

Publications

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APPLICATION OF BIOINSTRUMENTATION IN DEVELOPING A PRESSURE SUIT FOR SUBORBITAL FLIGHT

COMPUTING IN CARDIOLOGY CONFERENCE,
VANCOUVER, 11 – 14 SEPTEMBER 2016

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Applied Aviation Sciences Department

Embry-Riddle Aeronautical University



EMBRY-RIDDLE
Aeronautical University™
DAYTONA BEACH, FLORIDA

EMBRY-RIDDLE'S U-2 SUIT

- Minimal stowage profile
 - Medium weight (~15 kgs)
 - 12 sizes: this is a S – Long – anyone 172cm and under fits in this
 - Donning/doffing requires suit-tech
 - Low-cost – it was free! (Normal cost: \$300,000)
 - Active, air-flow based cooling
- Inspection cycle: every 150 hrs
- 6 layers: underwear, comfort liner, ventilation layer, double-walled gas container, restraint layer, and
 - Fypro-fabric exterior cover: *old gold*. Designed for comfort, visibility, and mobility – and Space!



FINAL FRONTIER DESIGN SUIT

- Effective range of motion
- Minimal stowage profile
- Lightweight – about 8 kgs)
- Adjustable sizing
- Operating pressure up to 5 psid
- Fast donning/doffing
- Low cost: \$100,000
- Active airflow based cooling
- Adaptable to various air pressures
- Designed for comfort and mobility



TESTING AND DEVELOPMENT

- Comfort (unpressurized)
- Visibility
- Mobility (unpressurized)
- Valsalva



TESTING AND DEVELOPMENT

- Wind loading protection
- Flotation provision
- Ease of donning/doffing
- Tactility



TESTING AND DEVELOPMENT

- Oxygen breathing system
- Comfort (pressurized)
- Leakage (pressurized)
- Structural integrity



TESTING AND DEVELOPMENT

- Impact and penetration protection
- Water immersion protection
- Slow Onset Hypoxia



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BIOINSTRUMENTATION

SPECIFICATIONS

HR Range:	25 – 240 BPM
BR Range:	4 – 70BPM
Temp Range:	10 – 60°C
Acc Range:	±16g
Charge Cycles:	300 ¹
Transmit Range:	To 100m ²
Frequency:	2.4 – 2.4835GHz
Output Power:	+10dBm
Garment Washes:	80

OPERATING LIMITS:

Temperature:	-10 – 50°C
Humidity:	5 – 95%



- Heart rate, inc. R-R & ECG data
- Breathing Rate
- Accelerometer data
- Posture indication
- Skin temperature
- Internal logging of all major parameters
- ROG subject status



BIOINSTRUMENTATION



BioRadio:

- Spirometer
- Surface Temperature Sensor
- Hand Dynamometer
- ECG data
- Blood Pressure
- Pulse Oximeter

BIOINSTRUMENTATION



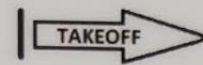
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UNUSUAL ATTITUDE PROFILES

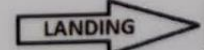
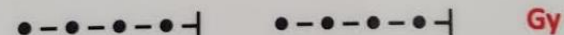
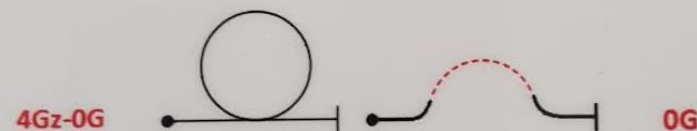
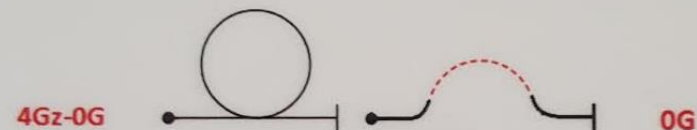
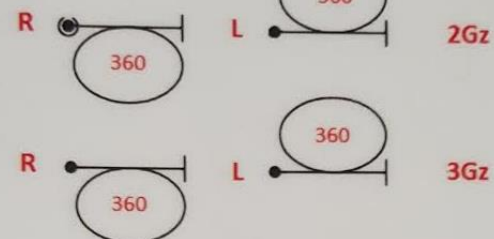


PATTY WAGSTAFF

AEROBATIC SCHOOL



Gx



-Gx

Max
A/C

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ARRHYTHMIAS

- Arrhythmias defined as follows:
- Sinus arrhythmia (SA) - R-R interval varying by more than 0.16 s between successive beats
- Repeated premature atrial contraction (PAC) - three or more successive but not continuous PACs
- Ventricular tachycardia (VT) - three or more successive ventricular ectopic beats.

