RECOMMENDED CIVIL ROTORCRAFT WATER IMPACT DESIGN LIMIT CURVES

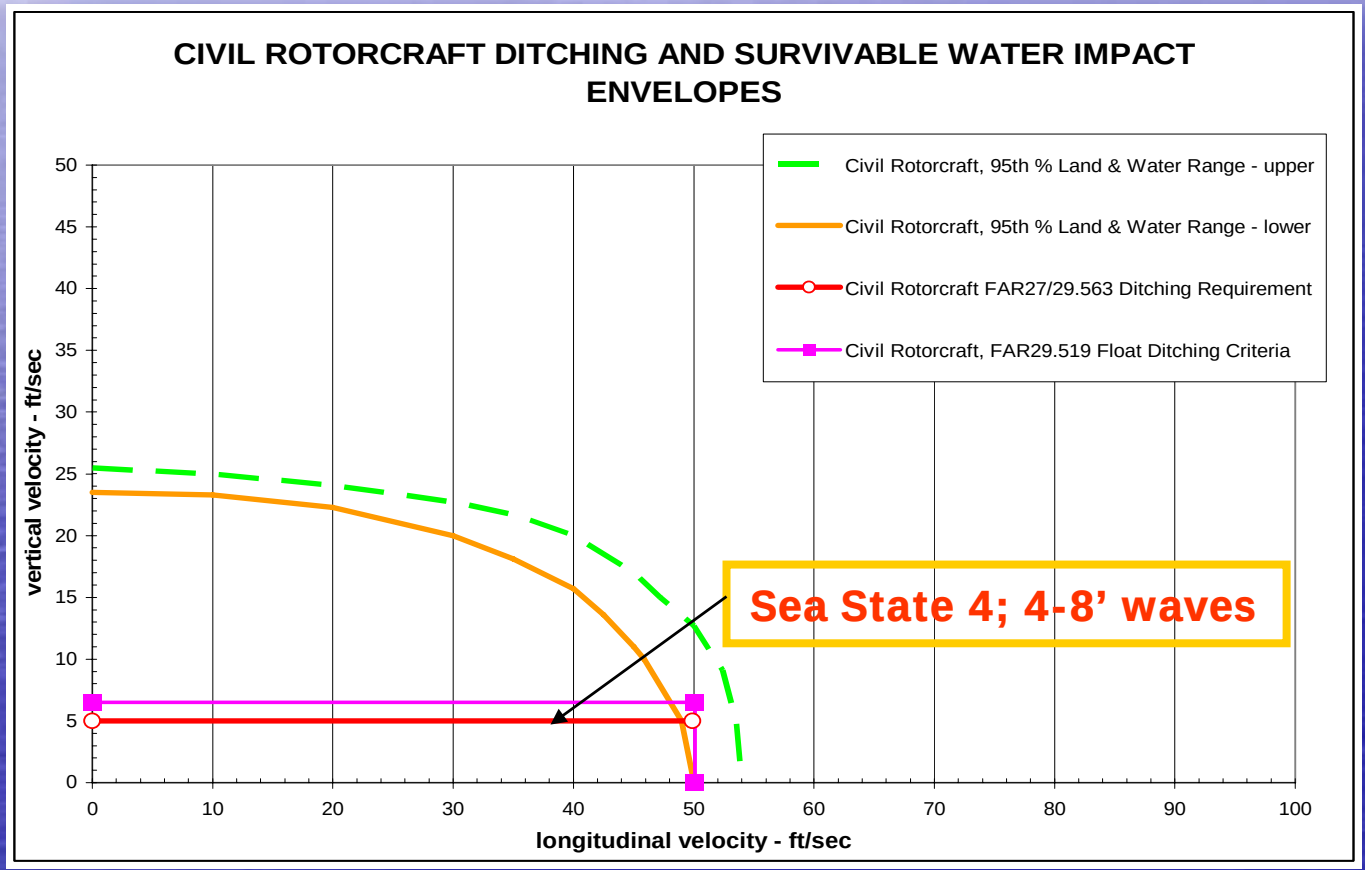
5th TRIENNIAL INTERNATIONAL FIRE & CABIN SAFETY RESEARCH CONFERENCE

OCTOBER 30, 2007

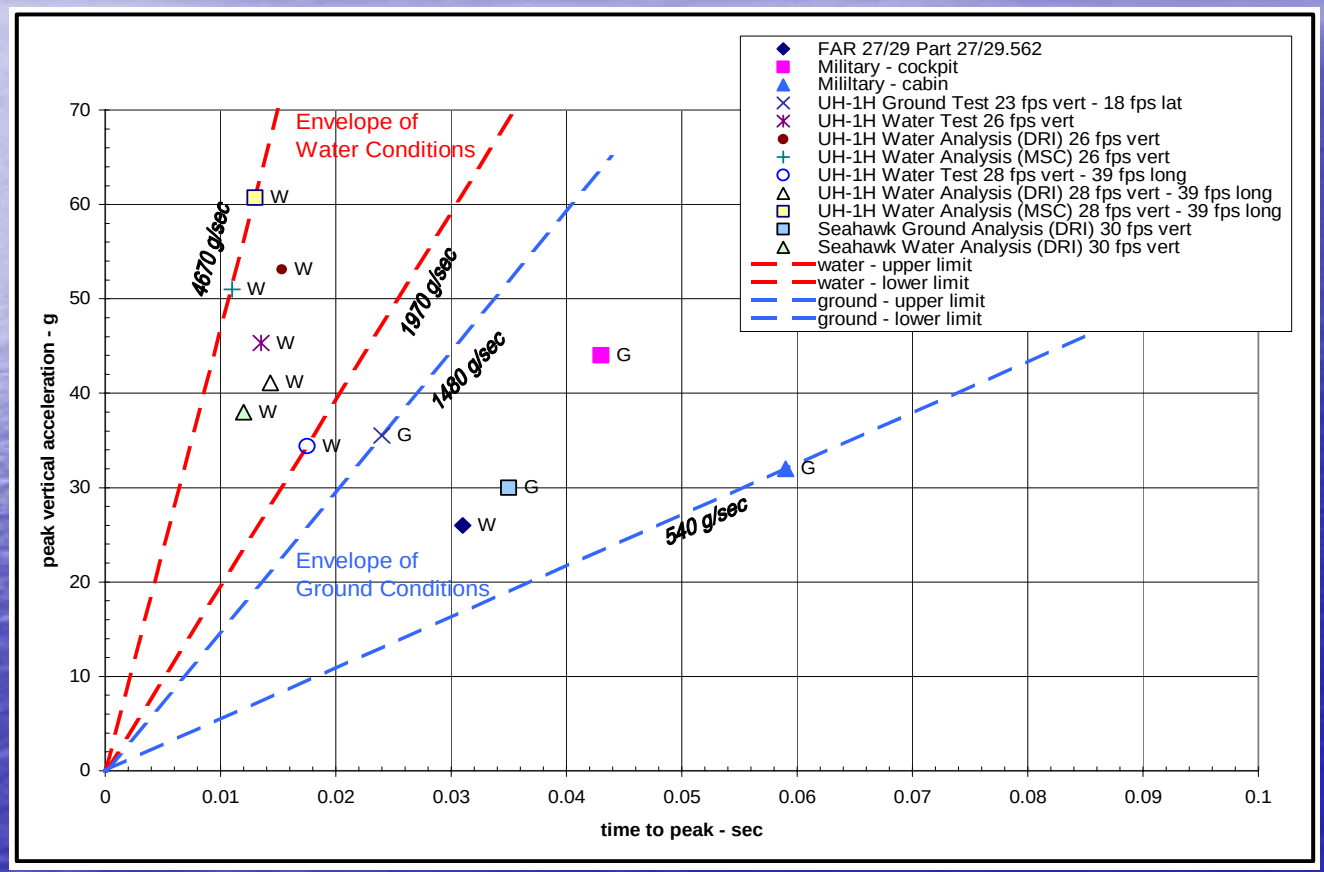
Presented By; Gil Wittlin

DYNAMIC RESPONSE INC.

CURRENT CIVIL WATER IMPACT & DITCHING ENVIRONMENT



ACCELERATION PEAK g-TIME CHARACTERISTICS



CIVIL ROTORCRAFT SEAT DYNAMIC TEST REQUIREMENTS (27.562)

60 Deg. Orientation

- Peak = 30 g
- Vel. Change = 30 fps
- Rise time = 0 .031 sec.
- Onset rate = 967 g/sec

- Vertical components;
  26 fps, 26 g, 838 g/sec.

