A Machine Learning Approach to Predict Aircraft Landing Times using Mediated Predictions from Existing Systems

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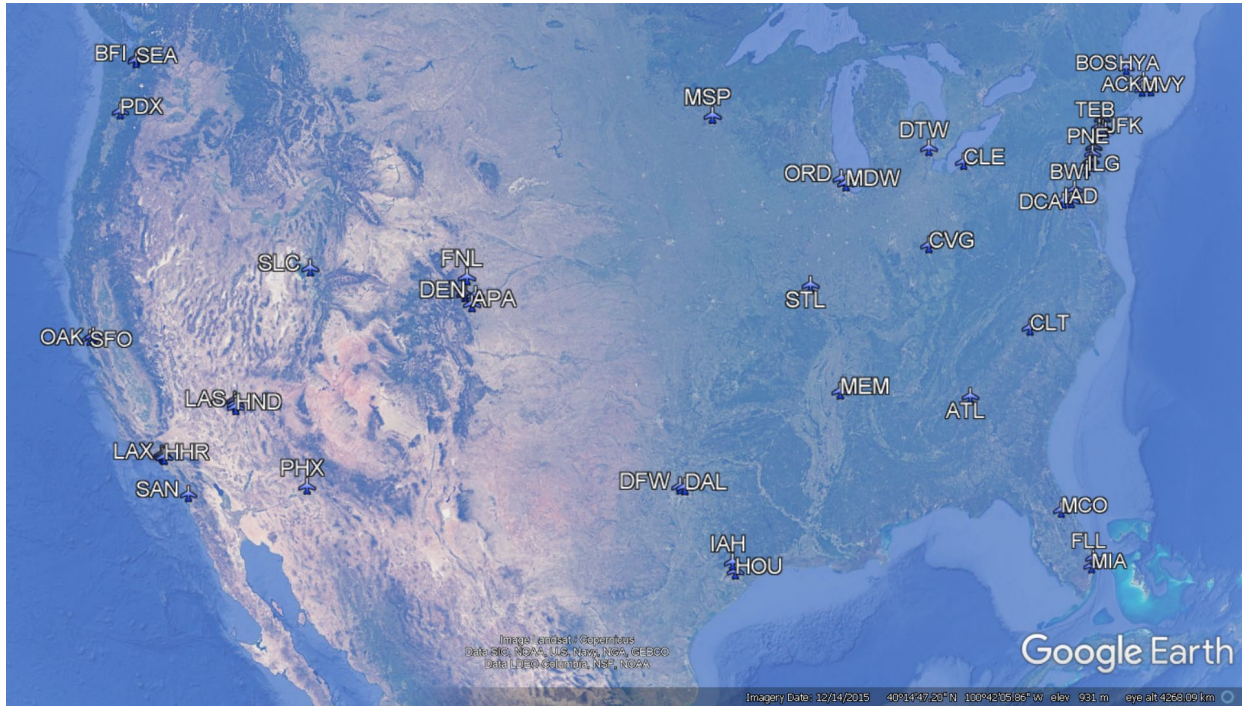
Context

- NAS users need accurate arrival times
- Different NAS systems publish different estimates
- Flights have a large amount of associated data
- Users expect to understand reasoning behind prediction values



