

AVIATION OPERATIONAL MEASURES FOR
FUEL AND EMISSIONS REDUCTION
WORKSHOP



Fuel Conservation
Airframe Maintenance for
Environmental Performance

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Maintenance Personnel

Opportunities for fuel conservation:

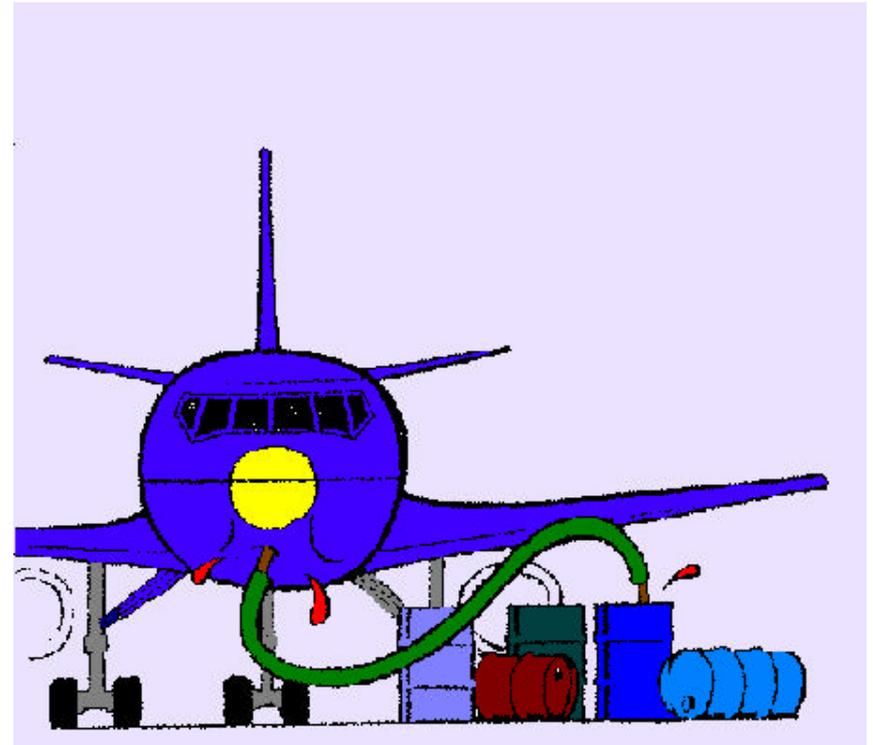
- **Airframe maintenance**
- **Systems maintenance**



Excess Drag Means Wasted Fuel

1% Drag in Terms of Gallons per Year

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



Total Drag Is Composed Of:

Compressible Drag » Drag due to Mach

- Shock waves, separated flow

Induced (Vortex) Drag » Drag due to Lift

- 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

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

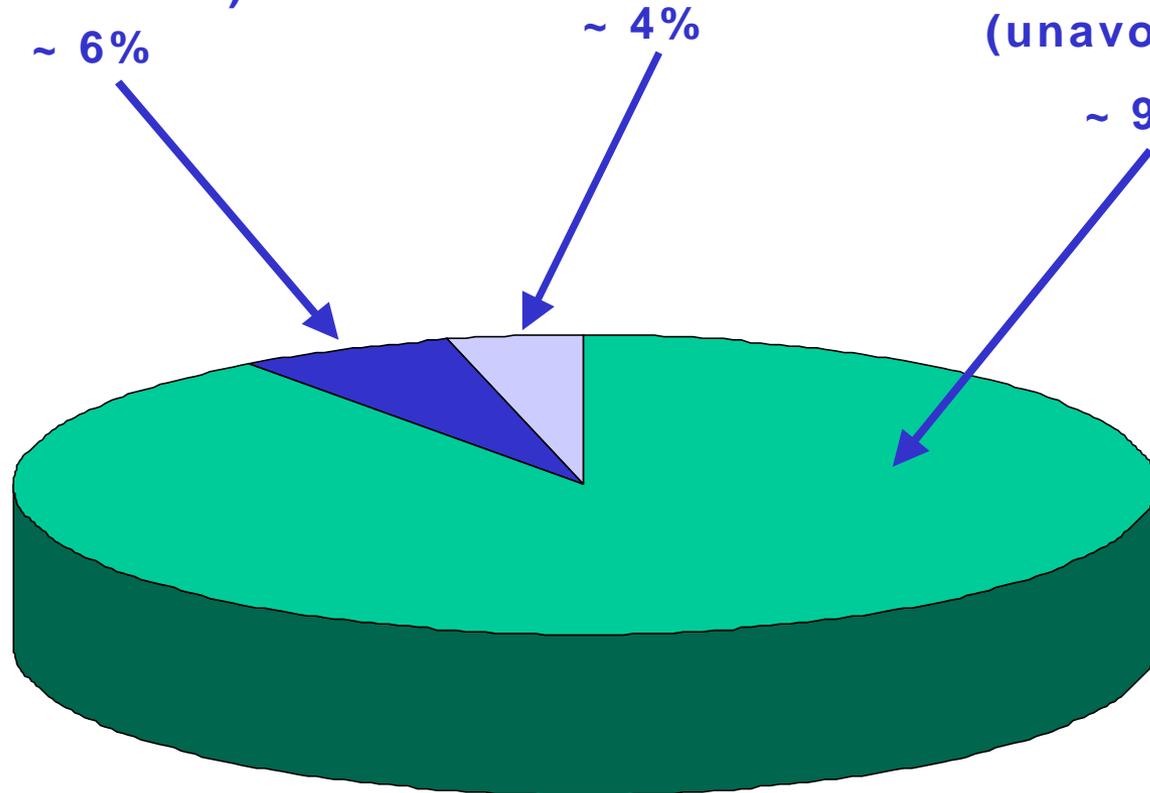
~ 6%

Excess drag (this can increase)

~ 4%

Drag due to airplane size and weight (unavoidable)

~ 90%



What Is Excrescence Drag?

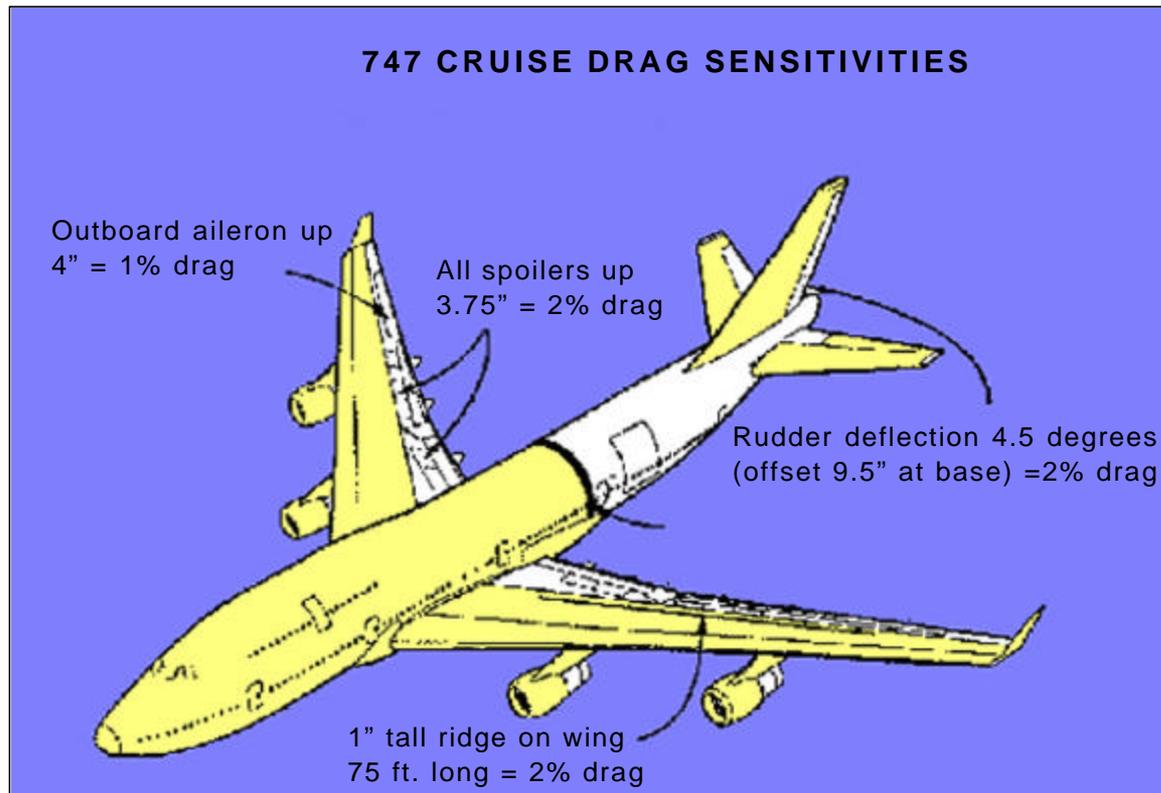
The additional drag on the airplane due to the sum of all **deviations** from a **smooth sealed external surface**

