Score Sheet. 600.445 Homework #1 – Fall 2012

Name: ______________; Email: ______________
Name: ______________; Email: ______________

<table>
<thead>
<tr>
<th>Question</th>
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<td>Total</td>
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<td></td>
</tr>
</tbody>
</table>

I/we worked _alone_ on this assignment and followed all other guidelines:

__________________________  ______________________
signature                    date

__________________________  ______________________
signature                    date
1. I would really appreciate typed, double spaced and READABLE output that is firmly attached together. Sketches can of course be hand drawn. I am not looking for beauty, just legibility and room to mark them up. Generous margins are also nice.

2. **Put your name and email address** on each sheet and number the sheets.

3. Attach the grade sheet as the first sheet and attach all sheets together.

4. You must include a self-addressed, seal-able 8 ½ x 11 inch envelope if you expect to the homework to be returned (per JHU’s interpretation of FERPA).

5. You should work in teams of two on this exercise. In many future problems you will be asked to work alone, but you may do this one together.

6. You are encouraged to make free use of any published materials, the web, etc. in developing your answer but a) you must give full and proper citations to any references consulted and b) you may not consult, discuss, or otherwise communicate about this assignment with any human being except your lab partner, the course instructor, or the TAs.

7. I do not expect truly expert answers at this point, nor am I expecting a great deal of clinical expertise beyond that included in the referenced book chapters. The main purpose of this exercise is to get you thinking analytically about the relationship between systems, application needs, and technology.

8. Note that Homework #2 will be a continuation of this assignment.
Total Knee Replacement Surgery

- Consider the problem of Total Knee Replacement surgery, which was discussed in class. This problem will provide the context for this homework assignment.
- A typical implant system is shown on the next slide. This is a Zimmer system.
- The standard way of preparing the femur and tibia for TKR is to affix guide blocks to the bones and then use these blocks to guide a saw blade in making cuts.
- In class we discussed several robotic solutions:
  - Robodoc – register & machine bone autonomously
  - Acrobot/Mako -- register & machine with cooperative control
Illustrations: Zimmer, Inc.
Some useful web links

• Acrobot: http://www.acrobot.co.uk
• Mako: http://www.makosurgical.com
• Robodoc: http://www.robodoc.com
• Blue Belt: http://www.bluebelttech.com
• Zimmer: http://www.zimmer.com
Closed Loop Interventional Medicine

**Information**

Patient-specific Information
- Images, lab results, genetics, etc.

General information
- Anatomic atlases, statistics, rules

**Process Loop**

**Patient-specific loop**

Model → Plan

**Patient-specific Evaluation**

**Statistical Analysis**

Action
Question 1: System discussion

• Develop system block diagrams & a step-by-step procedural flow for two robotic solutions (Robodoc, Mako/Acrobot) showing how these systems fit the paradigm of closed-loop interventional medicine. Your discussion should make clear what information is needed at each stage, how this information is used, and what the output is. **Note:** You can treat Mako & Acrobot as equivalent for this purpose.

• You should also discuss what the system does and what the surgeon does at each stage.

• You should also discuss major similarities and differences between the various systems.
Question 2 – Evaluation criteria

Develop an outline for evaluating alternative approaches to a surgical system or application, including such factors as “cost”, “safety”, “effectiveness of pain relief”, “accuracy”, “time”, etc. For each such criterion, include:

A. **Short** definition or explanation of the criterion
B. **Short** discussion of how that criterion should be assessed (e.g., units of measure, means of gathering information)
C. **Short** discussion of how important each criterion is to each relevant group affected (patient, surgeon, hospital administrator, insurance company, employer, etc.)

It is strongly recommended that your answer include a tabular summaries, with additional notes as needed if things don’t fit conveniently into boxes. See example on next pages, which is being written on the airplane, which may influence things a bit.
### Example: Air Transportation

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Definition</th>
<th>Measurement methods (note that different measurements may affect different groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trip Price</strong></td>
<td>Price to the consumer for a ticket from A to B</td>
<td>Dollars</td>
</tr>
</tbody>
</table>
| **Trip Cost**       | Cost to air line to fly passenger from A to B                             | Dollars per passenger mile  
Dollars per seat mile  
Dollars per seat mile  
Dollars per passenger trip |
| **Capital Equipment cost** | Cost                                           | Dollars – Note that the depreciation cost of the airplane is one factor that affects trip cost |
| **Trip time**       | The time it takes for the passenger to make a trip                        | Hours from door closed to door open  
Hours from boarding to debarkation  
Hours spent in airports |
| **Safety**          | Likelihood of encountering harm  
Likelihood of damage to equipment or property | Accident rates per seat mile  
Deaths / injuries per seat mile  
Near miss / incident rates |
| **Reliability**     | Likelyhood that the trip will be completed as planned.  
Likelihood of equipment failure | On time arrival and departure rates  
Equipment availability and failure rates  
Maintenance costs |
### Example: Air Transportation

