Aviation fuel consumption modeling

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Aviation fuel consumption modeling

Why do we need accurate fuel consumption modeling methods?

- Fuel is airline's greatest direct cost (more than labor)
- Fuel consumption feeds directly into emission calculations
- CO_2 and climate change concerns

Current fuel consumption methods

- EUROCONTROL's Base of Aircraft Data (BADA)
  - Thrust Specific Fuel Consumption (TSFC)
- ICAO's mode-based method
  - Consumption is a function of aircraft type and altitude
- ICAO's Time in Mode (TIM) method
  - Based on fixed times and fuel consumption during engine emission certification tests

Aviation fuel consumption modeling

BADA methods perform well in cruise

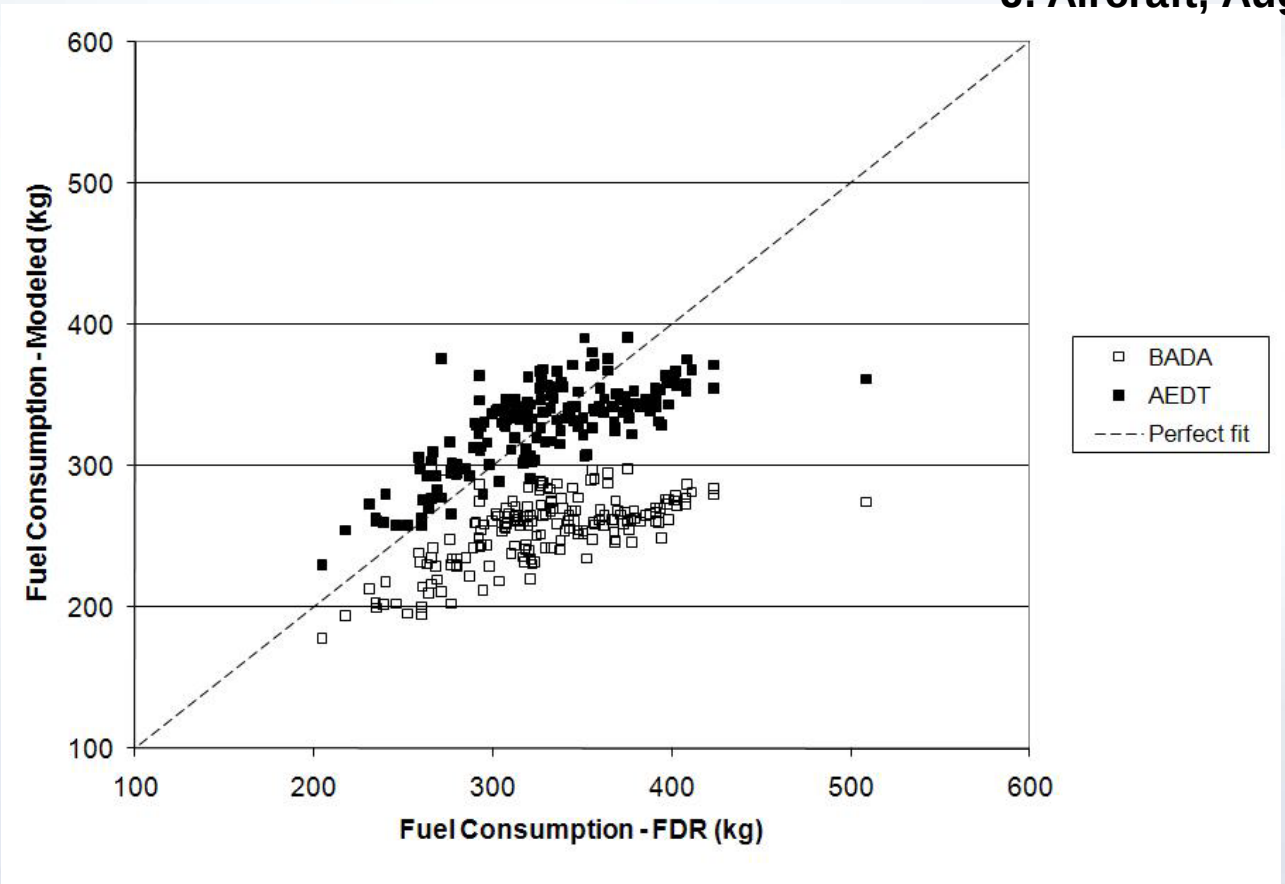
- RVSM program showed BADA within 3% of FDR reported cruise fuel consumption
- Earlier version of BADA (3.7) had inaccuracies at lower altitudes/airspeeds

