RNAV STAR Procedural Adherence

Next Steps
Data Visualization
- Bar charts
- Scatter plots
- Line graphs
- Heat maps

Method
- Statistical analysis
- Machine learning
- Predictive modeling

How Procedures Have Changed
- Data analysis
- Procedure updates
- Regulatory changes

Descriptive Data
- Frequency distributions
- Mean, median, mode
- Standard deviation

Why we looked at OPD STARs
- Industry trends
- Safety improvements
- Compliance monitoring
- Performance metrics
RNAV STAR Procedural Adherence
How Procedures Have Changed

No Procedures
Flying was dangerous and not standardized

Instrument Approach Procedures
A method to consistently guarantee safe distance

STARS (conventional)

STARS (RNAV OPD)
Robot introduced; FIPS 1301
Improvement in position and runway management FAA 2006
No Procedures

Flying was dangerous and not standardized
Beacon just north of Chey. Reserve about one mile on standard Beacon.

8500 safe at night. Can circle a radius of about 4 miles, at this elevation.

Increase to 9200' coming from Chey, and 9500' from the west. The above altitude will clear anything on the hill.

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
Why we looked at OPD STARs

ASRS Reports from Pilots
1. Controller interventions
2. Autopilot and FMS errors
3. Procedure design

ASRS Reports from Controllers
1. Inter-controller communications
2. Pilot non-compliance
3. Misinterpreted instructions

Factors Influencing Adherence
- Weather
- Mixed Equipment Performance
- Traffic
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
Data Source

Past
ARTCC radar tracks
(CTAS data)

NOW
TRACON data
(Sherlock2.0)

Longterm
Aircraft sensors
(FOOA-type)

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 (ballistic component)
- Temperature (Rapid Reflash NOAA)

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

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
Descriptive Data

Assess Levels of Use

Identify Human Intervention
Assess Levels of Use
Memphis

LATE ENTRY AND EARLY EXIT 7.13% 18,170

SKIP
6.54%
16,681

SKIP AND LATE ENTRY
0.37%
951

SKIP AND EARLY EXIT
3.15%
8,033

SKIP, LATE ENTRY, AND EARLY EXIT
0.51%
1,307

EARLY EXIT
19.70%
50,212

No STAR
20.52%
52,291

FULL LATERAL
18.99%
48,409

FULL LATERAL & VERTICAL
24.40%
62,194

LATE ENTRY
11.86%
30,229
Houston

- **Skip and Late Entry**: 3.40% (18,107)
- **Skip and Early Exit**: 3.96% (21,082)
- **Skip, Late Entry, and Early Exit**: 0.78% (4,151)
- **Early Exit**: 19.91% (106,043)
- **Full Lateral**: 13.50% (71,891)
- **Full Lateral & Vertical**: 9.27% (49,374)
- **Late Entry**: 14.17% (75,455)
- **Late Entry and Early Exit**: 5.70% (30,340)
- **No STAR**: 26.09% (138,973)
Denver

- SKIP, LATE ENTRY, AND EARLY EXIT: 4.57% (26,674)
- SKIP AND LATE ENTRY: 0.92% (5,349)
- SKIP AND EARLY EXIT: 15.45% (90,251)
- SKIP: 3.14% (18,347)
- EARLY EXIT: 20.07% (117,244)
- FULL LATERAL: 0.33% (1,944)
- FULL LATERAL & VERTICAL: 0.32% (1,888)
- LATE ENTRY: 1.67% (9,775)
- LATE ENTRY AND EARLY EXIT: 10.72% (62,648)
- No STAR: 48.42% (282,908)
Identify Human Intervention
Waypoint: VASHN

Magnitude of Excursion (ft) (bin)

Count of Waypoint

Waypoint Values:
-1300, -1100, -900, -700, -500, -300, -100, 100, 300, 500, 700, 900, 1100, 1300
Excursion above restriction

Excursion below restriction

AT or Below

AT or Above

Window

Excursion Percentage

0.14

0.12

0.10

0.08

0.06

0.04

0.02

0.00
Next Steps

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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