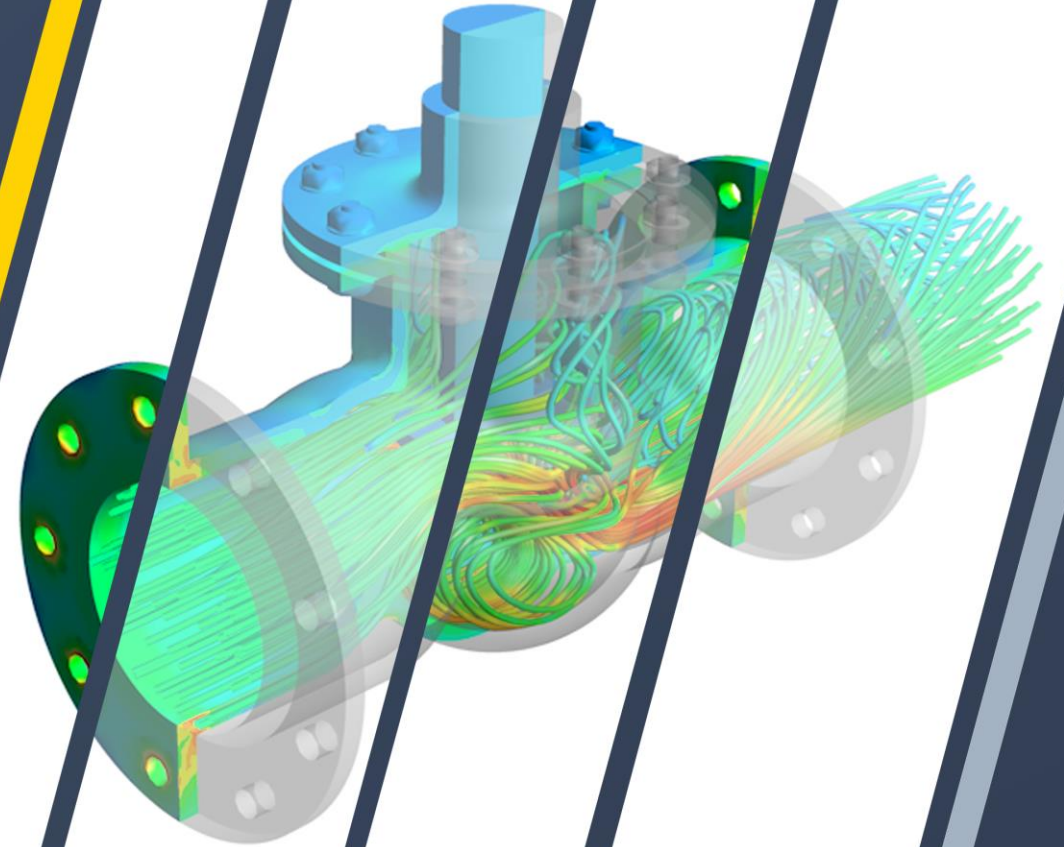# Lecture 01: Introduction

ANSYS CFX Rotating Machinery Modeling

Release 2019 R3

Motivation

- Flows within rotating systems occur frequently in science and engineering applications...

- Examples
  - compressors and turbines
  - fans and pumps
  - rotating cavities, seals, and bearings
  - mixing equipment
  - fluid coupling devices and torque converters
  - air motors
  - marine and aircraft propellers
  - and many more...

