# Negative G Tolerance Limits:
# "Push-Pull" in Aerobatics

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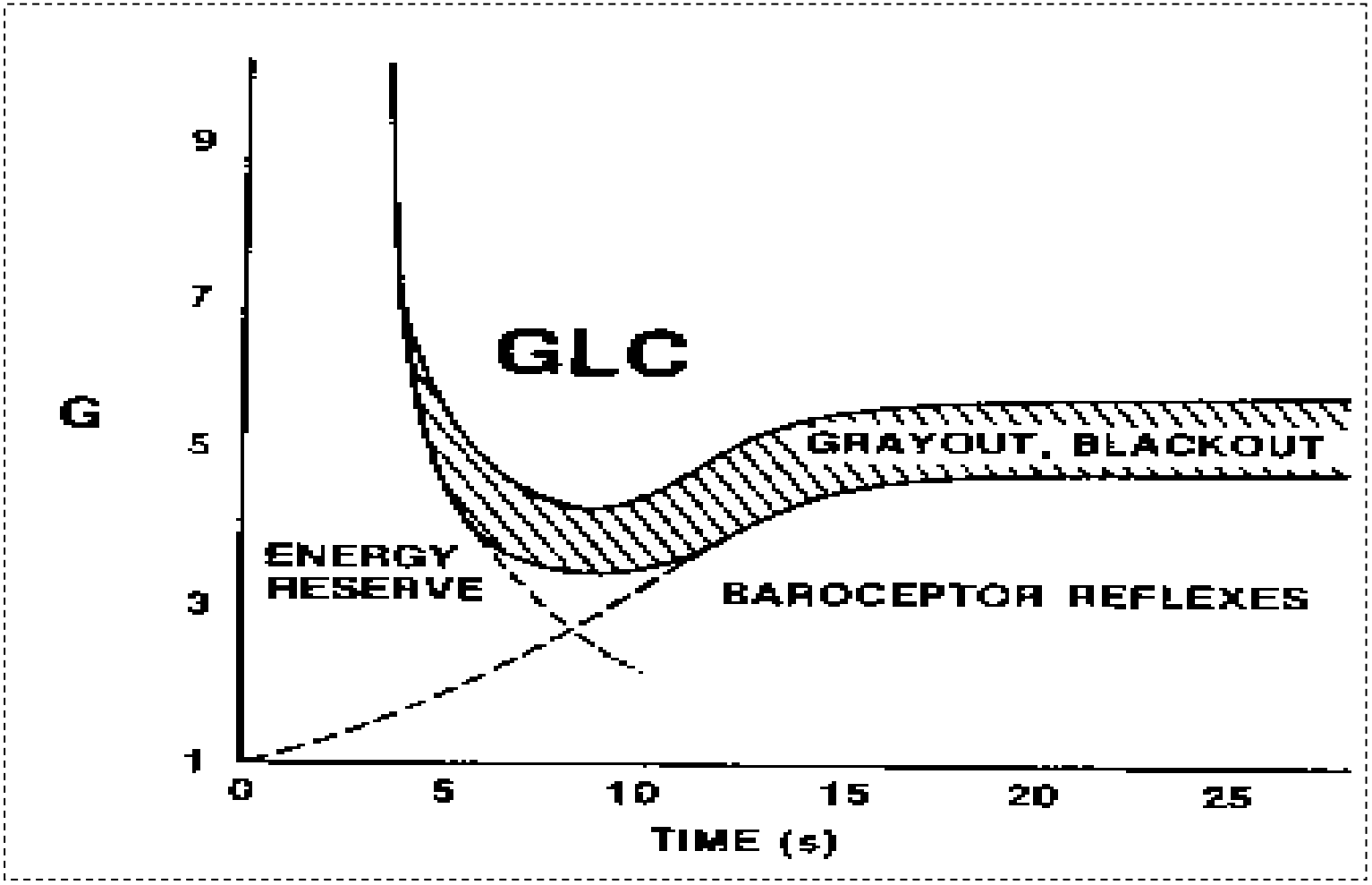
# Topics

- A Brief Review of $+G_z$ tolerance
- Effects of Previous - $G_z$ Exposure
- G Stress in Aerobatics
- Is GLOC Probable in Aerobatics?

