Introduction to Aerospace Propulsion

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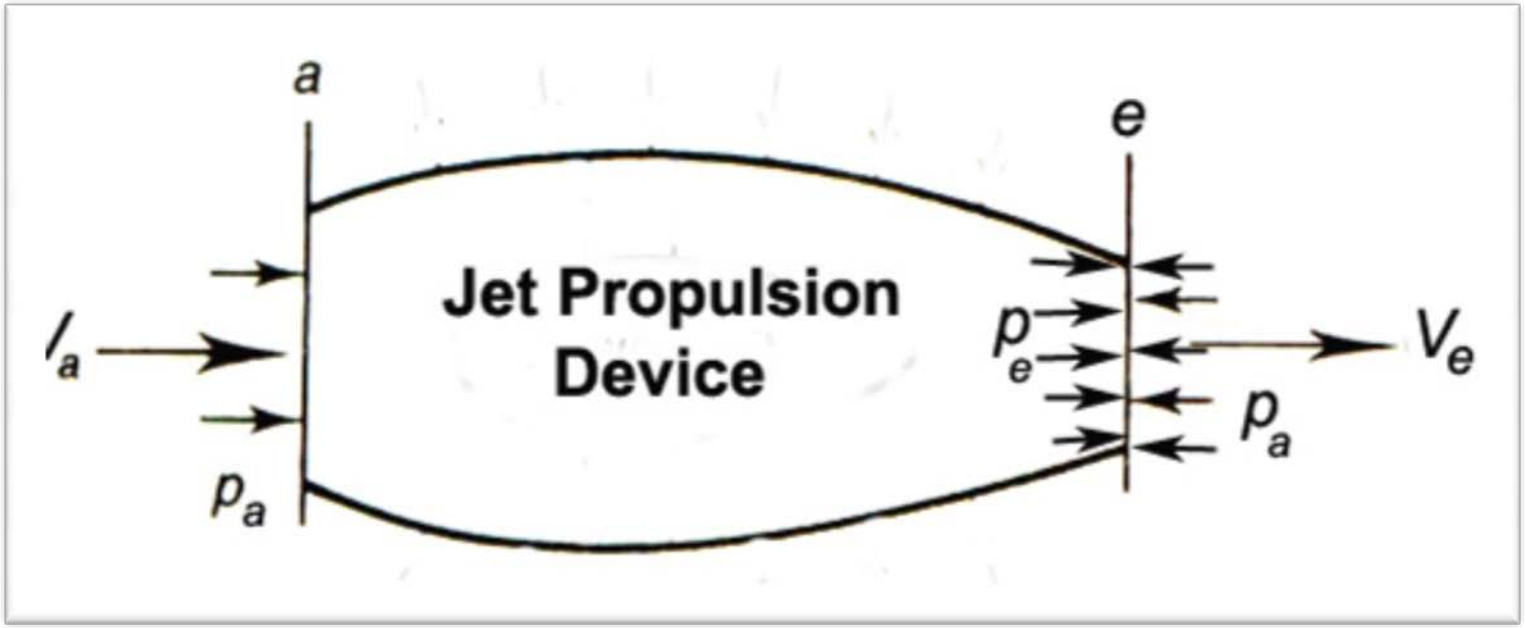
Lecture No - 3



$$\text{Thrust} = \dot{m}(V_e - V_a)$$

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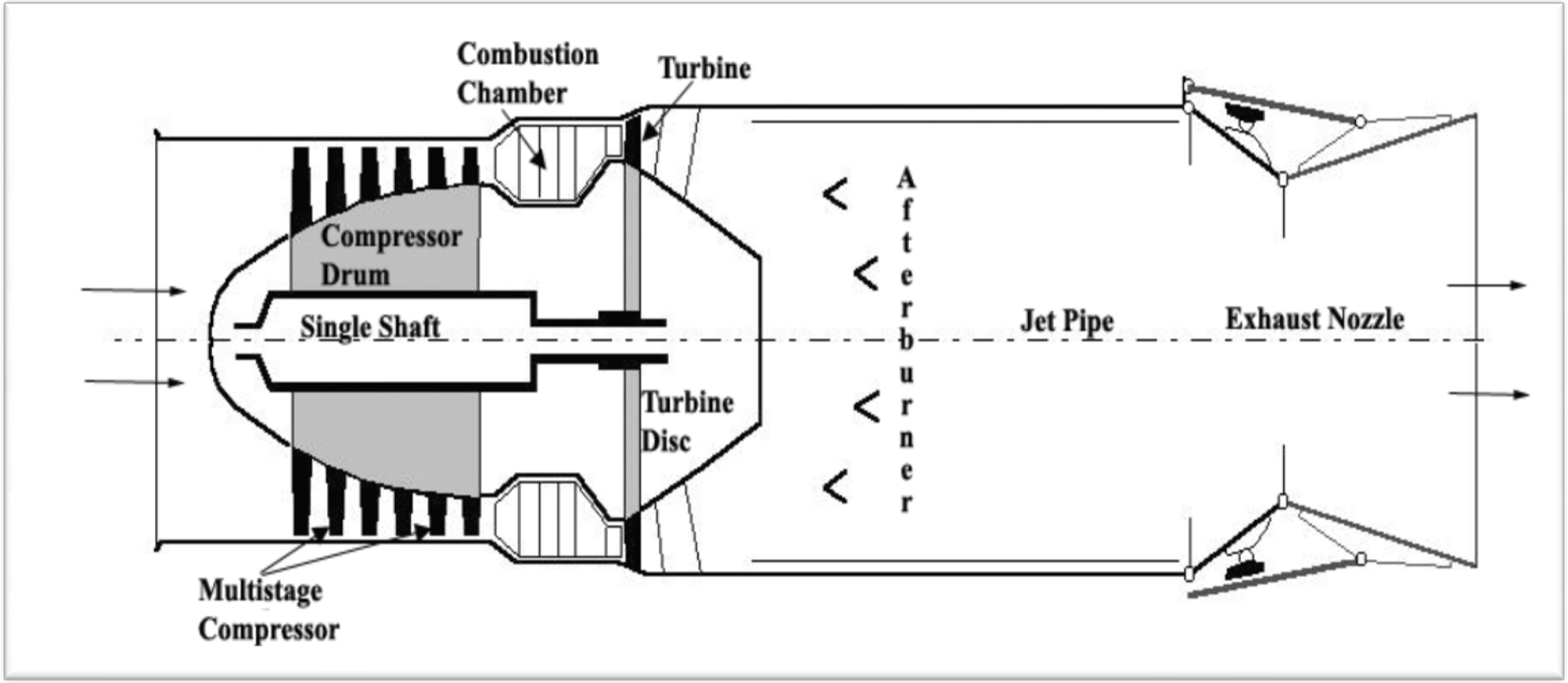
Simple Gas Turbine based Turbojet Engine



