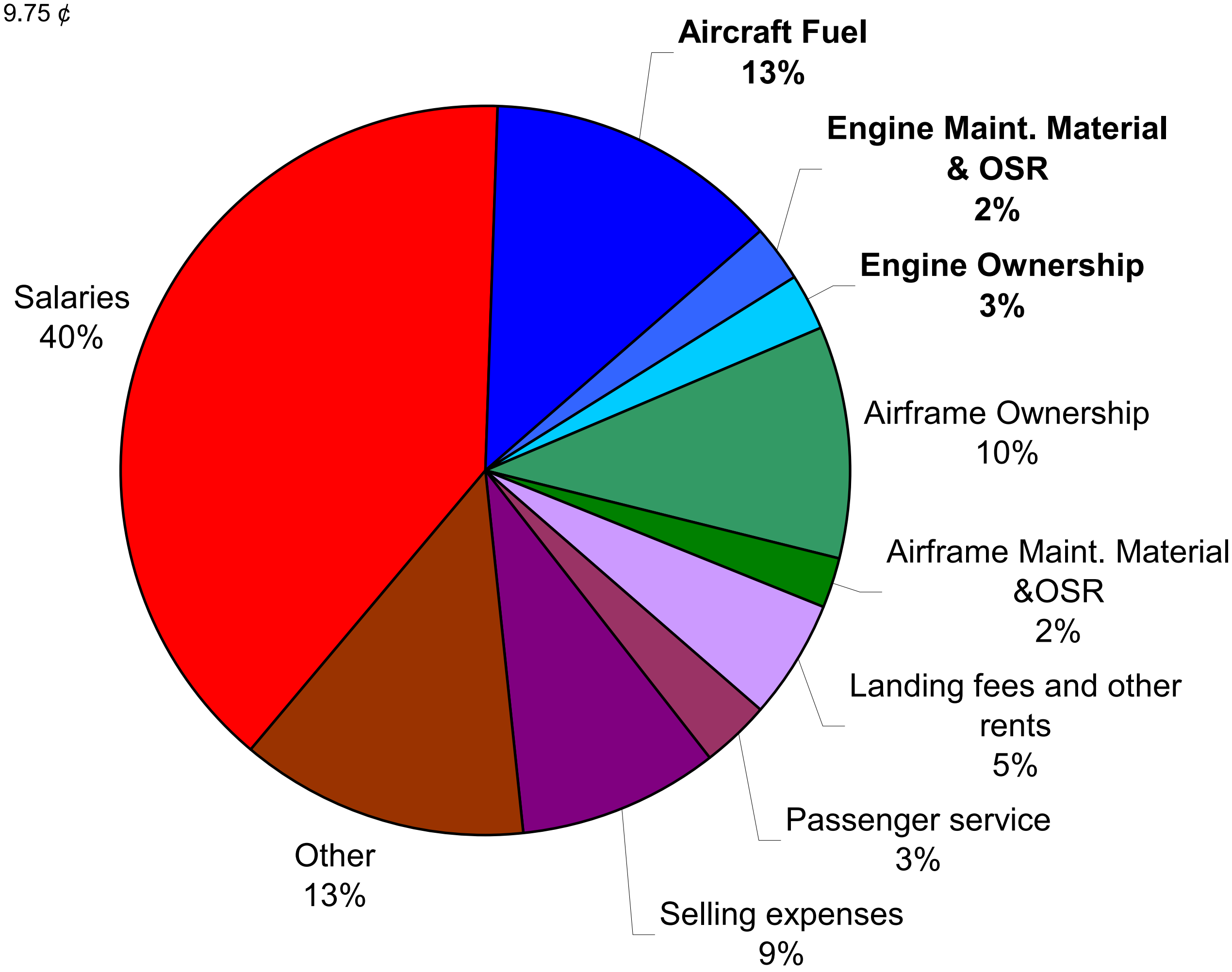
Propulsion Systems

Major US Airline Year 2000 Operating Costs

