RNAV STAR Procedural Adherence
RNAV STAR Procedural Adherence
Procedures are a first step towards autonomy

No Procedures
Flying was dangerous and not standardized

Instrument Approach Procedures
A method to consistently guarantee sensor clearance

STARs (conventional)

STARs (RNAV OPD)
Route evaluation, fuel burn, route standardization, and time management (IATA 2010)
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

Functionality

Procedural Complexity
When Doesn't This Work?

- Weather
- Mixed Equipment
- Traffic
Data Source

- **Now**
  - ARTCC radar tracks (CTAS data)

- **TRACON data**
  - (Sherlock2.0)

- **Longterm**
  - Aircraft sensors (FOQA-type)

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**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 (all wind components)
- 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

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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 (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
KDEN

Sheet 9

![Graph showing the relationship between Num Speed Restrict in Subroute and %any deviation. The graph indicates a peak at around Num Speed Restrict 4, with a decrease and then an increase towards the end.]
Miles Flown
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
Machine Learning Methods

Multivariate Analysis

Classification          Precursors
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**

- Required Slope L From
- Time

- Excursion 1-Sigma Error Bar
- Compliance 1-Sigma Error Bars

Dates:
- 2014-09-18
- 2014-11-13
- 2015-01-08
- 2015-03-05
- 2015-04-30
- 2015-06-25
- 2015-08-20
- 2015-10-15
- 2015-12-10
- 2016-02-04
- 2016-03-31
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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