Sinus Arrhythmia



Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
Usually 60-100 bpm	Irregular	Before each QRS, identical	.12 to .20	<.12

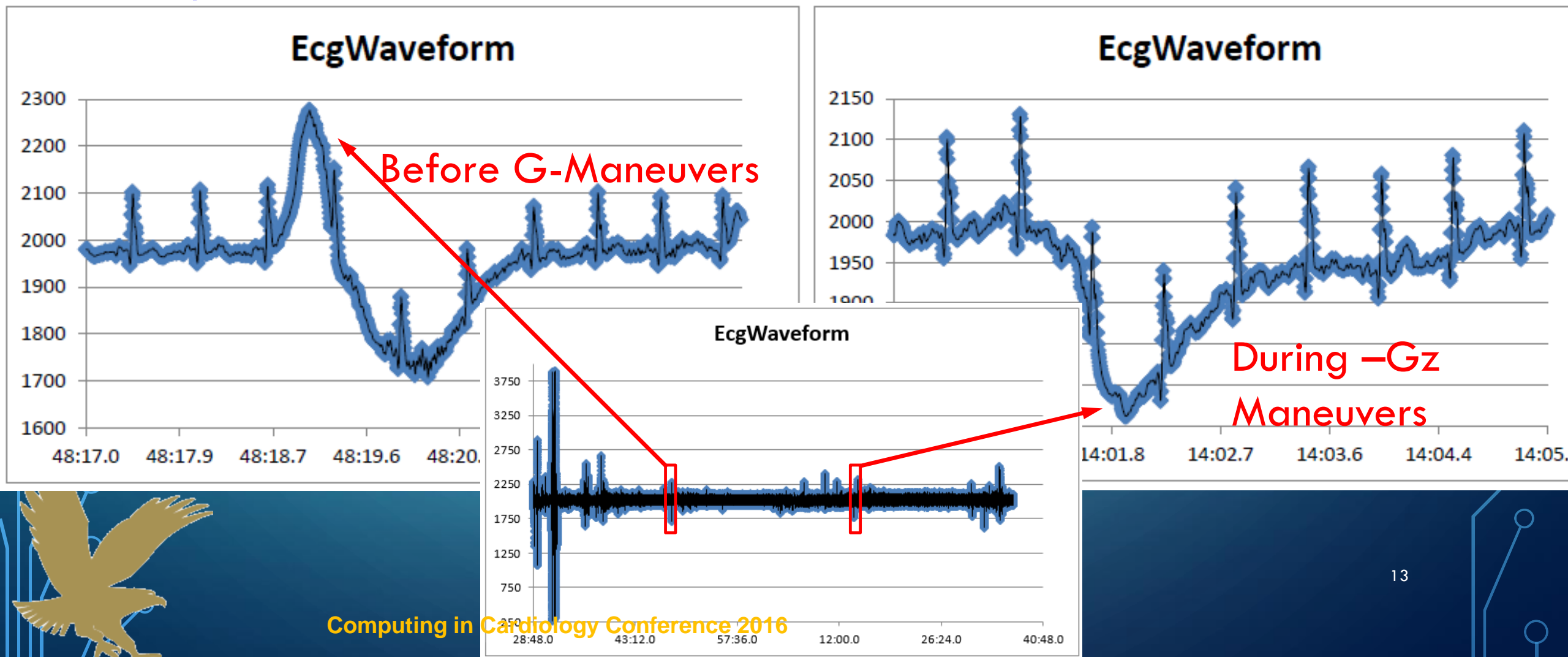
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RESULTS

- Some results from PoSSUM 1502, 1503, 1601 campaigns.