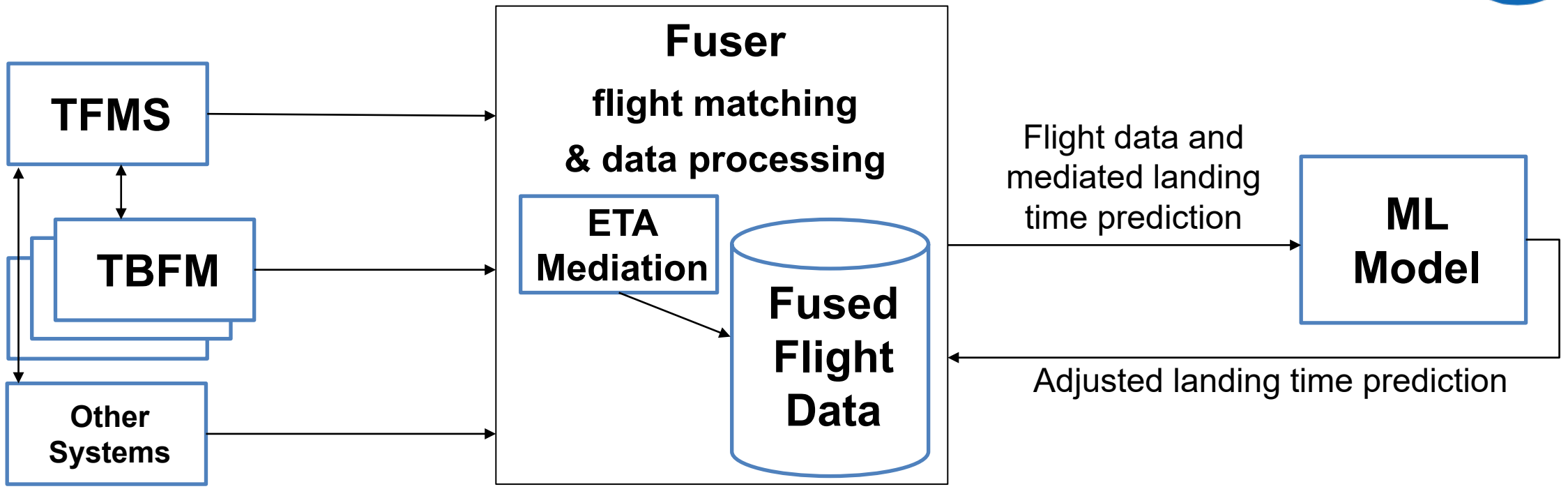
Airports with TBFM arrival runway ETA values

Map data: Google, SIO, NOAA, U.S. Navy, NGA, GEBCO, Landsat/Copernicus, LDEO-Columbia, NSF

Traffic Flow Management System (**TFMS**): NAS-wide flow management

Time Based Flow Management (**TBFM**): Limited coverage, more accurate

Approach



- Flight data collected and fused
- Runway arrival times (ETA) mediated to single landing time predictions
- Mediated ETA and remaining flight data used as features
- XGBoost model adjusts the landing time prediction
- Model output fused with rest of flight data

XGBoost – Input Data

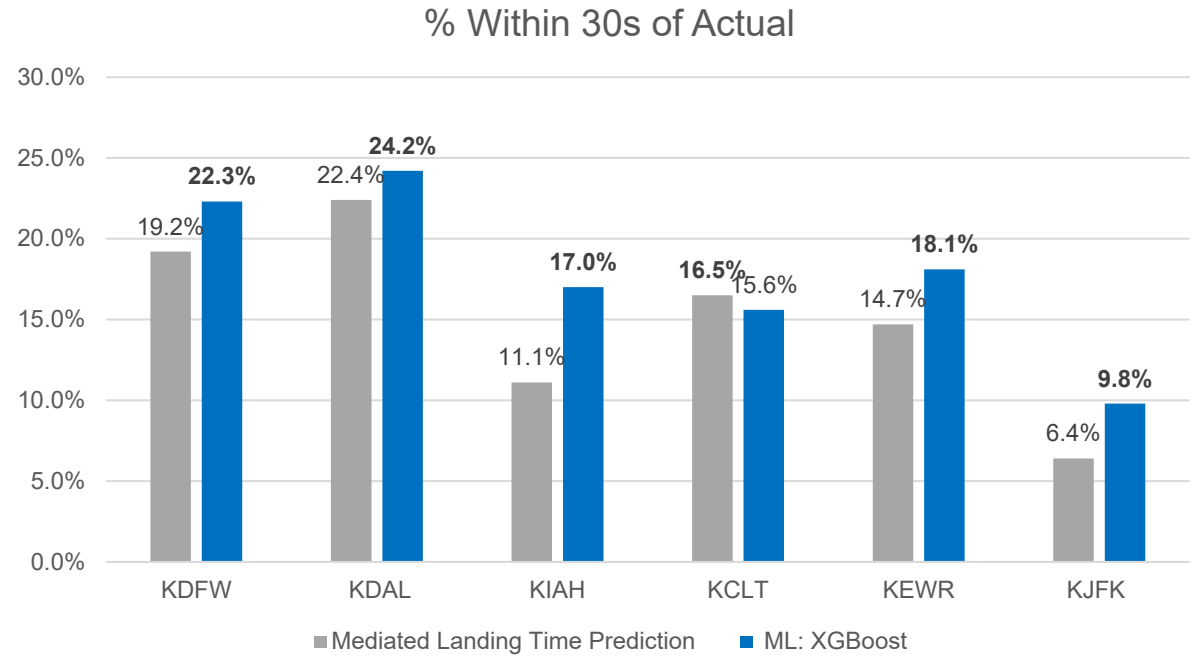
Timestamp Data	Description
timestamp	time at which prediction is generated
mediated landing time prediction	selected from TBFM STA, TBFM ETA, TFM ETA
first airborne surveillance timestamp	from TFMS or TBFM
actual take-off time	Actual runway departure time if reported, or first airborne surveillance timestamp
actual departure gate push-back time	Actual stand departure time if reported, or the actual take-off time
airline-scheduled gate push-back time	Airline-provided stand departure time if reported, or actual departure gate push-back time
airline-scheduled take-off time	Airline-provided runway departure time if reported, or actual take-off time
airline-scheduled landing time	Airline-provided runway arrival time if reported, or mediated prediction

