RNAV STAR Procedural Adherence
RNAV STAR Procedural Adherence
How Procedures Have Changed

No Procedures
Flying was dangerous and not standardized

Instrument Approach Procedures
A method to consistently guarantee terrain clearance

STARS (conventional)

STARS (RNAV OPD)
Robust procedures, set-backs, noise-standardization, and turn management (FAA 2014)
No Procedures

Flying was dangerous and not standardized
Just north of Chey, Reser about one mile on standard Beacon. 8500 safe at site. 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)
Based on the diagram provided:

- **2D**: Ground Based Lateral
- **3D**: RNAV Lateral & Vertical
  - Marked as **We’re Here**
- **4D**: Dynamic RNAV Paths RTA

The graph represents the progression of functionality over time, with an increasing trend towards procedural complexity.
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

Unique Paths:
- Transition-A, Common-Route_Runway-X
- Transition-B, Common-Route_Runway-X
- Transition-A, Common-Route_Runway-Y
- Transition-B, Common-Route_Runway-Y

Common Route

Runway-X

Transition-A

Runway-Y

Transition-B

Overlay Flights on Routes

- Flight Paths
- Route Metrics
- Other Options
- Unlabeled routes
- No route data
- Transition points
- Radar data
- Airspace boundaries
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 (FOQA-type)

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

Environmental Variables
- Wind (bipolar-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

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

TRACON data
(Sherlock2.0)

Longterm Aircraft sensors
(FOQA-type)
Descriptive Data

Assess Levels of Use

Identify Human Intervention
Assess Levels of Use
Memphis

- No STAR: 20.52% (50,212)
- Full Lateral: 18.99% (48,409)
- Full Lateral & Vertical: 24.40% (62,194)
- Early Exit: 19.70% (50,212)
- Lateral Entry: 11.86% (30,229)
- Late Entry and Early Exit: 7.13% (18,170)
- Skip: 6.54% (16,681)
- Skip and Late Entry: 0.37% (951)
- Skip, Late Entry, and Early Exit: 0.51% (1,307)

LATE ENTRY AND EARLY EXIT: 18,170
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

- Early Exit: 20.07% (117,244)
- No STAR: 48.42% (282,908)
- Late Entry: 15.45% (90,251)
- Late Entry and Early Exit: 10.72% (62,648)
- Full Lateral: 0.33% (1,944)
- Full Lateral and Vertical: 0.32% (1,888)
- Skip: 3.14% (18,347)
- Skip and Late Entry: 0.92% (5,349)
- Skip, Late Entry, and Early Exit: 4.57% (26,674)
Identify Human Intervention
Waypoint: VASHN

Magnitude of Excursion (ft) (bin)

Count of Waypoint

Count of Waypoint

-1900 -1700 -1500 -1300 -1100 -900 -700 -500 -300 -100 100 300 500 700 900 1100 1300
Excursion above restriction

Excursion below restriction

AT 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
RNAV STAR Procedural Adherence

How Procedures Have Changed

Data Source

Next Steps
Data Visualization
Expected Outcomes
Method

Descriptive Data

Why we looked at OPD STARs

Method: Data Visualization

Expected Outcomes:
- Increased efficiency
- Improved accuracy
- Enhanced decision-making