Longitudinal (10 Deg. Yaw)

- Peak = 18.4 g
- Vel. Change = 42 fps
- Rise time = 0.071 sec
- Onset rate = 259 g/sec

Compliance;

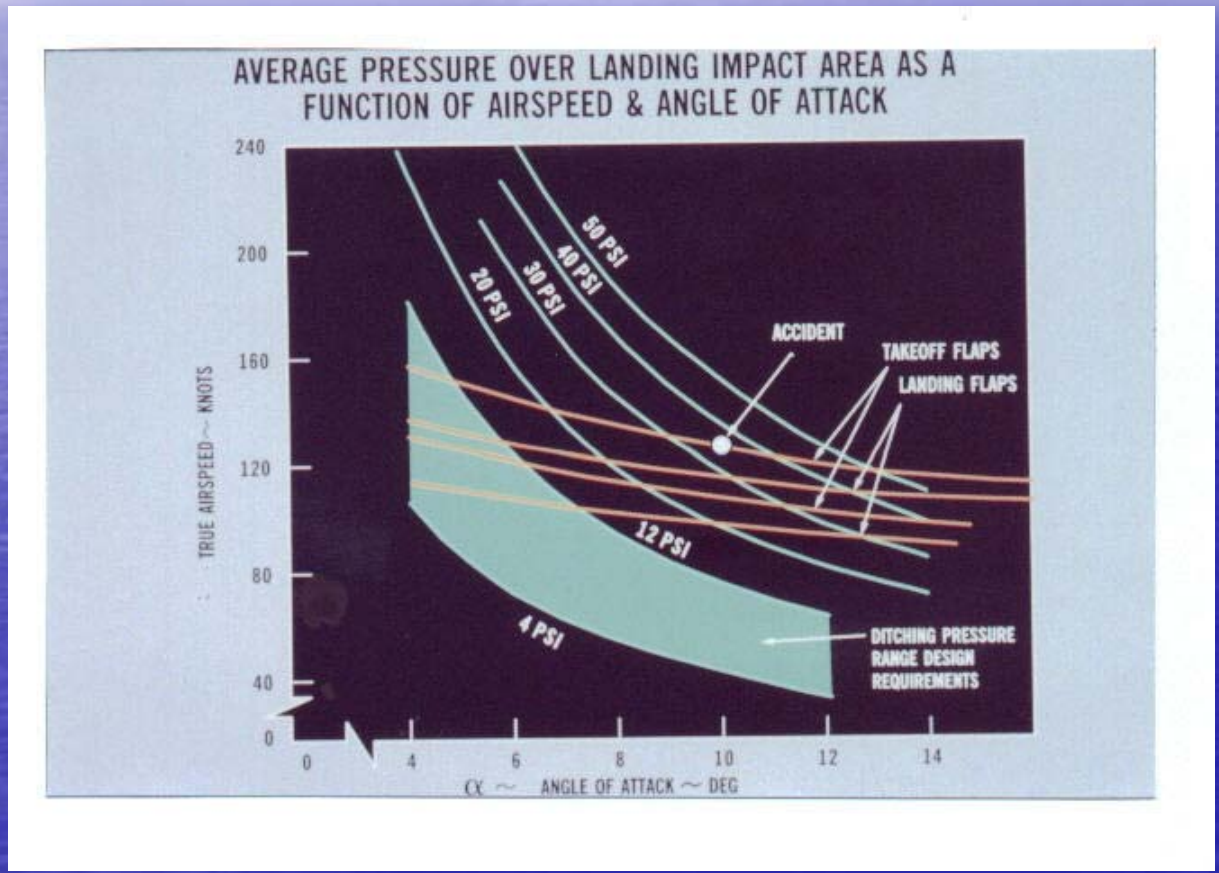
Lumbar Load, HIC, SI, Restraint loads

DITCHING COMPLIANCE PROCEDURES

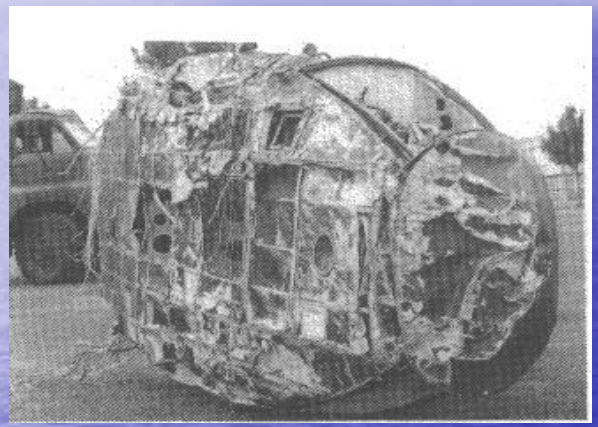
Reference: DRI 2000-2 " Task 2.3 Evaluation of FAR Part 27/29 Water Impact Standards"

- Scale Model Testing
  - rigid, costly
- Similarity to Existing Designs
  - size limitations
- Pressure Calculations
  - static flotation analysis
- Vertical Load Factor Calculations
  - stall speed, no sink velocity
- Procedures
  - under-estimate pressure & acceleration

DITCHING/WATER IMPACT; DYNAMIC CONDITION



WATER IMPACT DAMAGE



5FPS ROD

160FPSLong

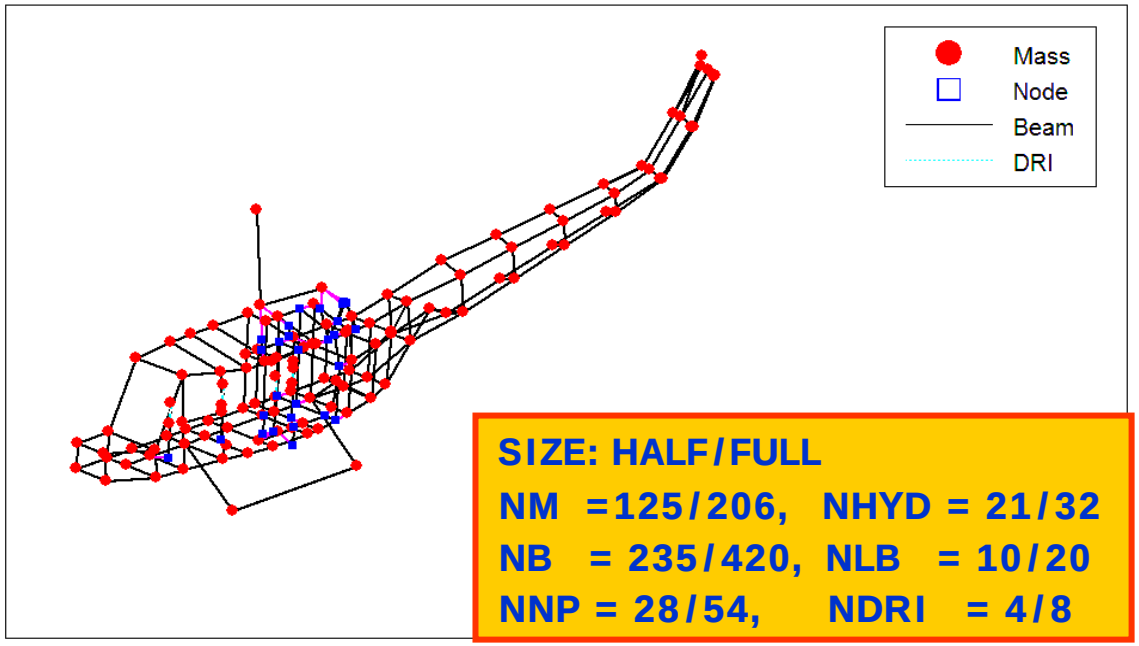
50FPS ROD

28FPS ROD

39FPS Long

BH205 BASIC 'KRASH' MODEL

bh205_cfg1_s2.inp
bh205_cfg1_s2 - Time: .000 [s]



SIZE: HALF/FULL
NM =125/206, NHYD = 21/32
NB = 235/420, NLB = 10/20
NNP = 28/54, NDRI = 4/8

MLS-KAP

BH205 DLE CONSIDERATIONS

CONSIDERATIONS		DITCHING	WATER IMPACT
Configurations Modeled		GTOW Max Design Landing Amphibious/Float Auxiliary Fuel Tank	GTOW Max Design Landing Amphibious/Float Auxiliary Fuel Tank S1, S2 Test Article
Design Envelope		FAR27/FAR29	Civil 95th Percentile -Upr Civil 95th Percentile-Lwr
Vertical Velocity	Ft/Sec.	0 to 25	10 to 28
Longitudinal Velocity	Ft/Sec.	0 to 80	0 to 60
Pitch Attitude	Degree	0, 5, 10	0, 4, 5, 10
Roll, Yaw	Degree	10, 10	10, 10
Sea State		Calm Sea State 4	Calm No
Landing Gear Position		Retracted, Extended	Retracted, Extended
Rigid seat		Yes	No
Load Limit Seat	g	12, 14.5	12, 14.5
Drag effects (Pitch-over)		Yes	No
Float Design Considerations	psi	3, 5, 10	10
Panel Design Strength Tradeoff	psi	Current- 2X current	No
Suction	psi	-10	No
Criteria			
Seat Stroke limit	In.	5	5
Lumbar Load Limit	Lb.	1500	1500
Underside Panel Failure	psi	Design	Design
Interior Bulkhead Failure	psi	Design	Design
Head Injury	HIC	1000	1000
Restraint Belt Load	Lb.	1750-2000	1750-2000
Mass Item Restraint	g	30/30/15 <1>	30/30/15 <1>
Engine			
Transmission			
Fuel			
<1> Vertical/Longitudinal/ Side			

