# Gas Turbine Design at Rolls-Royce

## Exploring the Limitations of a Systems Engineering Approach

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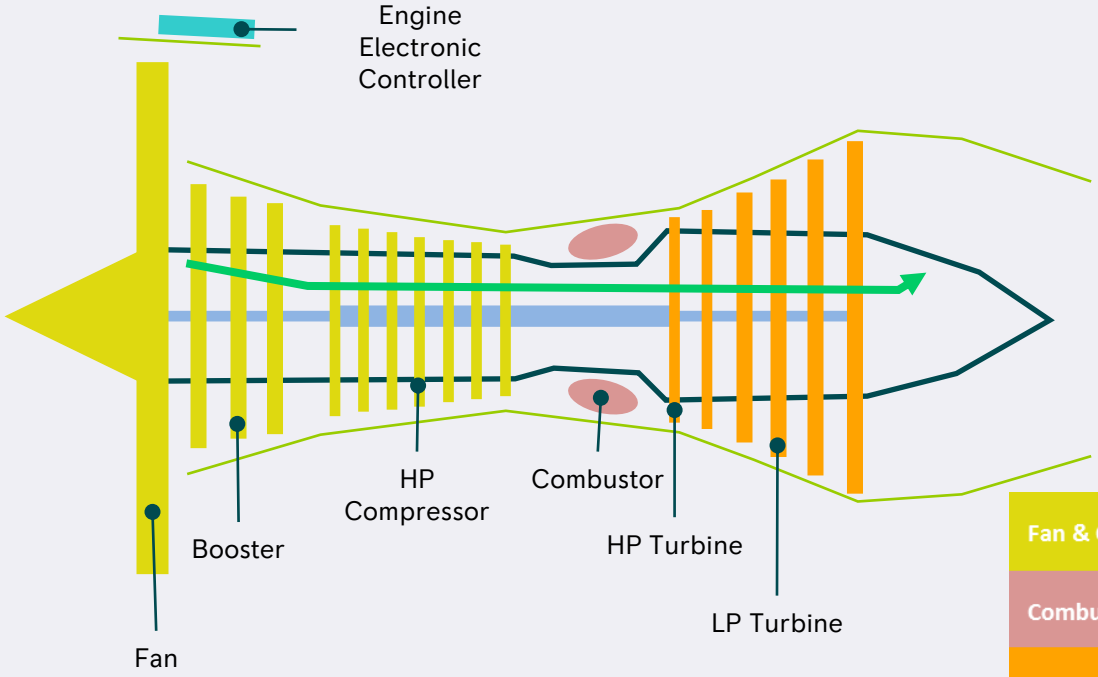
12 December 2019


