Discovery Channel Plane Crash

Triennial Cabin Safety Conference

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Objectives

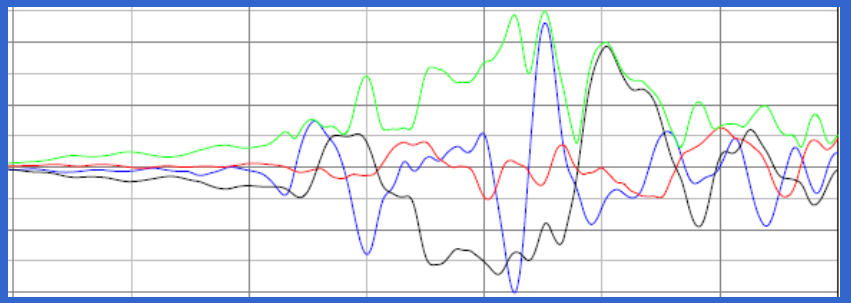
Visualize Crash Test Sequence

Aircraft Interior Regulations

- Survivability / Design Limits

Crash Pulse

- B727 Crash vs Reg's



Conclusions/Observations

Aircraft on Approach, Pilots Parachute Out

B727 Controlled by Remote (Chase Aircraft)

Historical Perspective

9/23/62 Lockhead Constellation Accident

NTSB Investigation Concluded:

Interior/Seats hindered evacuation

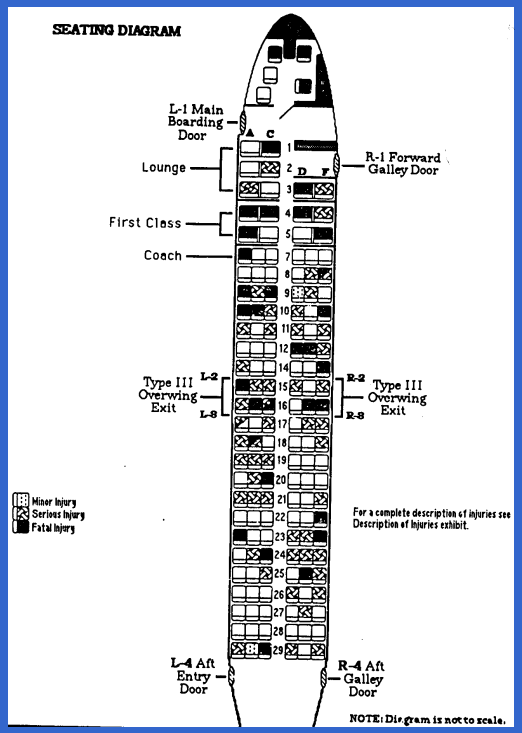
1981 NTSB Study (NTSB-AAS-81-2)

Surveyed 77 Survivable accidents 1970 to 1980

Poor cabin design contributed to fatalities in 60% of the accidents

Regulations, How are they doing?

- 1989 Dynamic Impact Regulations
- 2000 FAA Cost / Benefit Study
  (DOT/FAA/AR-00/13)
- 2005 Operational Rule
  (effective Oct. 2009)
  - New A/C Deliveries
- Is Test Standard Representative?



Video: External (Geo-Stabilized Helicopter)

Discovery Plane Crash Data

- Video (Go Pro and High Speed) - All
- String Pots (Floor Crush) - Barth
- Floor Accelerations - Barth
- Test Dummies – Dr. Cindy Bir Wayne State Univ., Barth
- General Flight Dynamics / Structure – Prof. John Hansman, MIT
- General Accident / Black Box – Anne Evans, former senior acc. inv., AAIB UK

String Pots
Forward Cargo

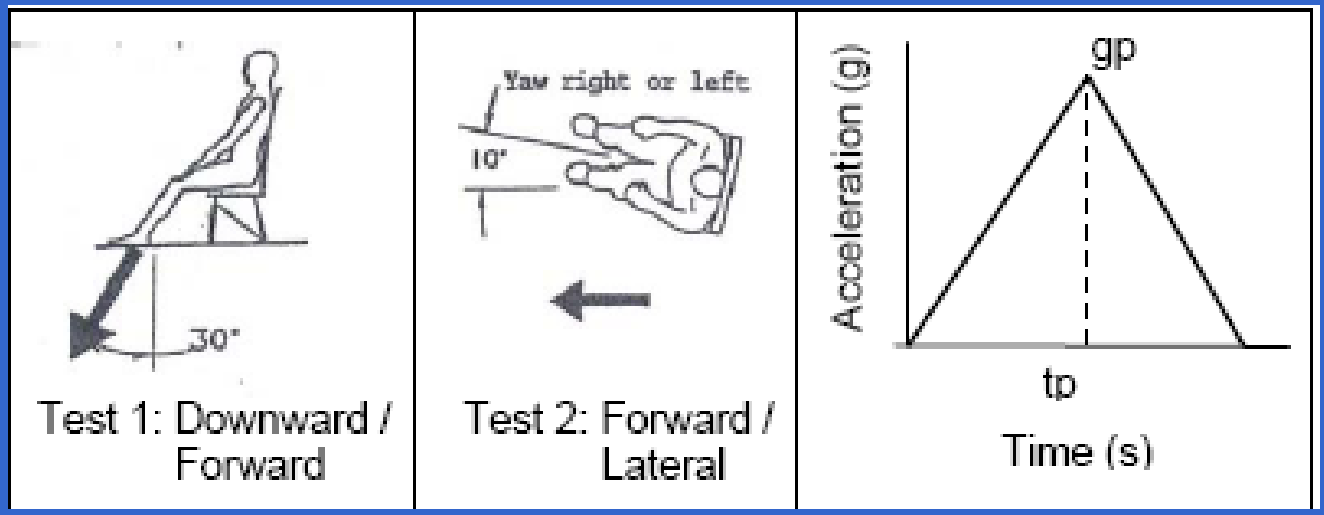
Sensors
Row 13, 20, 27

Instrumentation
Box

Trigger: 10g latching switch, vert.

