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 safety distances

STARS (conventional)

STARS (RNAV OPD)
Route selection, fuel savings, route standardization, and time management (RAA 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)
We’re Here
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 (bullwind 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)

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

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

Miles Flown
Assess Levels of Use
KMEM

- Full Lateral
- Early Exit Only
- Late Entry
- No STAR
- Early and Late
- SKIPS
- Early and Skip
KIAH

- No STAR
- early exit only
- LATE ENTRY
- FULL LATERAL
- SKIPS
- early and late
- early and skip
- late and skip
Identify Human Intervention
KIAH
Miles Flown

Sheet 1

<table>
<thead>
<tr>
<th></th>
<th>Avg. Cumulative Dist Travel On Route</th>
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<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>
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<tr>
<td>late and skip</td>
<td>424.75</td>
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<tr>
<td>early and late</td>
<td>402.75</td>
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<tr>
<td>early and skip</td>
<td>398.92</td>
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<tr>
<td>full lateral</td>
<td>416.83</td>
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</table>
Excursion Percentage

WP Type

Excursion above restriction

Excursion below restriction

AT
AT or Below
AT or Above
Window
Machine Learning Methods

Multivariate Analysis

Classification

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

Precursors

Adopt

Automatic Detection of Precursors in Timeseries

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

OUTLN Parameter Statistics for :Required_Slope_L_From

KLNDR1

KLNDR2

Time


Required Slope L From

-4 -3 -2 -1 0 1 2
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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