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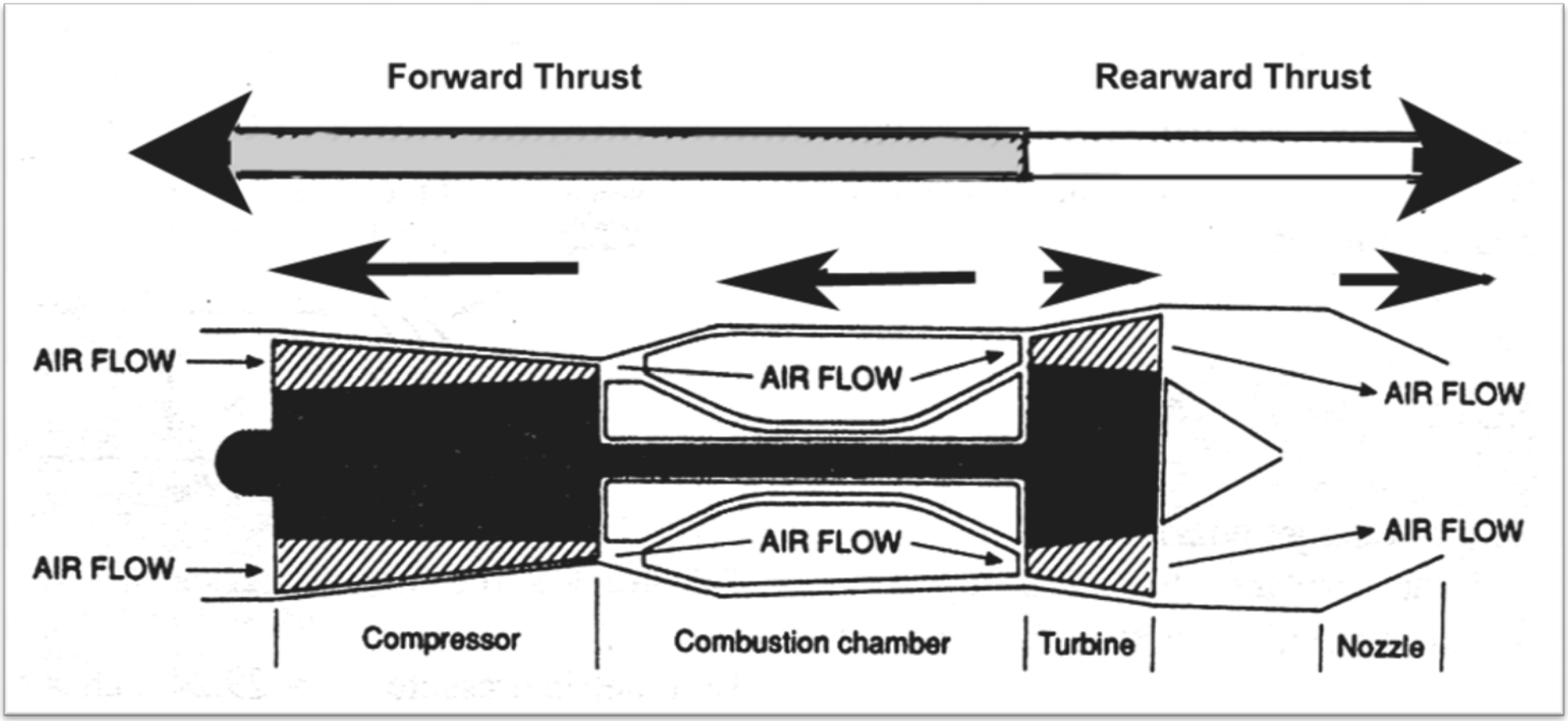
Mechanism of Creation of Thrust



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The net thrust F due to change in momentum is

Intake Ram drag

$$F = \dot{m} V_e - V_a \dot{m} + A_e (P_e - P_a)$$

Gross Momentum Thrust

Pressure Thrust

The propulsive efficiency η_p can be defined as the ratio of the useful propulsive energy or thrust power ($F.V_a$) to the sum of that energy and the unused kinetic energy of the jet , $\frac{\dot{m}(V_e - V_a)^2}{2}$.
The latter is the kinetic energy relative to earth.

propulsive efficiency

$$\eta_p = \frac{\dot{m}.V_a.(Ve - V_a)}{\dot{m}\left(V_a.(V_e - V_a) + \frac{(V_e - V_a)^2}{2}\right)} = \frac{2}{1 + \left(\frac{V_e}{V_a}\right)}$$

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When $V_e >> V_a$ i.e. a very large acceleration and, so with even with low mass flow,
Thrust produced, F = very high- , but propulsive efficiency, η_p = low , typical jet engine, which produces compact thrusters

When, $V_e = V_a$ the propulsive efficiency is 100%, but Thrust, $F \approx 0$; - has given rise to turbofans, where large part of the thrust is produced with high mass flow, low air acceleration and high propulsive efficiency, and only a small part of thrust is produced with high jet effect.