Proper maintenance can prevent an increase in excrescence drag



Most Important in Critical Areas

- Forward portion of fuselage and nacelle
- Leading areas of wings and tail
- Local Coefficient of Pressure (C_p) is highest

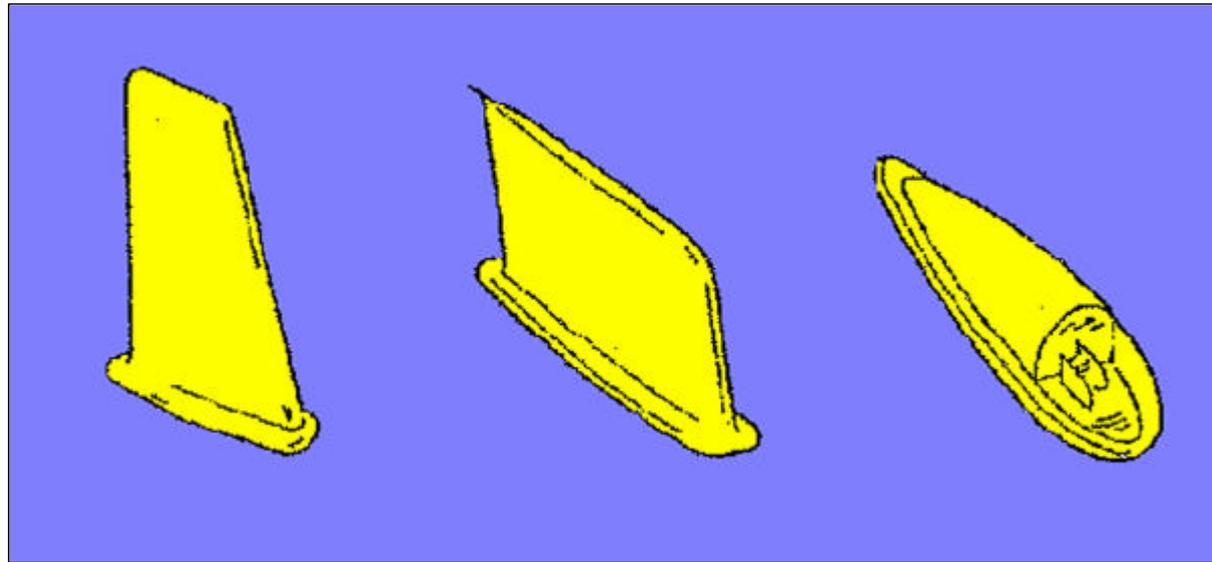


Aircraft Panel

Ottawa, 5-6 November 2002