# Stoll Curve of + $G_z$ Tolerance



# G Tolerance Decrements - Physiology

- Centrifuge
  - *practiced, young, select, motivated volunteers*
  - *optimal, relaxed tolerance*
- Reduced Tolerance from
  - Reduced CO or TPR, or increased capacitance
    - Dehydration
    - Drugs: -0.3$G_z$ from captopril
    - Cardiac Contractility or Control Abnormalities
    - High ambient temperatures

# Effects of Previous Negative G Exposure

- "Normal" +$G_z$ tolerance begins from stable, 1 G state
- Actually baseline of ~ +1.4 $G_z$ on centrifuge
  - Elevates resting HR in studies
- But…preceding exposure to < +1.0$G_z$ lowers subsequent tolerance
- Known for decades…rediscovered and studied

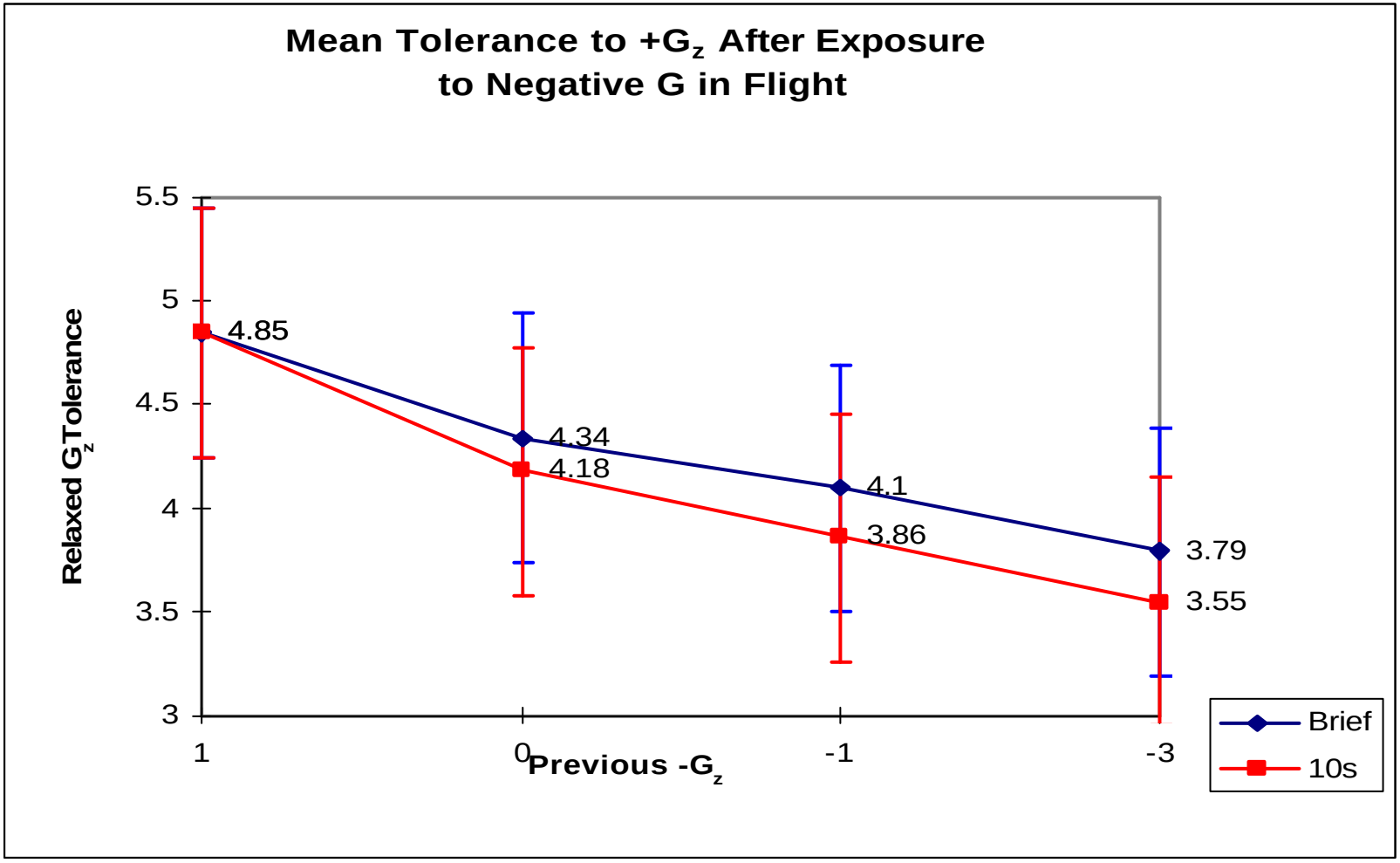
# GLOC Accidents from "Push-Pull"