AEDT introduced methods to address terminal area fuel consumption

- New methods based on work done at MIT on RVSM
- Boeing's BCOP used to develop data for new methods
- Airline FDR data used for validation

Aviation fuel consumption methods

New methods introduced to correct Inaccuracies in BADA below 10,000 ft
– J. Aircraft, Aug-Sept 2009



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The AEDT methods does not generate fuel consumption data

- An underlying source of accurate fuel consumption data is required
- BCOP has data for Boeing (and McDonnell Douglas) aircraft only

Third-party aircraft performance tools can be used

- Lissys' Performance Interactive Analysis and Optimization (PIANO)
- Relatively simple fuel tables combined with empirical adjustments
- Airline FDR data again used for validation

Aviation fuel consumption modeling

Departure:

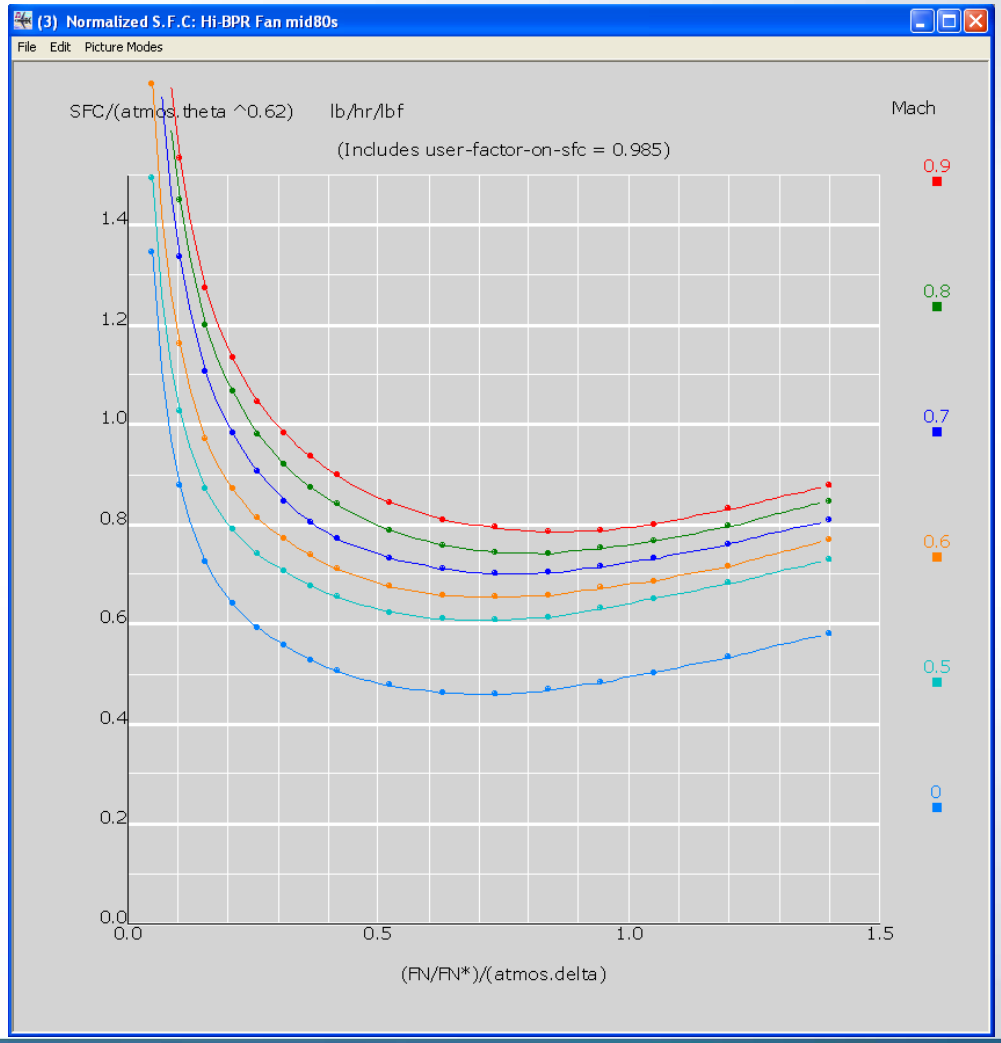
$$TSFC/\sqrt{\theta} = k_1 + k_2 M + k_3 h_{MSL} + k_4 F/\delta$$