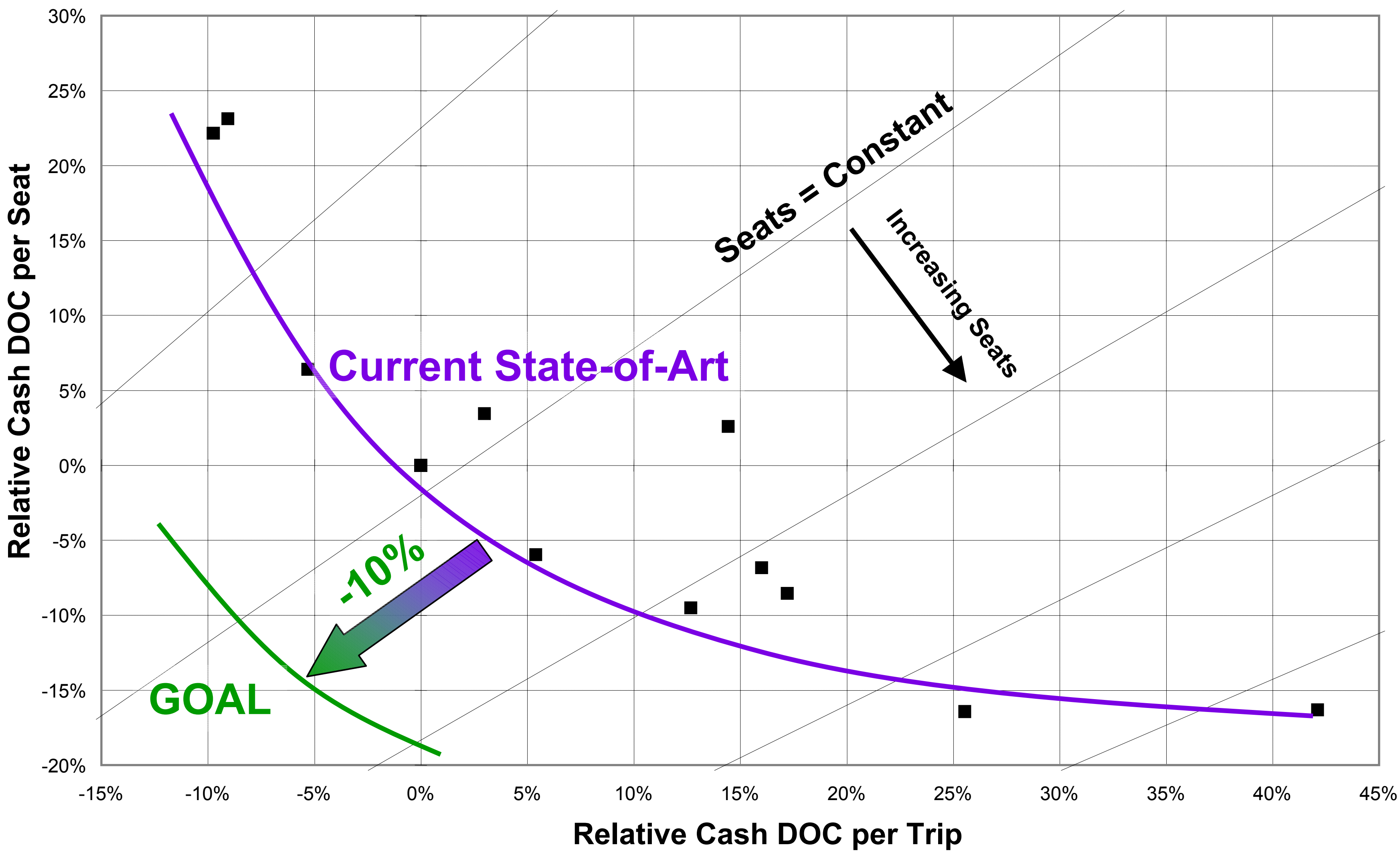
Cost per ASM = 9.75 ¢



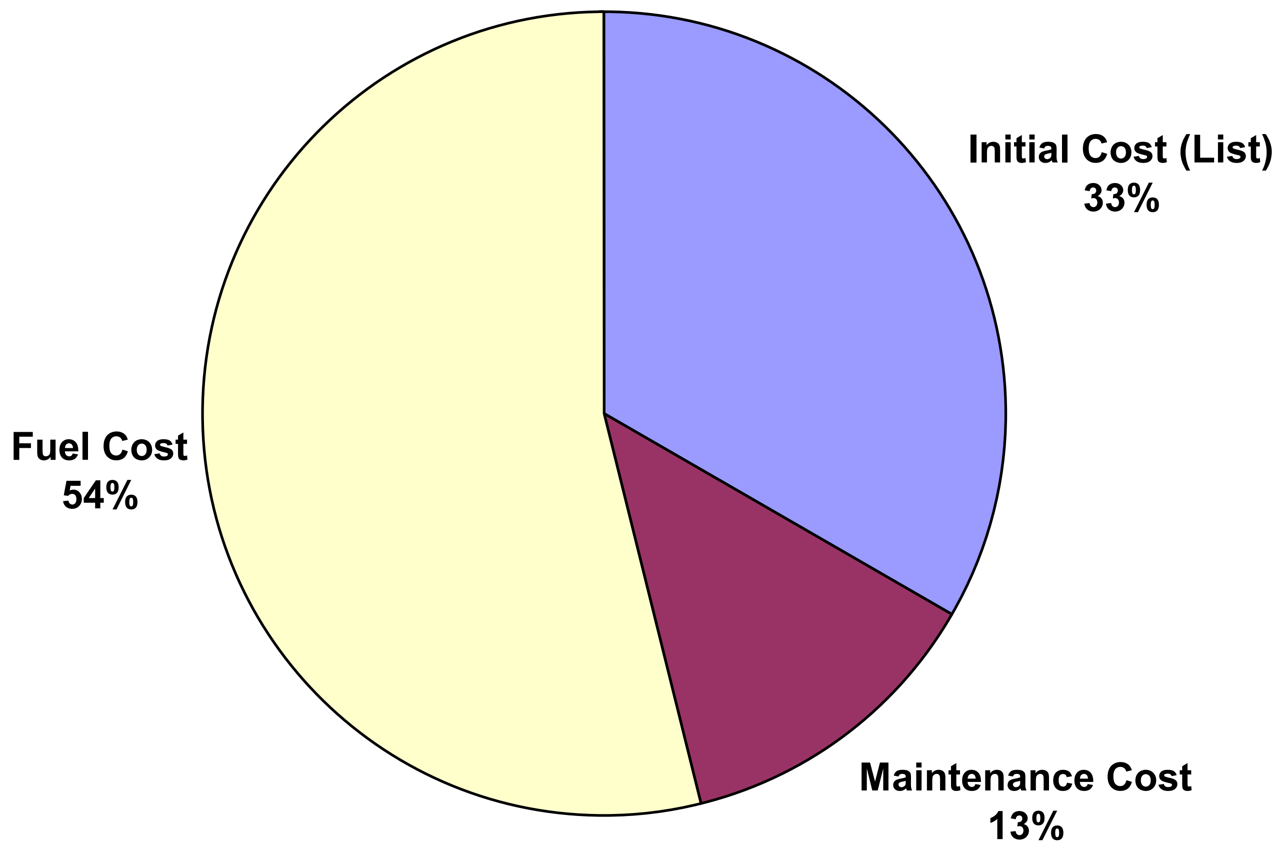
"Other" includes contracted services,
asset write-downs, other non-recurring items