PROCEDURAL STEPS

- **Establish respective ditching and water impact conditions & acceptance criteria;**

  occupant loads, seat stroke, sea state, structure load limit, panel failure

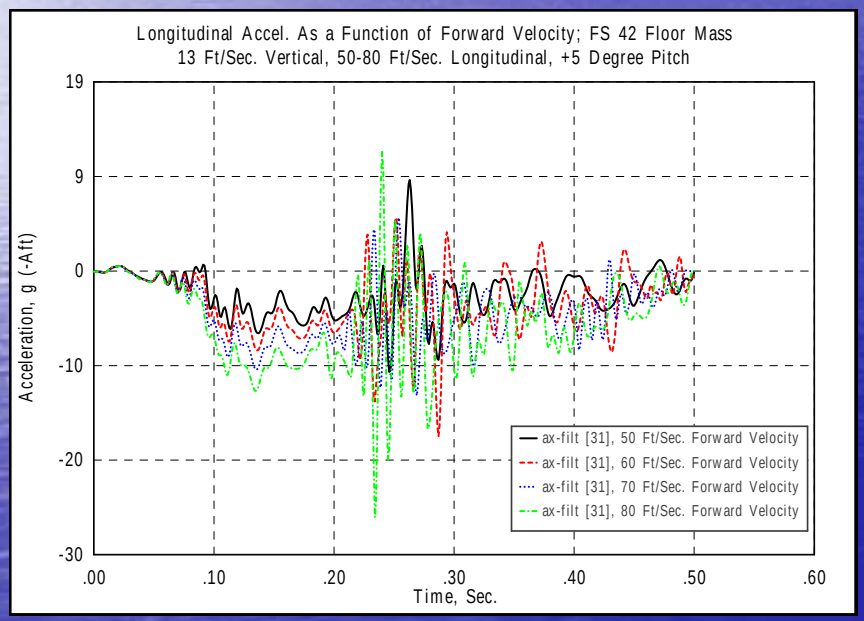
- Perform analysis to account for variations in;

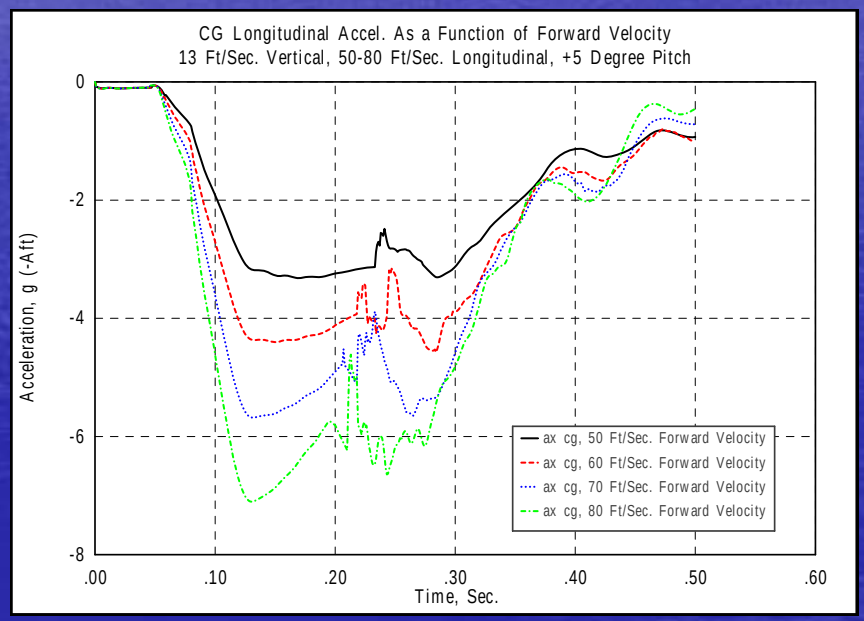
  seat load limit, gear position, symmetry, protrusions, suction, panel strength, bulkhead strength

- **Obtain Results;**

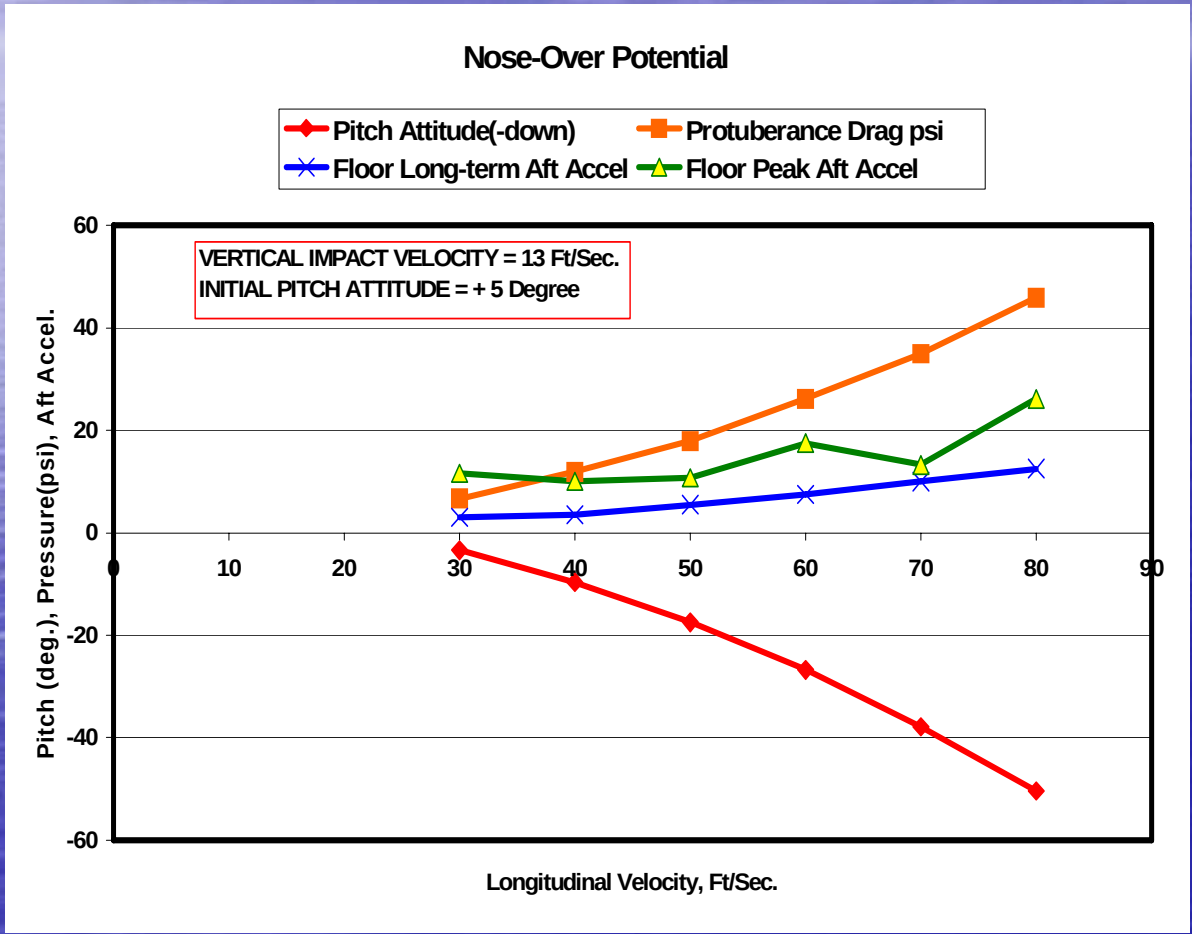
  strength envelopes, floor & cg responses, occupant & restraint response