- High Speed Video
- Test Dummies
- Accelerations (DTS E-Slice)

Emergency Landing Conditions



Test 1: Downward / Forward

Test 2: Forward / Lateral

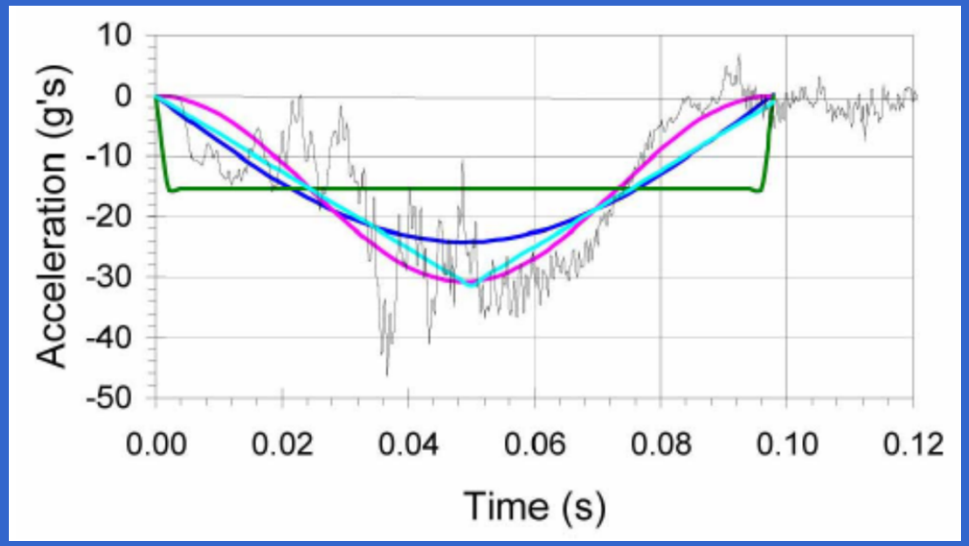
Test	GA Aircraft	Transport Aircraft	Rotorcraft (all)
1. Downward / Forward	tp = 0.050 s (crew) tp = 0.060 s (pass.) gp = 19 g (crew) gmax = 19 g (pass.) ΔV = 9.5 m/s	tp = 0.080 s gp = 14 g ΔV = 10.7 m/s (passenger)	tp = 0.031 s gp = 30 g ΔV = 9.1 m/s
2. Forward / Lateral	tp = 0.050 s (crew) tp = 0.060 s (pass.) gp = 26 g (crew) gp = 21 g (pass.) ΔV = 12.8 m/s	tp = 0.090 s gp = 16 g ΔV = 13.4 m/s (passenger)	tp = 0.071 s gp = 18.4 g ΔV = 12.8 m/s

Occupant Survivability

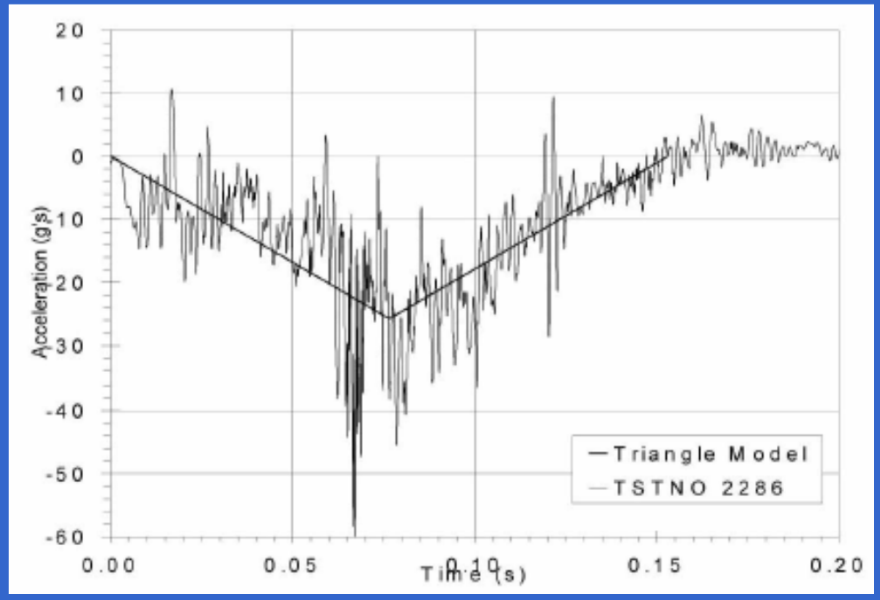
- Cockpit
  - Survivable Space
  - High Impact Loads
- Rows 1-7 (Right) & 1-11 (Left)
  - Non-Survivable
- Rows 8-16 (Fwd of Wing),
- Rows 17-23 (Overwing),
- Rows 24-32 (Aft of Wing),
  - All Intact, All Survivable
  - Evacuation Issue with Cables