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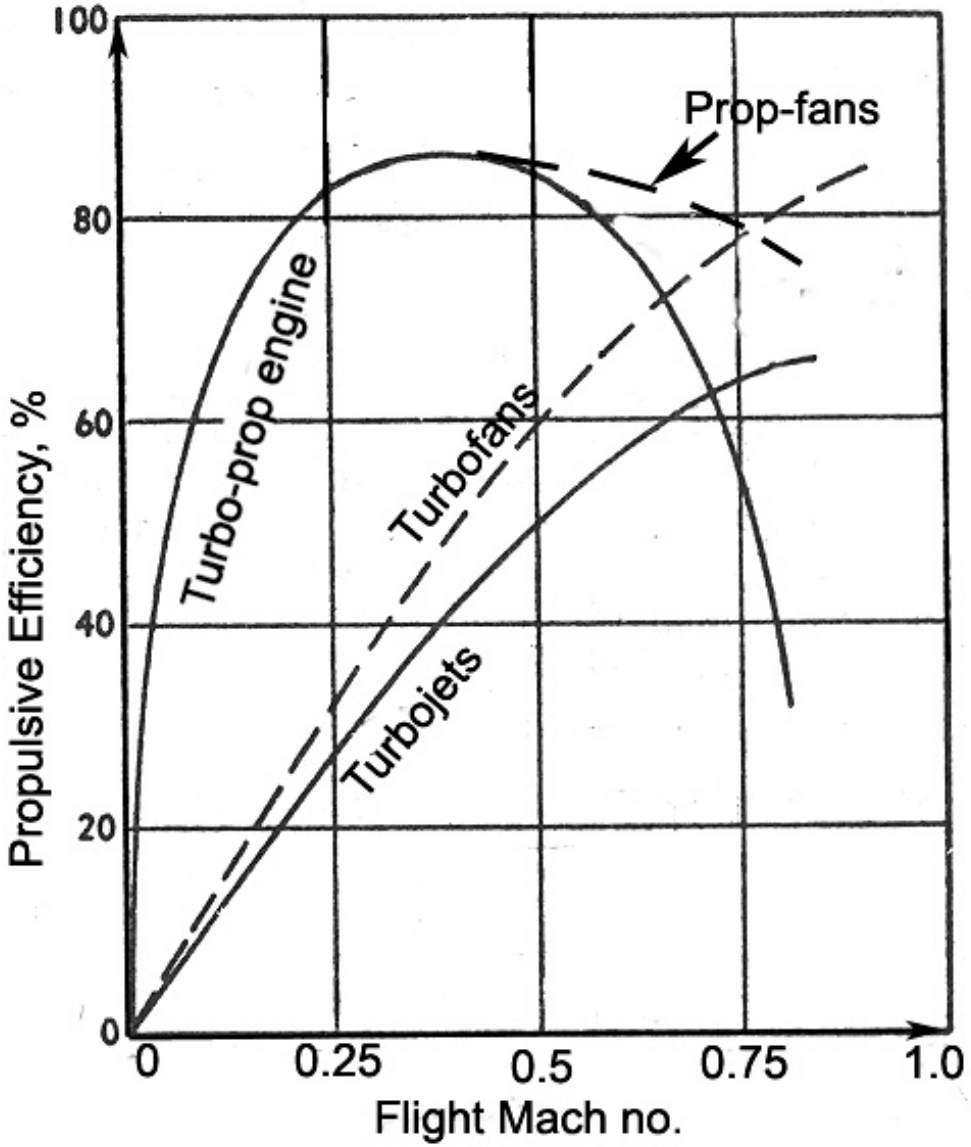
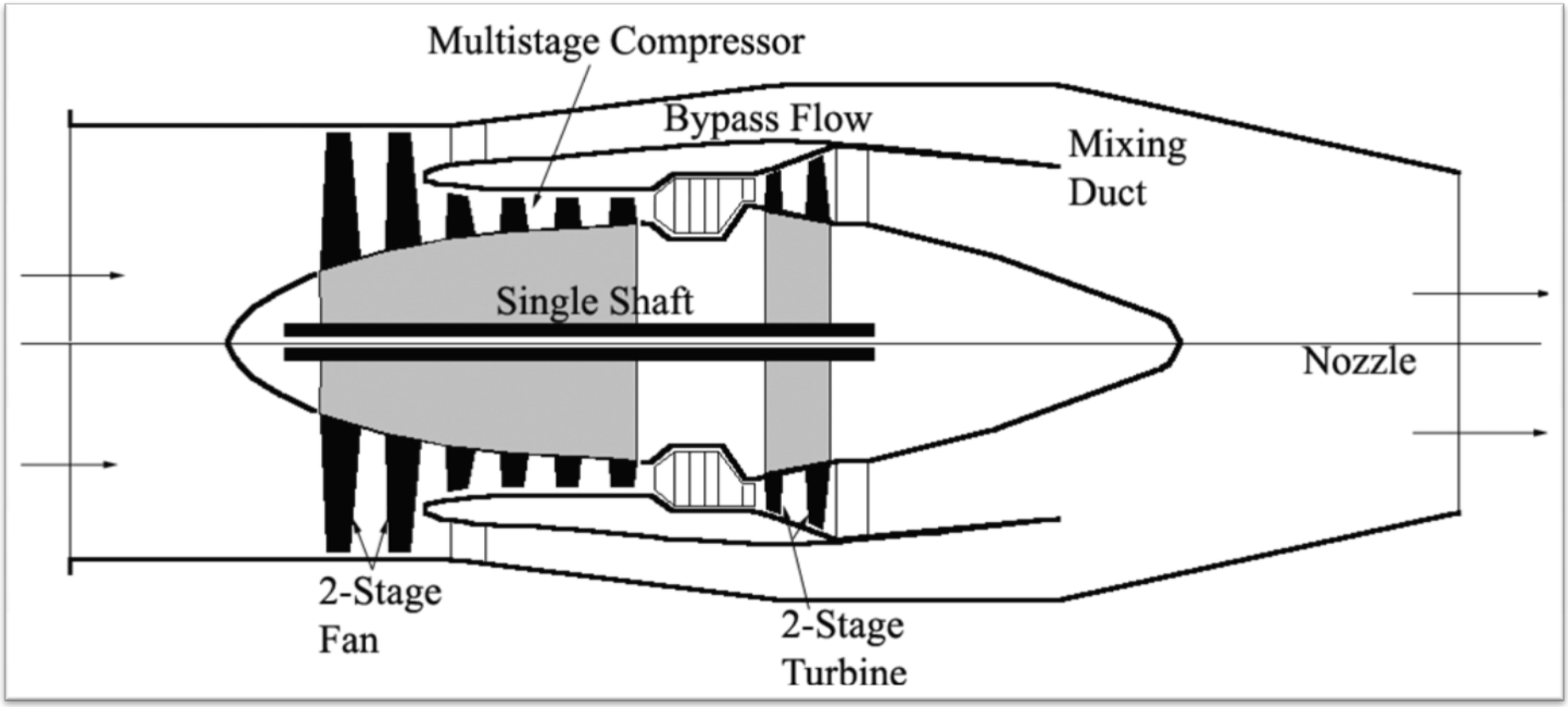


The graph captures the utility zones of various kinds of propulsive devices.

- At low subsonic speeds propellers are the better thrusting devices.
- At medium speeds (high subsonic) turbofans are the better thrusters
- At high (supersonic) speeds, there is no alternative but to go for pure jet engines

