Thanks to Prof. Steve Easterbrook
University of Toronto

Requirements Prioritisation
Basics of Prioritisation

→ **Need to select what to implement**
  - Customers (usually) ask for way too much
  - Balance time-to-market with amount of functionality
  - Decide which features go into the next release

→ **For each requirement/feature, ask:**
  - How important is this to the customer?
  - How much will it cost to implement?
  - How risky will it be to attempt to build it?

→ **Perform Triage:**
  - Some requirements *must* be included
  - Some requirements should definitely be excluded
  - That leaves a pool of “nice-to-haves”, which we must select from.
A Cost-Value Approach

→ **Calculate return on investment**
  - Assess each requirement’s importance to the project as a whole
  - Assess the relative cost of each requirement
  - Compute the cost-value trade-off:

![Graph showing cost-value trade-off with three priority levels: Low, Medium, and High.](image)
A Cost-Value Approach

→ Calculate return on investment
  ⇣ Assess each requirement’s importance to the project as a whole
  ⇣ Assess the relative cost of each requirement
  ⇣ Compute the cost-value trade-off:

→ Two approaches:
  ⇣ Absolute scale (e.g. dollar values)
    ➢ Requires much domain experience
  ⇣ Relative values (e.g. less/more; a little, somewhat, very)
    ➢ Much easier to elicit
    ➢ Prioritization becomes a sorting problem
Some complications

→ Hard to *quantify* differences
   - easier to say “x is more important than y”…
   - …than to estimate by how much.

→ Not all requirements comparable
   - E.g. different level of abstraction
   - E.g. core functionality vs. customer enhancements

→ Requirements may not be independent
   - No point selecting between X and Y if they are mutually dependent

→ Stakeholders may not be consistent
   - E.g. If X > Y, and Y > Z, then presumably X > Z?

→ Stakeholders might not agree
   - Different cost/value assessments for different types of stakeholder
Hierarchical Prioritisation

- Group Requirements into a hierarchy
  - e.g. A goal tree

- Only make comparisons between branches of a single node:
Analytic Hierarchy Process (AHP)

**Source:** Adapted from Karlsson & Ryan 1997

→ **Create n x n matrix (for n requirements)**
  - For element (x,y) in the matrix enter:
    - 1 - if x and y are of equal value
    - 3 - if x is slightly more preferred than y
    - 5 - if x is strongly more preferred than y
    - 7 - if x is very strongly more preferred than y
    - 9 - if x is extremely more preferred than y
  - (use the intermediate values, 2,4,6,8 if compromise needed)
  - …and for (y,x) enter the reciprocal.

→ **Estimate the eigenvalues:**
  - E.g. “averaging over normalized columns”
    - Calculate the sum of each column
    - Divide each element in the matrix by the sum of it’s column
    - Calculate the sum of each row
    - Divide each row sum by the number of rows

→ **This gives a value for each requirement:**
  - …giving the estimated percentage of total value of the project
# AHP example - estimating costs

<table>
<thead>
<tr>
<th></th>
<th>Req1</th>
<th>Req2</th>
<th>Req3</th>
<th>Req4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>1</td>
<td>1/3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Req2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Req3</td>
<td>1/2</td>
<td>1/5</td>
<td>1</td>
<td>1/3</td>
</tr>
<tr>
<td>Req4</td>
<td>1/4</td>
<td>1/3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Normalize columns

<table>
<thead>
<tr>
<th></th>
<th>Req1</th>
<th>Req2</th>
<th>Req3</th>
<th>Req4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>0.21</td>
<td>0.18</td>
<td>0.18</td>
<td>0.48</td>
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<tr>
<td>Req2</td>
<td>0.63</td>
<td>0.54</td>
<td>0.45</td>
<td>0.36</td>
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<tr>
<td>Req3</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Req4</td>
<td>0.05</td>
<td>0.18</td>
<td>0.27</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Sum the rows

<table>
<thead>
<tr>
<th></th>
<th>sum</th>
<th>sum/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>1.05</td>
<td>0.26</td>
</tr>
<tr>
<td>Req2</td>
<td>1.98</td>
<td>0.50</td>
</tr>
<tr>
<td>Req3</td>
<td>0.34</td>
<td>0.09</td>
</tr>
<tr>
<td>Req4</td>
<td>0.62</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Result

