Airline Flight Data Examination to Improve flight Performance Modeling

Project 35

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Research Objectives

- Improve the aircraft weight versus stage length (trip distance) relationship, thereby improving the accuracy of the weight values used in the prediction of departure trajectories.
- Develop correlations to compute the departure thrust as a function of aircraft type, weight, and operating conditions, thereby improving the accuracy of the departure trajectories and their associated performance.
- Update AEDT to enable accurate modeling of reduced thrust departures, which are used in more than 90% of all commercial aircraft departures.

Operational Database

- A substantial Aircraft Communication Addressing and Reporting System (ACARS) database has been acquired that contains aircraft specific departure data for a wide range of commercial aircraft. The data includes a number of performance parameters along with the takeoff weight, percent of reduced power/thrust used to conduct the departure, the origin and destination airports, and current temperature.

Planned Action – Weight Estimation

- Aircraft Weight Estimation

  - AEDT now uses a “Stage Length Table” to estimate the aircraft departure weight. This table was last updated in 2003 and assumed a specific load factor, passenger weights, fuel loading requirements and no cargo. The operational database now provides and opportunity to generate an algorithm relating actual aircraft weights to the distance flown. The user input would remain a distance flown.

  - Currently the research has been regressing Great Circle Distances between the known airports to develop an algorithm. In addition, a Flight Planning database has recently been acquired that will provide an opportunity to support a regression of “Planned Trip Miles” versus aircraft weight which is expected to have an improved correlation.