A single spool bypass turbojet engine



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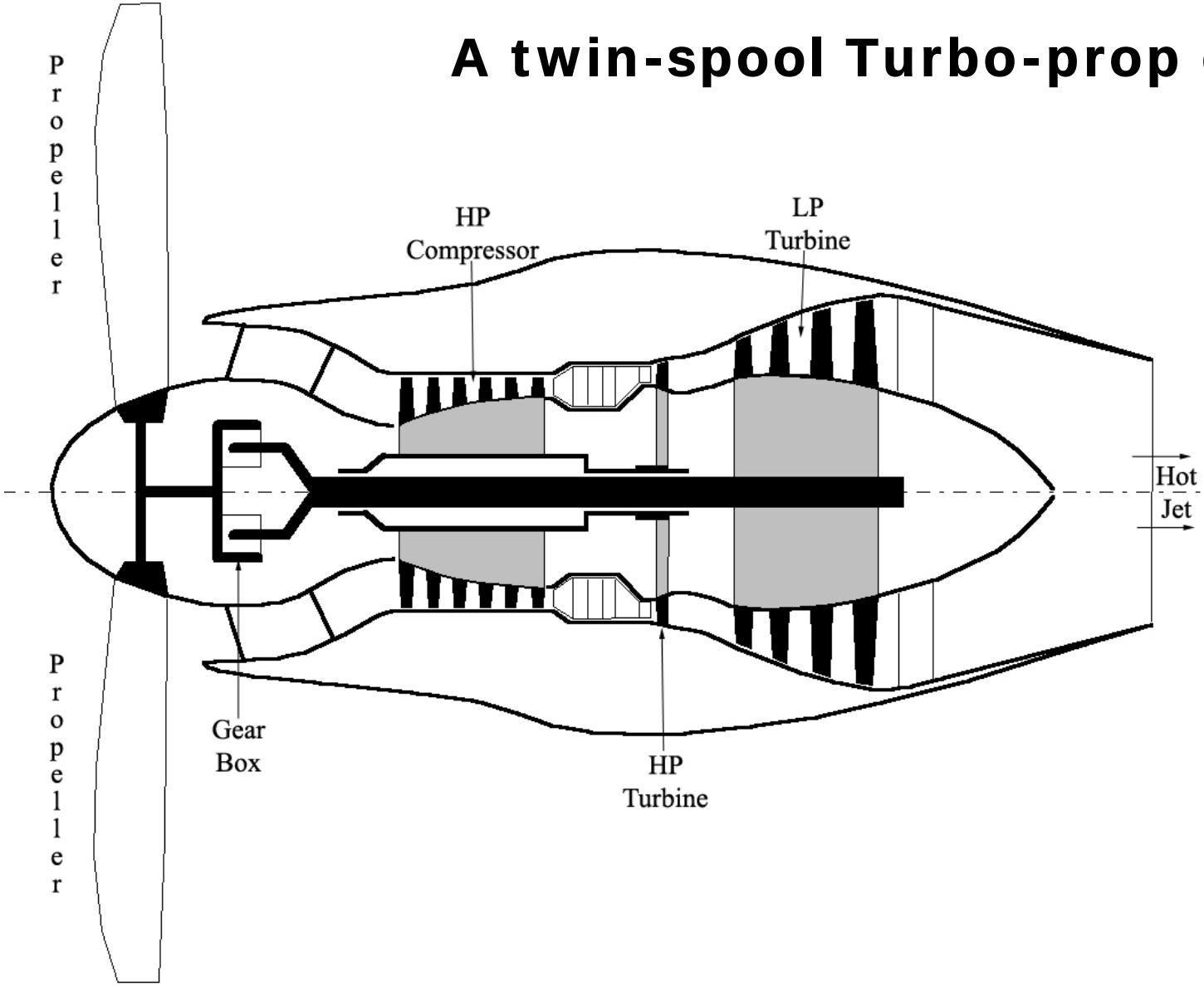
A twin-spool Turbo-prop engine



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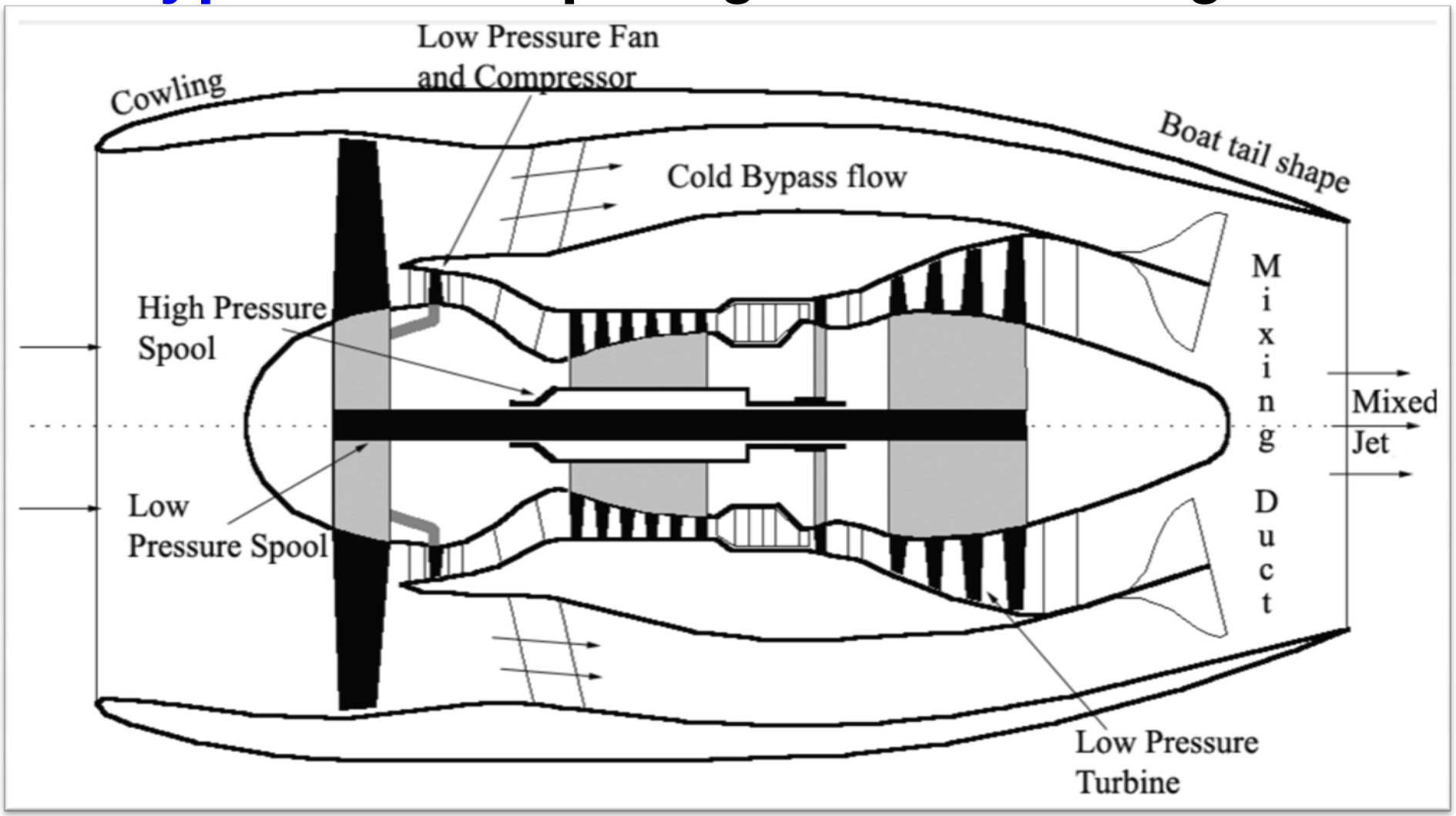
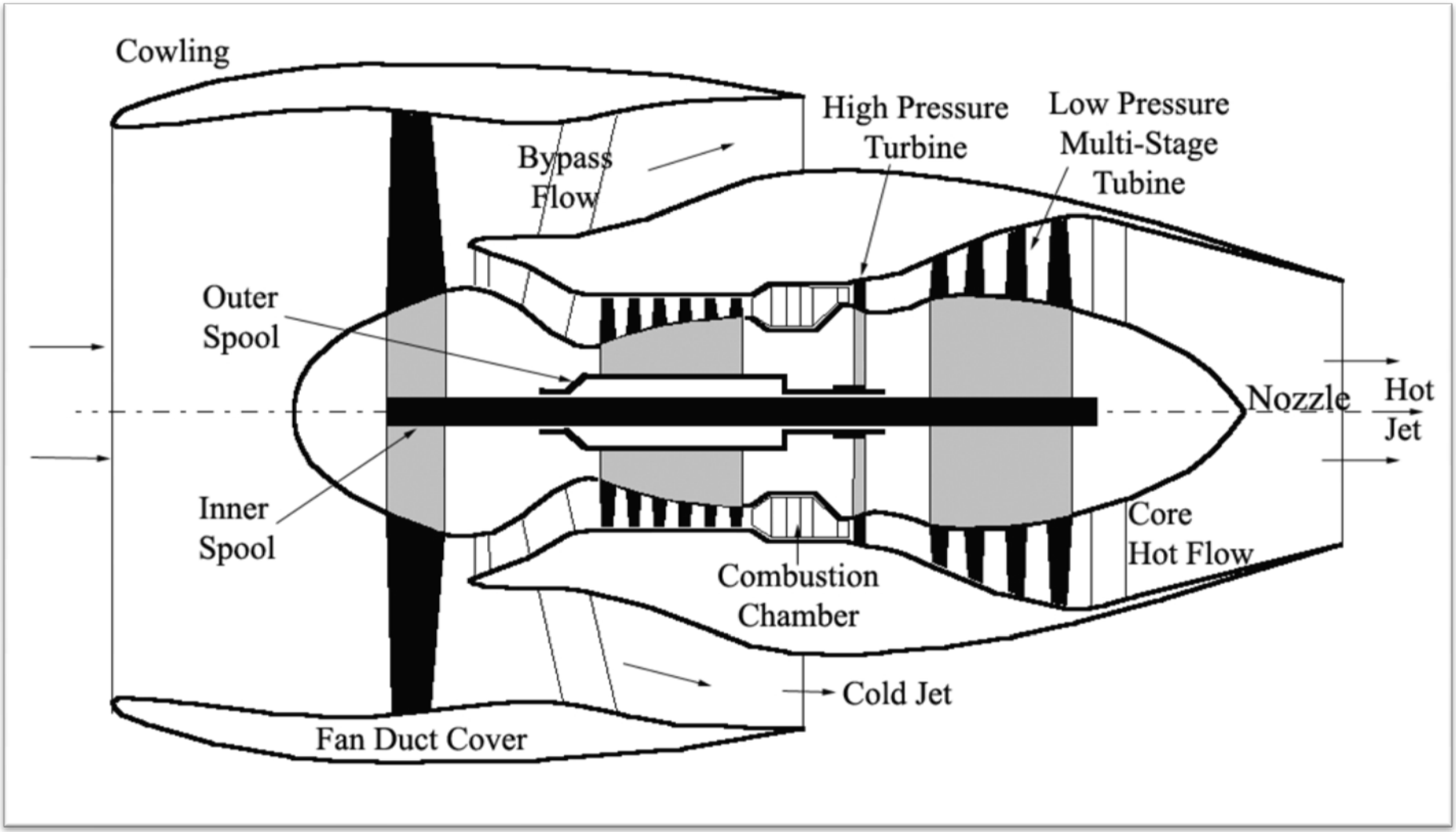
A bypass twin spool gas turbine engine