Cockpit Video

Crash Pulse Selection Method



2003, Varat M., Stein H,18th ESV, Paper 501



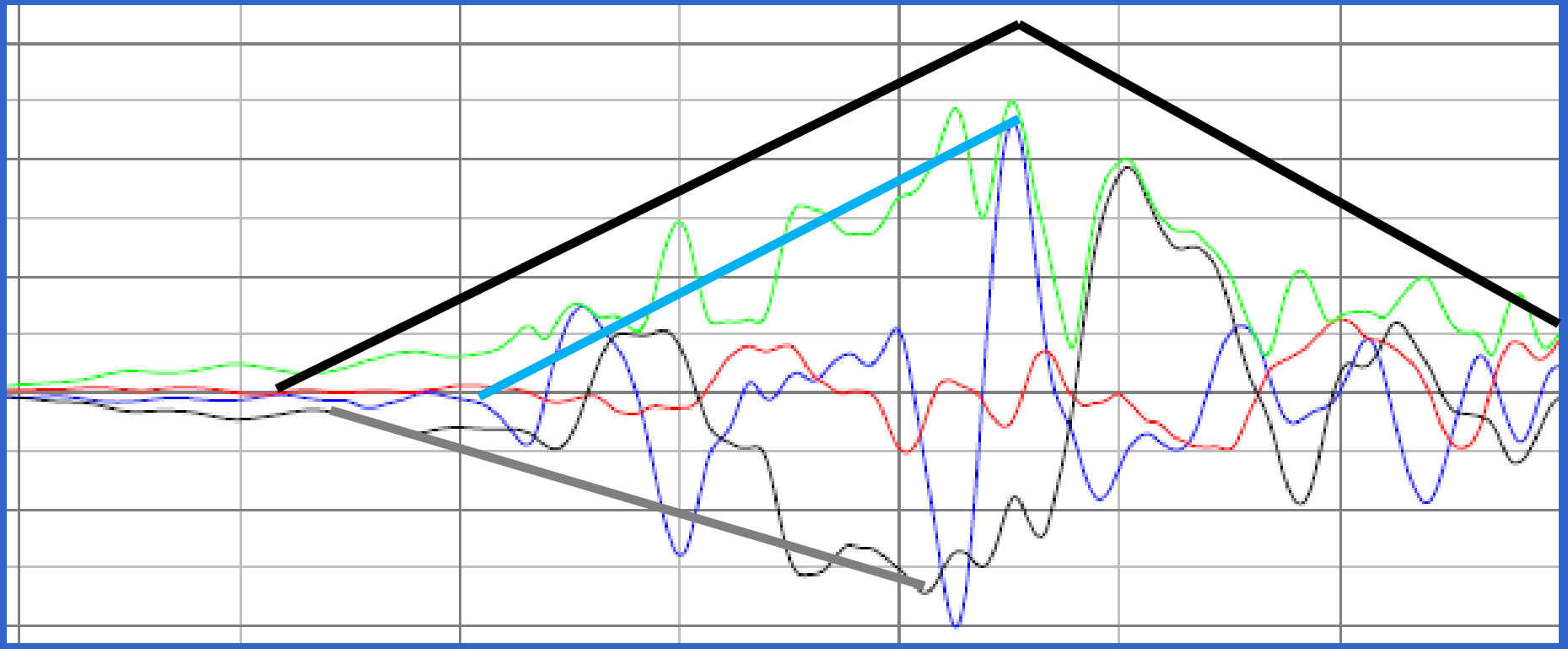
Large Aircraft Crash Test Challenges

- Impact time / Duration
  - Methods: Best Fit, 5% of Peak G, other…
- Response Relative to Location
  - Force, Velocity, Crush, Residual Velocity

Example: Best Fit, Each Component (X, Z)

- Triangle Shape
- Qualitative Assessment of Fit
- Qualitative Assessment of Primary Impact
- “Primary Impact” – Data Exhibited:
  - Impact < 0.200s, (followed by trend toward zero, then transient to smaller, secondary peak)
- Also Looked at:
  - Polynomial Fit, Moving Avg, Averaged Rows

