Evaluating the Design of Runways towards Mitigating Runway Excursions

Eunsun Ryu, Seth Young
• **Introduction**
• **Actual accident/incident data analysis**
• **Runway Centerline Deviation Study**
• **Conclusion**

*The Runway Centerline Deviation Study was supported by the Federal Aviation Administration and Center of Excellence in General Aviation (PEGASAS: The Partnership to Enhance General Aviation Safety, Accessibility, and Sustainability).*
Introduction
Why runway design is important

- 2000-2015, The entire number of accident on NTSB database: **30,176** cases
  - Runway related accidents: 15,613 (52%)
  - Fatal accidents: 6,395
  - Runway related fatal cases: 2,640
Type of accidents on runway

- Incursion
- Excursion
- Undershoot
- Veer-off
- Overrun
Why runway excursions should be mitigated
Runway Design - FAA
Runway Design Components

- Runway Width
- Runway Length
- Runway Orientation (Direction)
Safety Areas Around Runway (FAA)
Runway Design Category - FAA

Aircraft Approach Category (AAC)

Aircraft Design Group (ADG)
Runway Design Category - FAA

Aircraft Approach Category

<table>
<thead>
<tr>
<th>Code</th>
<th>Approach Speed $\left( \frac{V_{Ref}}{V_{App}} \right)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>~91kt</td>
</tr>
<tr>
<td>B</td>
<td>91~121kt</td>
</tr>
<tr>
<td>C</td>
<td>121~141kt</td>
</tr>
<tr>
<td>D</td>
<td>141~166kt</td>
</tr>
<tr>
<td>E</td>
<td>166kt~</td>
</tr>
</tbody>
</table>
## Runway Design Category - FAA

### Aircraft Design Group

<table>
<thead>
<tr>
<th>Code</th>
<th>Tail Height</th>
<th>Wingspan</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>~20ft (~6m)</td>
<td>~49ft (~15m)</td>
</tr>
<tr>
<td>II</td>
<td>20<del>30ft (6</del>9m)</td>
<td>49<del>79ft (15</del>24m)</td>
</tr>
<tr>
<td>III</td>
<td>30<del>45ft (9</del>13.5m)</td>
<td>79<del>118ft (24</del>36m)</td>
</tr>
<tr>
<td>IV</td>
<td>45<del>60ft (13.5</del>18.5m)</td>
<td>118<del>171ft (36</del>52m)</td>
</tr>
<tr>
<td>V</td>
<td>60<del>66ft (18.5</del>20m)</td>
<td>171<del>214ft (52</del>65m)</td>
</tr>
<tr>
<td>VI</td>
<td>66<del>80ft (20m</del>)</td>
<td>214<del>262ft (65</del>80m)</td>
</tr>
</tbody>
</table>
### Table A7.7. Runway design standards matrix, C/D/E - I

| Aircraft Approach Category (AAC) and Aircraft Design Group (ADG): | C/D/E - I |
|---|---|---|---|---|
| ITEM | DIM² | VISIBILITY MINIMUMS | | |
| | | Visual | Not Lower than 1 mile | Not Lower than 3/4 mile | Lower than 3/4 mile |
| Runway Design | | | | | |
| Runway Length | A | 100 ft | 100 ft | 100 ft | 100 ft |
| Runway Width | B | 10 ft | 10 ft | 10 ft | 10 ft |
| Shoulder Width | | 120 ft | 120 ft | 120 ft | 120 ft |
| Blast Pad Width | | 100 ft | 100 ft | 100 ft | 100 ft |
| Blast Pad Length | | 16 knots | 16 knots | 16 knots | 16 knots |
| Crosswind Component | | | | | |
| Runway Object Free Area (ROFA) | | | | | |
| Length beyond runway end | R | 1,000 ft | 1,000 ft | 1,000 ft | 1,000 ft |
| Length prior to threshold | | 500 ft | 500 ft | 500 ft | 500 ft |
| Width | C | 600 ft | 600 ft | 600 ft | 600 ft |
| Runway Obstacle Free Zone (ROFZ) | | | | | |
| Length | P | 600 ft | 600 ft | 600 ft | 600 ft |
| Width | Q | 800 ft | 800 ft | 800 ft | 800 ft |
| Precision Obstacle Free Zone (POFZ) | | | | | |
| Length | | | | | |
| Width | | | | | |
| Approach Runway Protection Zone (RPZ) | | | | | |
| Length | L | 1,700 ft | 1,700 ft | 1,700 ft | 1,700 ft |
| Inner Width | | 1,010 ft | 1,010 ft | 1,010 ft | 1,010 ft |
| Outer Width | | 29,465 | 29,465 | 48,978 | 78,914 |
| Acres | | | | | |
| Departure Runway Protection Zone (RPZ) | | | | | |
| Length | L | 1,700 ft | 1,700 ft | 1,700 ft | 1,700 ft |
| Inner Width | | 1,010 ft | 1,010 ft | 1,010 ft | 1,010 ft |
| Outer Width | | 29,465 | 29,465 | 29,465 | 29,465 |
| Acres | | | | | |
| Runway Separation | | | | | |
| Runway centerline to: | | | | | |
| Parallel runway centerline | H | 250 ft | 250 ft | 250 ft | 250 ft |
| Holding Position | | 300 ft | 300 ft | 300 ft | 300 ft |
| Parallel taxiway/taxiway centerline | D | 300 ft | 300 ft | 300 ft | 300 ft |
| Aircraft parking area | G | 400 ft | 400 ft | 400 ft | 400 ft |
| Helicopter touchdown pad | | | | | |