A high bypass twin spool Turbofan engine



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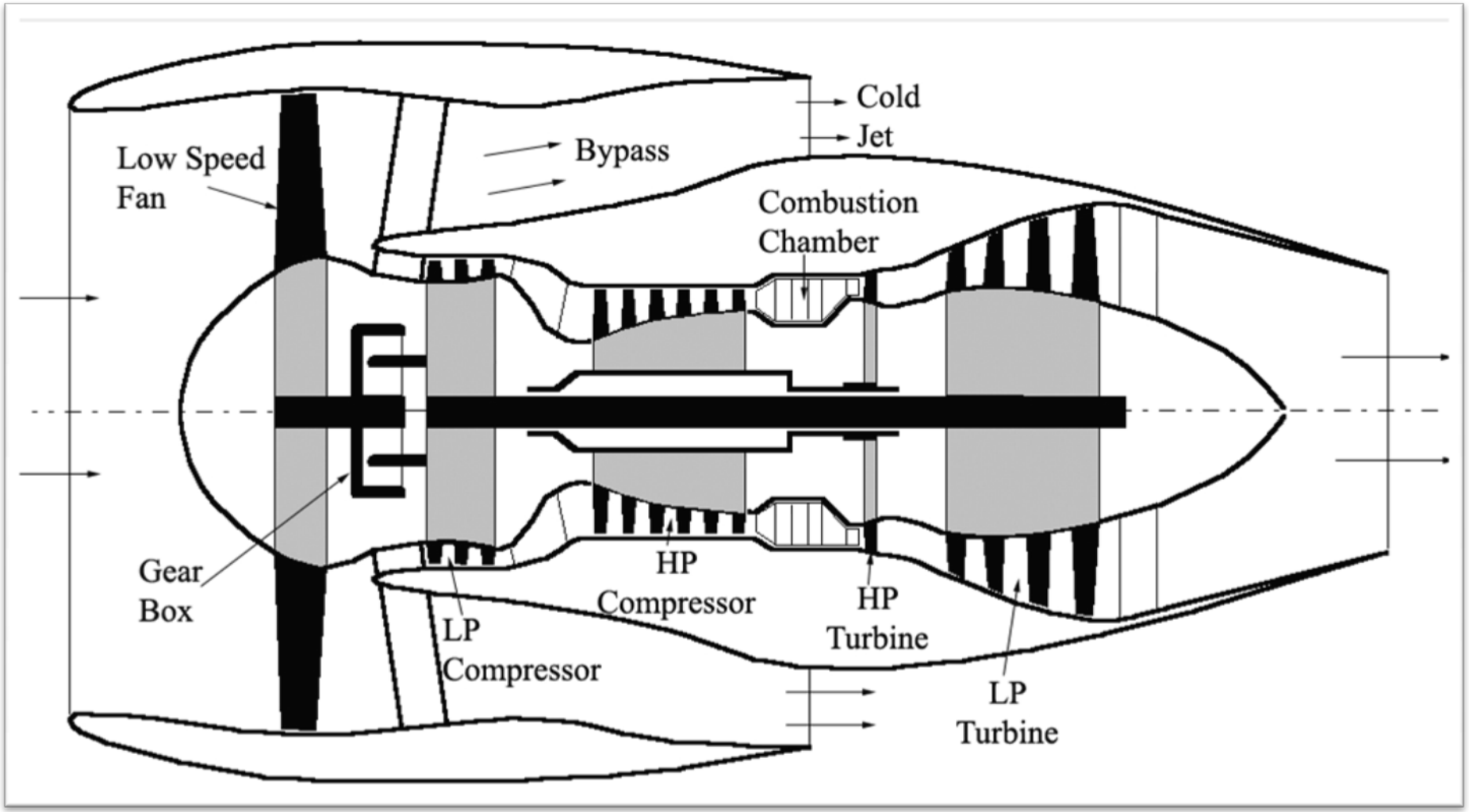
An Ultra-high bypass twin spool geared turbofan