Airplane Operating Cost Comparison

Three Class Seating
3000 nm Trip

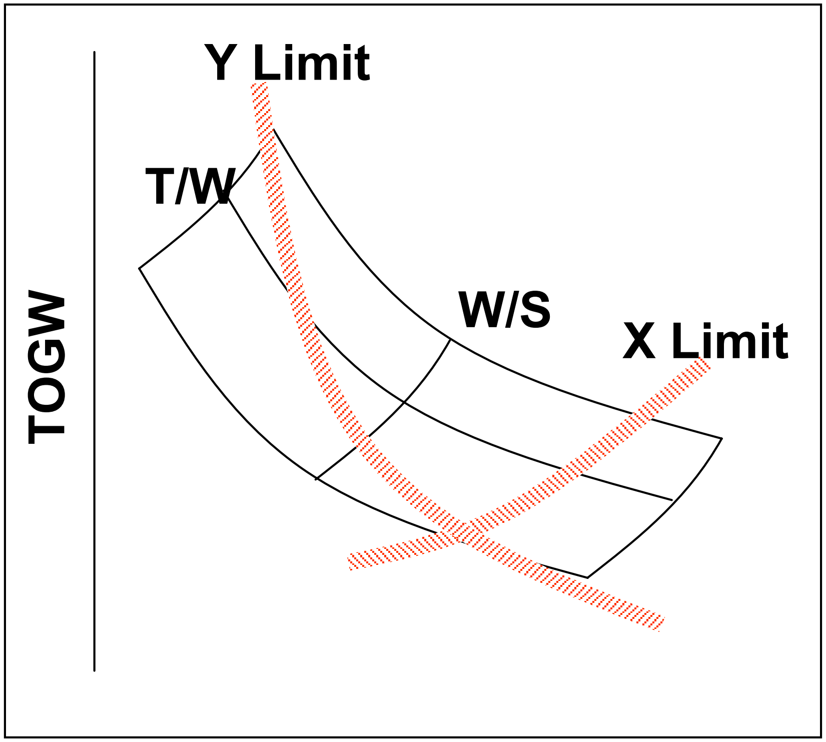


Typical Engine-Related Airline Cost Breakdown



777-200ER/PW4090
$0.75/gal Fuel Price

Thrust Sizing Requirements



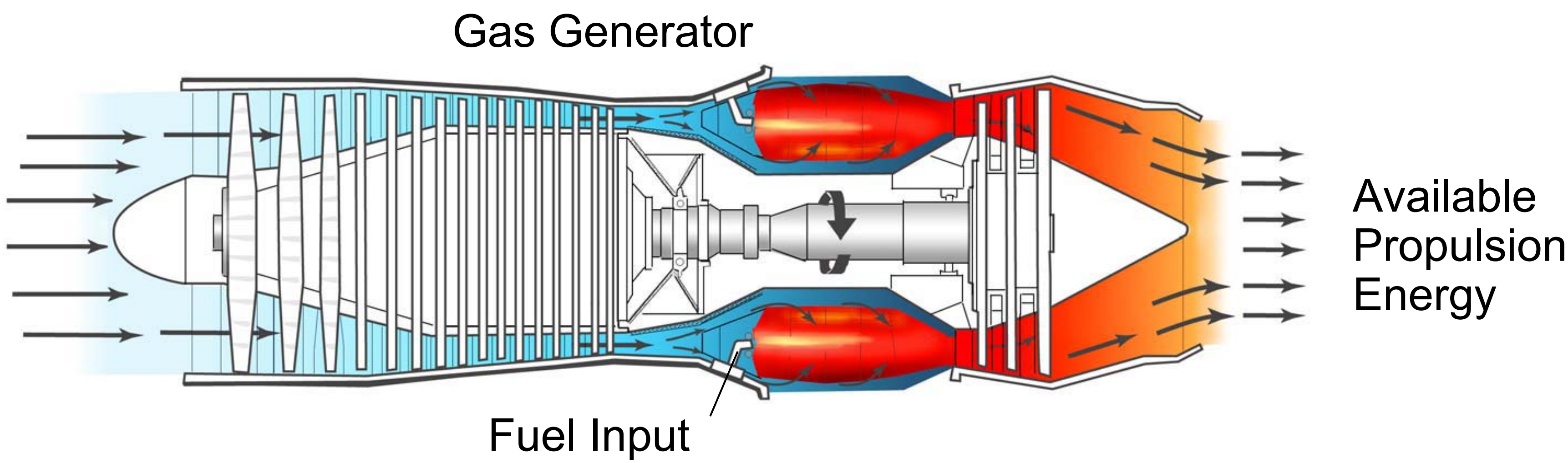
- Number of Engines
- Aircraft Max Take Off Gross Weight
- Take Off Field Length
- Time to Climb
- Cruise Altitude and Mach Number
- Lift to Drag of Wing
- Aircraft Potential Growth

Basic engine relationships

$$\frac{\text{Thrust}}{\text{Mass}} = (\text{Velocity of exhaust} - \text{velocity of aircraft})$$

$$\text{Overall engine efficiency} = \eta_{\text{thermal}} \times \eta_{\text{propulsive}}$$

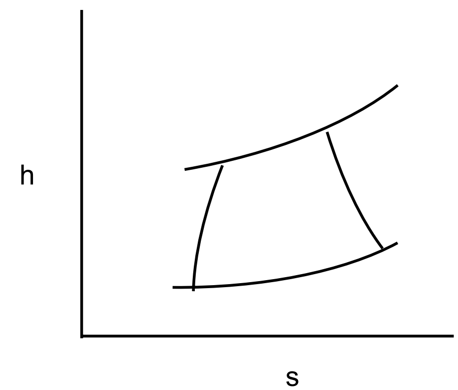
Overall Engine Efficiency Includes Two Processes: Energy Conversion and Thrust Production