<table>
<thead>
<tr>
<th></th>
<th>Passengers</th>
<th>Air Crew</th>
<th>Airlines</th>
<th>Airports</th>
<th>FAA/Regulators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trip Price</strong></td>
<td>High for family</td>
<td>Moderate to Low except as</td>
<td>Moderate: They want it high, but not</td>
<td>Low: They are happy so long as passengers and airlines use airport</td>
<td>Low: Not their problem</td>
</tr>
<tr>
<td></td>
<td>Moderate/low for business travelers</td>
<td>affects profits &amp; salaries</td>
<td>so high they lose business</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trip Cost</strong></td>
<td>Low: Except for indirect effect on price</td>
<td>Moderate to Low: Their salaries are costs</td>
<td>High: Affects profits</td>
<td>Moderate to low: except as affects own costs</td>
<td>Moderate to low: Some concern in cost of safety &amp; required changes</td>
</tr>
<tr>
<td><strong>Capital cost of planes</strong></td>
<td>Low: Don’t know. Fancy planes are nice to fly in, but…</td>
<td>Low: They don’t buy jets</td>
<td>Moderate to High: depends on airline &amp; other costs</td>
<td>Low: Not their business</td>
<td>Low: but see above</td>
</tr>
<tr>
<td><strong>Trip time</strong></td>
<td>Moderate to High depending on trip</td>
<td>Moderate to High depending on trip and traveler</td>
<td>Moderate to High: affects customers, costs, equipment utilization</td>
<td>Moderate: Mostly factors concerning gate turnaround</td>
<td>Low: Except as affects overall system</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>High: I would rather not be in a crash. Probably don’t look at near misses</td>
<td>High: They are in the plane too. Care about near misses</td>
<td>High: bad for business. Care about near misses</td>
<td>High: bad for business. Ground events are major concern</td>
<td>High: this is their job. Care a lot about near misses</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Moderate to High depending on trip. Primarily concerned as affects trip time.</td>
<td>Moderate to High: They are measured on this. Also greatly affects eqpt. &amp;crew scheduling; maintenance costs</td>
<td>High: Customer satisfaction. Also greatly affects eqpt. &amp;crew scheduling; maintenance costs</td>
<td>Moderate: Can affect gate use efficiency</td>
<td>High for safety related things. Moderate to High for air traffic efficiency concerns.</td>
</tr>
</tbody>
</table>
Question 3: Evaluating Current Practice

Produce tables evaluating each of the abovementioned methods using the criteria you have developed in Question 1. Include short explanations justifying your characterizations.

A. (5 points) Fixture blocks
B. (5 points) Robodoc
C. (5 points) Acrobot

Finally, if you had to choose between these approaches,

D. (5 points) which would you choose and why?
Question 4: Suggest alternatives

Briefly outline two distinctly different approaches (other than the ones analyzed above) to the problem of assisting a surgeon to perform TKR surgery. For each approach provide whatever narrative description and sketches you need to convey your concept, including information flow and procedural flow.

A. First alternative
B. Second alternative
Question 5: Evaluation

Evaluate both of your alternatives, using the same criteria used in Questions 2 & 3

A. First alternative
B. Second alternative

Finally,
C. Of all the alternatives discussed, which would you choose, and why
Question 6: Fleshing out the preferred embodiment

A. Based upon your analysis in Question 5, select one of your proposed system solutions for further design evaluation. For this design, provide an additional 2-3 pages total (discussion + sketches) outlining the technical approach. Your discussion should clearly define
   - Preoperative, intraoperative, and postoperative information needed.
   - How this information will be obtained.
   - Important components and human interfaces.
   - What components need to be developed.
   - What components (if any) need to be “invented”

B. Summarize the step-by-step procedural flow for your solution

C. Discuss the steps, timeline, and estimated resource requirements to implement your solution for clinical use
VERY IMPORTANT NOTE

• There are no “right” answers to this assignment. Mostly, I am encouraging you to think. Grading will be based on your analysis and reasoning.

• I do not want extremely long answers. At the same time, you should provide enough material so that we can understand your reasoning and evidence that you have thought seriously about the problem.