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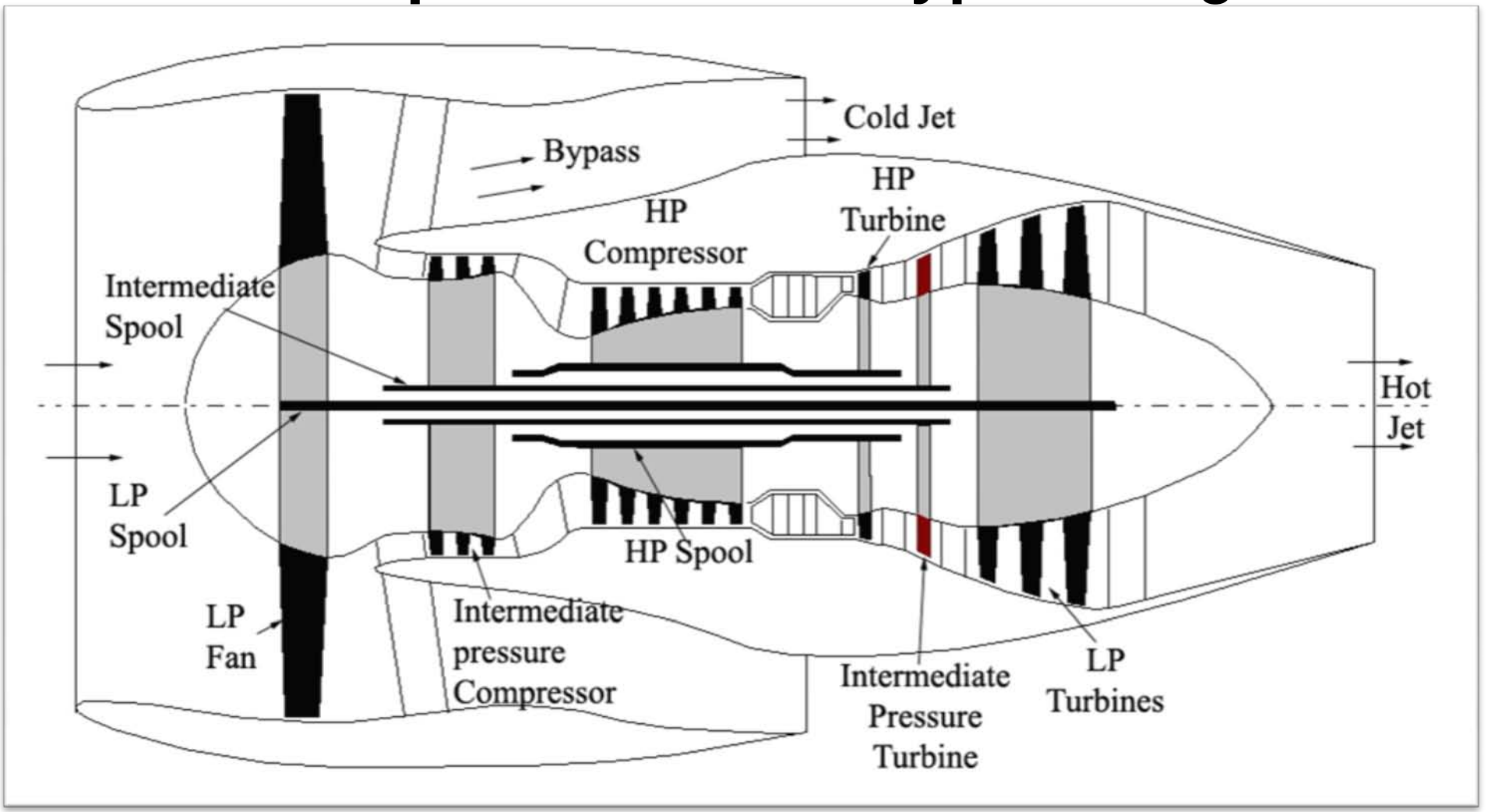
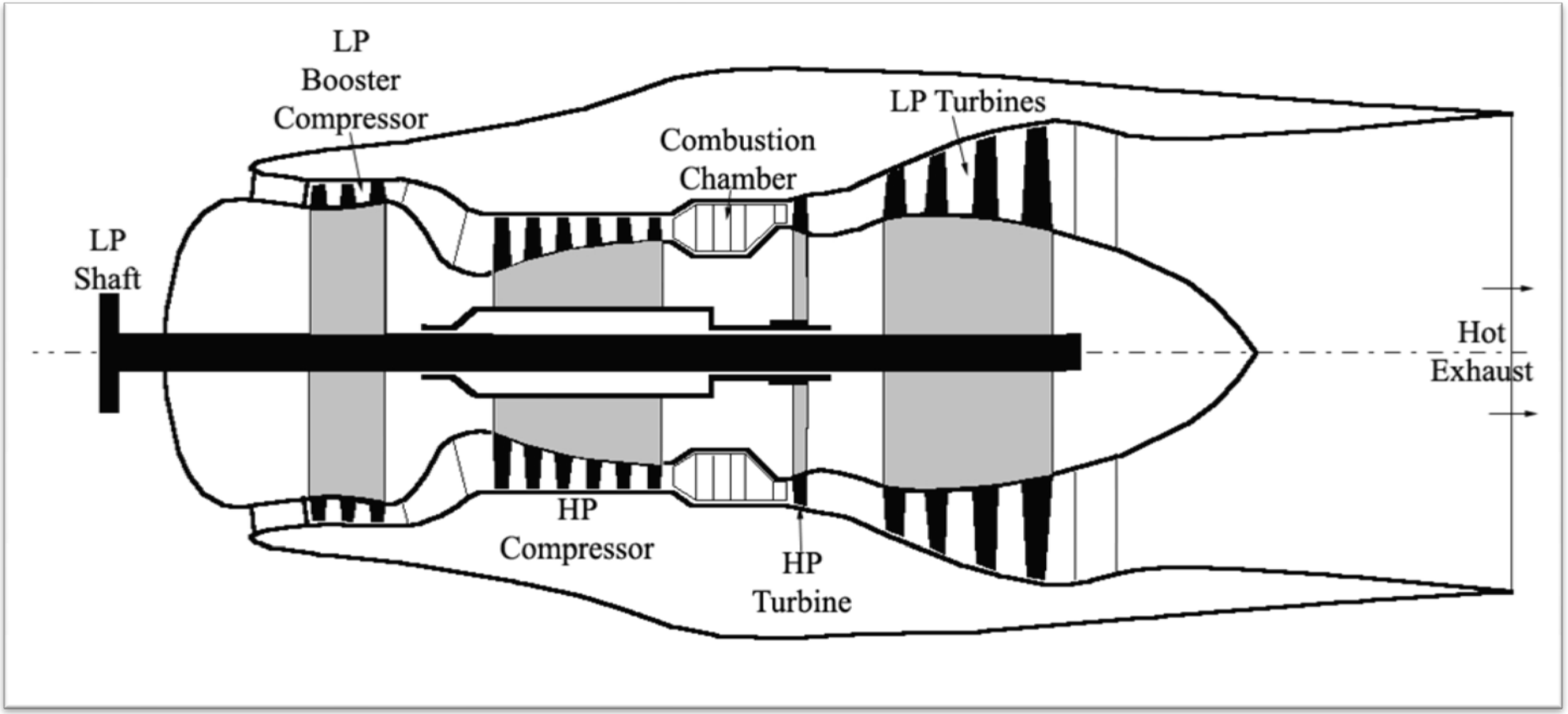
A three-spool turbofan bypass engine