Note:
- Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.
# Runway Length

<table>
<thead>
<tr>
<th>Airplane Weight Category MTOW</th>
<th>Design Approach</th>
<th>RWY Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,500lbs (5,670kg) or less</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach speeds less than 30kt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach speeds of at least 30kt but less than 50kt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach speeds of 50kt or more</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With less than 10 passengers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With or more 10 passengers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 12,500lbs (5,670kg) but less than 60,000lbs (27,200kg)</td>
<td>Family grouping of large airplanes</td>
<td>5325-4B 12~15p.</td>
</tr>
<tr>
<td>60,000lbs (27,200kg) or more Regional Jets</td>
<td>Individual large airplane</td>
<td>Airplane Manufacturer Websites</td>
</tr>
</tbody>
</table>
Runway Orientation
Runway Orientation
Runway Design - ICAO

Twice as RWY Width

Requirement 90m

Recomm: 240m for Code 3&4
Runway Design Standard - ICAO
Runway Design Standard - ICAO

Aeroplane Reference Field Length

<table>
<thead>
<tr>
<th>Code #</th>
<th>Reference Field Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>~800m (~2625ft)</td>
</tr>
<tr>
<td>2</td>
<td>800<del>1200m (2625</del>3937ft)</td>
</tr>
<tr>
<td>3</td>
<td>1200<del>1800m (3937</del>5906ft)</td>
</tr>
<tr>
<td>4</td>
<td>1800m~ (5906ft~)</td>
</tr>
</tbody>
</table>
Categories for Greatest Main Gear Span and Wingspan

<table>
<thead>
<tr>
<th>Code #</th>
<th>Wingspan</th>
<th>Main gear span</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>~15m (~49ft)</td>
<td>~4.5m</td>
</tr>
<tr>
<td>B</td>
<td>15<del>24m (49</del>79ft)</td>
<td>4.5~6m</td>
</tr>
<tr>
<td>C</td>
<td>24<del>36m (79</del>118ft)</td>
<td>6~9m</td>
</tr>
<tr>
<td>D</td>
<td>36<del>52m(118</del>171)</td>
<td>9~14m</td>
</tr>
<tr>
<td>E</td>
<td>52~65m(171)</td>
<td>9~14m</td>
</tr>
<tr>
<td>F</td>
<td>65m~(214)</td>
<td>14~16m</td>
</tr>
</tbody>
</table>
# Example Runway Design Categories

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>FAA</th>
<th>ICAO</th>
</tr>
</thead>
<tbody>
<tr>
<td>C172S</td>
<td>A-I</td>
<td>1A</td>
</tr>
<tr>
<td>ERJ-145</td>
<td>C-II</td>
<td>4B</td>
</tr>
<tr>
<td>B737-800</td>
<td>D-IV</td>
<td>4C</td>
</tr>
</tbody>
</table>
Previous Studies about RWY Excursion Modeling
## Considered Database