B767- 400ER Weight vs GCD

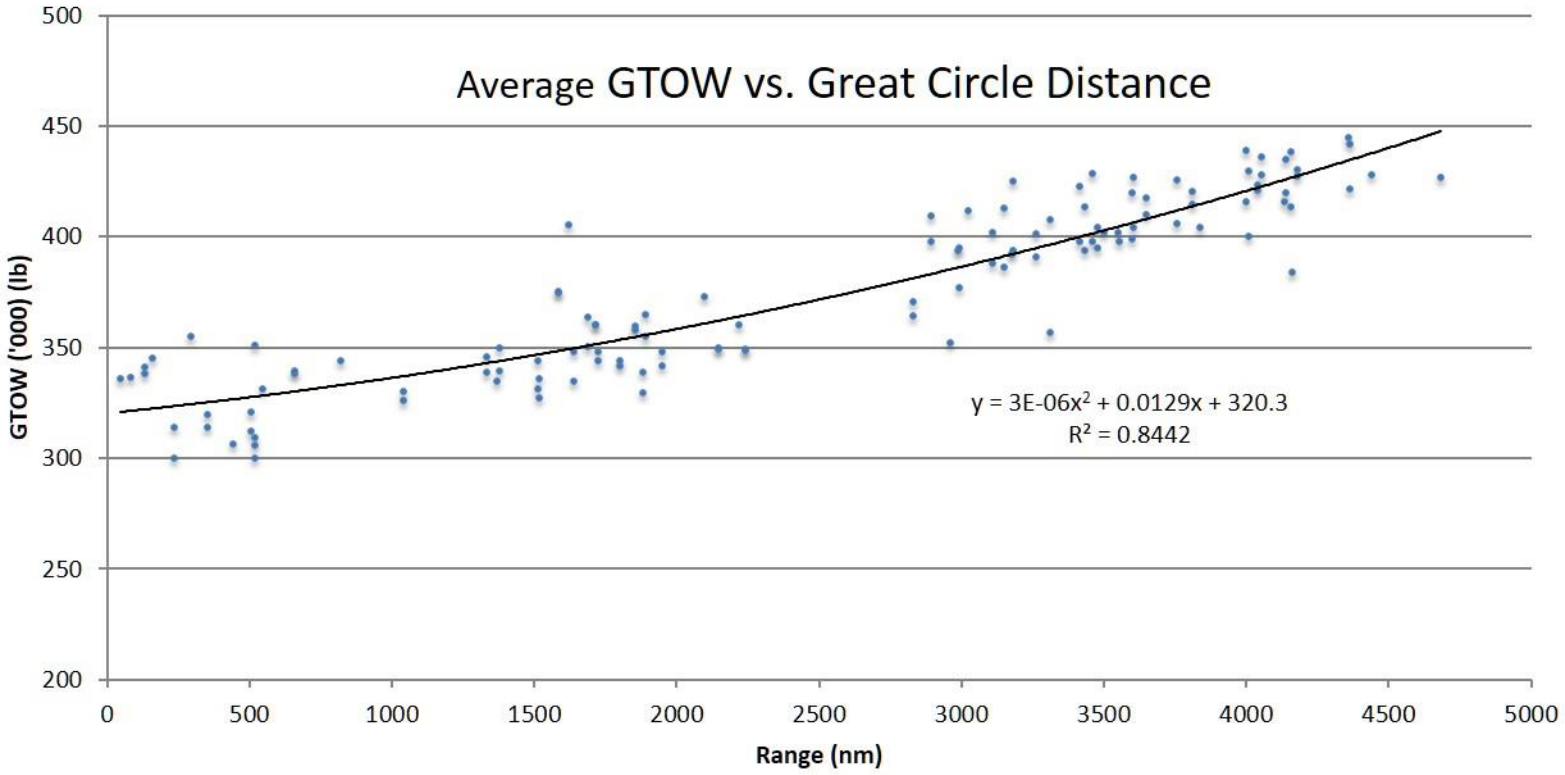

Figure 1

B767- 300ER Weight vs GCD

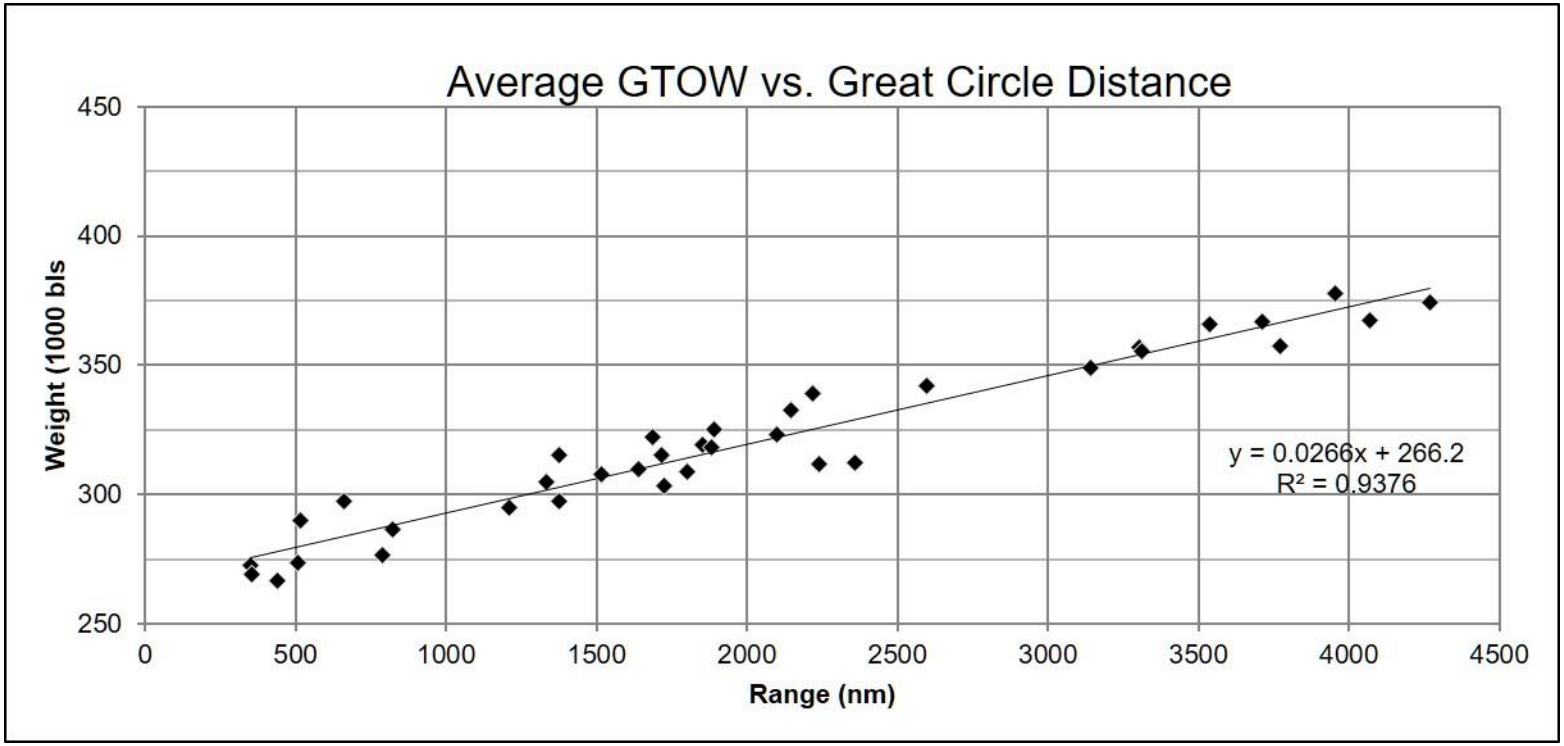

Figure 2

B737- 800 Weight vs GCD

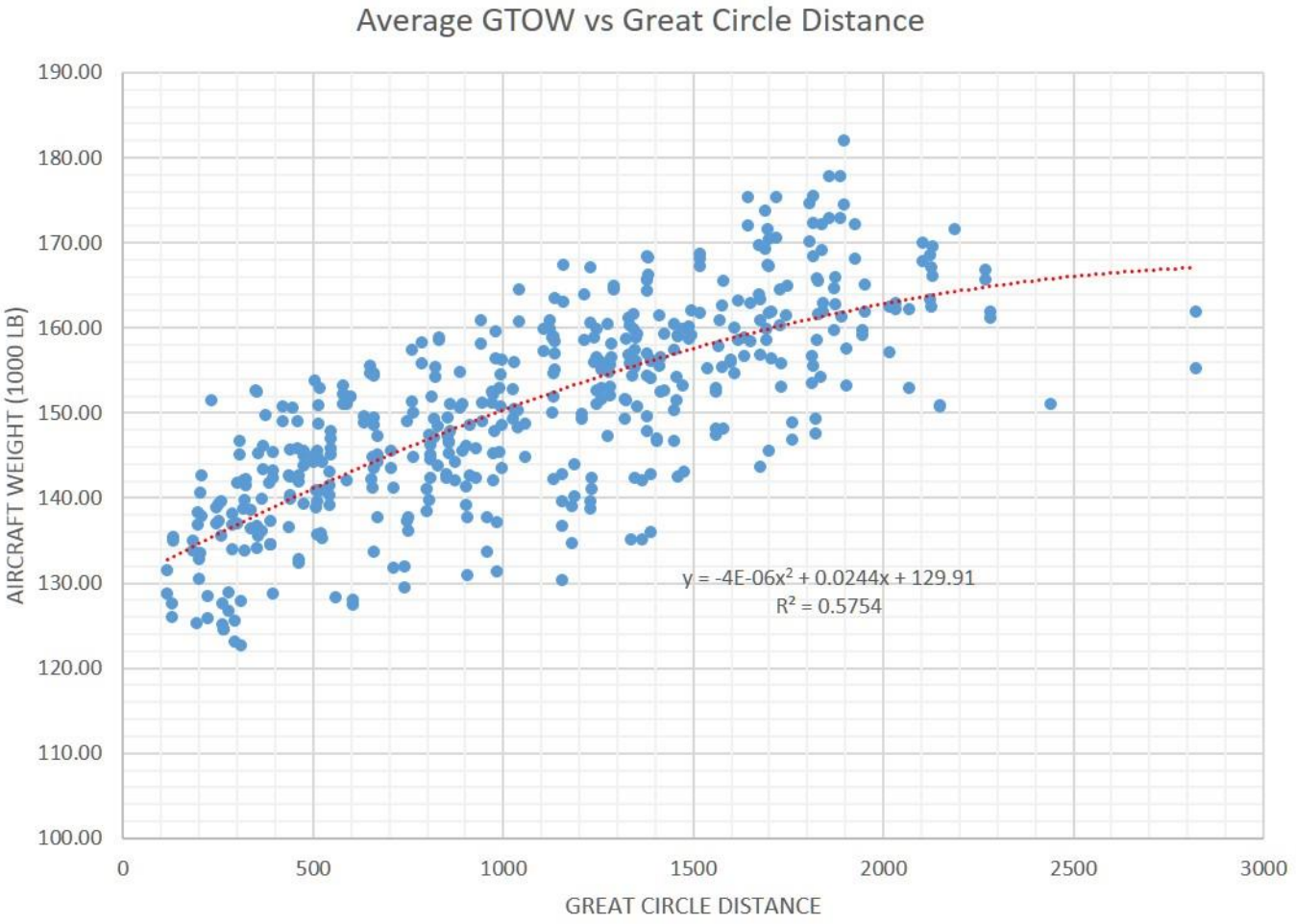

Figure 3

Planned Action – Reduced Thrust Determination

- The use of reduced thrust for a specific departure is determined by a regulatory certified performance analysis typically referred to as “assumed temperature”. It is typically employed to departures when the actual aircraft weight is well below the weight that would require the use of full rated takeoff power/thrust.
- While the use of reduced and derated power takeoffs has been utilized by air carriers for many years, until now, there has been no definitive database to substantiate it’s rate of use or the level of reduced thrust typically used.