# The Product

## Gas Turbine Engine




Fan & Compressors

Combustion

Turbines

Power Transmissions & Structures

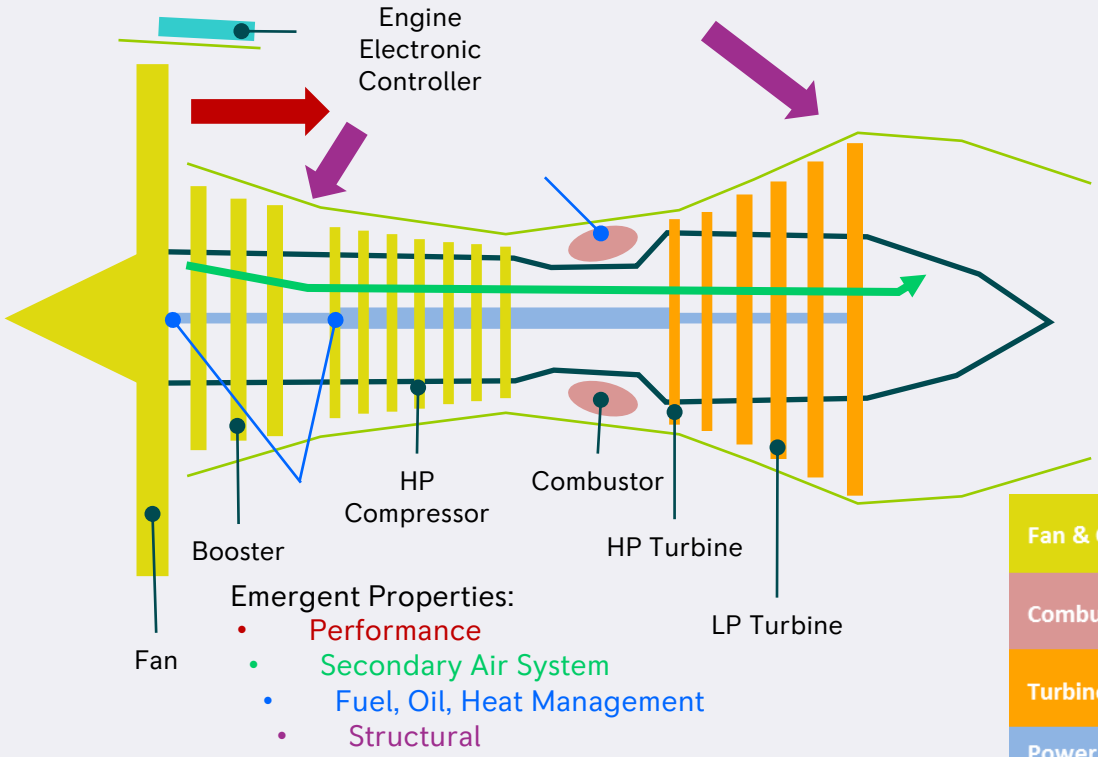
Installations

Control Systems

Sub-systems

# The Product

## Gas Turbine Engine




- Gas Turbine Engines are sold for Thrust