Row 13 Floor Accelerations

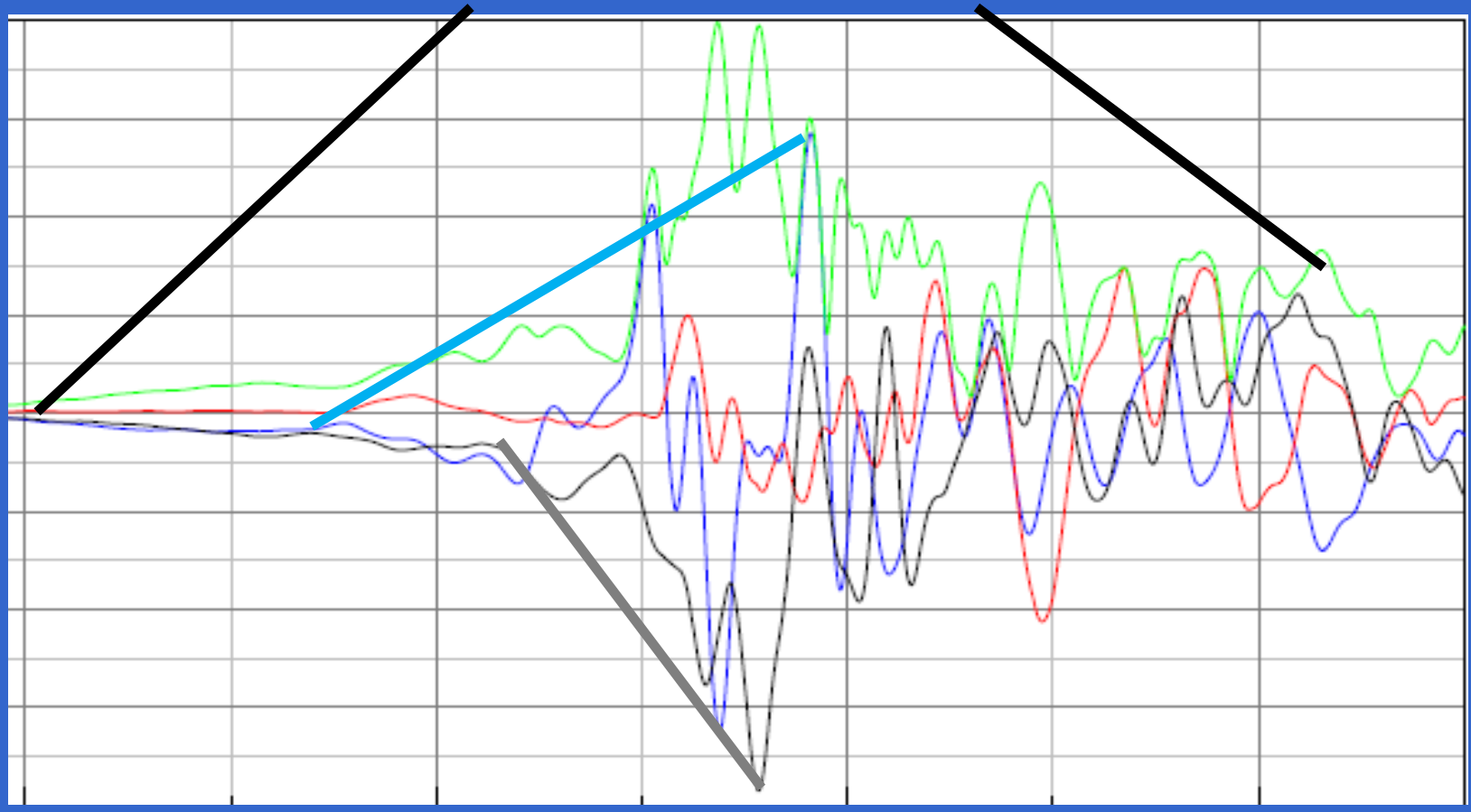


X Peak =~11.5 g, at ~ 0.052s, Onset = 221 G/s

Y Peak = ~5.7 g, at (NA)

Z Peak = ~8.6 g, at ~ 0.077s, Onset = 112 G/s

Row 20 Floor Accelerations

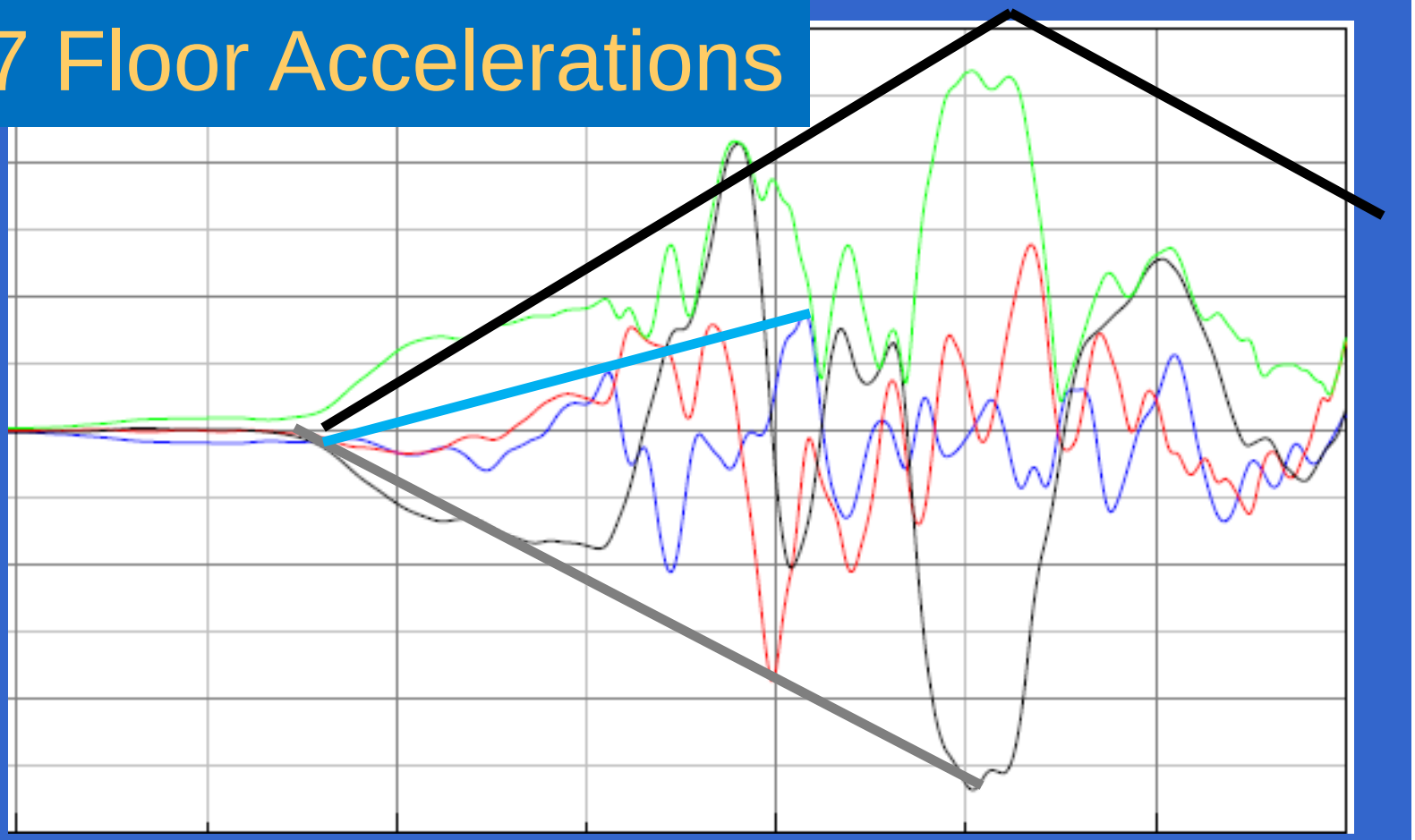


X Peak =~7.1 g, at ~ 0.061s, Onset = 116 G/s

Y Peak = ~5.1 g, at (NA)

