First Technology Safety Systems

Design Freeze Status

FLEX-PLI-GTR Development
Optional Instrumentation

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Comments addressed from Design Freeze meeting
February 20th 2008, JARI, Tsukuba, Japan
Update March 27th, 2008
Content

- Scope of the project
- Potential options and priorities for optional instrumentation
- On Board Data Acquisition packaging
- Computer Aided Engineering model
Project Scope

• Options should not make the standard version more expensive/complicated

• Standard instrumentation will meet all specifications
  – Purpose Regulatory Testing

• Versions with options may not meet all specifications
  – Purpose Research & Development Testing

• It may not be feasible to achieve all options simultaneously

• In the next phase we will concentrate on the standard design
  – Complete options design is outside the scope of this project
  – Optional Instrumentation design will be executed based on customer requests
<table>
<thead>
<tr>
<th>Channel</th>
<th>Purpose</th>
<th>Standard</th>
<th>Option</th>
<th>DAS</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur moment 1, 2 and 3</td>
<td>Calibration</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibia moment 1, 2, 3 and 4</td>
<td>Injury</td>
<td>4</td>
<td>0</td>
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<td>Tibia top acceln ax</td>
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<td>-1</td>
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<tr>
<td>MCL elongation</td>
<td>Injury</td>
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<tr>
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<td>Calibration</td>
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<tr>
<td>PCL elongation</td>
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<tr>
<td>LCL elongation</td>
<td>Calibration</td>
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<tr>
<td>Tibia top acceln ax, ay, az</td>
<td>Motion</td>
<td>0</td>
<td>3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Femur bottm acceln ax, ay, az</td>
<td>Motion</td>
<td>0</td>
<td>3</td>
<td></td>
<td>1</td>
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<tr>
<td>Tibia angular rate ωx, ωy, ωz</td>
<td>Motion</td>
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<td>3</td>
<td></td>
<td>2</td>
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<td>Femur angular rate ωx, ωy, ωz</td>
<td>Motion</td>
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<td>2</td>
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<tr>
<td>Femur top acceln ax, ay, az</td>
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<tr>
<td>Tibia bottom acceln ax, ay, az</td>
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<td>3</td>
<td></td>
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<td>Segment acceln ax</td>
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<td>15</td>
<td>Lab</td>
<td>4</td>
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<td><strong>Total</strong></td>
<td></td>
<td><strong>12</strong></td>
<td><strong>32</strong></td>
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</table>
Summary

On board pending feasibility
3 axis damped accelerometer
3 axis angular velocity sensor

Off board
Attachment place for 3 axis damped accelerometer
Attachment place for 1 axis damped accelerometer
On Board Data Acquisition Systems

- High priority
- ‘Standard’ option
- Improve free flight motion control
- Packaging space is optimized, though still limited
  - Potential solutions meet packaging space

http://www.e-sensing.com/

http://www.messring.de/
Options Packaging Space

Packaging DAS, battery, wiring, connectors, auxiliaries, etc.
Tibia and Femur Knee Part

Measurement Specialties M68C Endevco 7268C
DTS Angular Rate Sensors
Alternative Sensors in Knee
Triax and Angular rate sensors

• This idea is limited to the femur
• Calculate tibia motion from MCL, ACL, PCL
Triax accelerometer
Distal Tibia (shown) and Proximal Femur

Measurement Specialties M68C or Endevco 7268
Single axis accelerometer
x-direction each segment

- Dedicated nylon segment for optional accelerometer
- Threaded metal insert
- Kyowa ASE, Measurement specialties M62, Endevco 7264
Option CAE model development

- FTSS proposes to develop a Flex-PLI-GTR CAE model through a consortium project parallel to the hardware development
- FTSS offers to take the responsibility to develop the models and co-ordinate the project
- The model(s) will become part of the FTSS model database and will be maintained and further enhanced accordingly
- The consortium members will fund the consortium project and will receive a free license allowing to use the model in the next 3 years
DTS-ARS – The Next Generation in Angular Rate Sensors

The DTS-ARS is the latest in intelligent design from DTS. With ranges as high as 12,000 deg/sec, these incredibly small and lightweight sensors have a remarkable DC to 2,000 Hz bandwidth. Suitable for many automotive, aerospace, and industrial twelve applications, the DTS-ARS can also be used inside machined test dummies for precise measurements of head rotation, thorax rotation and other biodynamic measurements. Re-calibration services are available.

Applications:
- FMVSS 202a and rollover crash testing
- Side curtain deployment development
- Component testing
- Biodynamic research testing

DTS-ARS triax package with DTS mounting block
7.6 x 10.2 x 14.0 mm
<3.6 grams

DTS-ARS Specifications

<table>
<thead>
<tr>
<th>Range and Frequency Response</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bandwidth</strong> (Hz)</td>
<td><strong>Noise</strong> (rms full scale)</td>
</tr>
<tr>
<td>300 (5.2)</td>
<td>DC to 100</td>
</tr>
<tr>
<td>1500 (26.2)</td>
<td>DC to 1000</td>
</tr>
<tr>
<td>12000 (209.4)</td>
<td>DC to 1650</td>
</tr>
</tbody>
</table>

**Electrical**
- Excitation: 4.95 to 14.00 VDC; output not proportional to excitation
- Current: 6 mA nominal
- Zero Output: ±200 mV
- Full Scale Output: ± 2 V nominal

**Performance**
- Cross axis sensitivity: <1.0%
- Linearity: <0.5% full scale
- Influence of linear acceleration: 0.2 deg/sec/g
- Drift: 0.1 deg/sec/sec

Enclosure: Anodized aluminum
- Size: 0.3 x 0.4 x 0.58 inches
- Mass: <3 grams
- Shock: 2000 G, any direction

Cable:
- 2-conductor, 28 AWG
- Overall shield isolated from enclosure
- Standard 25 ft (8.3 m)
- Color code:
  - Black: +Excitation
  - Red: -Excitation
  - Green: +Signal
  - White: -Signal

Temperature Range:
- -40 to +85°C

Humidity:
- 99%, non-condensing

Connector:
- LEMO or other installed per request

Dallas 10:
- Installed in connector

Specifications may be revised without notice.

A six-axis package is easily obtained by taking the DTS-ARS triax package shown above and mounting three standard Endevco 7264 or MSF14 accelerometers.
Design frozen!