- Thrust is an emergent property!

Fan & Compressors
Combustion
Turbines
Power Transmissions & Structures
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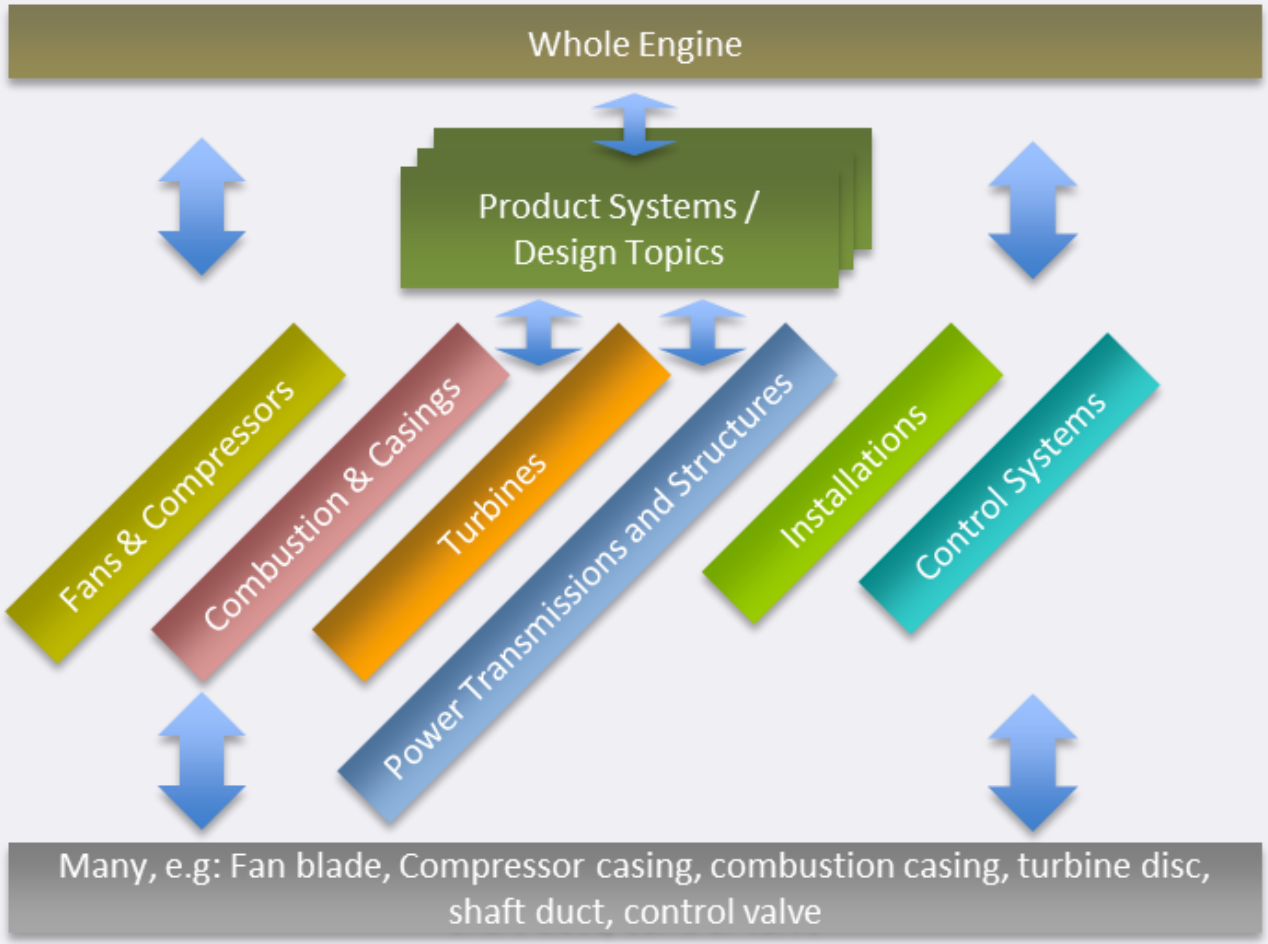
Sub-systems