Two spool turboshaft engine (for propeller)



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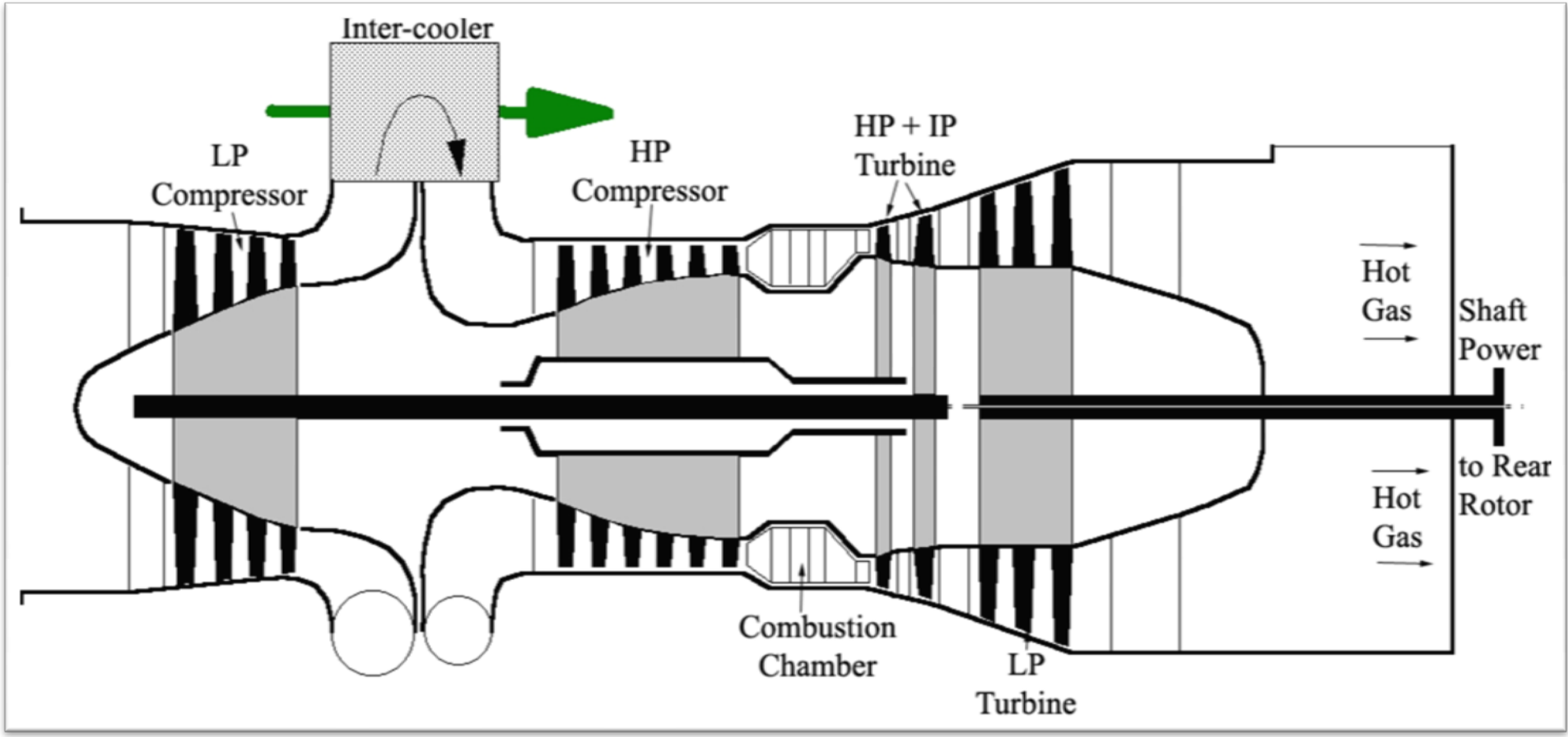
Twin spool powerplant with inter-cooling