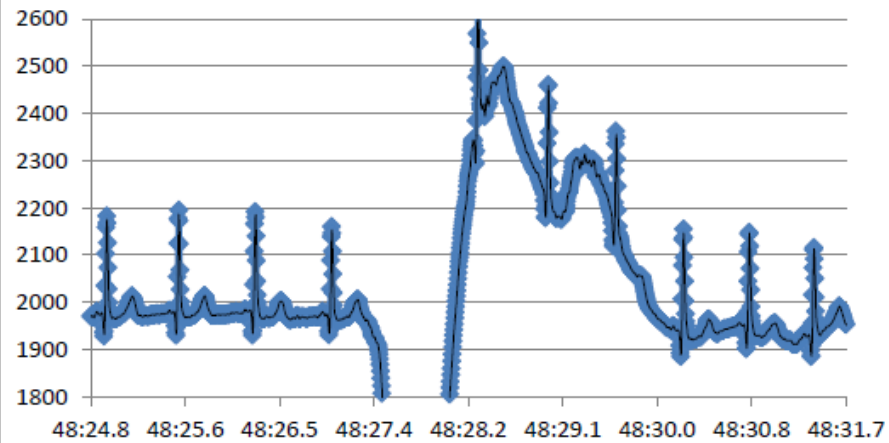
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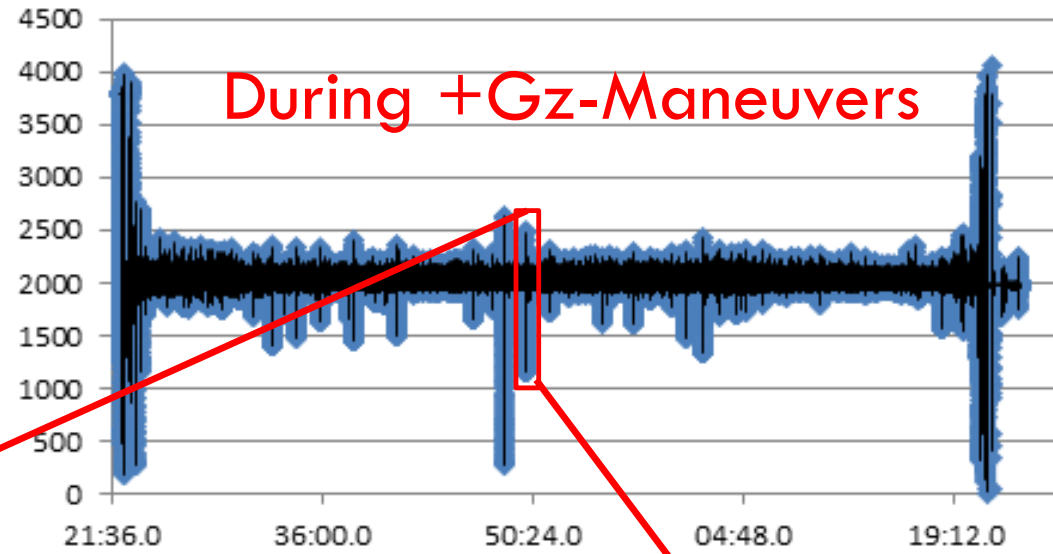
RESULTS

Participant 2:

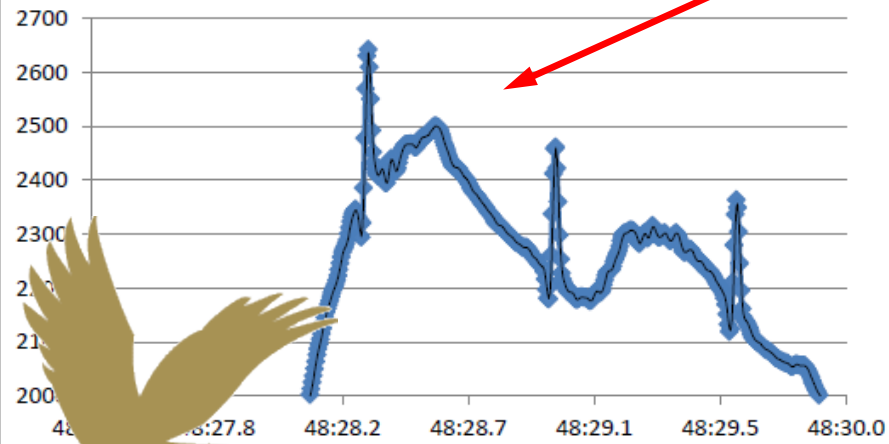
EcgWaveform



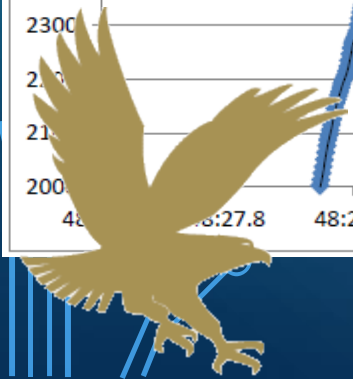
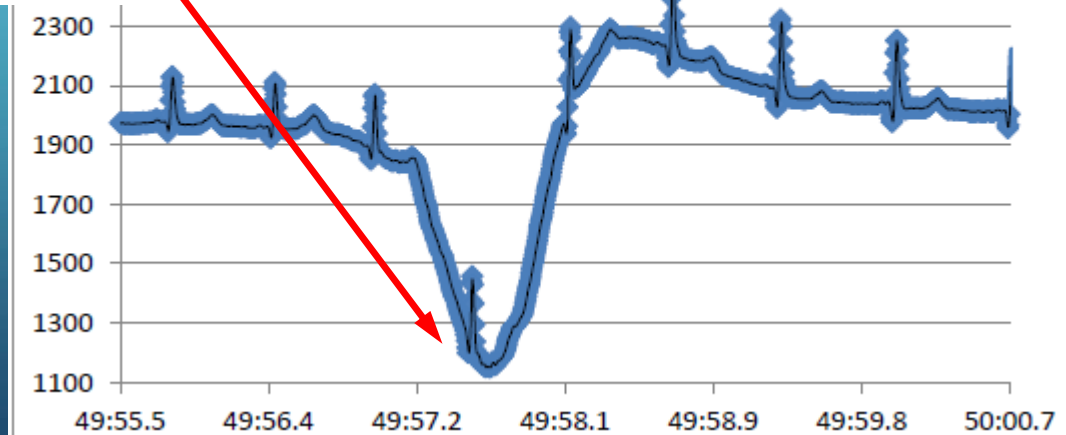
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EcgWaveform

