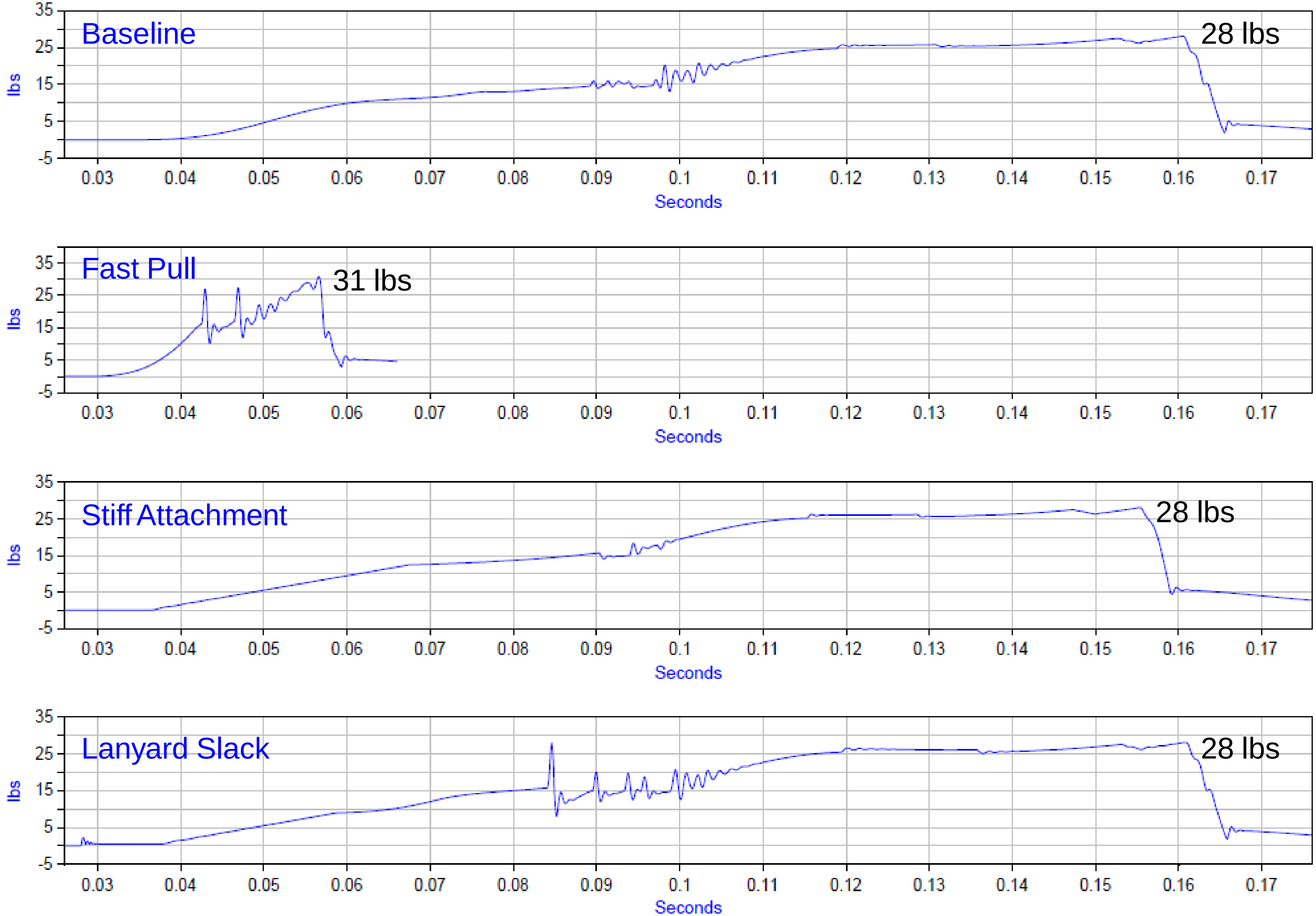




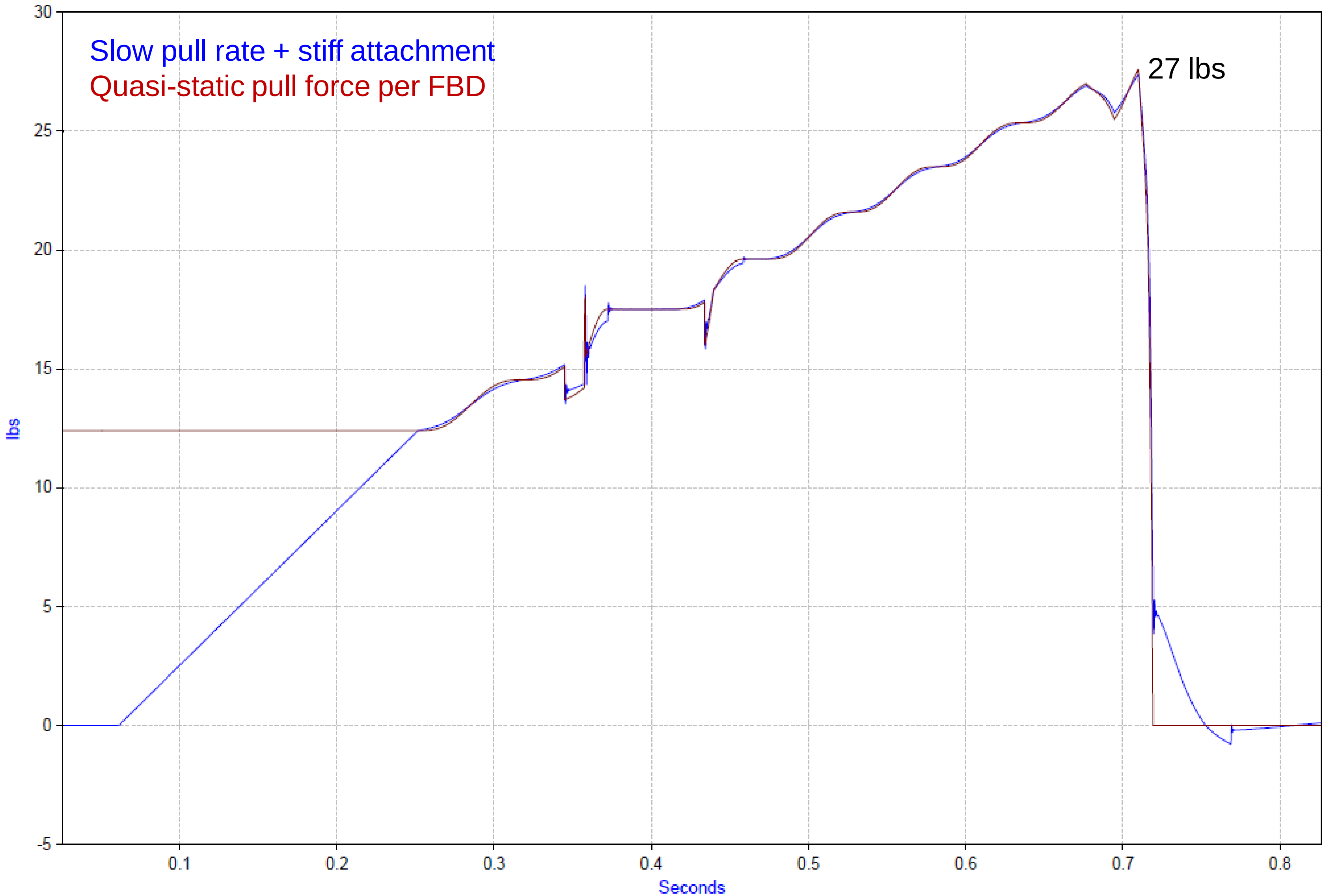
Case Studies

- Model captures major features of pull test data
  - Initial stretch of lanyard seating
  - Noise in force data as sear is pulled past discontinuities during stroke
  - Apparent “stall” observed in stroke data
  - Release force and
- Model used to assess affects of various plausible test methods/ setups
  - Case 1 – Fast pull rate
  - Case 2 – Stiff fixture attachment
  - Case 3 – Initial lanyard slack
  - Case 4 – Slow pull rate + stiff attachment

Case Study Comparison



Recommended Test Configuration



Conclusions

- A model of a typical mechanical initiator pull test presented
  - Model captures main features observed in pull test data
- Model used to assess various test fixture scenarios
  - Fast pull rate (leads to increased measured release forces)
    - Can lead to LAT failures
  - Stiff fixture attachment (little observed effect)
  - Lanyard slack (little observed effect)
  - Slow pull rate + stiff attachment (best estimate of quasi-static release force)
- Recommendations
  - If system requires pull initiator to meet pull force requirements at a specific pull rate, the rate and system stiffness should be defined in specification
  - If no pull rate defined in specification a slow pull rate with a stiff attachment yields the best measurement of the true initiator release force