- The operational database contains the actual reduced thrust used and reveals a wide spread of data for a given aircraft weight (Figure 7). While the aircraft weight, airport elevation, and temperature all effect the determination of reduced thrust use, it is the implementation of reduced thrust that contributes significantly to the variation. While the cause of the variation in the data is understood, the reduction of the data into an acceptable prediction will be the task for the researchers in conjunction with an SAE A-21 Project Working Team.

Assumed Temperature Example

TMPF	SSWT	ATMPC	TMPF	FLWT	ATMPC
85	461050	30	85	462053	30
86	457068	31	86	459975	31
88	453823	32	88	457883	32
90	449721	33	90	455662	33
92	445546	34	92	453317	34
94	441055	35	94	450440	35
95	436837	36	95	447261	36
97	433333	37	97	443289	37
99	429727	38	99	439886	38
101	425943	39	101	437484	39
103	422154	40	103	435071	40

TMPF	SSWT	ATMPC	TMPF	FLWT	ATMPC
104	418360	41	104	432643	41
106	414505	42	106	430185	42
108	410596	43	108	427699	43
110	406746	44	110	425255	44
112	402931	45	112	422837	45
113	399117	46	113	420415	46
115	395303	47	115	417990	47
117	391387	48	117	415500	48
119	387444	49	119	412992	49
121	383103	50	121	410257	50
122	378707	51	122	407491	51

Example: Aircraft Actual Weight of 415,000 lbs. with ambient temperature of 85F

The maximum takeoff weight is the lesser of the Field Length Limit Weight (FLWT) and Second Segment Climb Limit Weight (SSWT). From the performance data above, the maximum weight is 461050 pounds using full rated takeoff power. The Actual weight of 415000 lbs. is well below the limit weight for full rated takeoff power.

Step 1: Determine the maximum assumed temperature associated with a FLWT just greater than the actual weight
415500 at AT48

Step 2: Determine the maximum assumed temperature associated with a SSWT just greater than the actual weight
418360 at AT41

Therefore the maximum assumed temperature takeoff power for an aircraft weighing 415000 lbs. is AT41
Note that the 415000 lb. aircraft can also use any assumed temperature below AT41 down to AT30.