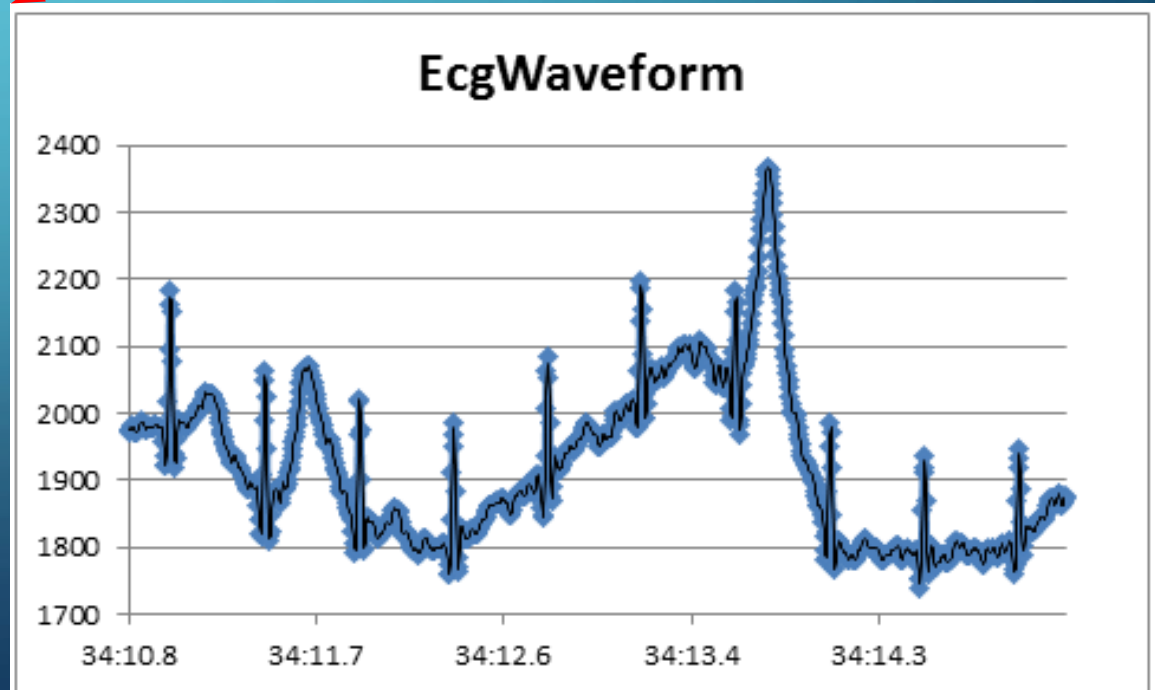
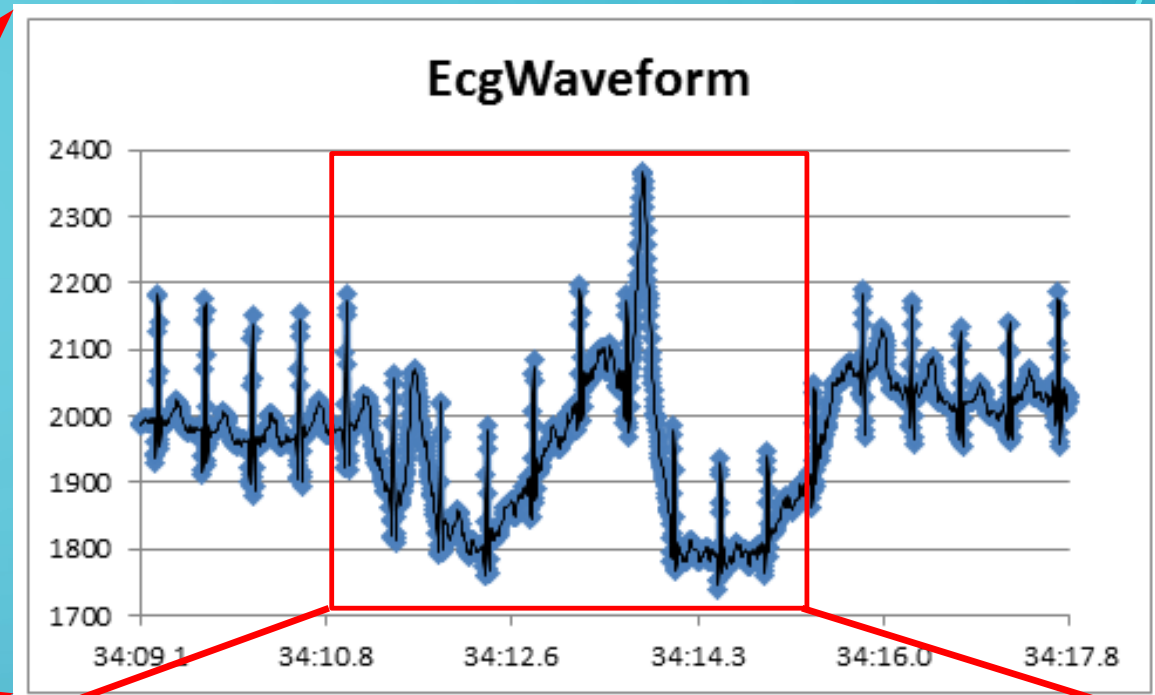
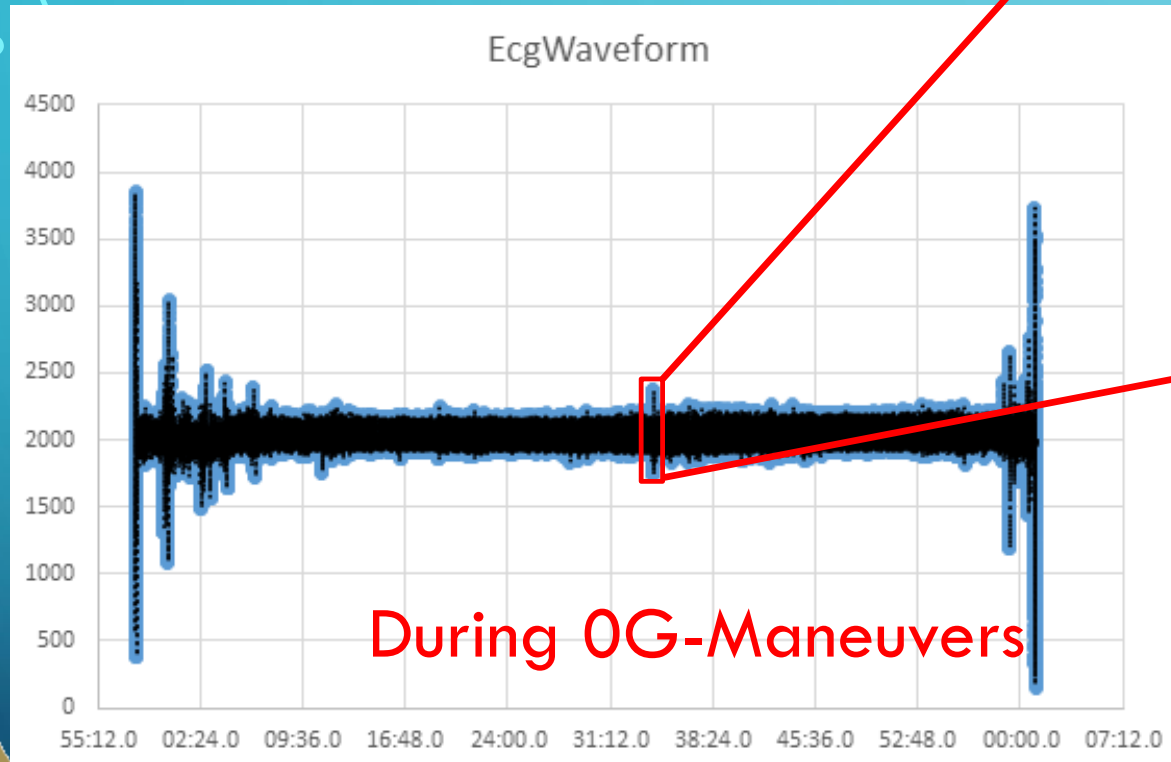