<table>
<thead>
<tr>
<th>Country</th>
<th>Database name</th>
<th>Report 3 (OR/US)</th>
<th>Report 51 (SEPAR)</th>
<th>Report 107 (VO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>FAA AIDS</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>ASRS</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>NTSB</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Canada</td>
<td>TSB</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Australia</td>
<td>ATSB</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>France</td>
<td>BEA</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>AAIB</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>New Zealand</td>
<td>TAIC</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Ireland</td>
<td>AAIU</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Spain</td>
<td>CIA/IAAC</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Indonesia</td>
<td>NTSC</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherland</td>
<td>NASB</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>MITRE</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICAO (International)</td>
<td>ADREP</td>
<td>O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>AAIBS</td>
<td></td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>South Africa</td>
<td>SACAA</td>
<td></td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Netherland</td>
<td>DSB</td>
<td></td>
<td></td>
<td>O</td>
</tr>
</tbody>
</table>
## ACRP Report 3 and 107

<table>
<thead>
<tr>
<th>Common data</th>
<th>Report 3 (OR/US)</th>
<th>Report 107 (VO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose of flight</td>
<td>Ceiling</td>
<td>Tailwind</td>
</tr>
<tr>
<td>Aircraft weight (MTOW)</td>
<td>Electrical storm</td>
<td>Rain</td>
</tr>
<tr>
<td>Foreign O/D</td>
<td>Terrain</td>
<td>Gust</td>
</tr>
<tr>
<td>Visibility</td>
<td></td>
<td>Fog</td>
</tr>
<tr>
<td>Crosswind</td>
<td></td>
<td>Log criticality factor</td>
</tr>
<tr>
<td>Snow</td>
<td></td>
<td>Night conditions</td>
</tr>
<tr>
<td>Icing condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hub/Non-hub</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Previous Model

\[
P\{\text{Accident Occurrence}\} = \frac{1}{1 + e^{-(b_0 + b_1 X_1 + b_2 X_2 + \cdots)}}
\]

\(X_i\): independent variables;

\(b_i\): regression coefficients
Previous Model

\[ \sum b_n \]

\[ = -13.088 + 1.682 \text{(User Class G)} - 0.770 \text{(Acft Class A/B)} \\
- 0.252 \text{(Acft Class D/E/F)} + 2.143 \text{(Visibility < 2SM)} \\
- 0.091 \text{(Xwind 2 – 5kt)} + 0.653 \text{(Xwind 5 – 12kt)} + 2.192 \text{(Xwind > 12kt)} \\
+ 0.066 \text{(Twind 5 – 12kt)} + 0.98 \text{(Twind > 12kt)} + 0.558 \text{(Temp < 5C)} \\
- 0.453 \text{(Temp 5 – 15C)} + 0.291 \text{(Temp > 25C)} + 2.67 \text{(Icing)} - 0.126 \text{(Rain)} \\
+ 0.548 \text{(Snow)} - 0.103 \text{(Frozen Precipitation)} - 0.036 \text{(Gust)} + 1.74 \text{(Fog)} \\
- 2.517 \text{(Turboprop)} - 0.334 \text{(Foreign OD)} + 4.318 \text{(Log Criticality Factor)} \\
- 1.36 \text{(Night)} \]
Example

\[ \sum b_n \]

\[ = -13.088 + 1.682(1) - 0.770(0) - 0.252(1) + 2.143(0) - 0.091(0) \]
\[ + 0.653(0) + 2.192(0) + 0.066(0) + 0.98(0) + 0.558(0) - 0.453(0) \]
\[ + 0.291(0) + 2.67(0) - 0.126(0) + 0.548(0) - 0.103(0) - 0.036(0) \]
\[ + 1.74(0) - 2.517(0) - 0.334(0) + 4.318 - 1.36(0) = -7.34 \]

\[ P\{\text{Accident Occurrence}\} = \frac{1}{1 + e^{-b_0 + b_1X_1 + b_2X_2 + \ldots}} = \frac{1}{1 + e^{-(-7.34)}} = 0.0006486 \]

If a smaller aircraft with MTOW less than 12,500lbs is operated on clear (visibility greater than 10SM), wind calm and warm (temperature 20°C) during daytime, the probability of runway excursion is 0.065%.
Actual Accident & Incident Data
Previous Models

- Commercial operation focused models
- Weather condition was significant factor for the model
- General aviation have different characteristics
  Ex) Runway size, aircraft type, preferred weather, …
NTSB Aviation Accident Database & Synopses

- Operated by NTSB
- Searched with “Runway Excursion”
- Most of the cases are accidents
- 425 cases were collected
- The oldest case was in 1991 May
ASRS

- Operated by NASA
- Searched with “Runway Excursion”
- Most of the cases are incidents
- 179 cases were collected
- The oldest case was in 2006 August
**FAA AIDS**

- Operated by FAA
- Searched with “Excursion”
- Most of the cases are incidents
- 39 cases were collected
- The oldest case was in 1988 October
How/what data were collected