% Reduced Thrust vs Aircraft Weight

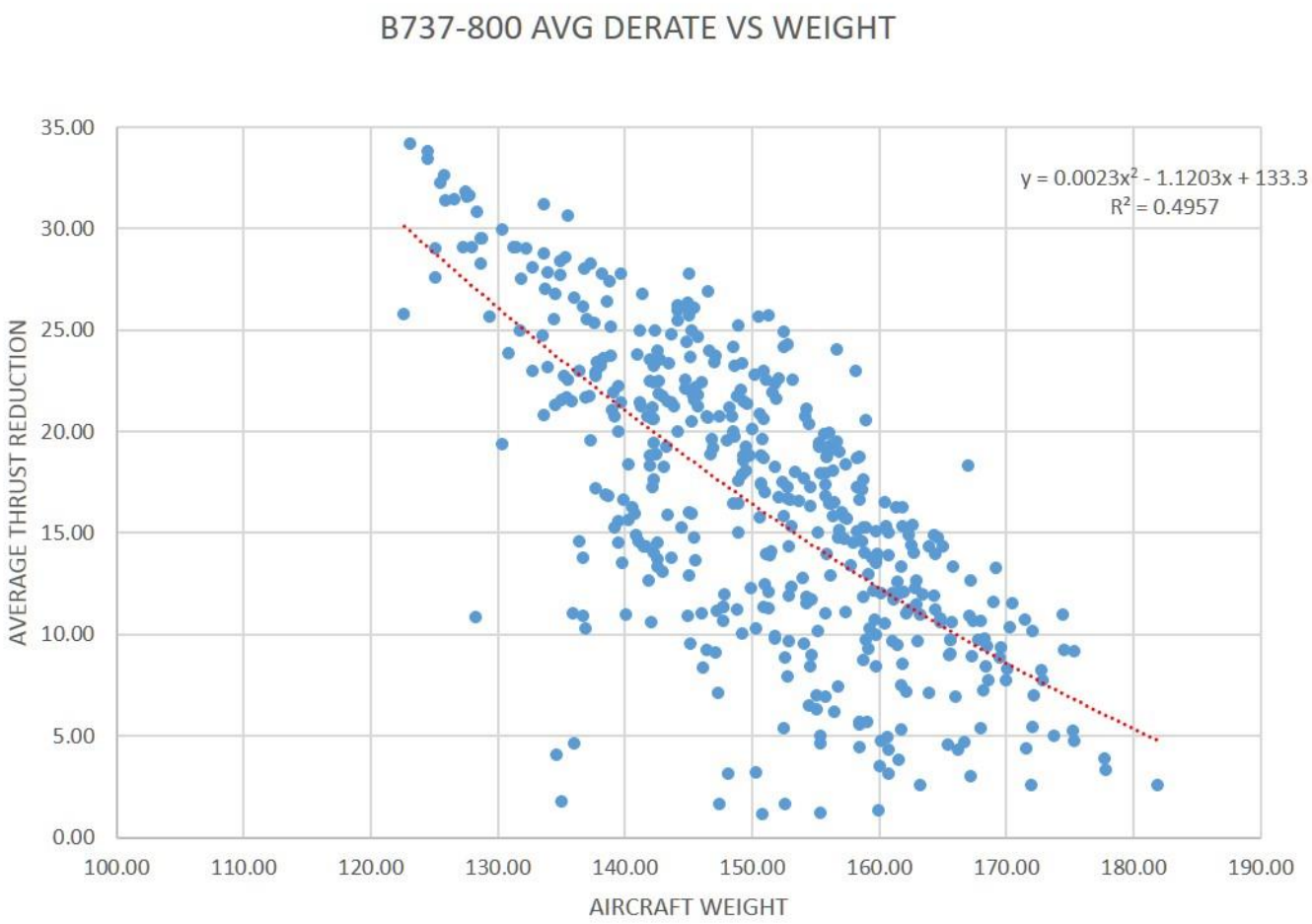

Figure 7

Reduced Thrust to Weight Variance

The following are known causes of the variance in the percentage of reduced thrust to weight data or in the weight to distance data:

- Temperature and airport elevation
- Some airports with characteristics preventing use of reduced thrust (short runways, severe obstacles).
- Charter flights
- Positioning flights
- Contaminated runways (water, snow/ice)
- ATC request to expedite climb
- Variation in pilot takeoff power selection
- Simple data recording errors
- Fuel “tankering” (opting to carry fuel for return trip if destination market pricing is high)
- Data Recording Errors

Objectives

- Provide aircraft specific algorithms to accurately estimate the actual weight of the aircraft based on stage length.

- Enable the AEDT to model aircraft specific reduced thrust departures using thrust coefficients in the same manner as is currently done for full-rated thrust departures.

- Provide aircraft specific percentage of departures using reduced thrust and the percentage of reduced thrust used.

Accomplishments:

- Data has been reduced for the following aircraft:
  - B767-300ER - 49,000 departures
  - B767-400ER - 10,600 departures
  - B737-800 - 99,000 departures

Objectives (cont'd)

Accomplishments:

- A preliminary Weight to Distance algorithm has been developed for all three aircraft.
- The B737-800 data is ready to be forwarded to Boeing for coefficient development.