Z Peak =~9.6 g, at ~ 0.033s, Onset = 291 G/s

Row 27 Floor Accelerations



X Peak =~4.4 g, at ~ 0.065s, Onset = 68 G/s

Y Peak = ~9.2 g, at (NA)

Z Peak =~13.4 g, at ~0.091s, Onset = 147 G/s

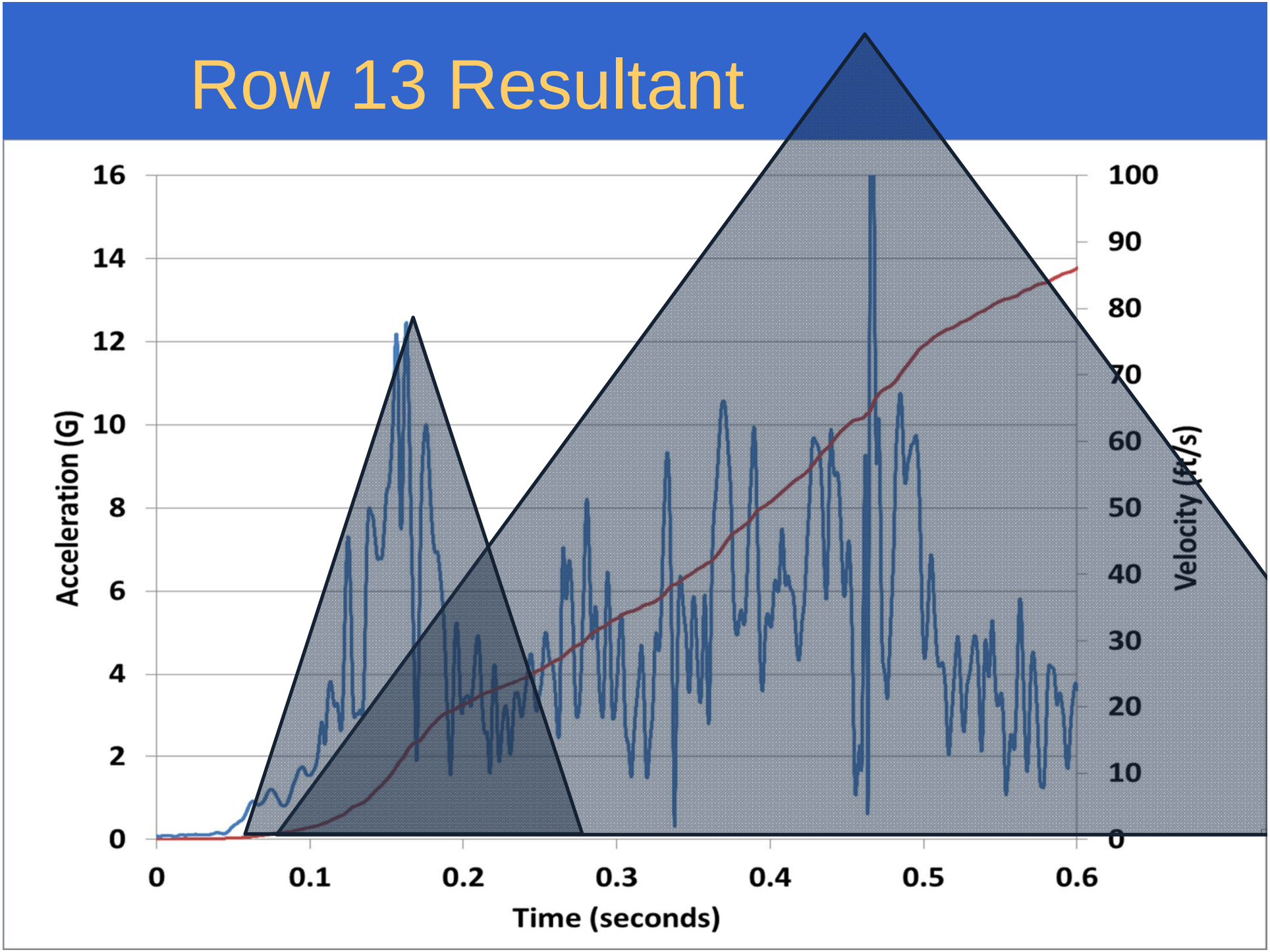
Results: Best Fit, Each Component (X, Z)

- Not Satisfied
- Too Much Interaction between X and Z
- Conclusion: Use Resultant