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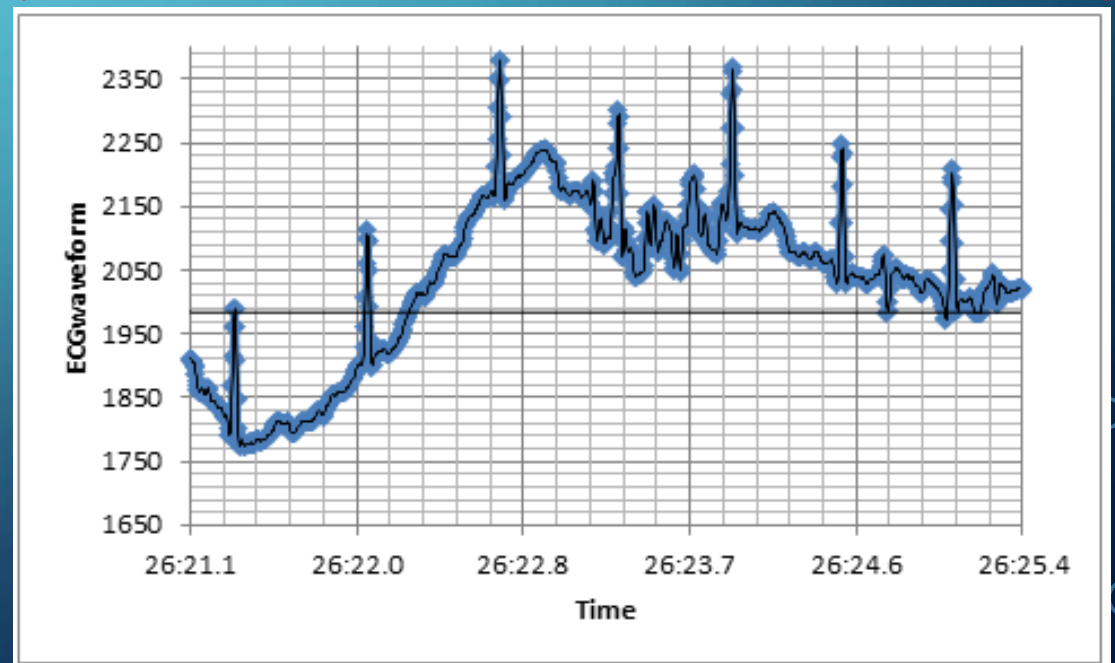