- Both the synopsis and narrative are searched with the keyword
- Search period: Acc/Inc before Sep.2015
- Total: 648 cases
Collected variables

- Event type
- Airport
- Aircraft model – MTOW
- FAR Part
- Purpose of flight
- Phase
- Damage
- Fire
- Visibility (Flight rules condition, visibility in SM)
- Ceiling (Coverage, height in ft)
- Light condition
- Wind (Direction, speed, cross/tailwind, gust/windshear/turbulence)

- Runway (Length, width, pavement material, condition, obstacle on threshold/end)
- Excursion direction
- Pilot (Age, flight hour, student)
- Injury severity
- Causal factors & Expected primary factor
- Result of excursion
Data Analysis

• Total: 648 cases

Event Type
- Accident: 235 (36.5%)
- Incident: 413 (63.5%)

Aircraft Damage
- Destroyed: 121 (18.8%)
- Substantial: 402 (62.5%)
- Minor: 3 (0.5%)
<table>
<thead>
<tr>
<th>Category</th>
<th>Removed case #</th>
<th>Most common</th>
<th>Second common</th>
<th>Third common</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Factor</td>
<td>Cases</td>
<td>%</td>
</tr>
<tr>
<td>Aircraft Weight</td>
<td>81</td>
<td>MTOW≤12,500lbs</td>
<td>505</td>
<td>89.9%</td>
</tr>
<tr>
<td>FAR Part</td>
<td>5</td>
<td>Part 91</td>
<td>556</td>
<td>87.1%</td>
</tr>
<tr>
<td>Mission</td>
<td>72</td>
<td>Personal</td>
<td>358</td>
<td>62.7%</td>
</tr>
<tr>
<td>Phase</td>
<td>23</td>
<td>Landing</td>
<td>461</td>
<td>74.4%</td>
</tr>
<tr>
<td>Fire</td>
<td>20</td>
<td>None</td>
<td>620</td>
<td>99.5%</td>
</tr>
<tr>
<td>Flight Rules Condition</td>
<td>65</td>
<td>VMC</td>
<td>558</td>
<td>96.5%</td>
</tr>
<tr>
<td>Light Condition</td>
<td>73</td>
<td>Day</td>
<td>517</td>
<td>90.7%</td>
</tr>
<tr>
<td>Visibility</td>
<td>127</td>
<td>5&lt;VIS≤10</td>
<td>465</td>
<td>90.3%</td>
</tr>
<tr>
<td>Ceiling Coverage</td>
<td>239</td>
<td>None</td>
<td>316</td>
<td>78.2%</td>
</tr>
<tr>
<td>Ceiling Height</td>
<td>162</td>
<td>None</td>
<td>316</td>
<td>65.7%</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>180</td>
<td>3&lt;Wind≤10</td>
<td>281</td>
<td>60.7%</td>
</tr>
<tr>
<td>Gust/Turbulence/ Windshear</td>
<td>-</td>
<td>No Info (No wind event)</td>
<td>544</td>
<td>84.6%</td>
</tr>
<tr>
<td>Cross/Tailwind</td>
<td>-</td>
<td>No Info (No X/Twind)</td>
<td>524</td>
<td>81.2%</td>
</tr>
<tr>
<td>Precipitation</td>
<td>-</td>
<td>None+No Info</td>
<td>609</td>
<td>93.7%</td>
</tr>
<tr>
<td>Any precipitation</td>
<td>-</td>
<td>None</td>
<td>609</td>
<td>93.7%</td>
</tr>
<tr>
<td>RWY Length</td>
<td>230</td>
<td>2500&lt;Length≤5000</td>
<td>210</td>
<td>50.8%</td>
</tr>
<tr>
<td>RWY Width</td>
<td>232</td>
<td>75&lt;Width≤100</td>
<td>126</td>
<td>30.7%</td>
</tr>
<tr>
<td>Contaminated RWY</td>
<td>230</td>
<td>Asphalt</td>
<td>330</td>
<td>76.6%</td>
</tr>
<tr>
<td>RWY Condition</td>
<td>282</td>
<td>Good</td>
<td>260</td>
<td>72.0%</td>
</tr>
<tr>
<td>Friction Aids</td>
<td>203</td>
<td>None</td>
<td>339</td>
<td>77.0%</td>
</tr>
<tr>
<td>Excursion Direction</td>
<td>90</td>
<td>Left</td>
<td>254</td>
<td>45.9%</td>
</tr>
<tr>
<td>Pilot Age</td>
<td>251</td>
<td>35&lt;Age≤60</td>
<td>181</td>
<td>46.2%</td>
</tr>
<tr>
<td>Student Pilot</td>
<td>180</td>
<td>Non-Student</td>
<td>390</td>
<td>84.2%</td>
</tr>
<tr>
<td>Flight Hours</td>
<td>215</td>
<td>1000&lt;FH≤5000</td>
<td>126</td>
<td>29.4%</td>
</tr>
<tr>
<td>Causal Factor</td>
<td>21</td>
<td>Human Factor</td>
<td>520</td>
<td>52.4%</td>
</tr>
<tr>
<td>Result</td>
<td>21</td>
<td>Loss of control</td>
<td>326</td>
<td>34.6%</td>
</tr>
</tbody>
</table>
Data Analysis