DRAG EFFECTS



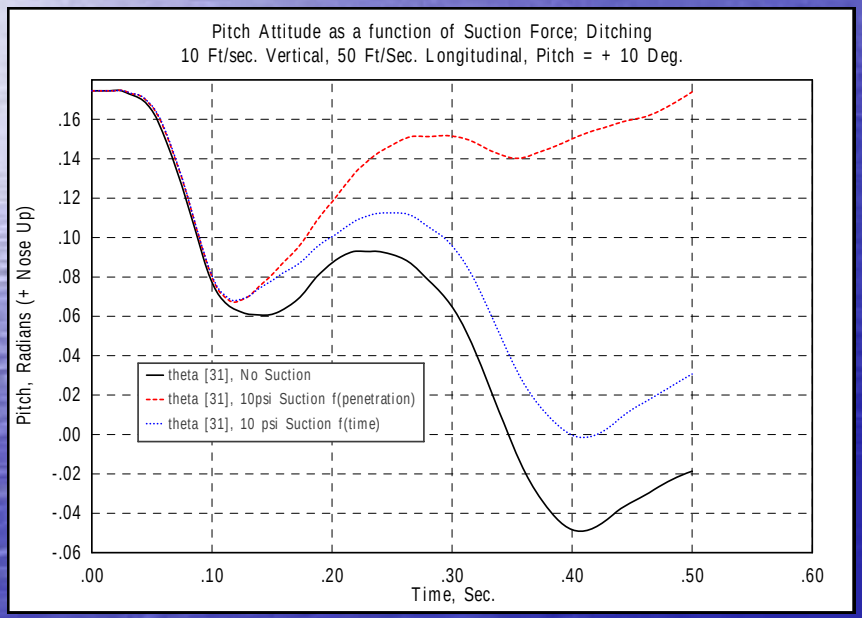


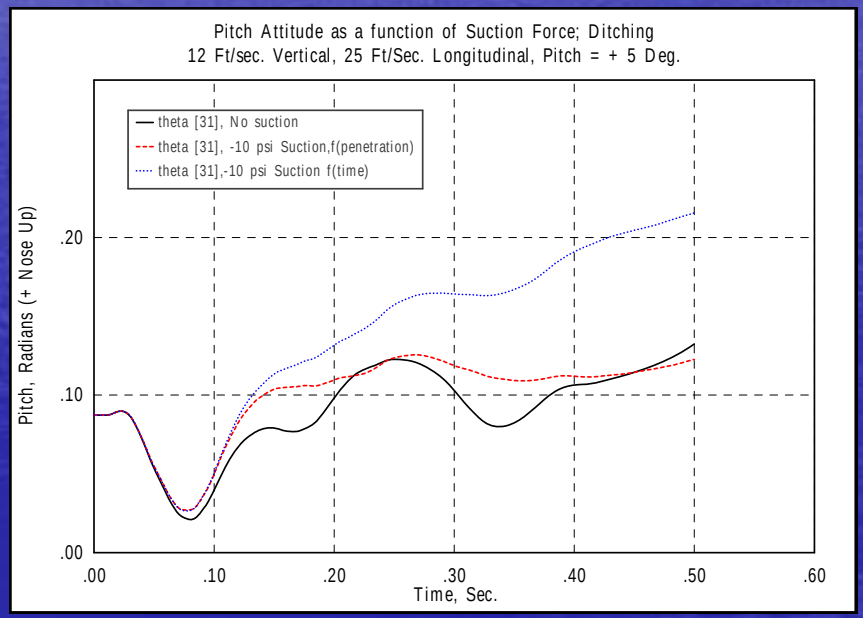
NOSE-OVER POTENTIAL



SUCTION FORCE EFFECT

VERTICAL VELOCIY = 10 FPS
LONGIT. VELOCITY = 50 FPS

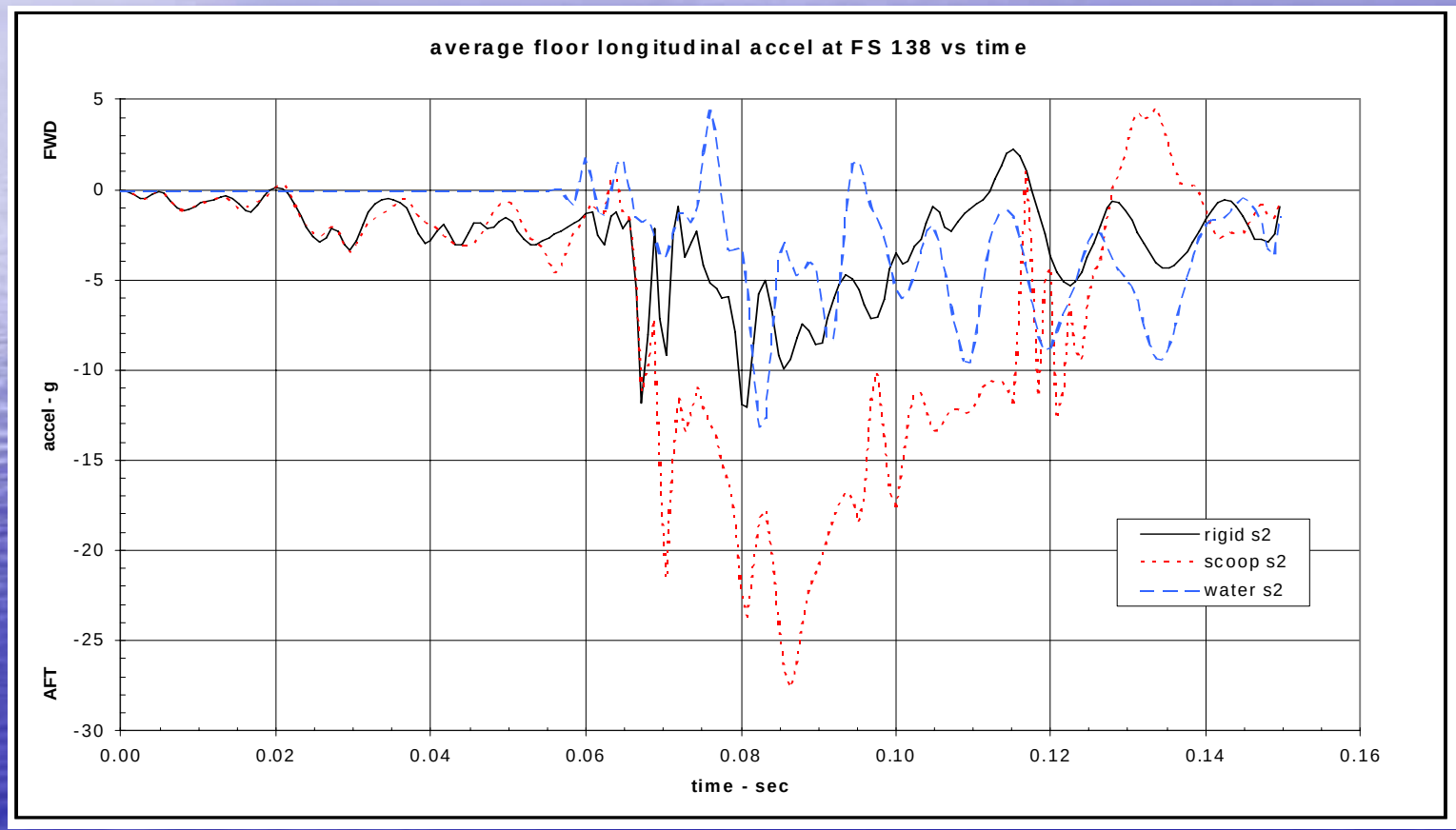