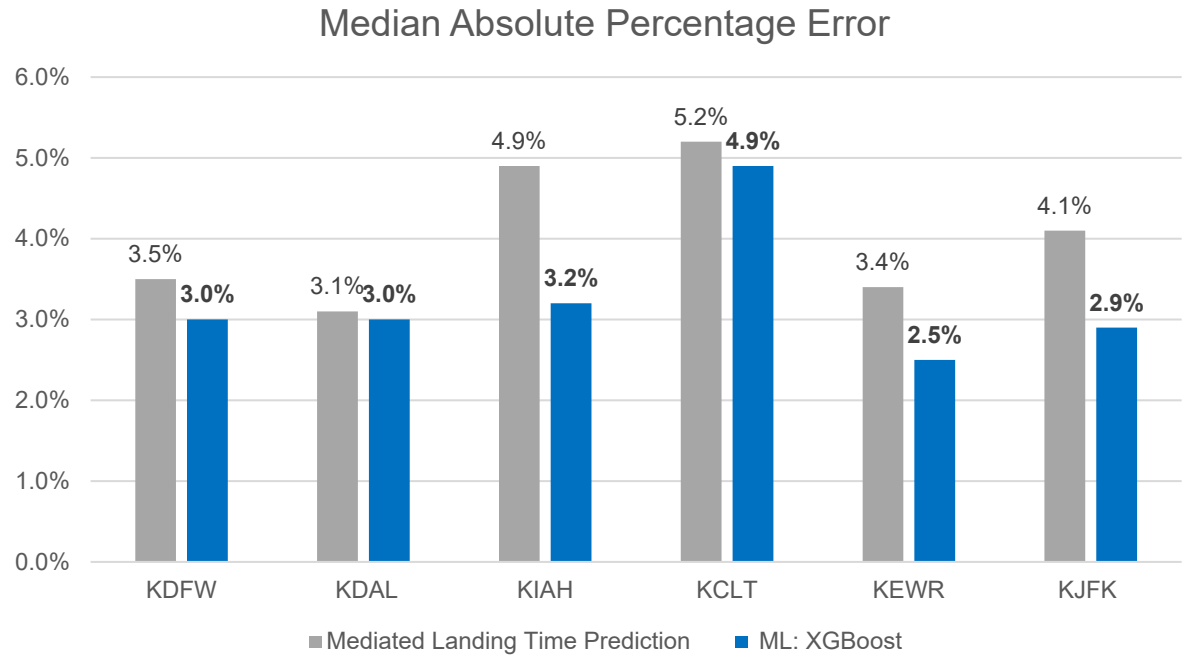
Encoded String Data	Description
TBFM arrival stream class	TBFM-assigned grouping of flights
TBFM arrival meter fix	TBFM-assigned location used for metering flights on the same flow
TBFM arrival runway	TBFM-assigned runway based on current airport configuration and TBFM adaptation
Major air carrier	Airline associated with the flight
Aircraft type	Grouped aircraft type (e.g., narrow body, wide body, and regional jet)