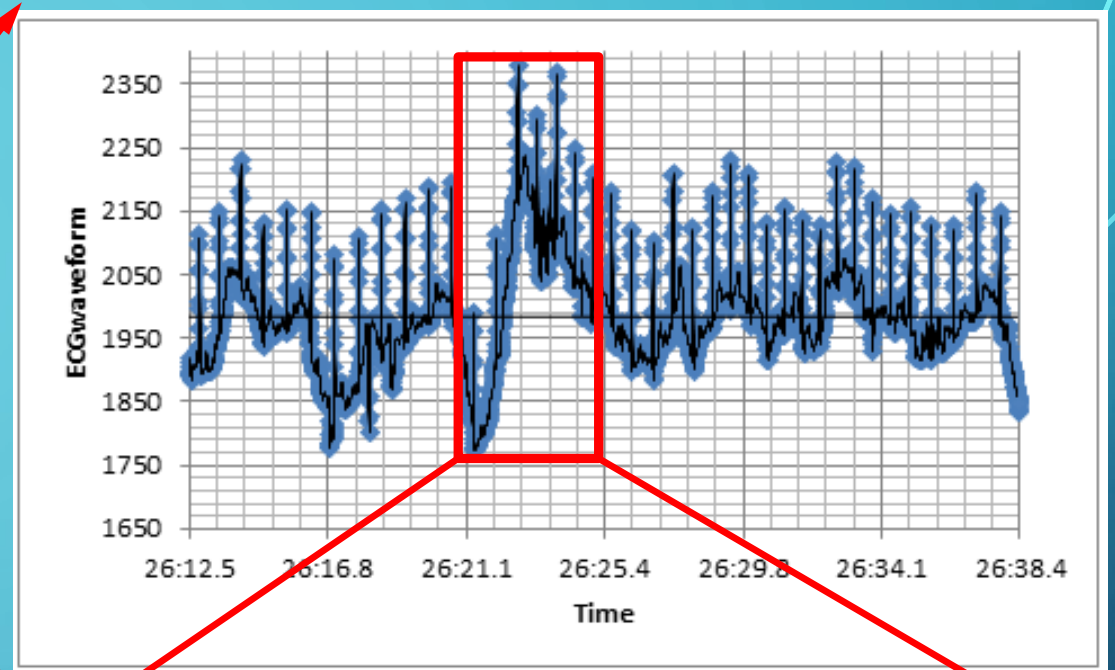
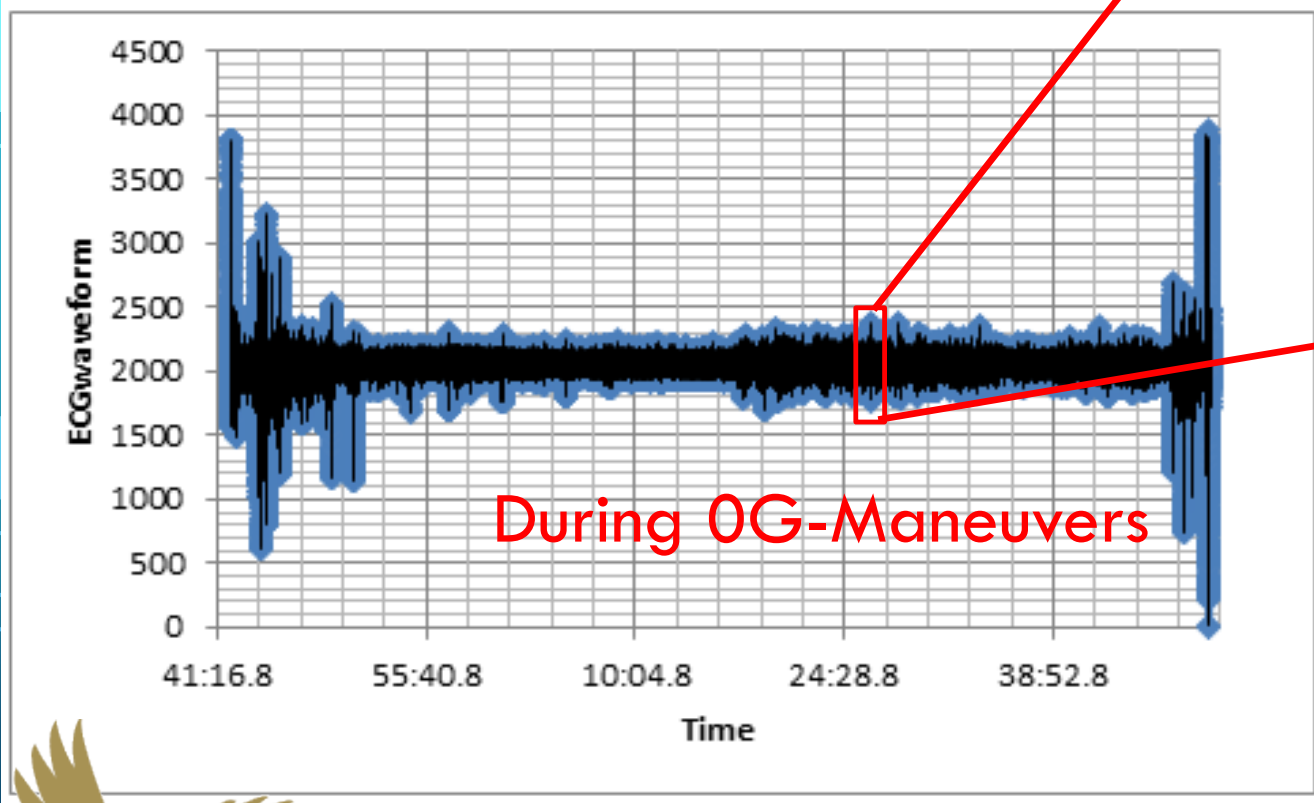
RESULTS