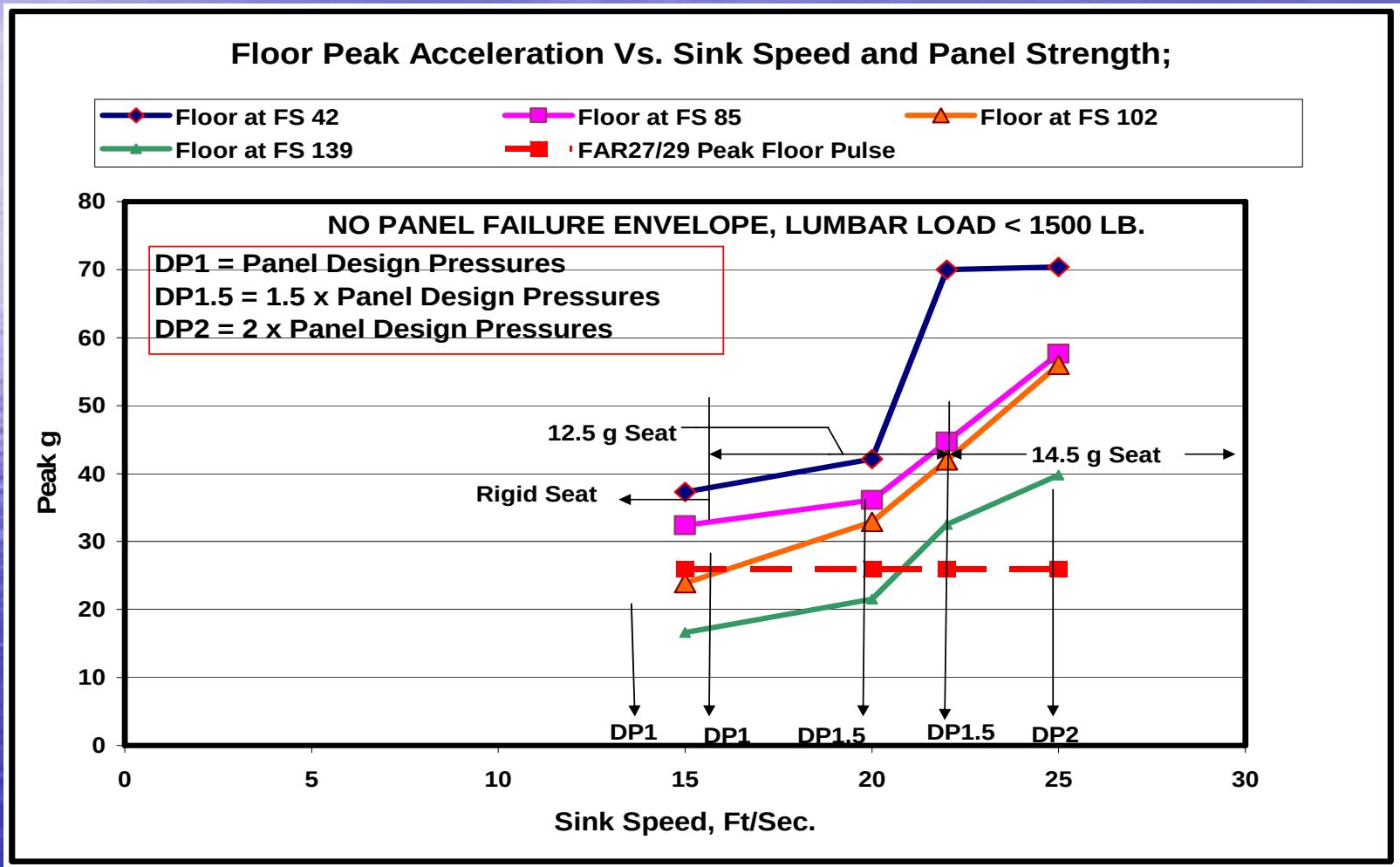
INITIAL PITCH = + 10 DEGREE

INITIAL PITCH = + 5 DEGREE

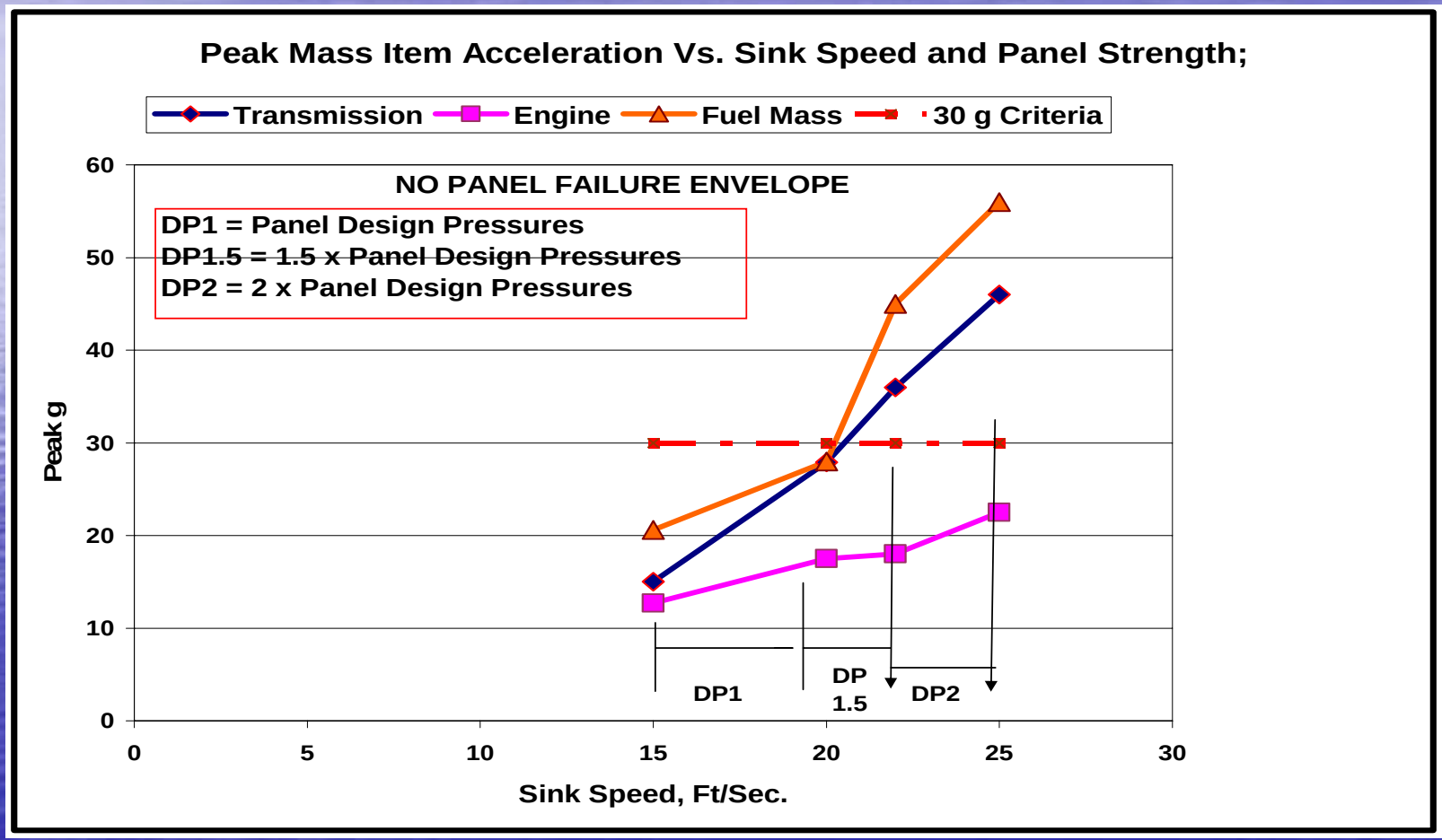
GROUND vs. WATER vs. SOIL



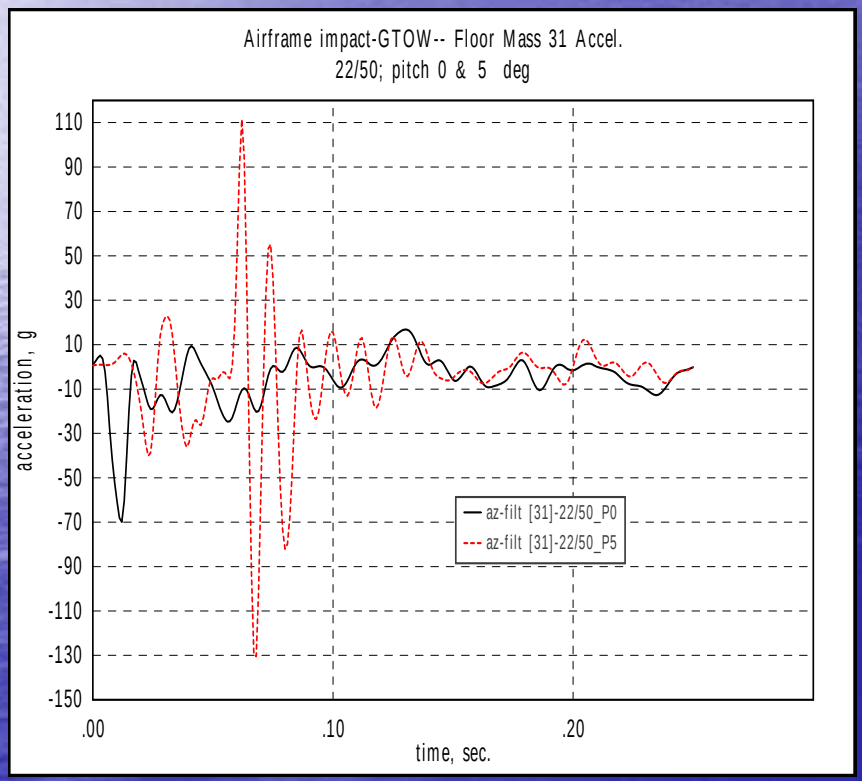
TRADE OFF –
Floor Gz- Sink Speed – Panel Design