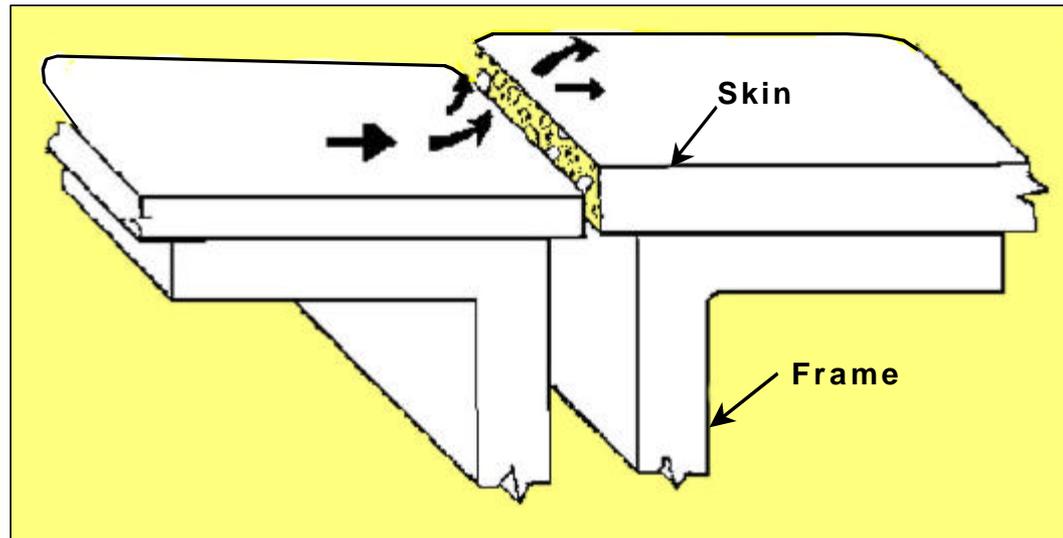
Discrete Items

- Antennas, masts, lights
- Drag is a function of design, size, position

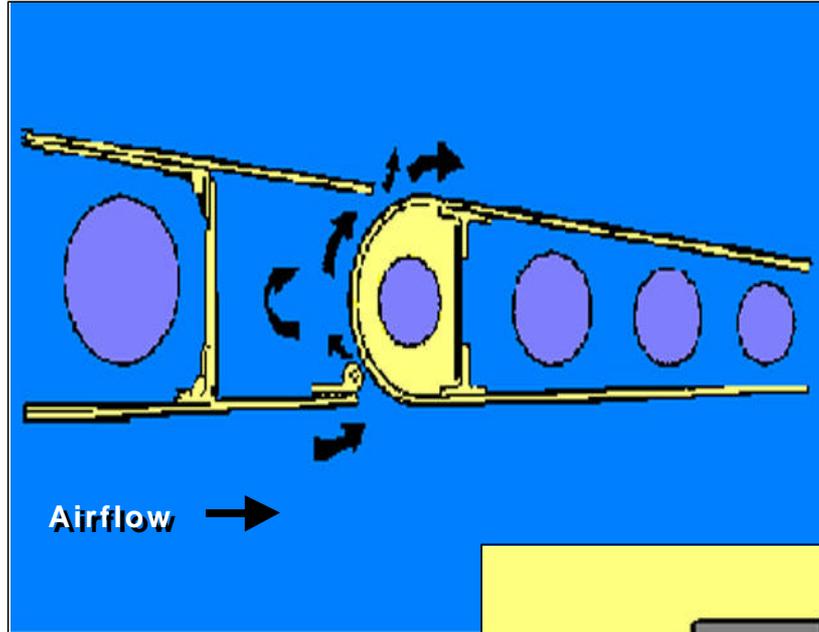


Mismatched Surfaces

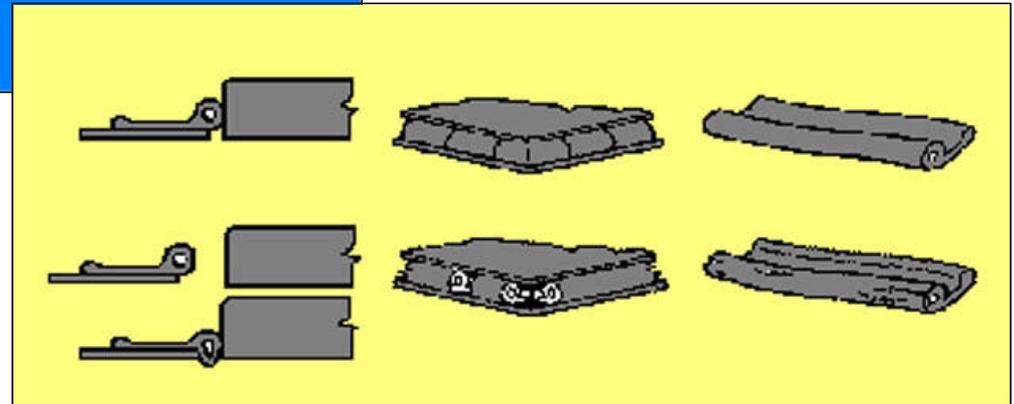
Steps at skin joints, around windows, doors, control surfaces, and access panels