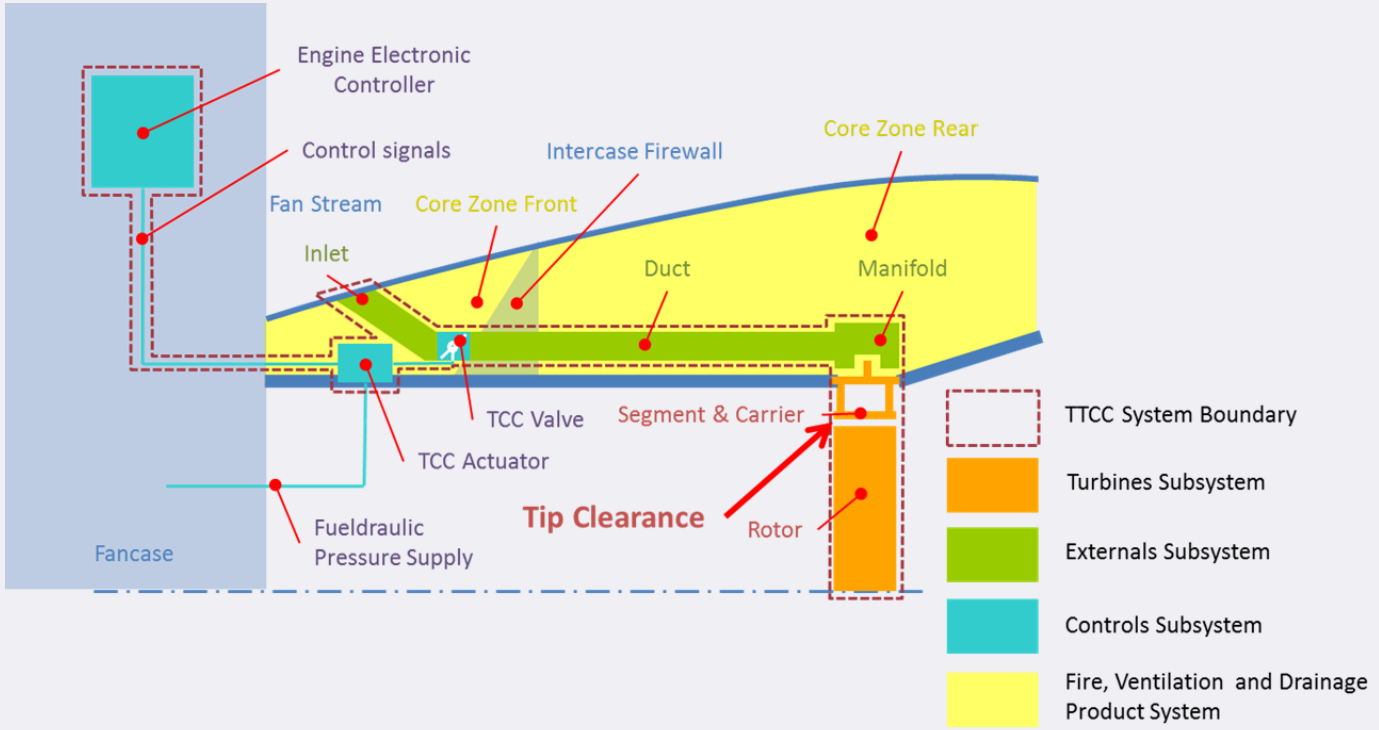
# Rolls-Royce Engineering Organisation



# Turbine Tip Clearance Control

**Operational Requirement:**

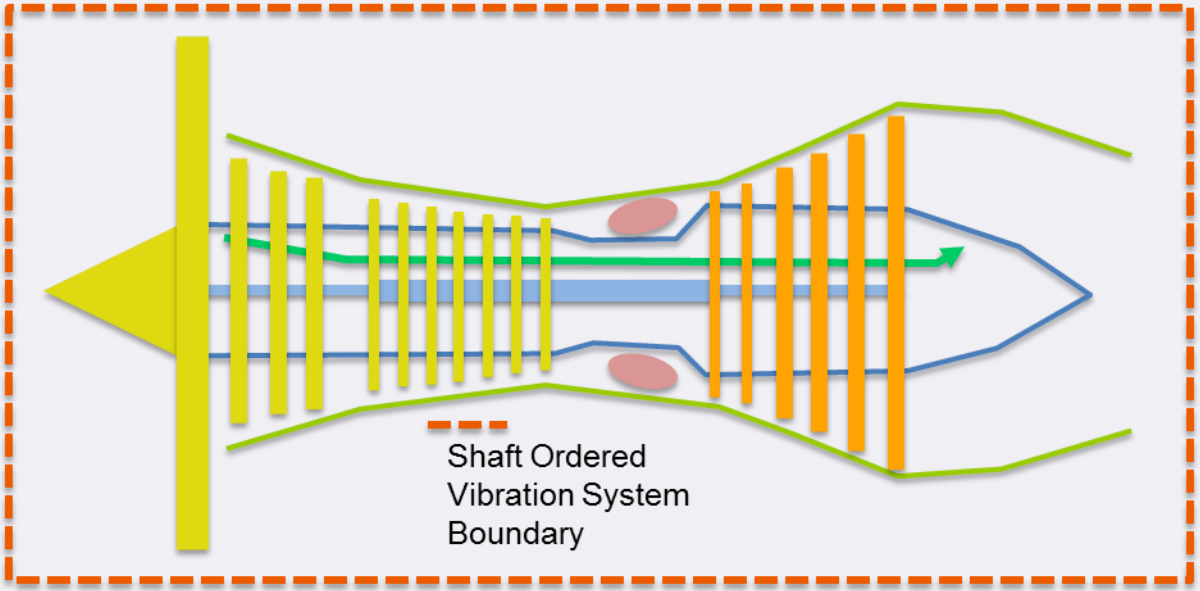
- **The system shall control turbine tip clearances throughout the flight, across the operating envelope and throughout a service interval prior to overhaul.**