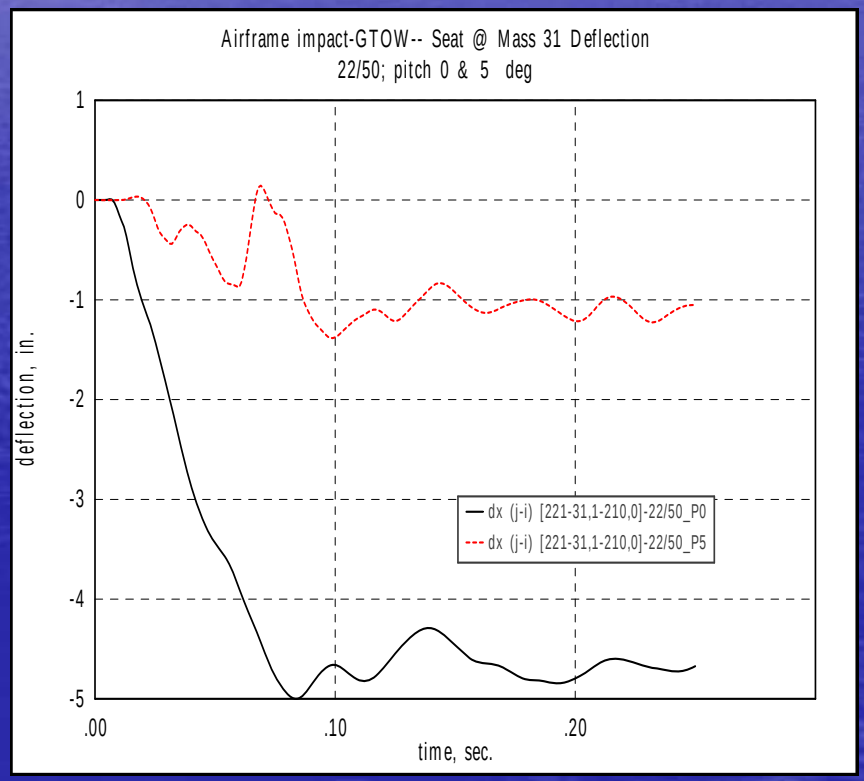


TRADEOFF –
Mass Accel.-Sink Speed-Panel Design

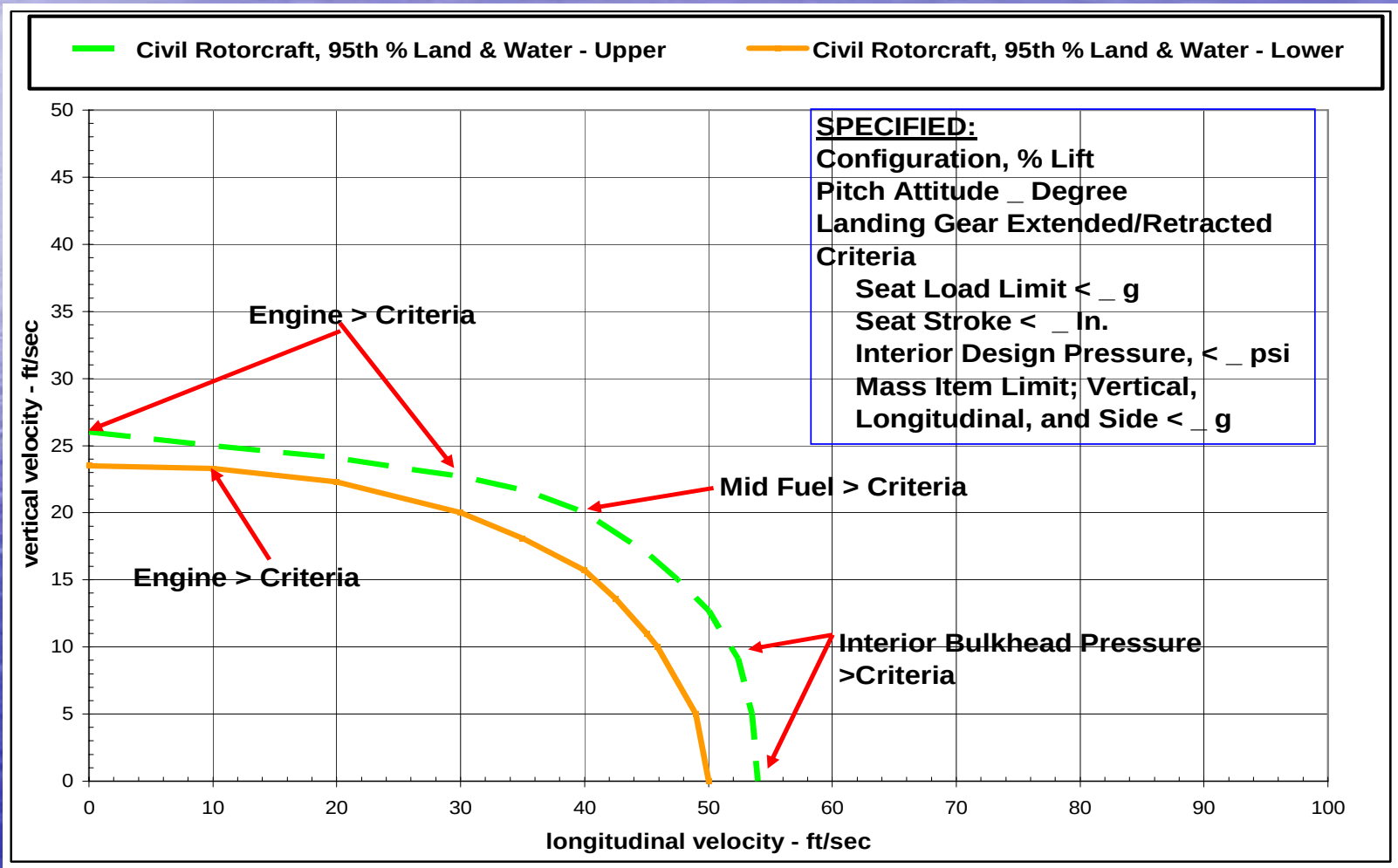


FLOOR ACCEL VS. SEAT STROKE

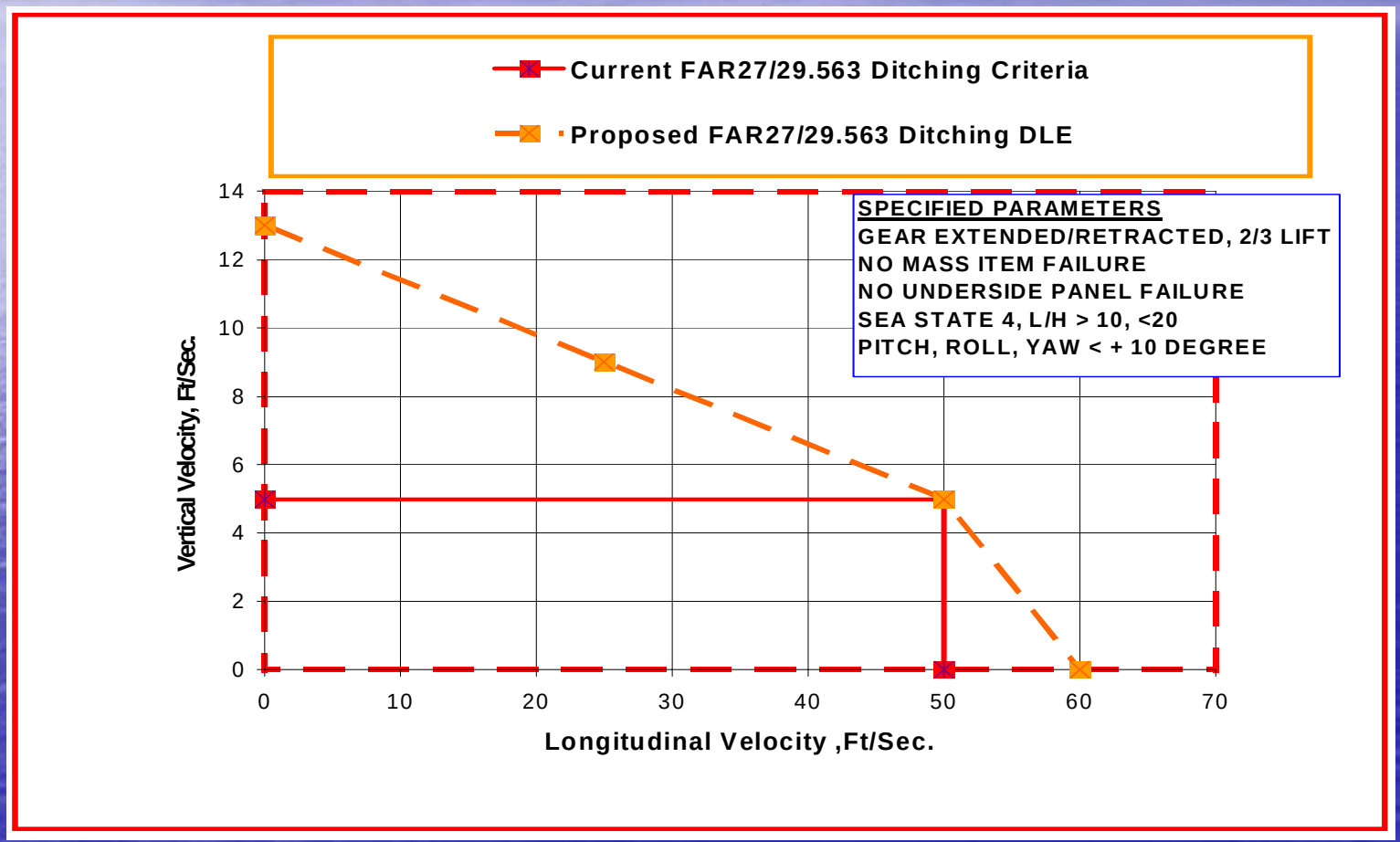




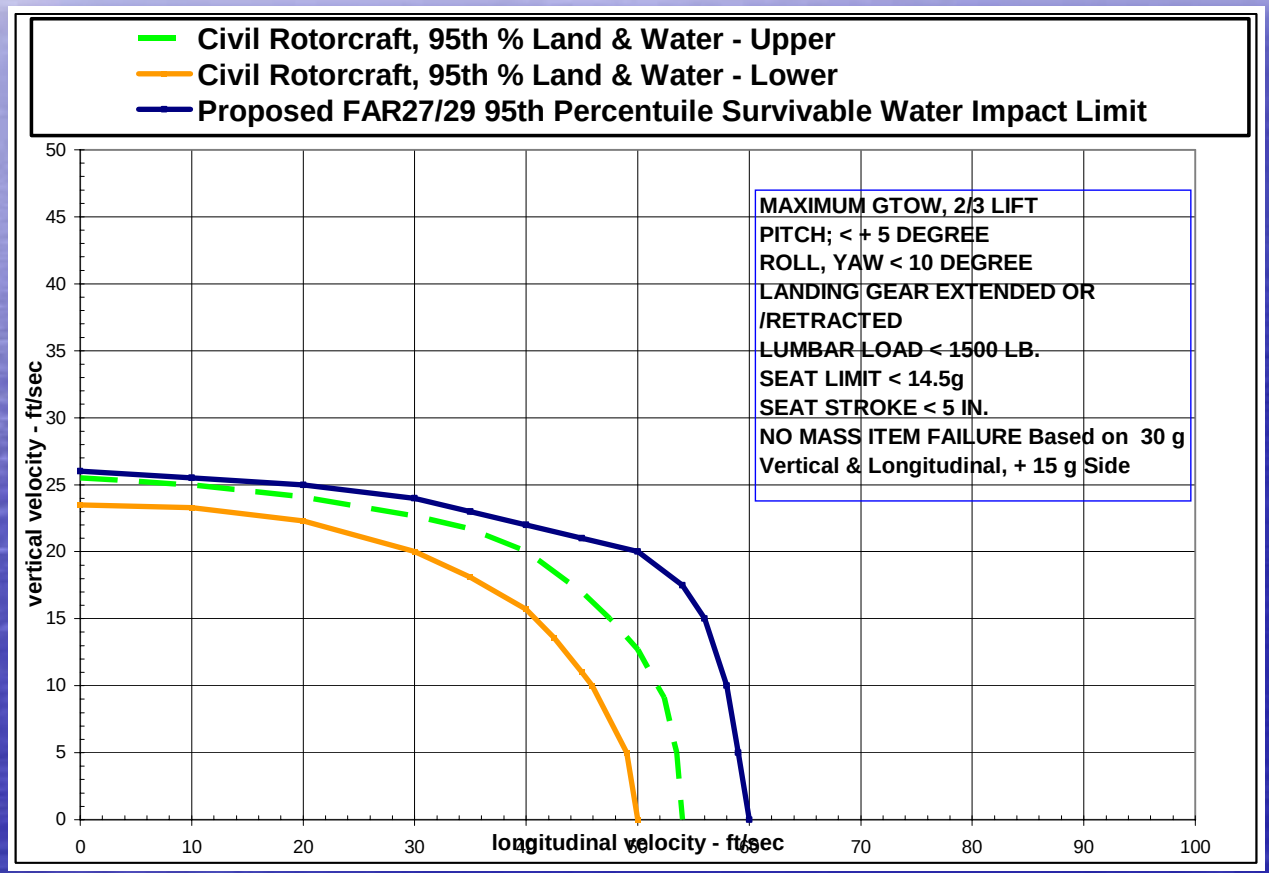
WATER IMPACT DLE PREMISE



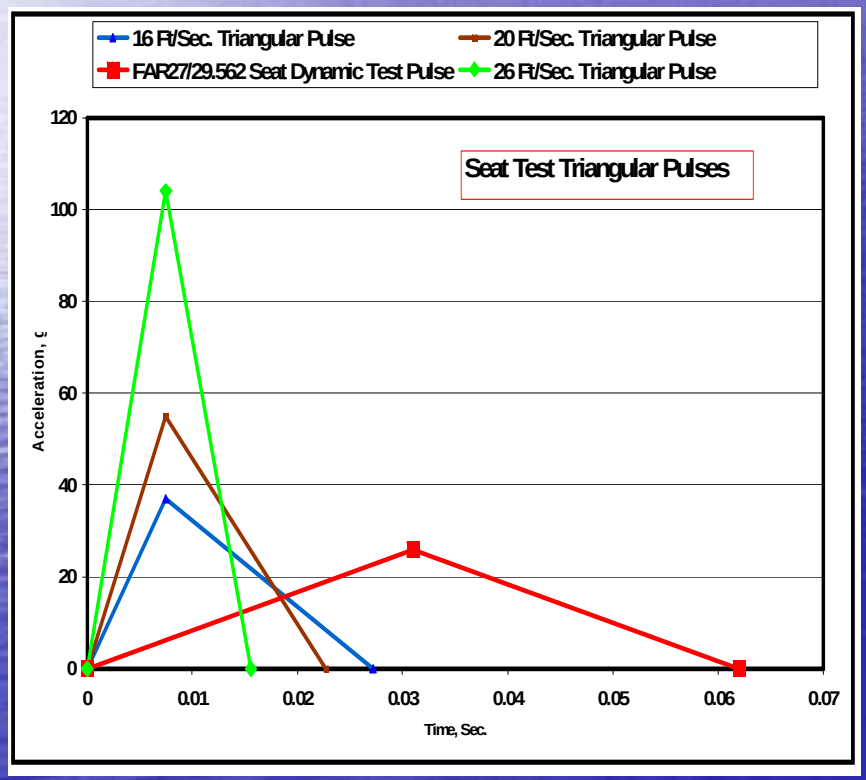
