Opportunities For Fuel Conservation

- Empty weight control
- Airframe maintenance
- Systems maintenance
Approximate %Block Fuel Savings Per 453 kg (1000 lb) ZFW Reduction

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<td>.9%</td>
<td>.7%</td>
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Reducing OEW Reduces ZFW

Items To Consider

- Passenger service items
- Passenger entertainment items
- Empty Cargo and baggage containers
- Unneeded Emergency equipment
- Excess Potable water
Reducing OEW Reduces ZFW

- Operating empty weight (OEW) increases on average 0.1% to 0.2% per year, leveling off around 1% after 5 to 10 years.
- Most OEW growth is mainly due to moisture and dirt.
Reducing Aircraft Drag Reduces Fuel Burned

Effect of a 1% Drag Increase In Terms Of Gallons Per Year

- 747 ≈ 100,000
- 777 ≈ 70,000
- 767 ≈ 30,000
- 757 ≈ 25,000
- 737 ≈ 15,000
- 727 ≈ 30,000

(Assumes typical aircraft utilization rates)
Total Drag Is Composed Of:

Compressible drag ≈ drag due to high Mach
  • Shock waves, separated flow

Induced (vortex) drag ≈ drag due to lift
  • Downwash behind wing, trim drag

Parasite drag ≈ drag **not** due to lift
  • Shape of the body, skin friction, leakage, interference between components
  • Parasite drag **includes** excrescence drag
Contributors To Total Airplane Drag

(For a new airplane at cruise conditions)

Pressure, trim and interference drag (optimized in the wind tunnel) ~ 6%

Excrescence drag (this can increase) ~ 4%

Drag due to airplane size and weight (unavoidable) ~ 90%
What Is Excrescence Drag?

The additional drag on the airplane due to the sum of all deviations from a smooth sealed external surface.

Proper maintenance can prevent an increase in excrescence drag.
Discrete Items

• Antennas, masts, lights
• Drag is a function of design, size, position
Mismatched Surfaces and Gaps

Steps at skin joints, around windows, doors, control surfaces, and access panels
Internal Airflow

Leaks through gaps, holes, and aerodynamic seals
Roughness
(Particularly Bad Near Static Sources)

- Non-flush fasteners, rough surface
- Waviness, gaps
Most Important in Critical Areas

- Structural Repair Manuals Identifies Critical Areas

747-400

**Diagram Notes:**
- The area from BS 1000 to BS 1241 is critical above the wing only.
- The area aft of BS 960 is non-critical under the wing only.
- For nacelles and pylons see Figure 6.

**Legend:**
- Critical area: a high degree of aerodynamic smoothness is necessary.
Average Results Of In-service Drag Inspections

Average total airframe drag deterioration ~ 0.65%, composed mainly of:

- Control Surface Rigging ≈ 0.25%
- Deteriorated Seals ≈ 0.20%
- Misfairs ≈ 0.1%
- Roughness ≈ 0.05%
- Other ≈ 0.05%

A well-maintained airplane should not exceed 0.5% drag increase from its new airplane level
Regular Maintenance Minimizes Airframe Deterioration

- Flight control rigging
- Misalignments, mismatches and gaps
- Aerodynamic seals
- Empty weight control
- Exterior surface finish
- Instrument calibration/maintenance
Maintain a Clean Airplane

- Maintain surface finish
- Fluid leaks contribute to drag
- Periodic washing of exterior is beneficial
  - 0.1% drag reduction if excessively dirty
  - Minimizes metal corrosion and paint damage
  - Location of leaks and local damage
- Customer aesthetics
• Speed measuring equipment has a large impact on fuel mileage - keep airspeed system maintained

• If speed is not accurate then aircraft is flying faster or slower than intended - airspeed reads 1% low, aircraft flying 1% fast

• On the 747-400, flying 0.01M faster than intended can increase fuel burn by over 1%
Proper and Continuous Airframe and Engine Maintenance Will Keep Aircraft Performing at Their Best!

Don’t let this...

Become this!
Conclusions

It Takes the Whole Team to Win

• Large fuel (and emissions) savings results from the accumulation many smaller fuel-saving actions and policies

• Dispatch, flight operations, flight crews, maintenance, management, all need to contribute
Thank You!
End of Fuel Conservation
Airframe Maintenance for Environmental Performance

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