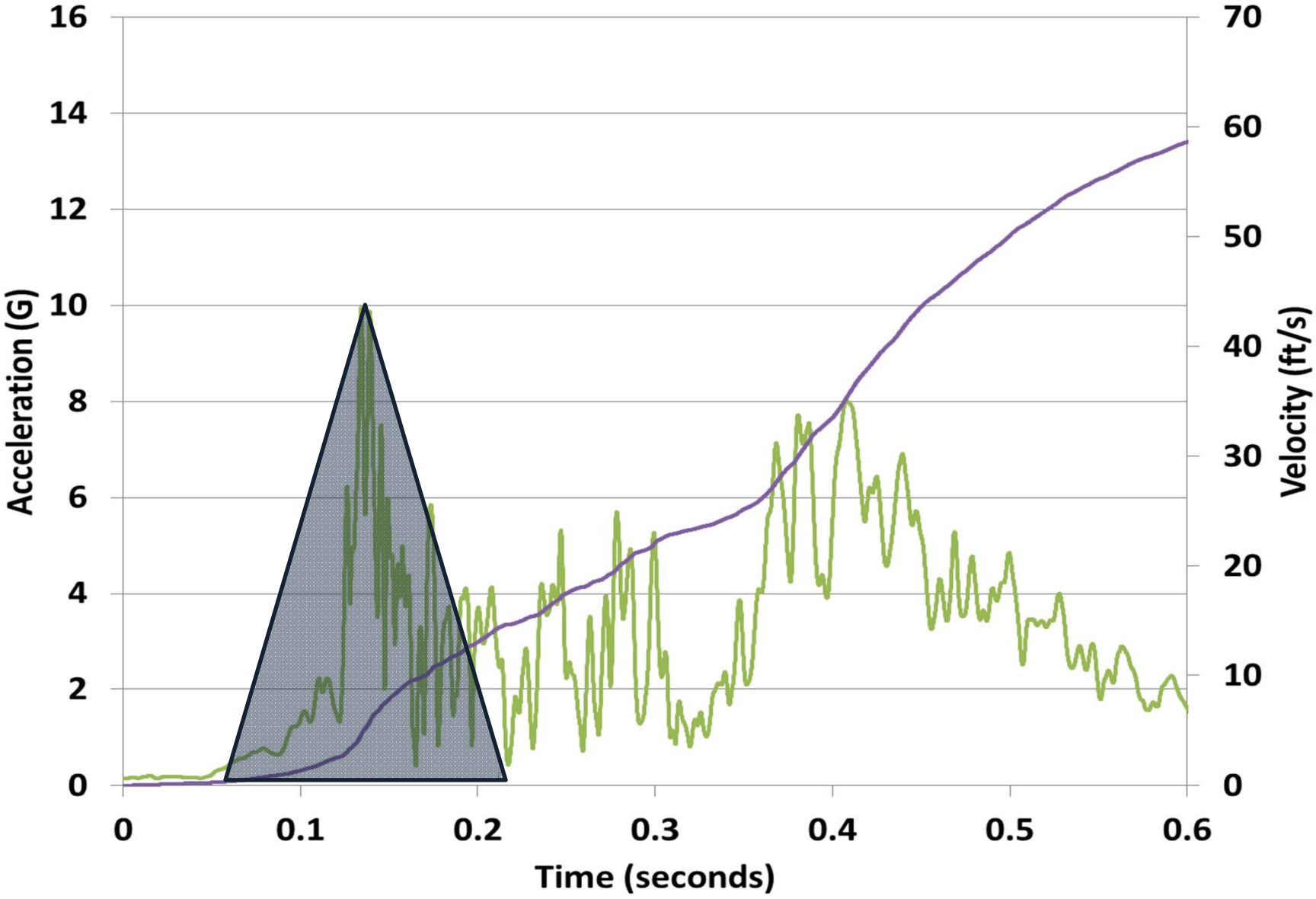
$$\text{Resultant} = \sqrt{x^2 + y^2 + z^2}$$

- Initial time based on 5% of Peak Acceleration
- Total Duration set at Double Time to Peak