PROPOSED FAR27/29.563 DITCHING DLE

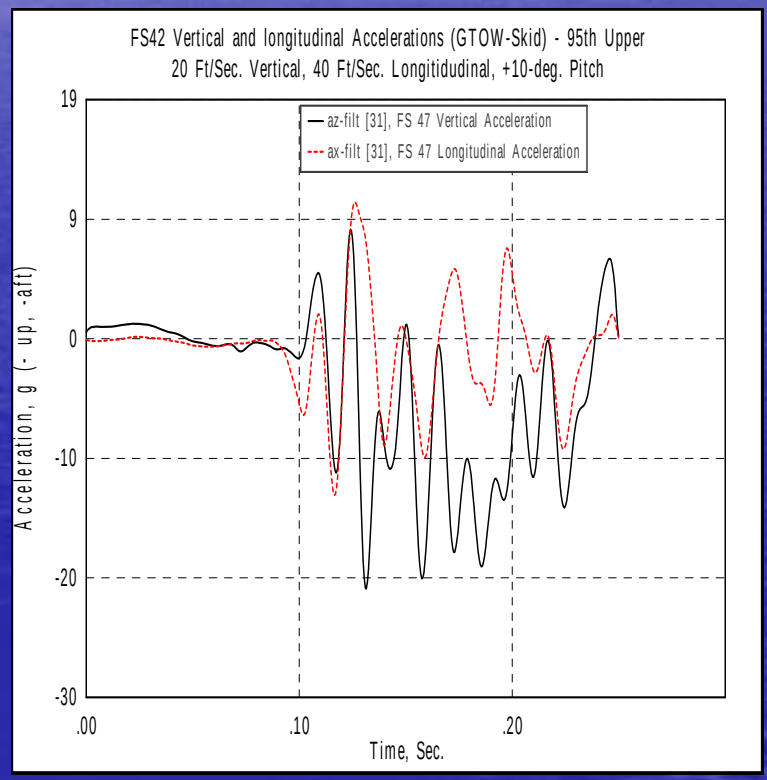


PROPOSED FAR27/29 95th PERCENTILE



FLOOR ACCELERATIONS – DITCHING & WATER IMPACT



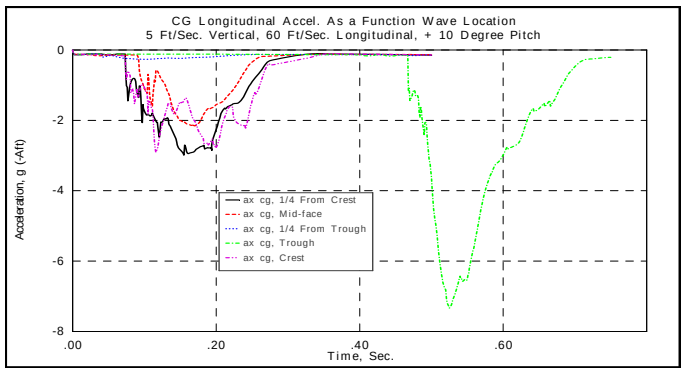


VERTICAL IMPACT

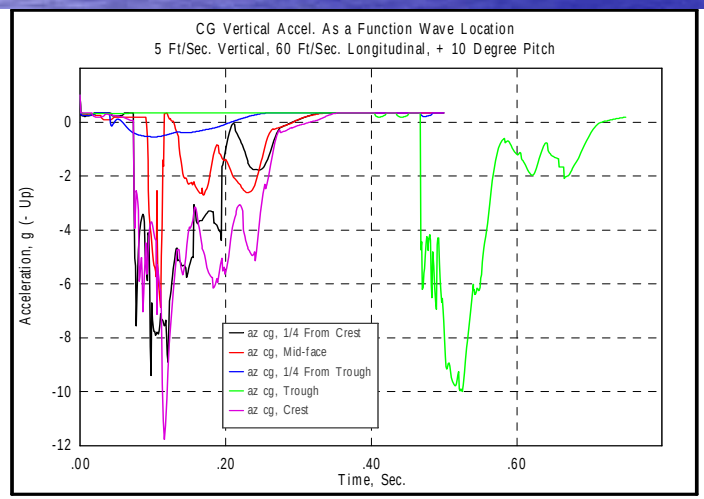
COMBINED VERTIAL-LONG.