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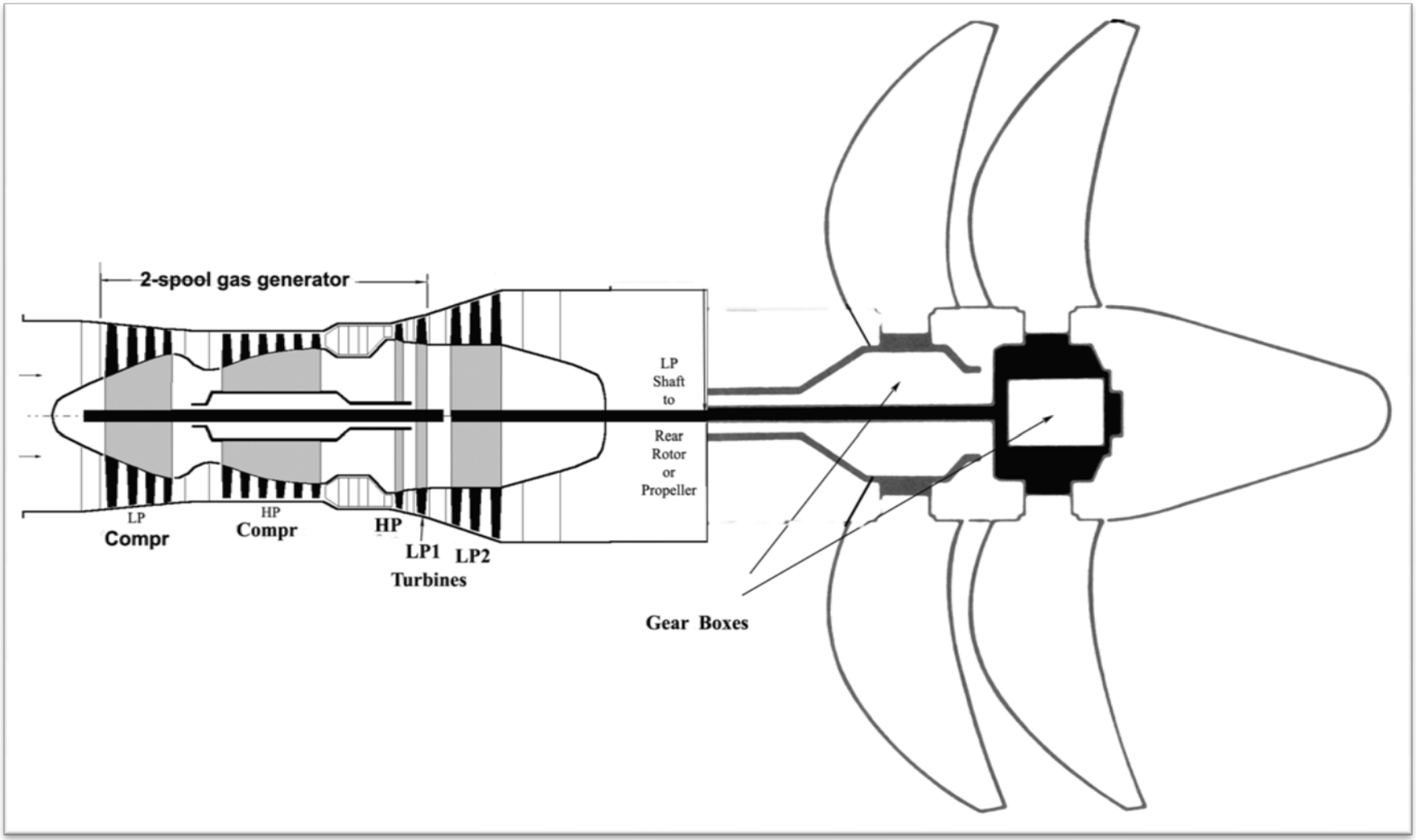
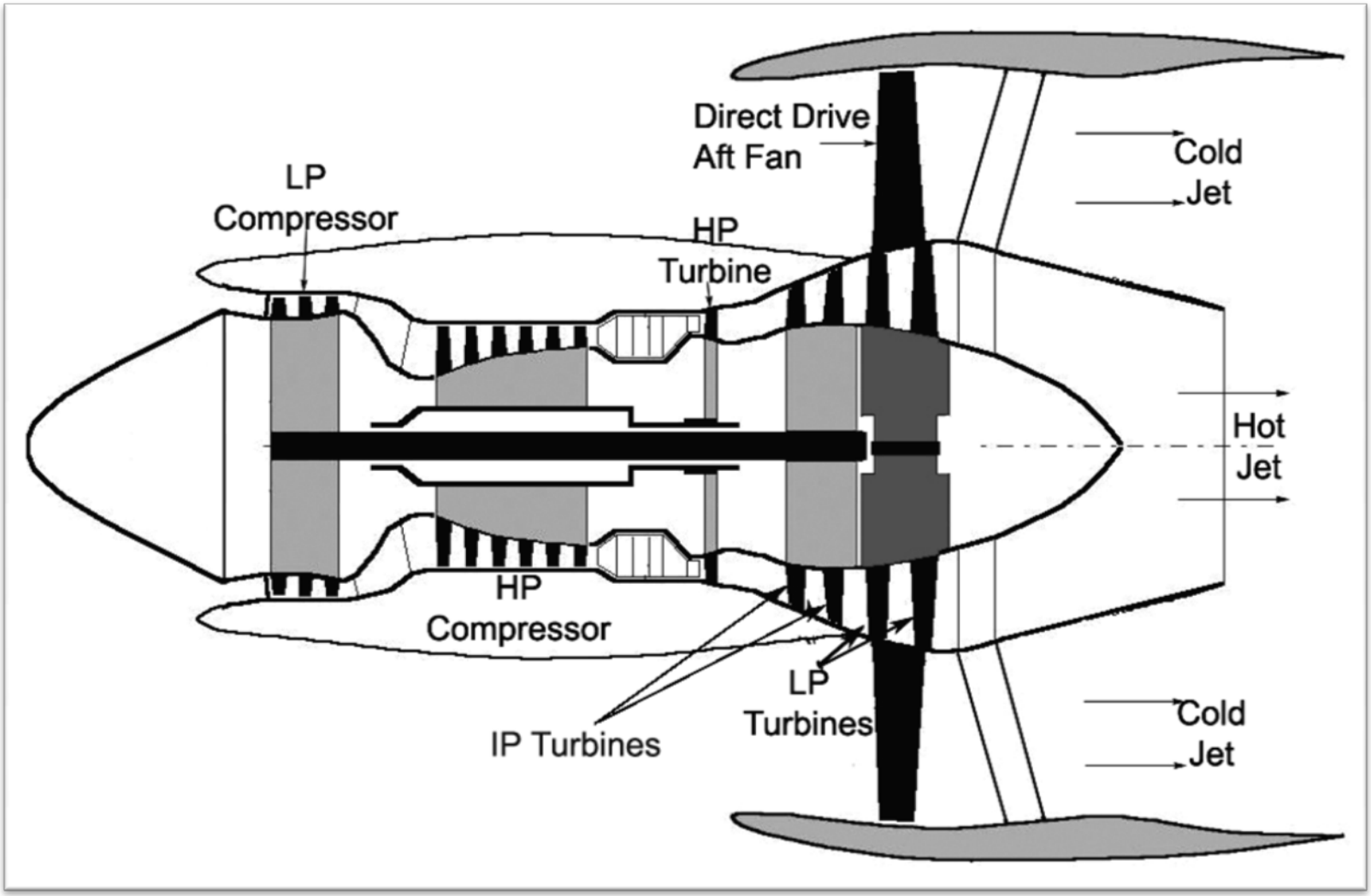
Three spool geared contra-rotating aft prop-fans



Two-spool high bypass aft-fan turbofan



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Frontal view of a geared two spool very high bypass turbofan engine

A contra-rotating twin rotor aft fan prop-fan test

Contra-rotating twin rotor aft-prop-fan flight test

Aircraft Engine development over the years have proceeded towards making them more compact (light-weight, small sized, measured in Thrust/weight ratio) and highly fuel efficient .

Recent research and developments focus on the following issues :

1)Energy Audit & search for new fuels

2)Chemical Pollution Audit

3)Noise Audit

4) Infra-red signature audit (for military aircraft)

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Space vehicle being lifted by a rocket engine