<table>
<thead>
<tr>
<th></th>
<th>Req1</th>
<th>Req2</th>
<th>Req3</th>
<th>Req4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req1</td>
<td>26%</td>
<td>50%</td>
<td>9%</td>
<td>16%</td>
</tr>
</tbody>
</table>

AHP example - estimating costs
Plot ROI graph

→ Repeat AHP process twice:
  ➔ Once to estimate relative value
  ➔ Once to estimate relative cost
Other selection criteria

- Cost (percent)
- Value (percent)

Above average cost
Below average value
Above average in both cost and value

5 10 15 20 25 30

Value (percent)

Cost (percent)

Relative Probability
Relative Loss

High Risk Exposure
Low Risk Exposure
Security Risk Management in Airline Turnaround Sector

→ Check-in passenger information
  - Risk1: Blacklisted passenger presents fake document, gets checked-in because personnel could be bribed
  - Risk2: Attacker uses phishing email to extract passenger booking number and uses it to check-in to the flight

→ Luggage information
  - Risk3: The personnel records values lower than actual weight of luggage and ground operations uses the information in the loading of the aircraft
  - Risk4: The personnel accepts luggage and adds contraband items to a passenger’s luggage

❖ Fuel slip
  - Risk5: A malicious insider with access to the computer that stores the fuel slip performs changes to the data contained in the fuel slip
  - Risk6: The attacker intercepts the fuel slip, changes the data contained and sends it to the supplier

❖ Cargo assignment
  - Risk7: A malicious insider with access rights performs changes to the cargo assignment document before it is sent to a service provider
  - Risk8: An attacker hacks the airline mailing list, receives the cargo assignment, changes the data contained and sends the cargo assignment to a service provider

[Matulevičius et al., 2016]
FDSE 2016
Security Risk Management in Airline Turnaround Sector

Risk reduction level vs Value

Risk reduction level vs Cost

Cost vs Value

Risk1: Blacklisted passenger presents fake document, gets checked-in because personnel could be bribed

Risk2: Attacker uses phishing email to extract passenger booking number and uses it to check-in to the flight

Risk3: The personnel records values lower than actual weight of luggage and ground operations uses the information in the loading of the aircraft

Risk4: The personnel accepts luggage and adds contraband items to a passenger’s luggage

Fuel slip

Risk5: A malicious insider with access to the computer that stores the fuel slip performs changes to the data contained in the fuel slip

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- Luggage information
  - Risk3: Personnel records values lower than actual weight of luggage and ground operations uses the information in the loading of the aircraft
  - Risk4: Personnel accepts luggage and adds contraband items to a passenger’s luggage
- Fuel slip
  - Risk5: A malicious insider with access to the computer that stores the fuel slip performs changes to the data contained in the fuel slip

<table>
<thead>
<tr>
<th>Risk</th>
<th>Value-RRL</th>
<th>RRL-cost</th>
<th>value-cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk1</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Risk2</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Risk3</td>
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<td>5</td>
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<td>Risk4</td>
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<td>Risk6</td>
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</tr>
<tr>
<td>Risk8</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

[Matulevičius et al., 2016]
FDSE 2016
Take Home

→ Why Prioritization is needed
  ✈ Basic Trade-offs

→ Cost-Value Approach
  ✈ Sorting Requirements by cost/value
  ✈ Estimating Relative Costs/Values using AHP
Exercise
AIS – Airline Information System

→ Invoicing
Rinv01. AIS should create an invoice for a booking.
Rinv02. AIS should send a created invoice to the customer
Rinv03. Customer should pay the invoice using AIS
Rinv04. AIS should close a paid invoice

→ Boarding
Rboa1. AIS should create a boarding pass
Rboa2. AIS should register a boarded customer

→ Booking
Rboo1. AIS should allow the customer to book an available flight
Rboo2. Customer should query the airline company for available flights
Rboo3. Customer should choose the number of seats on the available flights
Rboo4. AIS should book an airline flight based on the booking info
Exercise
Requirements Prioritisation

→ Perform requirements prioritisation
  - Use the AHP method
  - Prioritise requirements according to
    - Value
    - Cost
  - Show prioritisation results in a plot