Arrival:

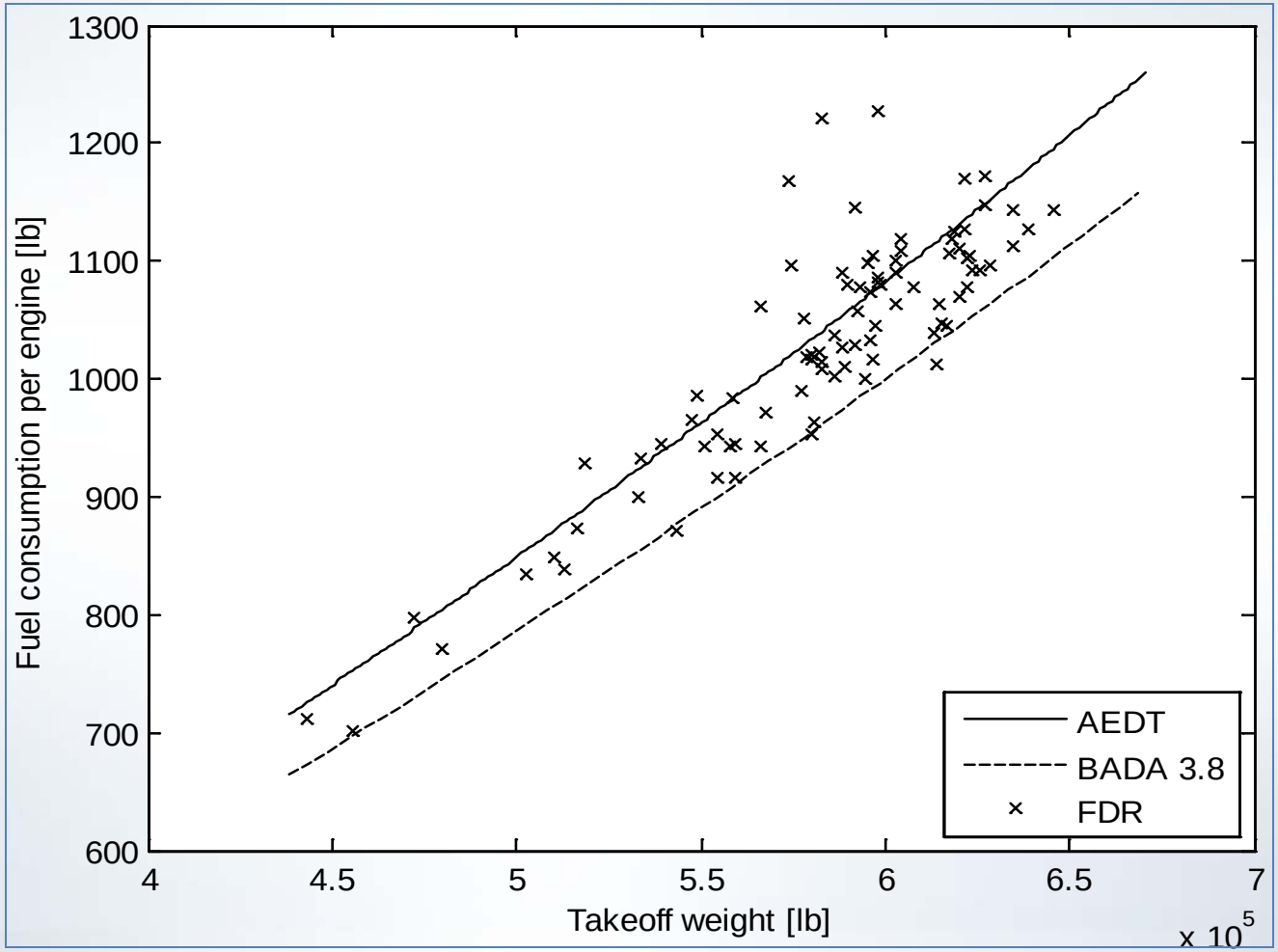
$$TSFC/\sqrt{\theta} = \alpha + \beta_1 M + \beta_2 e^{-\beta_3 \left(\frac{F}{\delta} \Big/ F_0 \right)}$$