Participant 3:



RESULTS

Participant 4:

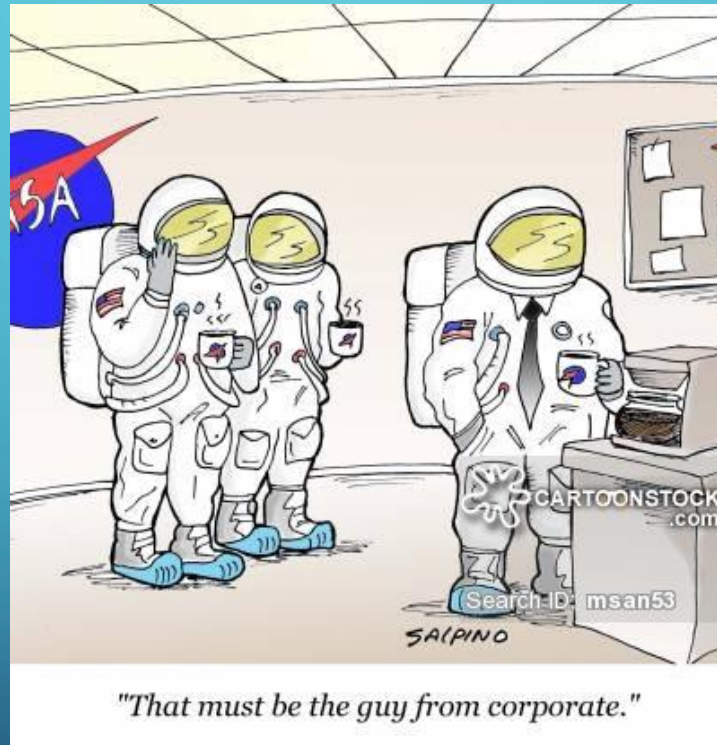


RESEARCH

- No G-LOC observed
- SA has often been recorded after high-G stress when heart rate is returning to normal from a more rapid rhythm. Some pilots showed marked respiratory arrhythmia even before undergoing high-G stress
- In the Low grading system for ventricular ectopy (used to express the severity of PVC) (5), arrhythmias of grade 3 or more are considered clinically severe.
 - Presence of paired PVC (5% of our subjects) is classified as grade 4a (physiologic response to high-G stress during G-training).



QUESTIONS?



"That must be the guy from corporate."