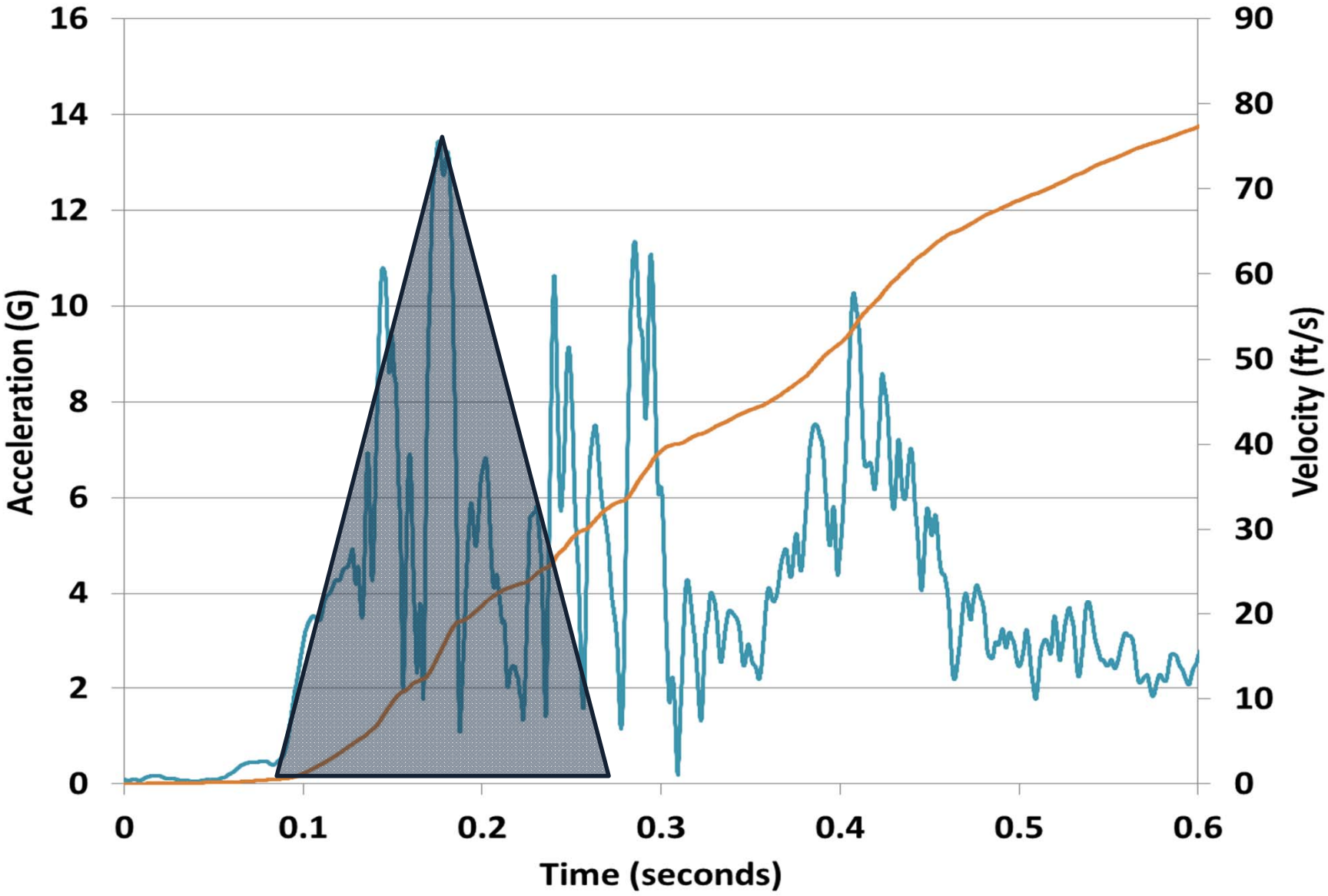
Row 13 Resultant



Row 20 Resultant



Row 27 Resultant



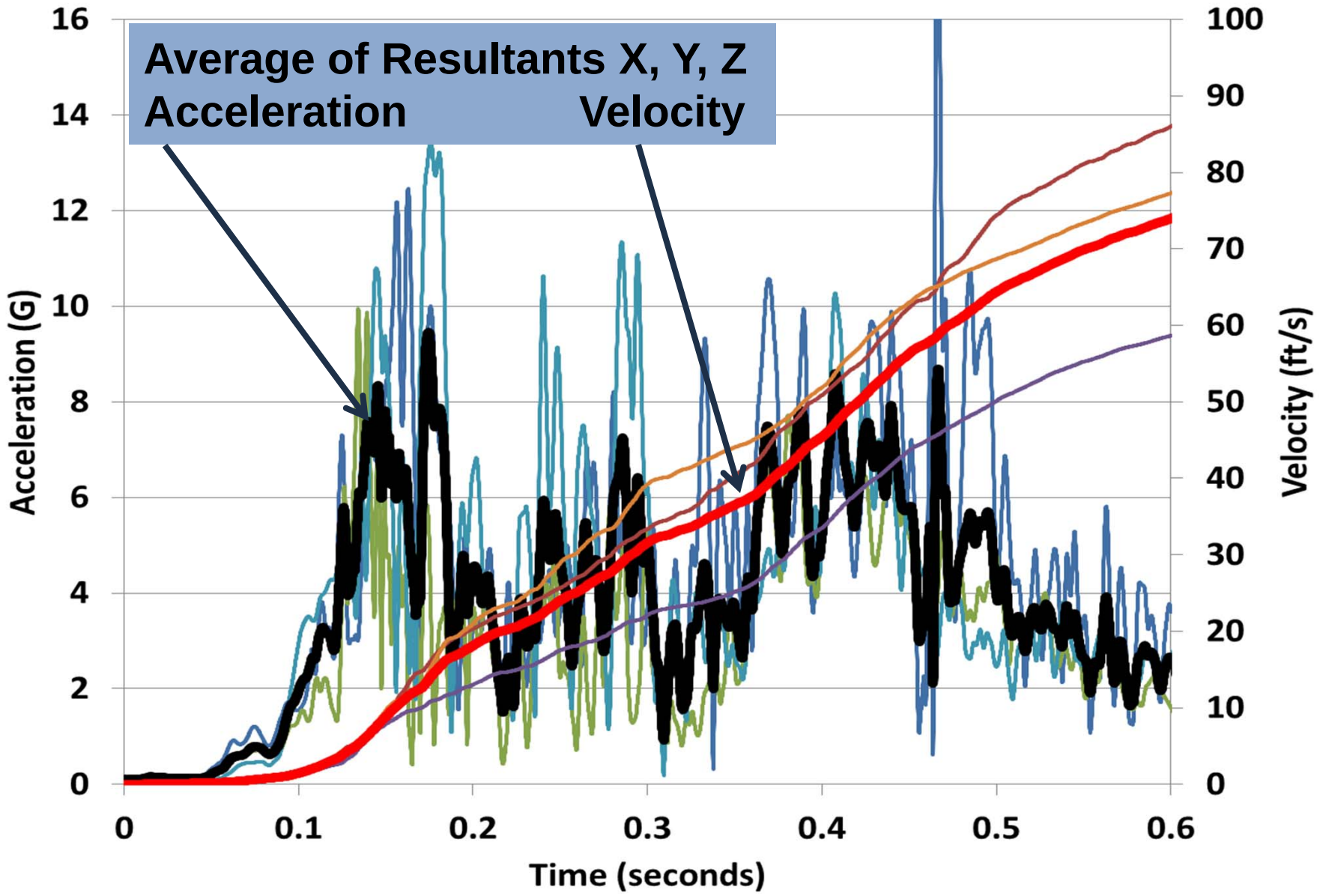
Resultant $= \sqrt{x^2 + y^2 + z^2}$

- Method: OK
- Limitations:
  - Neglects Large Portion of Impact
  - Specific to Aircraft Cabin Section
    (Forward, Overwing, Aft)

