The IRIS runway model
A decision support model for assessing runway conditions

Alex Klein-Paste
Associate professor
NTNU, dept of Civil and Transport Engineering
Norwegians love to fly…

Data from 2014:

Population : 5.1 Million
Airports: 52
Aircraft movements: 0.93 Million
Landings on contaminated runways

- dry (25.6%)
- damp (19.5%)
- wet (18.1%)
- rime on ice/compact snow (6%)
- dry snow on ice/compact snow (7.4%)
- Coverage ≤25% (9.2%)
- rime (3.1%)
- ice (3.8%)
- dry snow (1.4%)
- slush (1.9%)
- wet snow on ice/compact snow (1.1%)
- wet snow (0.9%)
- wet ice/compact snow (0.9%)
- slush on ice/compact snow (0.7%)
- compact snow (0.3%)

n = 353547

27.6%
IRIS project

• Integrated Runway Information System
• 2008 – 2013
• Large scale data collection

> 110,000 landings
IRIS project
Can descriptive data be used to support assessment of runway surface conditions?
Talpa-ARC

Contamination type
Depth
Temperature
Coverage

TALPA matrix

Prediction 0 - 6
**IRIS runway model**

<table>
<thead>
<tr>
<th>Contamination type</th>
<th>Depth</th>
<th>Coverage</th>
<th>Use of sand</th>
<th>Use of frozen sand</th>
<th>Use of chemicals</th>
<th>Runway surface temperature</th>
<th>Air temperature</th>
<th>Dew points temperature</th>
</tr>
</thead>
</table>

**Prediction 1 - 5**
Structure

\[ P = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 \]

Base Prediction

Additional factors

1. Poor
2. Poor-medium
3. Medium
4. Medium-Good
5. Good

\[ +2 \]
\[ +1 \]
\[ 0 \]
\[ -1 \]
\[ -2 \]
Structure

\[ P = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 \]

- Contamination type
- Spatial Coverage
- Depth loose contamination
- Spatial Coverage
- Contamination type
- Runway temperature
- Humidity
- Chemicals
- Sanding
### Base prediction

<table>
<thead>
<tr>
<th>$x_i = 1$</th>
<th>$x_i = 2$</th>
<th>$x_i = 3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet ice (27)</td>
<td>Wet snow (5)</td>
<td>Slush (6)</td>
</tr>
<tr>
<td>Wet compact snow (28)</td>
<td>Wet snow on ice (57)</td>
<td>Ice (7)</td>
</tr>
<tr>
<td></td>
<td>Wet snow on compact snow (58)</td>
<td>Compact Snow (8)</td>
</tr>
<tr>
<td></td>
<td>Slush on ice (67)</td>
<td>Rime on Ice (37)</td>
</tr>
<tr>
<td></td>
<td>Slush on compact snow (68)</td>
<td>Rime on compact snow (38)</td>
</tr>
<tr>
<td>$x_i = 4$</td>
<td></td>
<td>Dry snow on ice (47)</td>
</tr>
<tr>
<td>Rime (3)</td>
<td></td>
<td>Dry snow on compact snow (48)</td>
</tr>
<tr>
<td>Dry snow (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frozen ruts (9)</td>
<td>Dry (NIL)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Damp (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet (2)</td>
<td></td>
</tr>
</tbody>
</table>
Example: $x_2$ Coverage

$x_2 = 0 \quad | \quad S > 50$

$x_2 = +1 \quad | \quad 10 < S \leq 50$

$P = 5 \quad | \quad S \leq 10$
Example: $x_4$ RWY temperature

<table>
<thead>
<tr>
<th>RWY temp</th>
<th>profile 1</th>
<th>profile 2</th>
<th>profile 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{RWY} \geq -0.5$</td>
<td>-2</td>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>$-0.5$</td>
<td>-2</td>
<td>0</td>
<td>-1</td>
</tr>
<tr>
<td>$-2$</td>
<td>-8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$-8$</td>
<td>$\geq T_{RWY}$</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Validation

• 3 winter seasons on two airport in Norway

• 9073 SNOWTAM reports
  – 27219 runway sections

• 46153 landings of Boeing 737-600,700,800
  – 1261 Friction limited landings
Validation

- Inspectors did not see the results of the model while doing their judgment
- No data when the runway is closed
Validation

IRIS Model

Runway inspectors

n=27219

Percentage reported

poor  medium  good

poor  medium  good

n=27219
Validation

IRIS Runway model

1 – poor
2 – poor/medium
3 – medium
4 – medium / good
5 – good

2 – 3 = -1
Validation

![Friction Measurements](chart1)

- Friction Measurements: 61%
- Runway Inspectors: 77%
- IRIS Model: 86%

n=1261
Implementation
IRIS vs TALPA

27 219 SNOWTAM rapports
IRIS vs TALPA

Runway inspectors
n=27219

IRIS Model
n=27219

Talpa
n=27219
IRIS vs TALPA

6418 Friction-limited landings
IRIS vs TALPA

(a) assigned RWYCC

(b) RWYCC, upgraded

IRIS runway model
Pireps

- We got very few pireps....
The pireps were the least conservative!!
## Pireps

<table>
<thead>
<tr>
<th>Difference (# categories)</th>
<th>Number of landings</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>9 %</td>
</tr>
<tr>
<td>-3</td>
<td>9 %</td>
</tr>
<tr>
<td>-2</td>
<td>3 %</td>
</tr>
<tr>
<td>-1</td>
<td>88 %</td>
</tr>
<tr>
<td>0</td>
<td>n=33</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difference (# categories)</th>
<th>Number of landings</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>9 %</td>
</tr>
<tr>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

(a) PIREP FL-landing

(b) PIREP non-FL landing
Discussion

• Assessments based on descriptive information

• Can we improve further?
  – Data quality
  – Detecting significant changes
  – Human interpretation
Conclusions

• The IRIS runway model outperformed the Talpa / ICAO methodology

• Pireps were found to be the least conservative