RNAV STAR Procedural Adherence
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Procedures are a first step towards autonomy

No Procedures
Flying was dangerous and not standardized

Instrument Approach Procedures
A method to consistently guarantee lower distance

STARs (conventional)

STARs (RNAV OPD)
Route instructions, fuel loadings, course standardization and time management (PFA 2016)
No Procedures

Flying was dangerous and
not standardized
Instrument Approach Procedures

A method to consistently guarantee terrain clearance

Two pages from Elrey Jeppesen’s "Little Black Book": The Arps Ranch (far left) and Bitter Creek. At first, Jeppesen collected this navigational information to help his fellow pilots.
STARs (conventional)

Standardized Routing & Terrain Clearance
STARs (RNAV OPD)

Noise reduction, fuel savings, route standardization, and flow management. (FAA, 2014)
When Doesn't This Work?
Data Source

Now
ARTCC radar tracks (CTAS data)

TRACON data (Sherlock2.0)

Longterm
Aircraft sensors (FOQA-type)

Expand Capability

Procedural Characteristics
- Waypoint type
- Window size
- Speed Restrictions
- Altitude Restrictions
- Route name (e.g., transition)
- Slope-degree angles
- Leg type (e.g., track to fix)

Environmental Variables
- Wind (full wind component)
- Temperature (Rapid Refresh NOAA)

Aircraft Variables
- Type and equipment suffix
- Groundspeed
- Altitude (several samples)
- Rate of descent
- Required slope to next restriction
- # of flights on the arrival
**Procedural Characteristics**
- Waypoint type, window size
- Speed Restrictions
- Altitude Restrictions
- Route name (e.g., transition)
- Slope-degree angles
- Leg type (e.g., track to fix)

**Environmental Variables**
- Wind (tailwind component)
- Temperature (Rapid Refresh NOAA)

**Aircraft Variables**
- Type and equipment suffix
- Groundspeed
- Altitude (several samples)
- Rate of descent
- Required slope to next restriction
- # of flights on the arrival

(Sherlock2.0)

Longterm Aircraft sensors
(FOQA-type)
Method
Overlay Flights on Routes

- Entry Waypoint
- Waypoint in route
- Exit Waypoint

- Identify route flown
- Determine adherence of lateral flight trajectory with waypoint restrictions
- Characterize lateral adherence (join late/skip/early exit)

Full Lateral Adherence of VKTRY2 into KDFW
Descriptive Data

Assess Levels of Use

Identify Human Intervention
Assess Levels of Use
Identify Human Intervention
Miles Flown

Sheet 1

<table>
<thead>
<tr>
<th></th>
<th>Avg. Cumulative Dist Travel On Route</th>
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<tbody>
<tr>
<td>Late entry only</td>
<td>430.78</td>
</tr>
<tr>
<td>Early exit only</td>
<td>395.92</td>
</tr>
<tr>
<td>Full-skip only</td>
<td>419.97</td>
</tr>
<tr>
<td>late and skip</td>
<td>424.75</td>
</tr>
<tr>
<td>early and late</td>
<td>402.75</td>
</tr>
<tr>
<td>early and skip</td>
<td>398.92</td>
</tr>
<tr>
<td>full lateral</td>
<td>416.83</td>
</tr>
</tbody>
</table>
Machine Learning Methods

Multivariate Analysis

Classification

Precursors

Decision trees weigh multiple variables to predict the class of a variable

Adopt
Automatic Detection of Precursors in Timeseries
Multivariate Analysis

Classification

Precursors
Decision trees weigh multiple variables to predict the class of a variable.
Change in Behavior

![Graph showing outln parameter statistics for Required Slope L From with time series data for KLNDR1 and KLNDR2.]
Adopt
Automatic Detection of Precursors in Timeseries
Output Tool

Data Visualization & synthesis

- Monitor trends
- Observe efficacy of mitigation strategies
- Observe factors that influence degradation
- Set acceptability metrics
- Decision support for designers
Monitor trends

Observe efficacy of mitigation strategies

Observe factors that influence degradation

Set acceptability metrics

Decision support for designers
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