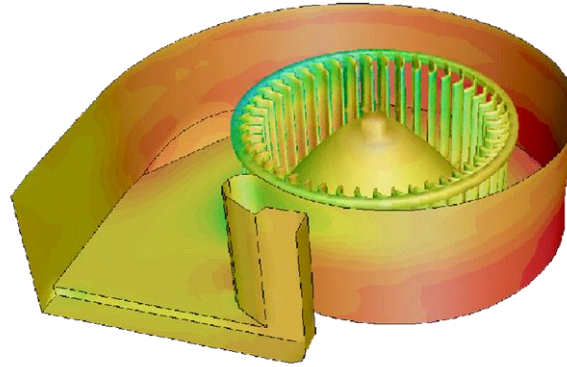- Computational Fluid Dynamics (CFD) now plays a central role in the design and analysis of these systems
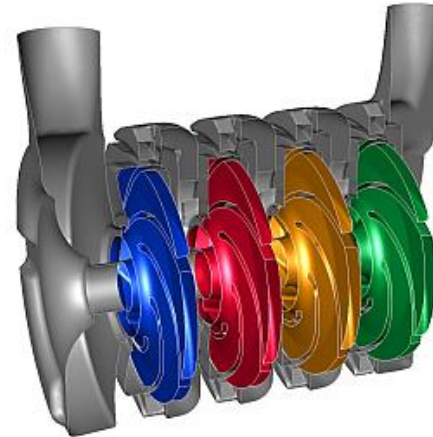
CFX

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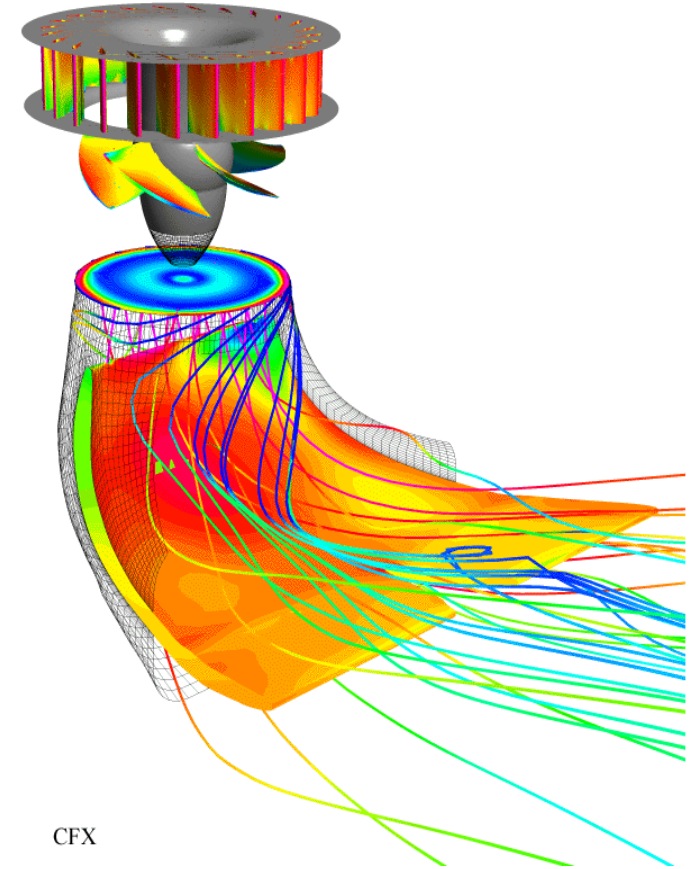
Examples of Rotating Machinery

Multistage compressor
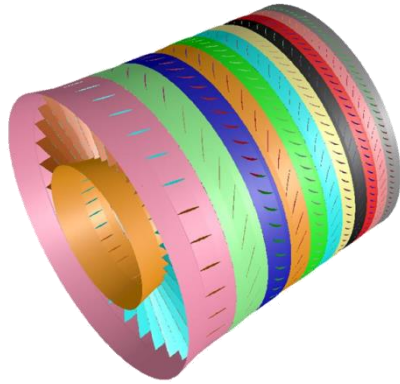
**HVAC blower unit**