- RCAF
- USAF
- Other military
- Civilian Aerobatic?

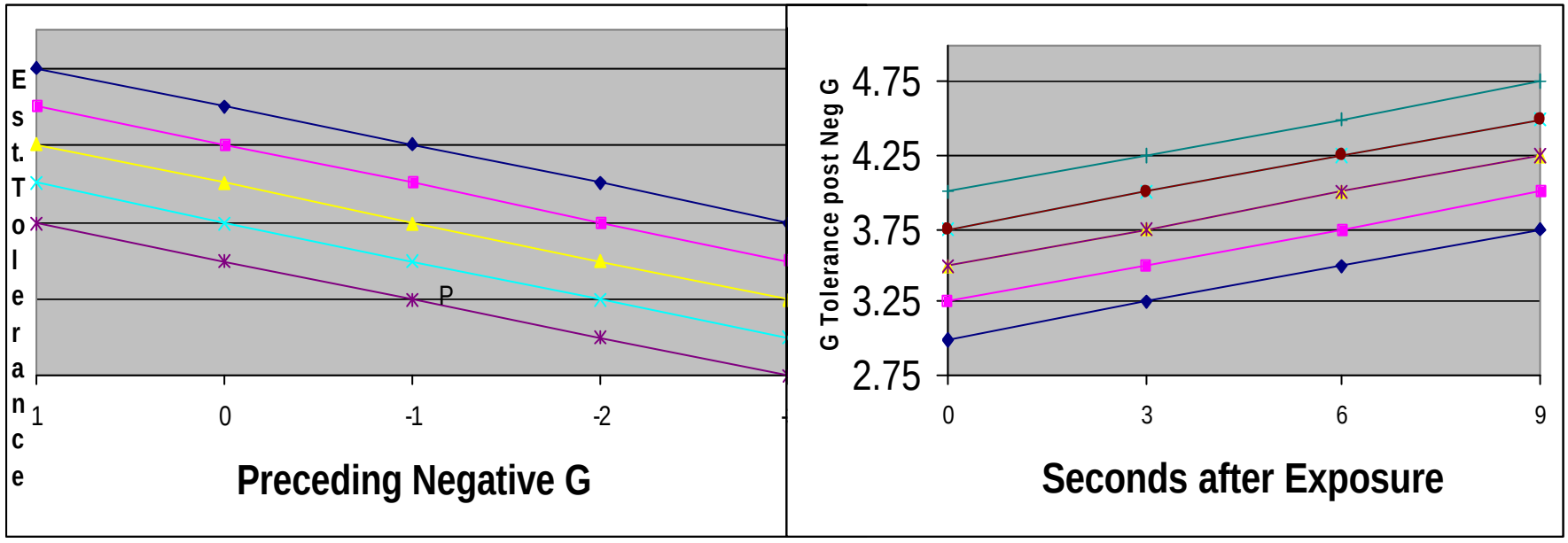
# Studying Negative $G_z$ Effects

- Centrifuge: only a few have 2-3 d.f.
  - Wright-Patterson, Königsbruck
- Aircraft - ideal (?)
- Horizontal Table studies
  - Participant supine on rotating centrifuge arm
  - Head at center of rotation, feet out = **+$G_z$**
  - Move participant out along radius of turn, head first = **-$G_z$**

