RNAV STAR Procedural Adherence

Next Steps
- Data Visualization Exposed
- Additional Information Needed
- Further Analysis Required

Method

Descriptive Data

Why we looked at OPD STARs

How Procedures Have Changed

Data Source
RNAV STAR Procedural Adherence

How Procedures Have Changed

Next Steps
Data Method
How

Method

Data Source

Descriptive Data

Why we looked at OPD STARs
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)
Robust en-route route selection, navigation and traffic management (FAA 2004)
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

Time

2D

RNAV Lateral

3D

RNAV Lateral & Vertical

4D

Dynamic RNAV Paths RTA

Functionality

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
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)

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 (bulkwind 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
Descriptive Data

Assess Levels of Use

Identify Human Intervention
Assess Levels of Use
IOAO ~ KLGA~ KBOS~ KEWR -- KOEN
2014 Median 2015 Median 2016 Median IQR
Rate (Percent of Traffic)
Airport
Rate (Percent of Traffic)
Memphis

- No STAR: 20.52% (52,291)
- Full Lateral: 18.99% (48,409)
- Full Lateral & Vertical: 24.40% (62,194)
- Early Exit: 19.70% (50,212)
- Late Entry: 11.86% (30,229)
- Skip: 6.54% (8,033)
- Skip and Late Entry: 0.37% (951)
- Skip, Late Entry, and Early Exit: 0.51% (1,307)
- Late Entry and Early Exit: 7.13% (18,170)

Total: 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

- **Skip**
  - 10.01%
  - 53,285

- **Early Exit**
  - 19.91%
  - 106,043

- **No STAR**
  - 26.09%
  - 138,973

- **Late Entry**
  - 14.17%
  - 75,455

- **Full Lateral**
  - 13.50%
  - 71,891

- **Full Lateral & Vertical**
  - 9.27%
  - 49,374

- **Late Entry and Early Exit**
  - 5.70%
  - 30,340
Denver

- No STAR: 48.42% (282,908)
- Early Exit: 20.07% (117,244)
- Late Entry: 1.67% (9,775)
- Full Lateral: 0.33% (1,944)
- Full Lateral & Vertical: 0.32% (1,888)
- Early Exit and Late Entry: 10.72% (62,648)
- Skip: 3.14% (18,347)
- Skip and Late Entry: 0.92% (5,349)
- Skip, Late Entry, and Early Exit: 4.57% (26,674)
- Skip and Early Exit: 15.45% (90,251)
Identify Human Intervention
Waypoint: VASHN

Magnitude of Excursion (ft) (bin)

Count of Waypoint

Waypoint Magnitude:

-1900, -1700, -1500, -1300, -1100, -900, -700, -500, -300, -100, 100, 300, 500, 700, 900, 1100, 1300
Waypoint: JOBEE

Magnitude of Excursion (ft) (bin)

Count of Waypoint

-3000 -2800 -2600 -2400 -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400
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

Next Steps
Data Visualization Strategies
Method

Data Source

How Procedures Have Changed

Descriptive Data

Why we looked at OPD STARs

Analysis Techniques
- Statistical Analysis
- Machine Learning
- Data Visualization
- Interpretation of Results