Tube axial fan

Multistage pump

Wind turbines

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Goals of the Training

- Examine the major classes of rotating machinery problems
  - Single Rotating Component Analysis
  - Multiple Rotating Component Analysis
  - Transient TBR methods
- Present the workflow for modeling rotating machinery problems with ANSYS CFX
  - Problem definition
  - Model setup
  - Solution process
 - Post-processing (special turbomachinery mode in CFD-Post)
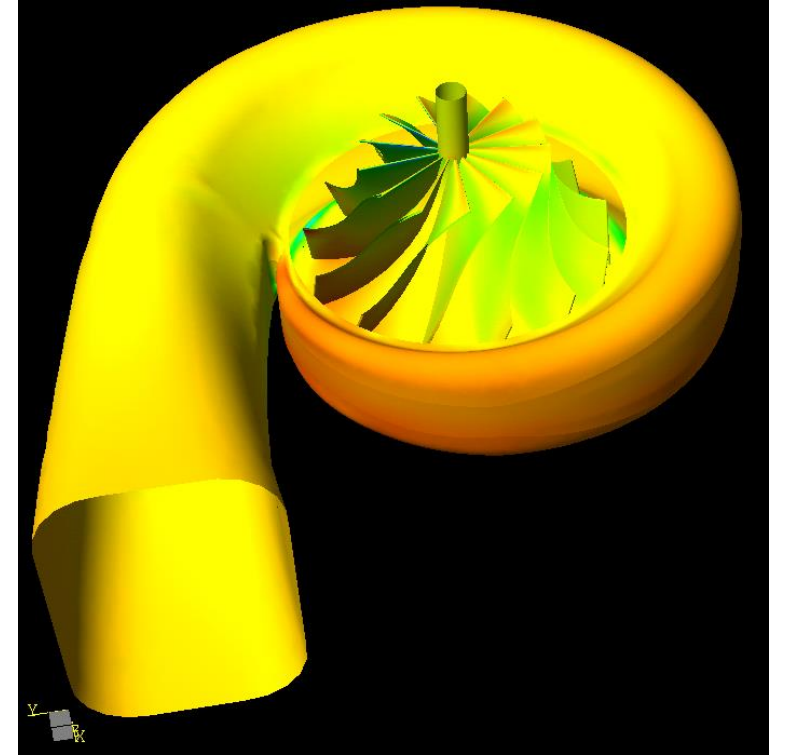
Types of Rotating Machines

- Turbomachinery
  - Machines which add work to or extract work from a fluid
  - Examples
    - *compressors, fans, pumps* - add work to achieve a pressure or velocity rise in the fluid
    - *turbines, windmills* - extract work from fluid to produce power or drive other machines

- Mixing equipment
  - Machines which are designed to mix fluid (and possibly solid) materials for use in a chemical processing applications
  - Example: industrial mixing tanks

- Other Devices
  - Disk cavities and labyrinth seals in gas turbine engines
 - Electric motors and generators
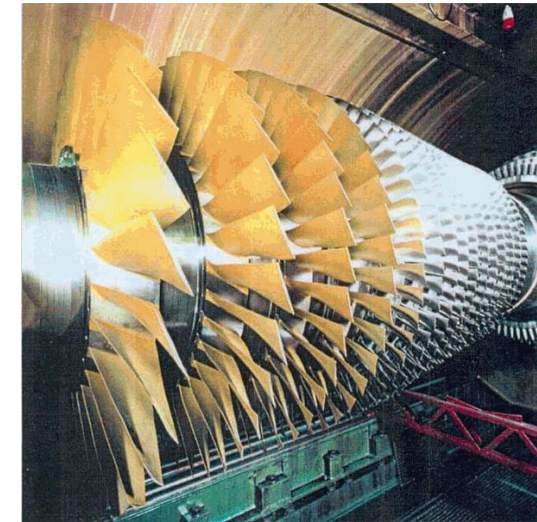
Compressor section of a large land-based gas turbine
Courtesy Siemens AG
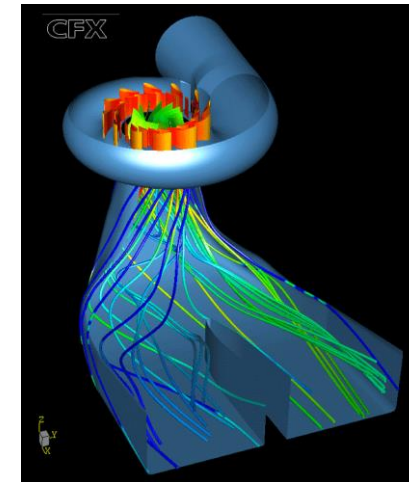
Francis turbine
Courtesy Turboinstitut
Republic of Slovenia

Classification of Turbomachinery

- Axial machines
  - Flow through the machine is aligned with the axis of rotation
    - Examples: propellers, axial fans/compressors/turbines