bold face indicates required input data

XGBoost – Results

- Separate models were trained for each included airport
- Results generally favored ML
- Mean absolute percentage error is less decisive
  - –Likely affected by outliers
  - –Huber loss function was used to reduce model sensitivity to outliers

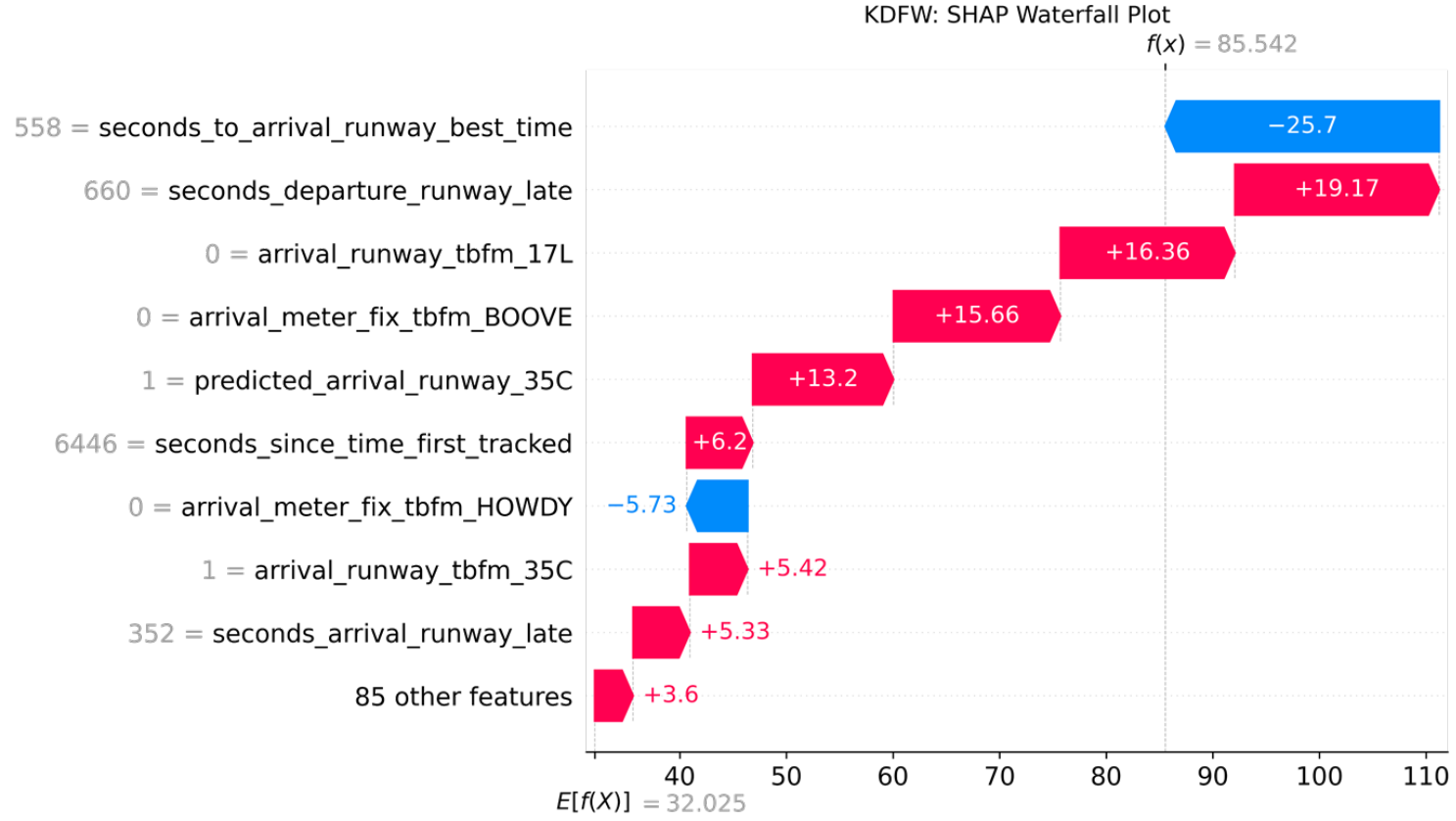


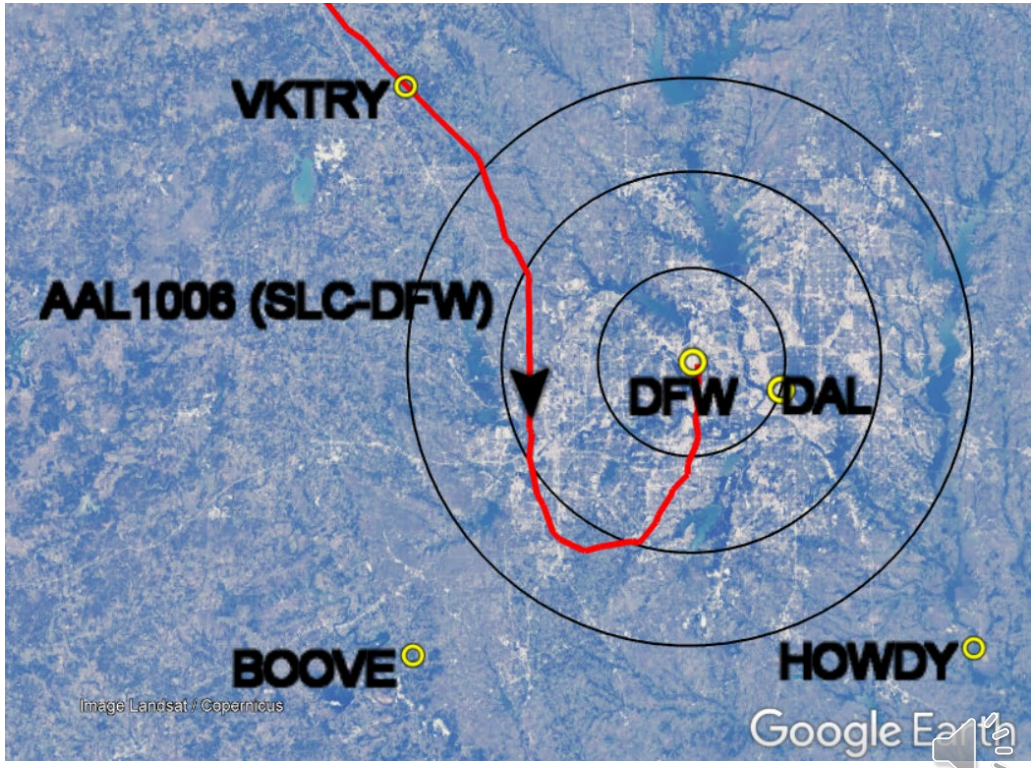


bold face indicates more favorable value

XGBoost – Results (example)

- AAL1006 (SLC-DFW)
  - –Model adjusted the mediated prediction 86 seconds later
  - –Actual landing time was several minutes later still
- Flight needed to adjust its trajectory to accommodate landing direction





Map data: Google, Landsat/Copernicus

Conclusion and Next Steps

- Existing NAS arrival estimates are good but can be improved with XGBoost
- Limited features helps explainability, but may hurt predictability
  - –Expected arrival runway counts (traffic congestion indicator)
  - –Physical flight properties (speed, altitude, heading)
  - –Current or predicted airport configuration
  - –TBFM metering status or frozen STA indicators
  - –Weather factors
- Mediation of the landing time prediction can be improved