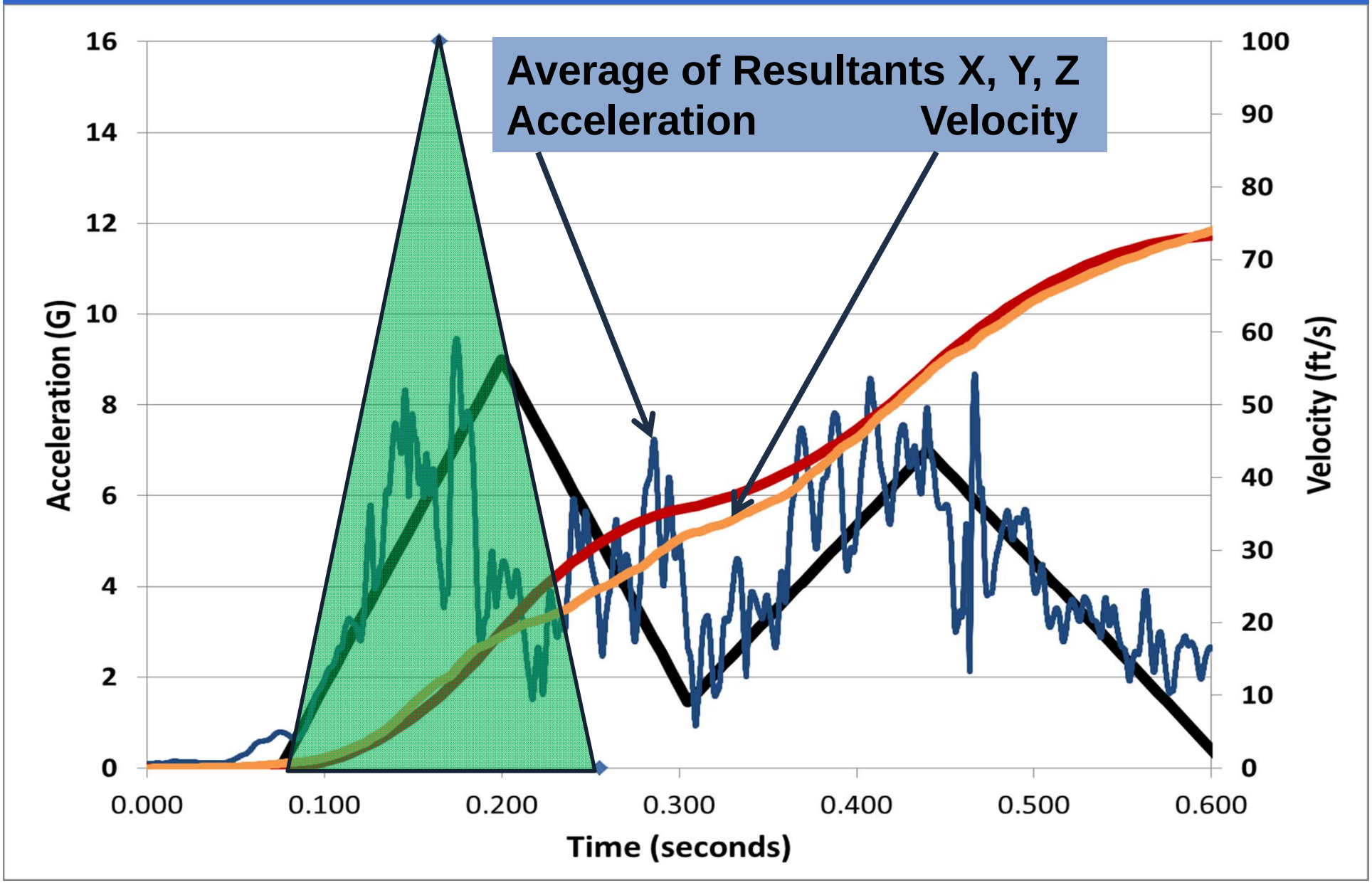
New Modifications

- Allow Transient, Longer Pulse
- Average the Resultants of Rows 13, 20, 27

Avg Resultant Rows 13, 20, 27



Plane Crash “Ideal” Impact Pulse



Regulatory Comparison

- Peak G about 30% lower than Regulatory
- Onset Approximately 120 G/s
  - Transport Aircraft Pulses ~ 175 G/s
  - General Aviation Pulses ~ 350 to ~ 520 G/s
- Total Velocity Change
  - About Double the Regulatory Pulses

Conclusions

- Plane Crash Test
  - Well within Design Limits
  - Clearly Long, Drawn out Impact (for most of Cabin)
- Plane Crash “Ideal” Pulse Reasonable
- Regulatory Pulses
  - Good Representation of Survival / Design Limits
  - Represent only Primary Impact

  (Capture Only Small Portion of Total Velocity)

Observations

- Influence from Experiment and Test Equipment Limitations? (Velocity/Crush)
- Typical Survivable Crash
  - Long and Drawn out
  - Primary Impact Mitigated
- Need Better Understanding of:
  - Secondary Response
  - Cumulative Effects

Thank You!

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