# Shaft Order Vibration

**Operational Requirement:**

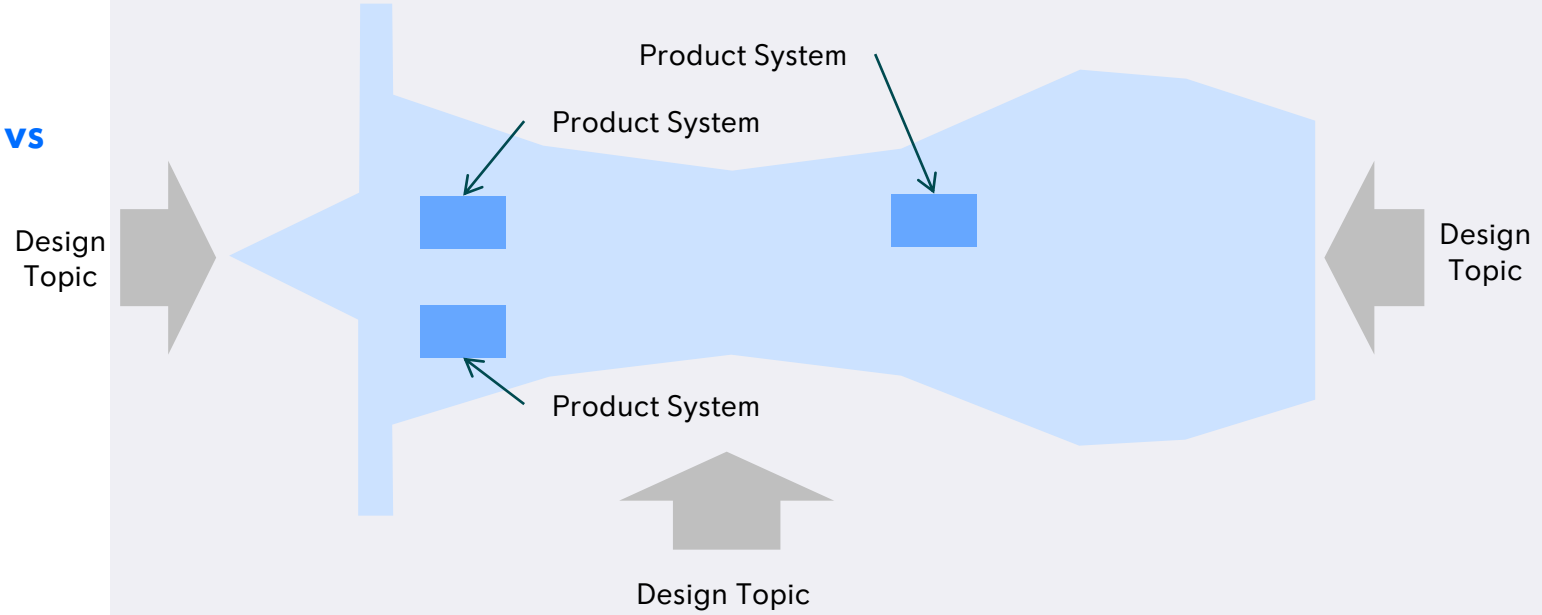
- **All elements of the engine shall operate correctly for their declared lives when subject to operational vibration levels.**




**Shaft order vibration is an emergent problem**

**The focus is how solve the non functional design problem**
***(preferably without adding new systems and / or functionality)***

# Product System vs Design Topic




**It is believed that both Product Systems and Design Topics arise simply from the need to divide the design work up to execute.**

**The engine *as a whole* is a functional system.**

**Product System: Encapsulated functional system within the whole product**

- **Traditional Systems Engineering focuses here**
- **Software-based systems are in this space**

**Design Topic: Viewpoint on the whole product addressing a specific concern**

- **Dominated by physical constraint and non-functional interaction**
- **Gas turbines are to a great extent dominated by these**

## Why is No one Talking about Design Topics?

# *Continuum of Engineered Systems*

***What exactly do I need to do?*** ***How exactly do I need to do it?***

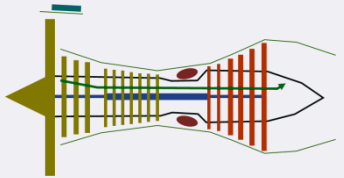
No physical constraint

***Most Systems practice and thought***


INCOSE System Engineering Handbook (v4.0 based upon ISO/IEC/IEEE 15288:2015):

- appears to focus on systems where functionality is the overriding concern.
- has a chapter on Specialty Engineering Activities, but this deals with non-functionals each as a one-off with no generic material

Maximum physical constraint



***Is there a need to redress the balance?***


# Thank you