Aircraft weight

- 90% Less than 12,500
- 5% Greater than 12,500 and less than or equal to 50,000
- Greater than 50,000 and less than or equal to 100,000
- Greater than 100,000
Data Analysis

FAR Part

87%

91
103
121
135
137
141
Data Analysis

Mission

- Personal: 63%
- Instructional: 20%
- Passenger: 6%
- Business: 6%
- Aerial Application: 6%
Data Analysis

Phase

- Landing: 74%
- Takeoff: 19%
- Taxi
- Approach
Data Analysis

Aircraft Damage

- Substantial: 64%
- Minor: 20%
- None: 16%
- Destroyed: 0%
Data Analysis

Flight Rules Condition

- VMC: 97%
- IMC: 3%
- Marginal: 0%
Data Analysis

RWY Length

- 12% for Length <= 1000
- 29% for 1000 < Length <= 2500
- 51% for 2500 < Length <= 5000
- 2% for 5000 < Length <= 8000
- 2% for 8000 < Length <= 10000
- 2% for Length > 10000
Data Analysis

RWY Width

- Width <=60: 16%
- 60<Width<=75: 25%
- 75<Width<=100: 31%
- 100<Width<=150: 26%
- 150<Width<=200: 26%
Data Analysis

Pavement Condition

- 72% Good
- 18% Fair
- 8% Poor

Legend:
- Excellent
- Good
- Fair
- Bad
- Poor
Data Analysis

Friction Aids

- None
- Grooved
- Porous friction courses
- Aggregate friction seal coat
- Rubberized friction seal coat
- Seal Coat Separating

21%  
77%
Data Analysis

Obstacle location

- None: 24%
- Both: 57%
- THLD: 8%
- End: 11%
Data Analysis

Pilot Age

- Age < 25: 5%
- 25 <= Age < 40: 16%
- 40 <= Age < 60: 40%
- 60 <= Age: 39%
Data Analysis

Flight Hour

- 29% for FH<=80
- 16% for 80<FH<=200
- 13% for 200<FH<=500
- 12% for 500<FH<=1000
- 11% for 1000<FH<=5000
- 10% for 5000<FH<=10000
- 9% for 10000<FH