Internal Airflow



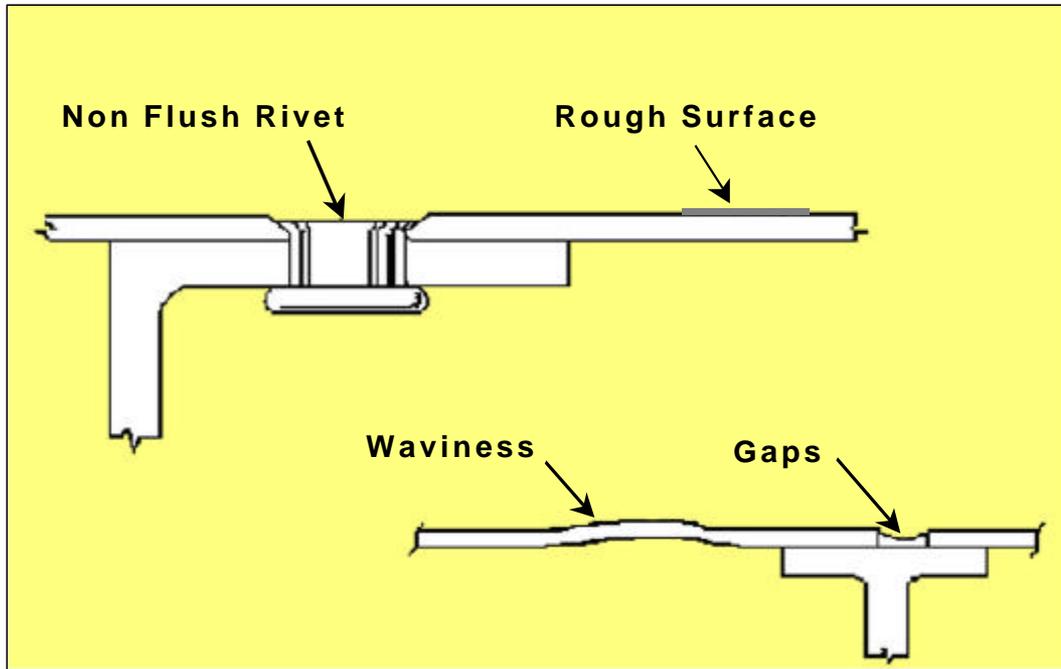
- Leaks through gaps, holes, and seals



Roughness

(Particularly Bad Near Static Sources)

- Non-flush fasteners, rough surface
- Waviness, gaps
- Deteriorated paint and decals



Average Results of In-Service Drag Inspections

- **Total Airframe Drag Deterioration ~ 0.65%**
 - **Control Surface Rigging » 0.25%**
 - **Deteriorated Seals » 0.20%**
 - **Misfairs » 0.1%**
 - **Roughness » 0.05%**
 - **Other » 0.05%**

A well maintained airplane should never exceed 0.5% drag increase from its new airplane level



Regular Maintenance Minimizes Deterioration

- Rig flight controls
- Misalignments and mismatches
- Maintain seals
- Maintain surface finish
- OEW control
- Instrument calibration



OEW Control

- Operating empty weight grows on average 0.1 to 0.2% per year, leveling off at about 1% after 5 years
- Mainly due to moisture and dirt



Instrument Calibration

- **Speed measuring equipment has a large impact on fuel mileage**
- **If speed is not accurate the airplane may be flying faster or slower than intended**
- **Flying 0.01M faster can increase fuel burn by 1%**



Airspeed System Error Penalty

- Calibrate airspeed system
- Airspeed reads 1% low, you fly 1% fast
- About 2% drag penalty in a 747



Conclusions

It Takes the Whole Team to Win



- **Large fuel (and emissions) savings can result from the accumulation of many smaller fuel-saving actions and policies**
- **Flight operations, flight crews, maintenance, and management all need to contribute**
- **Program should be tailored to your airline**
- **Boeing offers Fuel Conservation module as part of the “Performance Engineer Training – Operations Course”**



Conclusions

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Questions?