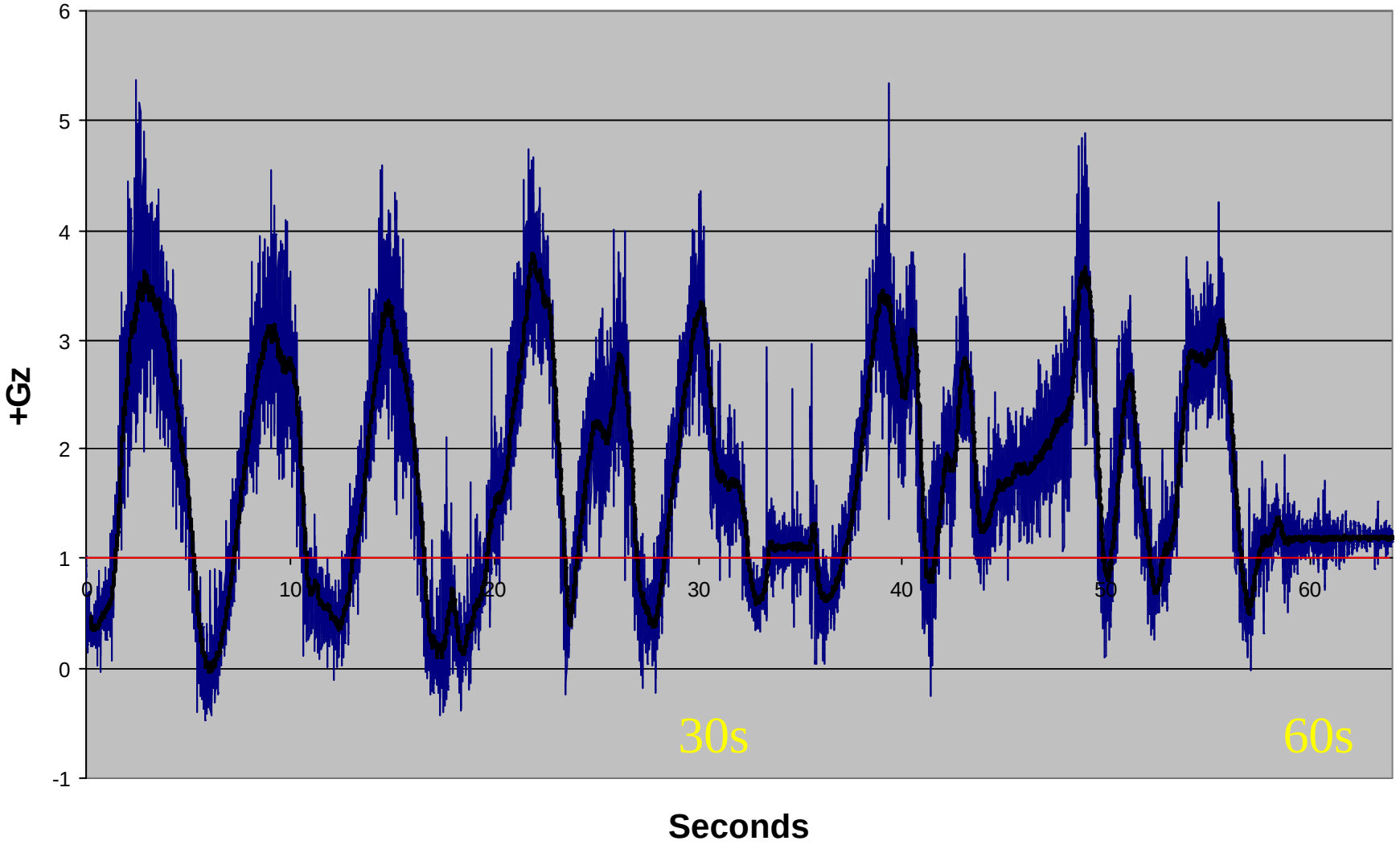
# Preceding Negative G

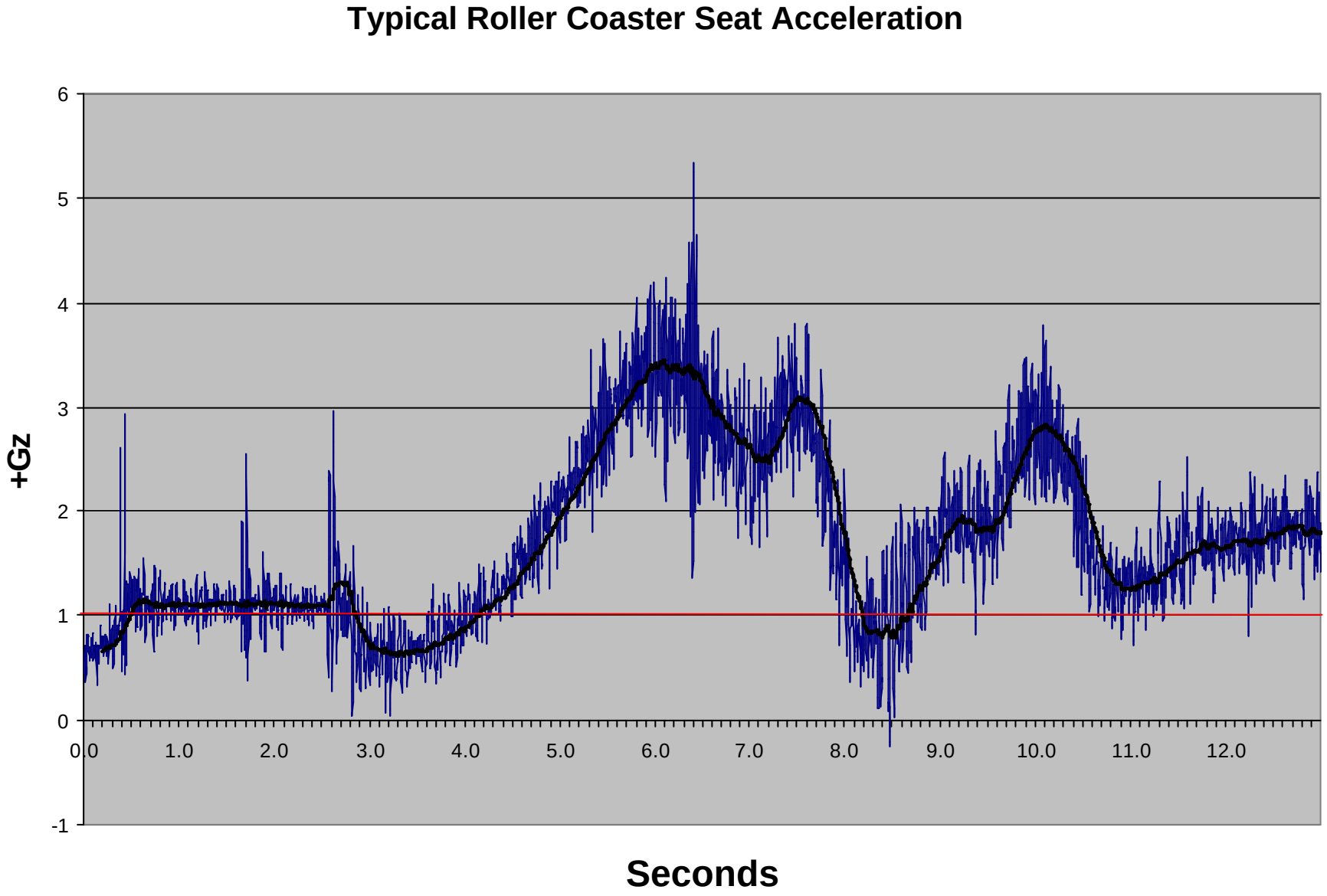


# Negative to Positive G Prediction Nomogram



## Typical Roller Coaster Seat Acceleration

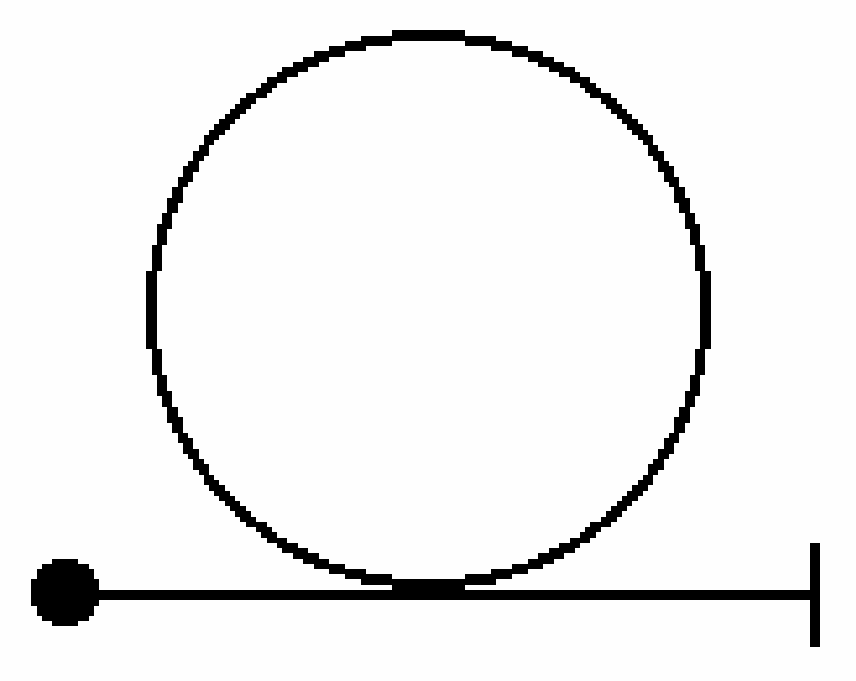



Typical Roller Coaster Seat Acceleration
+Gz
