1. When do drivers feel that map reading is unsafe while driving?
2. How many streets should be displayed on an in-vehicle navigation system?
3. What size text should be used for the street labels?
4. What is the effect of time of day (day vs. night) on map reading?

On-the-Road Evaluation:

1. How do the previous simulator results compare with the on-the-road results?

2. MAP TASKS

Sample Map:

```
FRANK  ALBERT  EDWARD  DEBORAH  DAVID
FLORENCE  HENRY  JANET  THERESA  GRACE
```

Task 1 - On Street

**What street are you on?**
- Subject Finds: Edward
- Subject Responds: male (M key)

Task 2 - Cross Street

**What is the 3rd Cross Street?**
- Subject Finds: Suzanne
- Responds: female (F key)

**What is the 4th Cross Street?**
- Subject Finds: only 3 streets
- Responds: not there (0 key)

Task 3 - Where is?

**Where is Jonathan?**
- Response: behind (↓)

**Where is Florence?**
- Response: left (←)

**Where is David?**
- Response: right (→)

**Where is Albert?**
- Response: ahead (↑)

**Where is Tammy?**
- Response: not there (0)
3  METHOD

Expressway Driving Scenario

Map

Response Keypad

### Subjects

<table>
<thead>
<tr>
<th>Session</th>
<th>Age 18 - 30</th>
<th>Age &gt;65</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Day</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Night</td>
<td>2</td>
<td>2</td>
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</tbody>
</table>

### Main Test Conditions

<table>
<thead>
<tr>
<th>Text Size</th>
<th>12 Streets</th>
<th>24 Streets</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 POINT</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>12 POINT</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>14 POINT</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

4  ON-THE-ROAD EVALUATION RESULTS

**Task 1 - On Street**

- Frequency (%)
  - Cumulative (%)
  - $\bar{x} = 1.8$ s

**Task 2 - Cross Street**

- Frequency (%)
  - Cumulative (%)
  - $\bar{x} = 3.4$ s

**Task 3 - Where is?**

- Frequency (%)
  - Cumulative (%)
  - $\bar{x} = 5.2$ s

**Issue 1 - When is map reading unsafe?**

- Very Unsafe 5
- Unsafe 4
- Sometimes Unsafe 3
- Safe 2
- Very Safe 1

**Error Rates**

1. Age Effect

   - Mature
   - Young

2. Number of Streets Effect

   - 24 Streets
   - 12 Streets
**Issue 2 - How many streets to display?**

**Task 3 Streets Effect**

Recommendation:
Display ≤12 Streets

**Issue 3 - What text size to use?**

**Task 1 Point Size Effect**

Recommendations:
1. When possible, Use 14 point.
2. Do not use <12 point

**Issue 4 - Day/Night Effects**

**Task 1 - Night learning is more difficult**

Recommendation:
Issues of color, luminance, and contrast for night-use maps need to be addressed in further research.

**Response Time Regression Equations (ms)**

**Task 1 - On Street**

\[
RT = 6710 + 325\times(A) + 6.67\times(S) + 33.75\times(P)^2 - 832.50\times(P) + 9.58\times(C)
\]

**Task 2 - Cross Street**

\[
RT = 1210 + 575\times(A) + 370\times(X) + 40.83\times(S) + 8.08\times(P-12)\times(SL) + 40.83\times(S-12)\times(MINIMUM(1,X-2))
\]

**Task 3 - Where is?**

\[
RT = [1630 + 1235\times(A) + 380\times(T) + 136\times(S) + 27\times(A)\times(SL) + 475\times(L)]\times(SR)
\]
Regression Equations Terms

A = Age \{ -1 if young \\
+1 if mature \}
S = Number of streets (S \geq 1)
P = Point size (10 \leq P \leq 14)
C = Clutter \{ 0 if \leq 12 point \\
(P-12)(S-12.52) if > 12 pt. \}
SL = Street level\{ -1\ast(24-S) if S \leq 12 \\
+1\ast(S-12) if S > 12 \}
T = Time of day \{ -1 for day \\
+1 for night \}
X = Target cross street (X \geq 1)
L = Target location \{ -1 if ahead \\
0 if not there \\
+1 if behind, left or right \}
SR = Search result \{ 1 if found \\
1.70 if not found \}

5 SIMULATOR VALIDATION RESULTS

Subjects

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Age 18 - 30</th>
<th>Age 65&lt;</th>
<th>Trials per Subject</th>
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<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>Simulator</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>On-the-Road</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Response Time Comparison

**Task 1 - On Street**

- Simulator \( \bar{x} = 1.64 \) s
- On-the-Road \( \bar{x} = 1.79 \) s

**Task 3 - Where is?**

- Simulator \( \bar{x} = 5.96 \) s
- On-the-Road \( \bar{x} = 5.20 \) s

Differences in Experimental Findings

**Task 1 - Point Size Effects**

- On-the-Road
- Simulator

**Task 3 - Point Size Effects**

- On-the-Road
- Simulator

Conclusions:
The optimal point size was also dependent upon the display resolution and location (character visual angle).