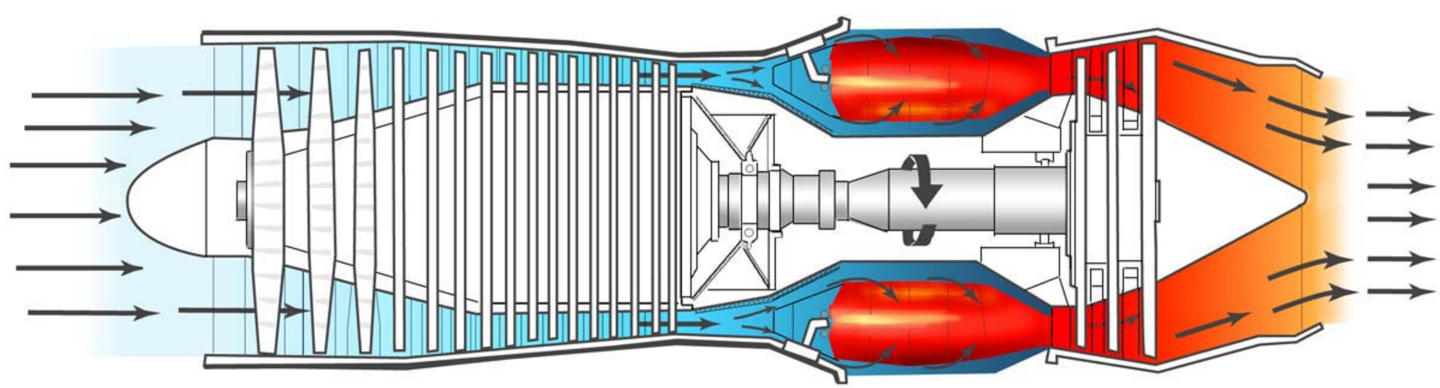
$$\eta_{overall} = \eta_{thermal} \times \eta_{propulsive}$$

Thermal efficiency measures the process of converting chemical energy of the fuel into energy available for propulsion