6
5
4
3
2
1
0
-1
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
Seconds

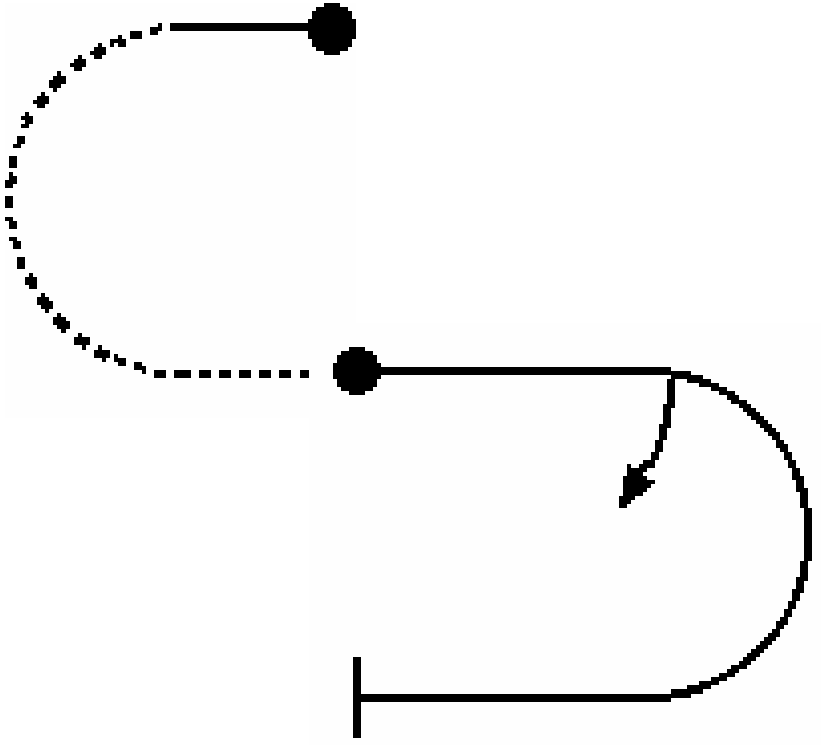
# G Stress During Aerobatics

- 1-20min  of Varying + and - $G_z$
- Warm Environments... Usually
- No G protection
- AGSM Training…???

# Loop



# English Bunt - Split S



# Conclusions

- Aerobatics impose negative to positive $G_z$
- Duration of negative and positive $G_z$ may approach limits
- No pathophysiological effects of GLOC in *centrifuge* participants.
- Aerobatic pilots are not relaxed.
- GLOC Potential exists.
- Research, Training Needed.