Aviation fuel consumption methods

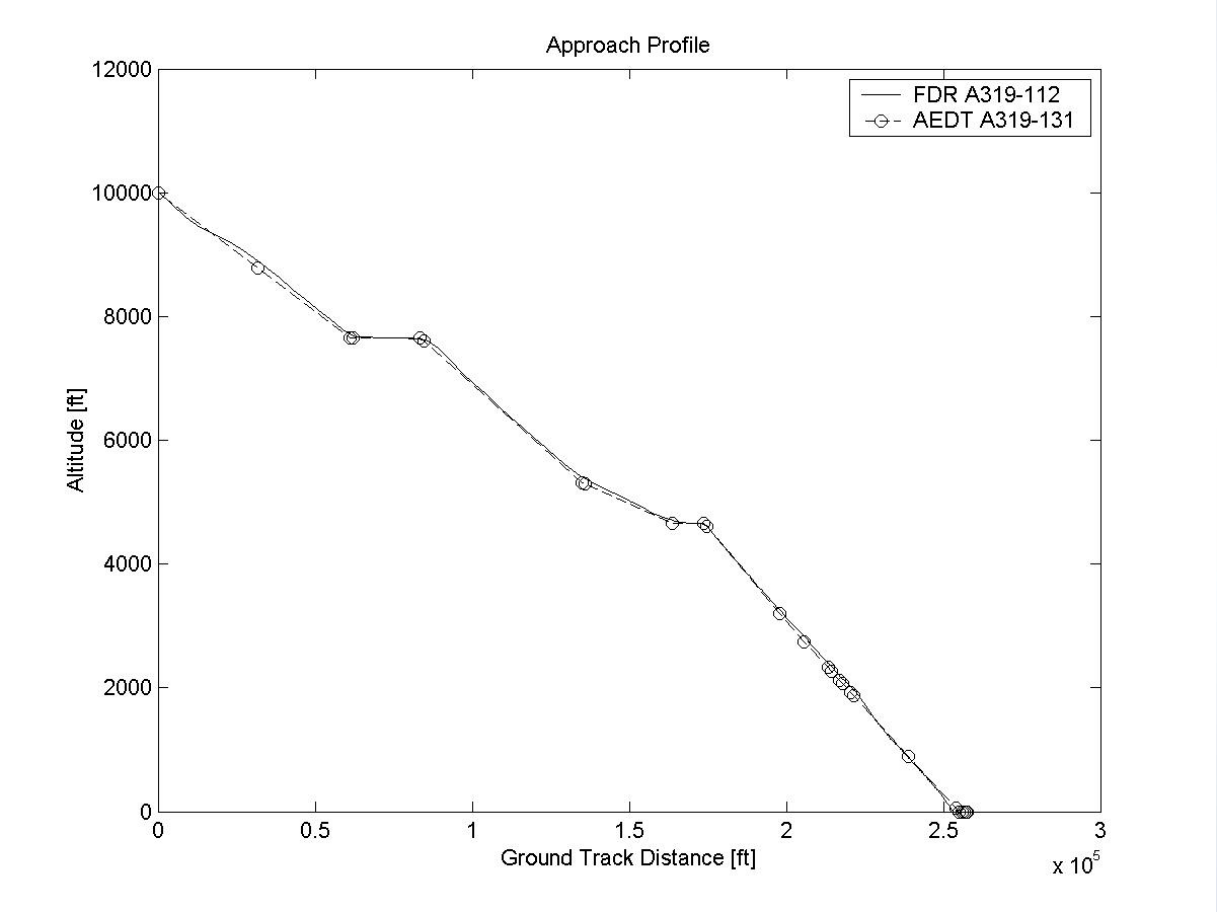
TSFC plot from PIANO