CG PULSES- DITCHING/WAVE

LONGITUDINAL- TRIANGULAR



Vel. change = 24 fps
Peak = 7.3 g
Time = 0.200 sec.
Tr = 0.040 sec.

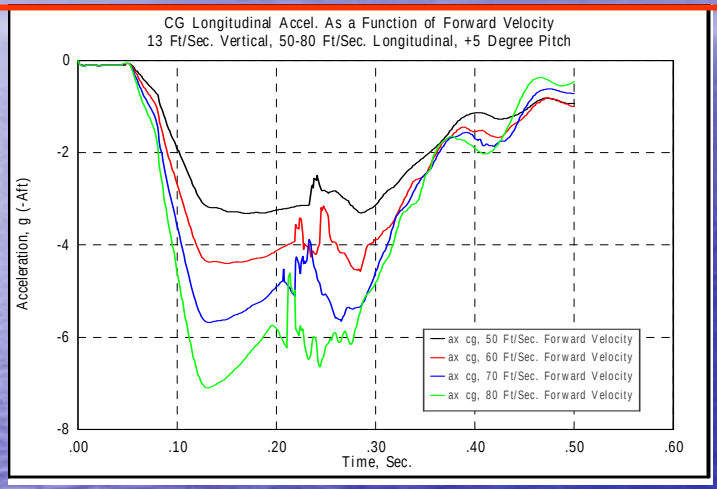


Vel. change = 24 fps
Peak = 10.0 g
Time = 0.150 sec.
Tr = 0.040 sec.

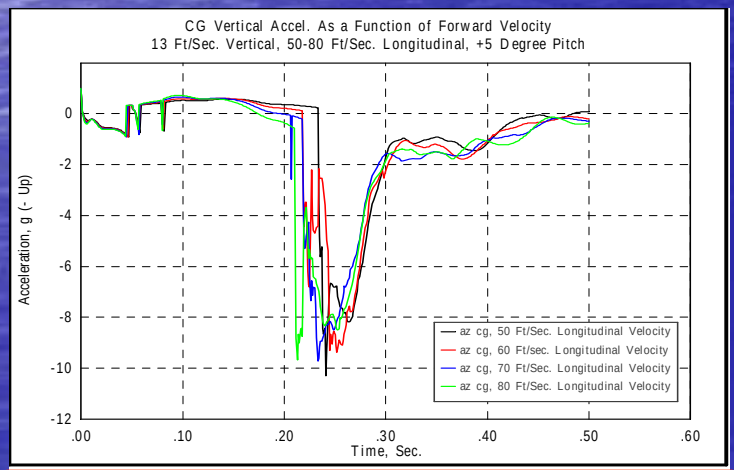
VERTICAL - TRIANGULAR

CG PULSE -WATER IMPACT

LONGITUDINAL-TRAPAZOID



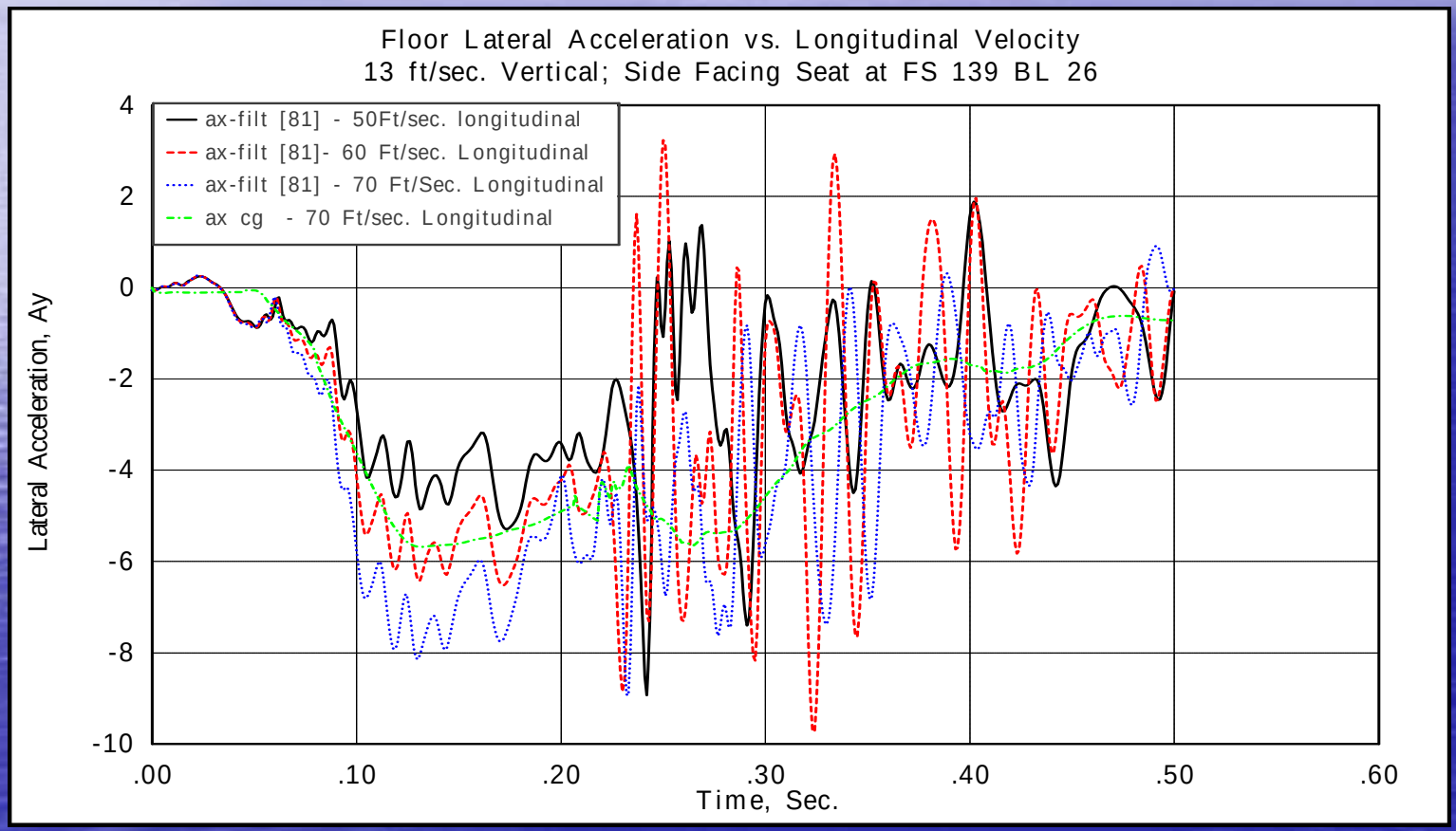
Vel. change = 55 fps
Peak = 5 g
Time = 0.440 sec.
Tr = 0.060



Vel. Change = 14.5 fps
Peak = 9.0 g
Time = 0.100 sec.
Tr = 0.060

VERTICAL-TRIANGULAR

FLOOR LATERAL ACCELERATION; FS 139 BL 26



CONCLUSIONS

- 500 ditching and water impact scenarios analyzed
- Design Criteria and DLE based on multiple considerations;
  - structure, occupant, restraint loads, sea state, impact conditions, float and underside design
- FAR27/29.563 Ditching Recommendations
- FAR27/20.562 Considerations
- DOT/FAA/AR-07/8" The Development of Ditching and Water impact Design Limit Curves For Civil Rotorcraft", May 2007

RECOMMENDATIONS

- 95th Percentile Water Impact Envelope
- Ditching Strength Envelope
- Floor Pulses Associated with Ditching and Water Impacts vs. 27/29.562
  - Floor & CG vertical, combined vertical-longitudinal, lateral