- Function of overall pressure ratio and component efficiencies -

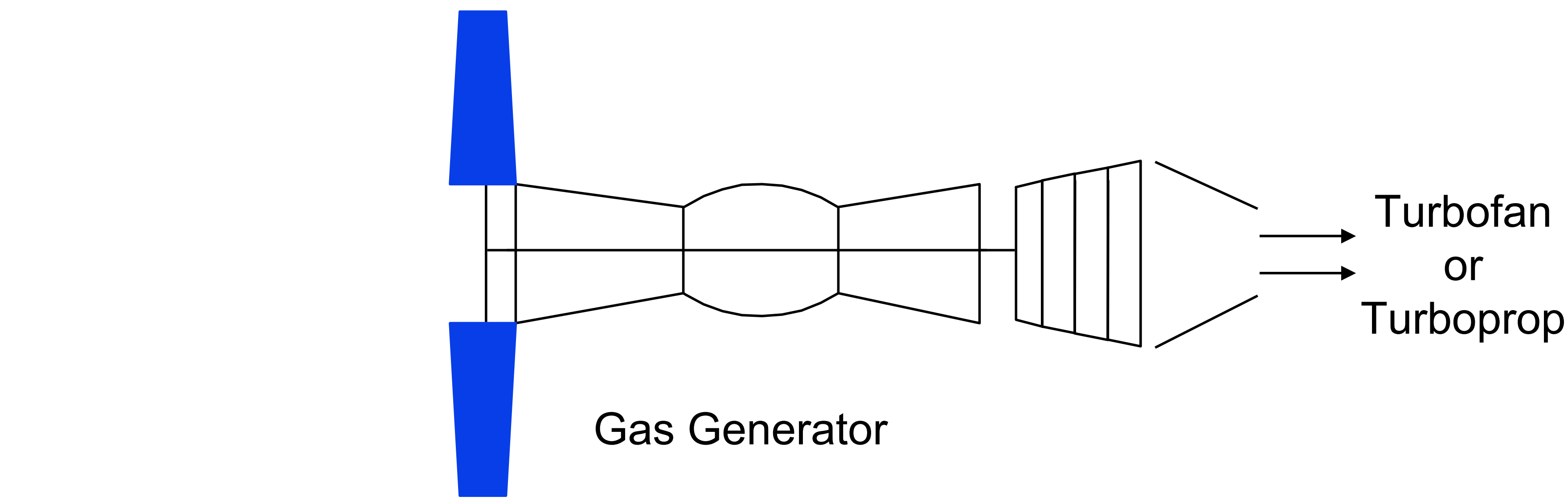


Current engines at 40:1 overall pressure ratio



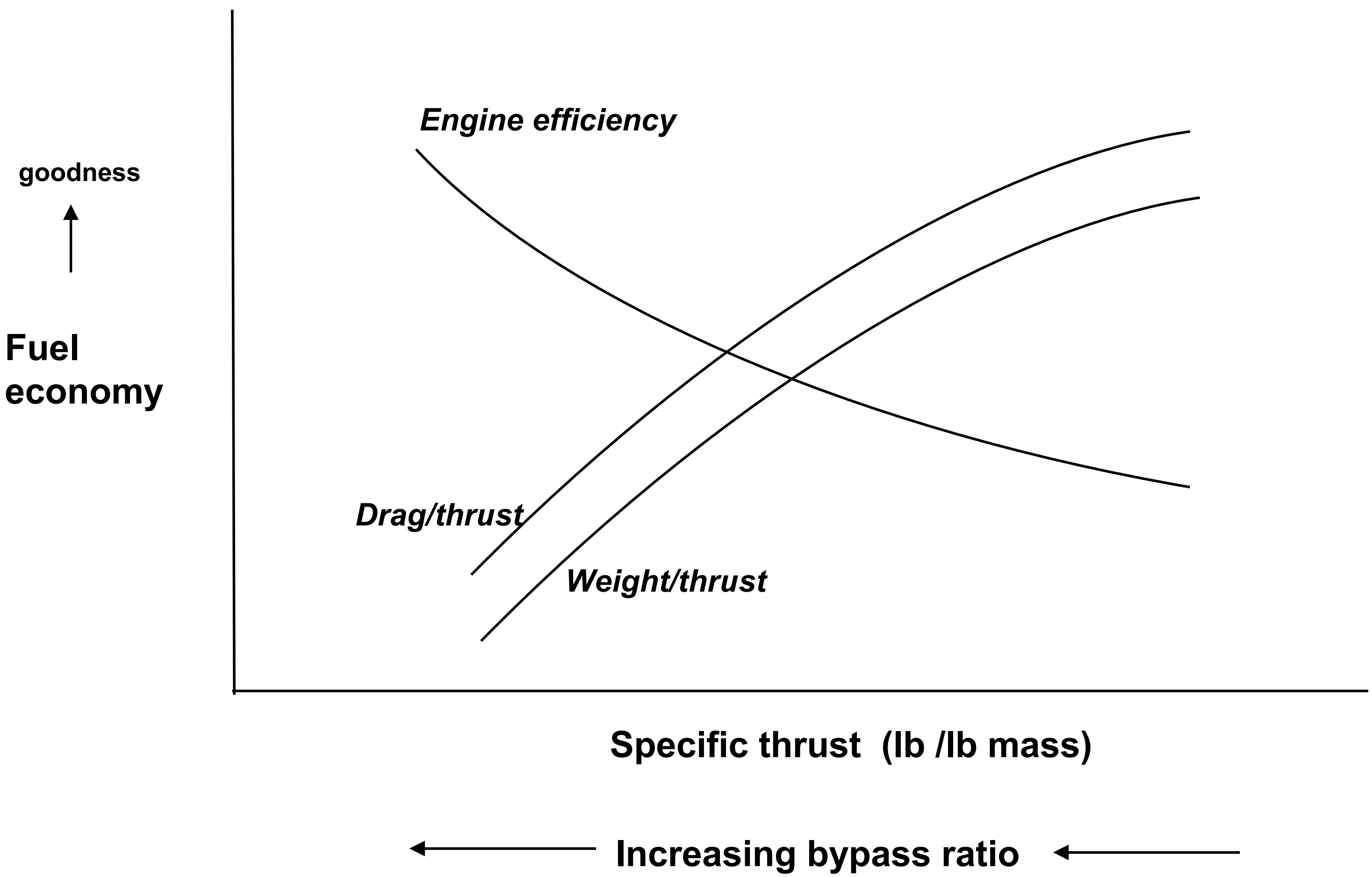
Future engines at 60:1 overall pressure ratio

Propulsive efficiency measures the process of converting energy available for propulsion into useful propulsive power



$\eta_{propulsive} \longrightarrow 100\%$ as $V_{exhaust} \longrightarrow V_o$

Lower specific thrust is fundamental to improving fuel economy



Commercial Turbofan