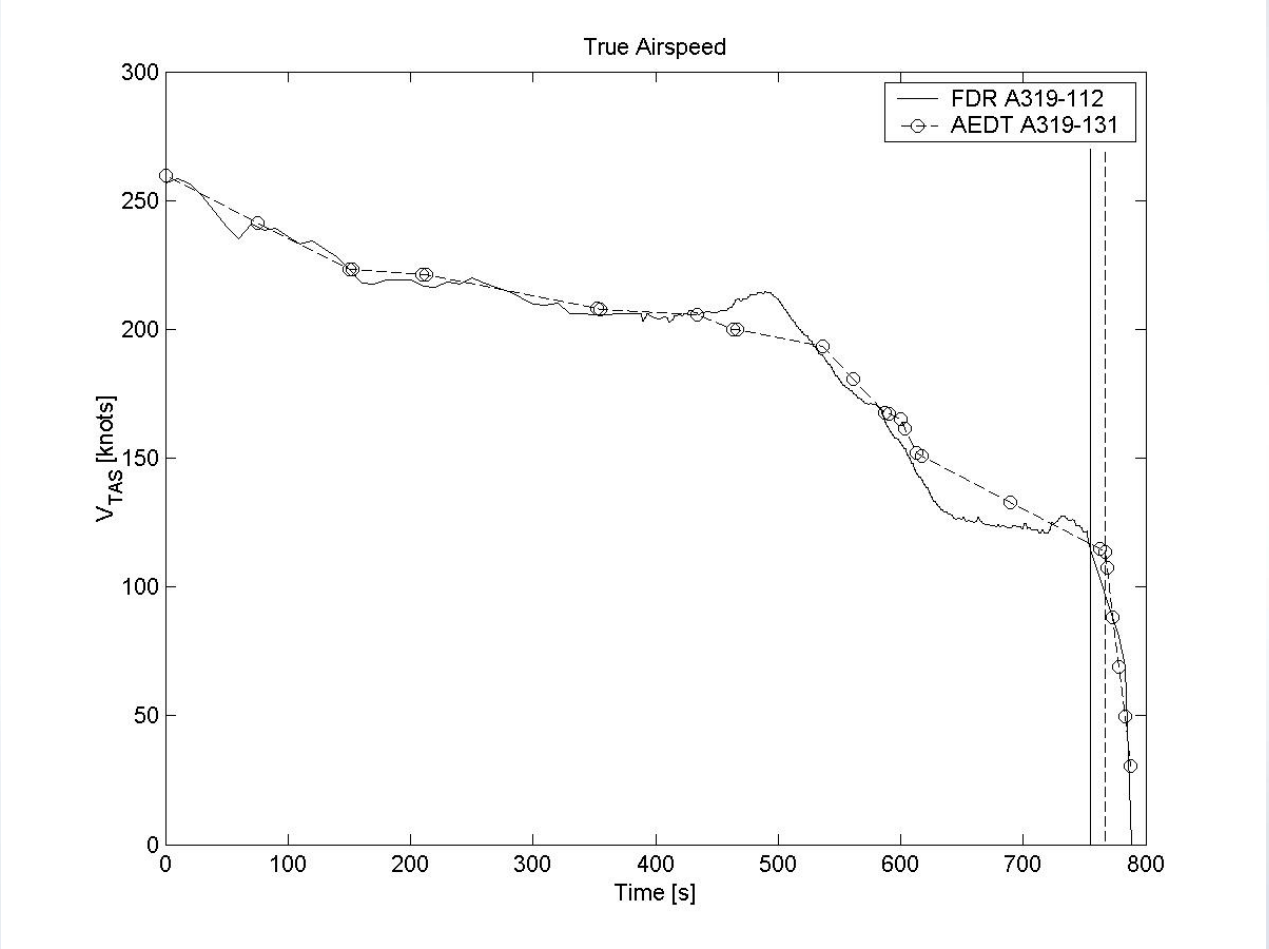
Aviation fuel consumption methods – A340-500