The pie chart shows the percentage distribution of flight hours across different intervals.
<table>
<thead>
<tr>
<th>Category</th>
<th>Removed case #</th>
<th>Most common</th>
<th>Second common</th>
<th>Third common</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor</td>
<td>Cases</td>
<td>%</td>
<td>Factor</td>
</tr>
<tr>
<td>MTOW &amp; FAR Part</td>
<td>5</td>
<td>MTOW≤12,500 &amp; FAR Part 91</td>
<td>472</td>
<td>84.4%</td>
</tr>
<tr>
<td>Phase &amp; Mission</td>
<td>75</td>
<td>Landing &amp; Personal</td>
<td>275</td>
<td>48.4%</td>
</tr>
<tr>
<td>Visibility &amp; Visibility condition</td>
<td>138</td>
<td>5&lt;VIS≤10 &amp; VMC</td>
<td>455</td>
<td>90.1%</td>
</tr>
<tr>
<td>Ceiling height &amp; Ceiling coverage</td>
<td>240</td>
<td>None &amp; None</td>
<td>316</td>
<td>78.4%</td>
</tr>
<tr>
<td>Visibility &amp; Precipitation</td>
<td>242</td>
<td>5&lt;VIS≤10 &amp; None</td>
<td>359</td>
<td>88.0%</td>
</tr>
<tr>
<td>Friction aids &amp; Pavement condition</td>
<td>282</td>
<td>None &amp; Good</td>
<td>188</td>
<td>52.1%</td>
</tr>
<tr>
<td>Student &amp; Pilot age</td>
<td>253</td>
<td>Non-student &amp; 60≤Age</td>
<td>150</td>
<td>38.5%</td>
</tr>
<tr>
<td>Excursion direction &amp; Obstacle presence</td>
<td>245</td>
<td>Left &amp; Both</td>
<td>107</td>
<td>26.9%</td>
</tr>
<tr>
<td>Wind event &amp; Excursion direction</td>
<td>90</td>
<td>No Info &amp; Left</td>
<td>187</td>
<td>33.8%</td>
</tr>
<tr>
<td>Pilot age &amp; Causal factor</td>
<td>262</td>
<td>60≤Age &amp; Human factor</td>
<td>108</td>
<td>28.3%</td>
</tr>
<tr>
<td>Flight hour &amp; Causal factor</td>
<td>216</td>
<td>1000≤FH&lt;5000 &amp; Human factor</td>
<td>83</td>
<td>19.4%</td>
</tr>
<tr>
<td>Result &amp; Causal factor</td>
<td>51</td>
<td>Loss of control &amp; Human factor</td>
<td>201</td>
<td>21.3%</td>
</tr>
<tr>
<td>Category</td>
<td>Removed case #</td>
<td>Most common Factor &amp; RWY Width</td>
<td>Cases</td>
<td>%</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>----------------</td>
<td>--------------------------------</td>
<td>-------</td>
<td>---</td>
</tr>
<tr>
<td>RWY Length &amp; Width</td>
<td>232</td>
<td>2500&lt;Length≤5000 &amp; 60&lt;Width≤75</td>
<td>85</td>
<td>20.7%</td>
</tr>
<tr>
<td>Primary factor &amp; RWY Width</td>
<td>233</td>
<td>Human factor &amp; 75&lt;Width≤100</td>
<td>92</td>
<td>22.4%</td>
</tr>
<tr>
<td>Excursion Direction &amp; RWY Width</td>
<td>249</td>
<td>Left &amp; 75&lt;Width≤100</td>
<td>51</td>
<td>12.9%</td>
</tr>
<tr>
<td>Primary Factor &amp; RWY Width</td>
<td>233</td>
<td>Human factor &amp; 75&lt;Width≤100</td>
<td>92</td>
<td>14.3%</td>
</tr>
<tr>
<td>Obstacle Presence &amp; RWY Width</td>
<td>232</td>
<td>Both &amp; 60&lt;Width≤75</td>
<td>69</td>
<td>16.8%</td>
</tr>
<tr>
<td>Pavement Condition &amp; RWY Width</td>
<td>283</td>
<td>Good &amp; 60&lt;Width≤75</td>
<td>81</td>
<td>22.5%</td>
</tr>
<tr>
<td>Pilot Age &amp; RWY Width</td>
<td>272</td>
<td>60≤Age &amp; 75&lt;Width≤100</td>
<td>46</td>
<td>12.1%</td>
</tr>
<tr>
<td>Flight hour &amp; RWY Width</td>
<td>265</td>
<td>1000&lt;FH≤5000 &amp; 75&lt;Width≤100</td>
<td>36</td>
<td>9.5%</td>
</tr>
<tr>
<td>Wind Event &amp; RWY Width</td>
<td>232</td>
<td>No Info &amp; 75&lt;Width≤100</td>
<td>89</td>
<td>21.7%</td>
</tr>
</tbody>
</table>
Runway Centerline Deviation Study
Purpose
Investigate the severity of deviation of taking off or landing aircraft in general aviation

How we could get deviation data
• Use 4 Velodyne LiDAR sensors (Scan angle: 30 degree)
• To expand the Field of View (FOV)
  Each sensor faces different directions
  Two sensors were paired as one group and installed on a runway lighting system pillar
• Each pillar was placed on the side of Runway Safety Area (RSA)
Point cloud

- Video -
*Analyzed by Zoltan Koppanyi
Conclusion
RWY Excursion Model for GA Airport

- General aviation have clearly different characteristics from commercial operations

- Previous models considered weather condition significantly, however, it may not affect GA flights as much as for commercial flights

- Based on the model for general aviation airport and centerline deviation data, current runway design standards can be re-evaluated
Future Work

• More data collection of aircraft deviation
• Development of frequency model for general aviation
• Data collection of runway excursion accidents from international accident database other than U.S
• Compare the difference of accidents regarding FAA & ICAO design standards
Thank you!