Aviation fuel consumption methods – A319 arrival



Aviation fuel consumption methods – A319 arrival



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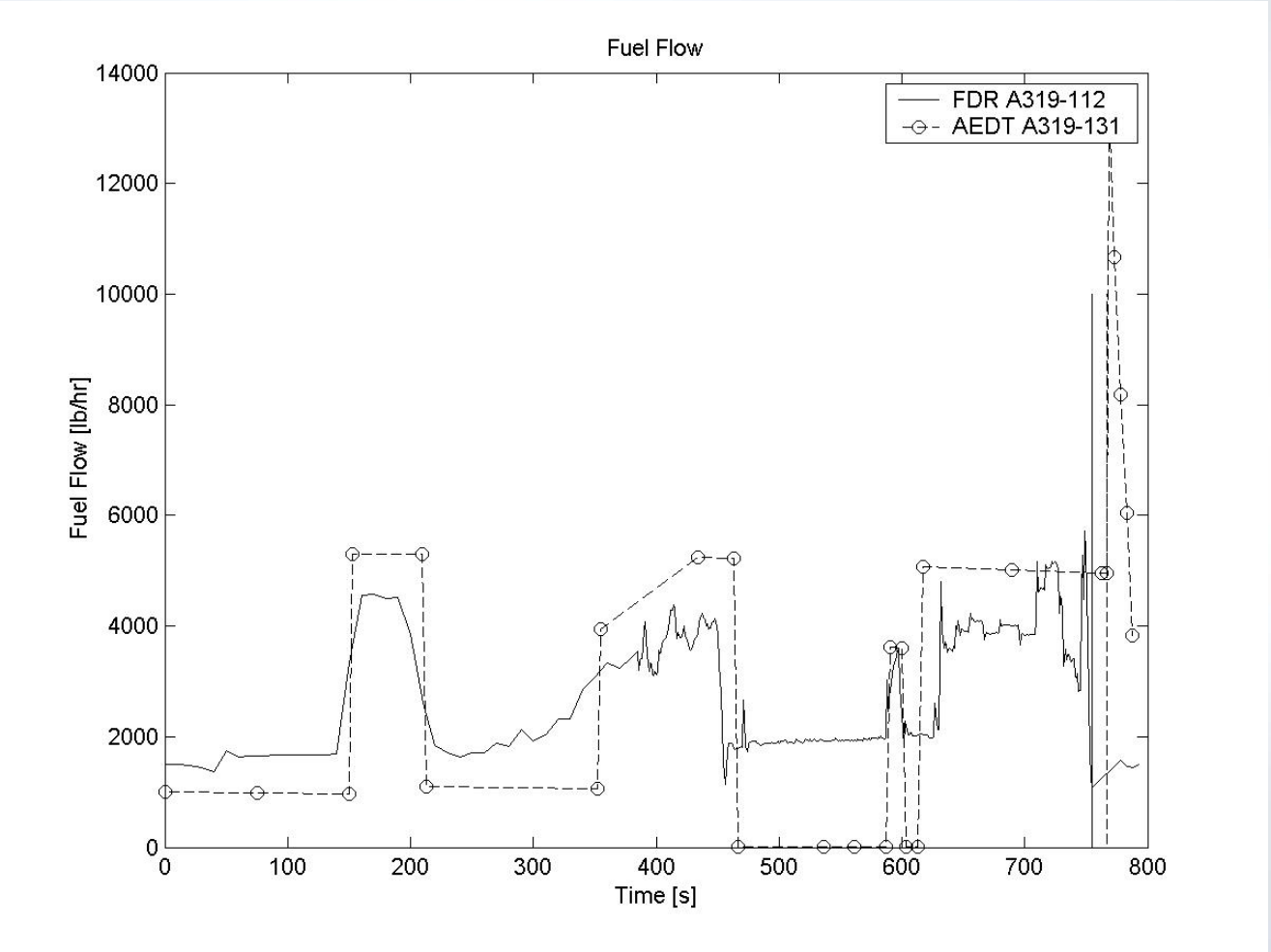
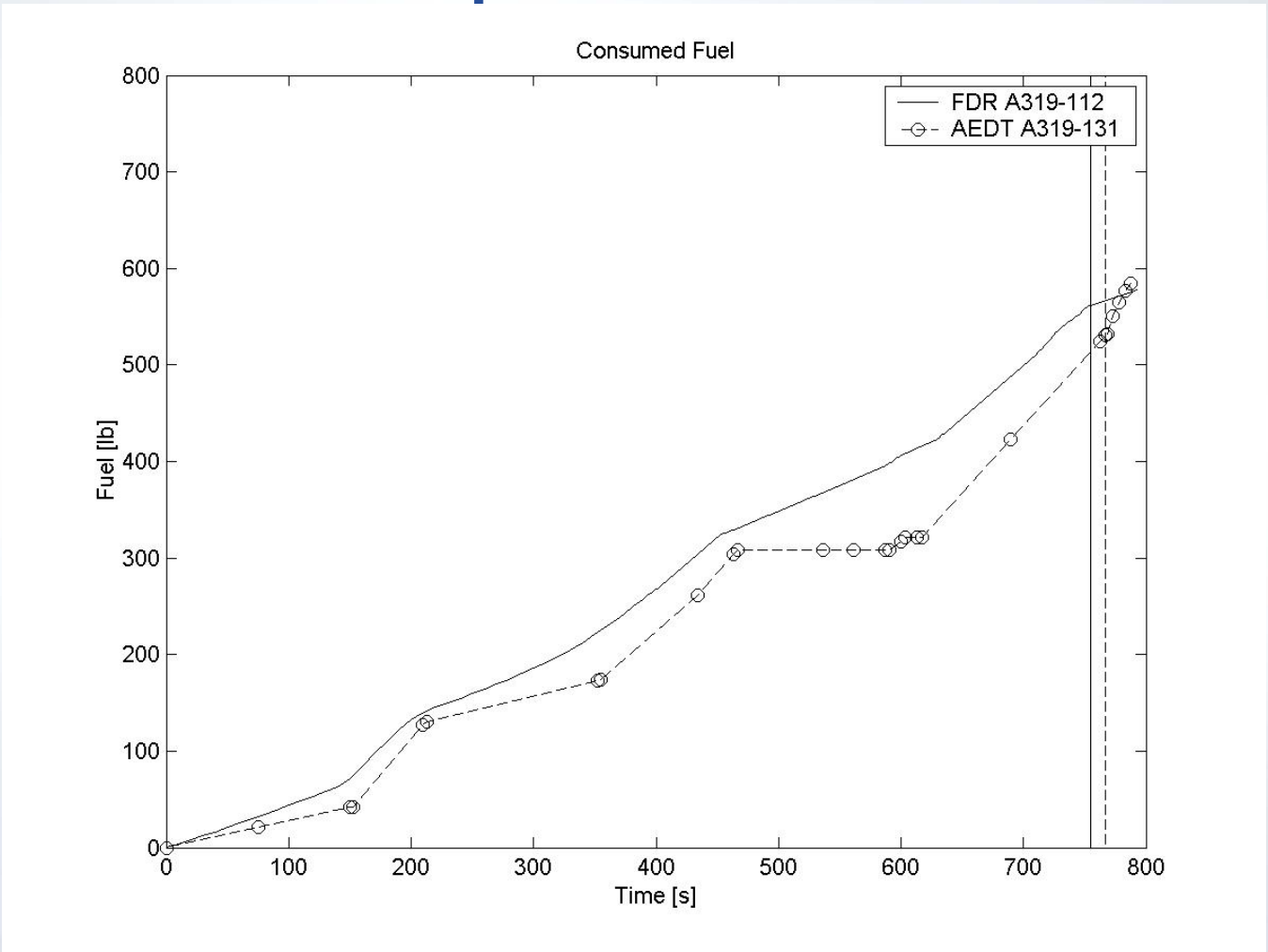


Aviation fuel consumption methods – A319 arrival



Aviation fuel consumption modeling

We can't validate third-party methods for all aircraft

- We only have FDR data for civil transports
- Do we need 'gold-standard' data for every aircraft?
  - Non-competitive engines and aircraft are soon non-production engines and aircraft

How far down the 'food-chain' do we need to go?

- ICAO cuts off emissions requirements at a given thrust; the implicit assumption is that at some point, the emission contribution isn't significant

Aviation fuel consumption modeling – next steps

We (FAA) will continue to push for manufacturers' performance models

- We are working on acquiring access to more tools
- We will look to expand the fuel consumption methods beyond the terminal area

We will work to develop a fuel consumption A-21 AIR