- Centrifugal/Radial machines
  - Flow through the machine is (in general) perpendicular to the axis of rotation
    - Examples: liquid pumps, centrifugal fans/compressors, radial turbines

- Mixed flow machines
  - Flow through the machine is somewhere between axial and centrifugal
    - Example: mixed flow compressor, oil well pump, water propulsion system

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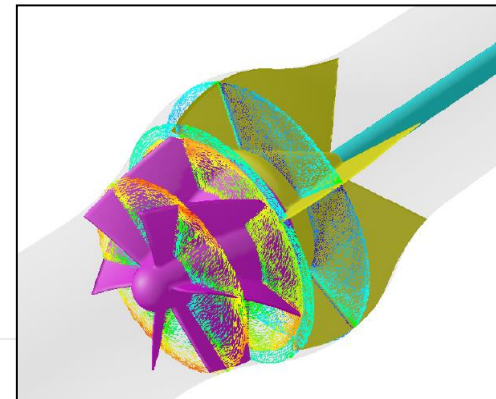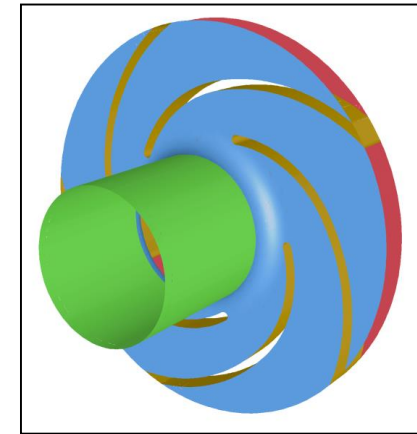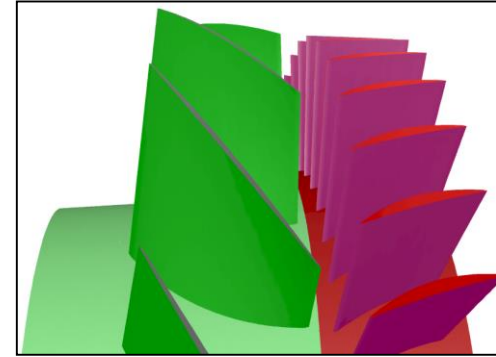
Rotating Machinery Systems

- Rotating machines usually consist of <u>multiple components</u> to facilitate the flow process in the system

- Example: Liquid pump components
  - Inlet duct – directs flow to the eye of the impeller
  - Impeller – increases the pressure of the fluid
  - Volute – collects and diffuses the flow

- Example: Axial gas turbine compressor components
  - Stator blade passage followed by a rotor blade passage
  - Stator directs the flow into the rotor at an optimal flow angle to facilitate maximum pressure rise in the rotor
  - Full compressor will consist of several stages to achieve a desired pressure rise →multistage compressor
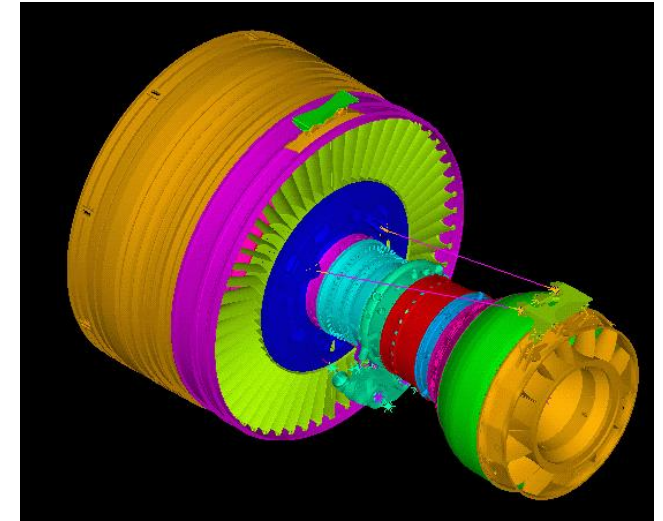
High bypass ratio aero-engine

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Multistage Turbomachine Example


1.5 stage axial turbine
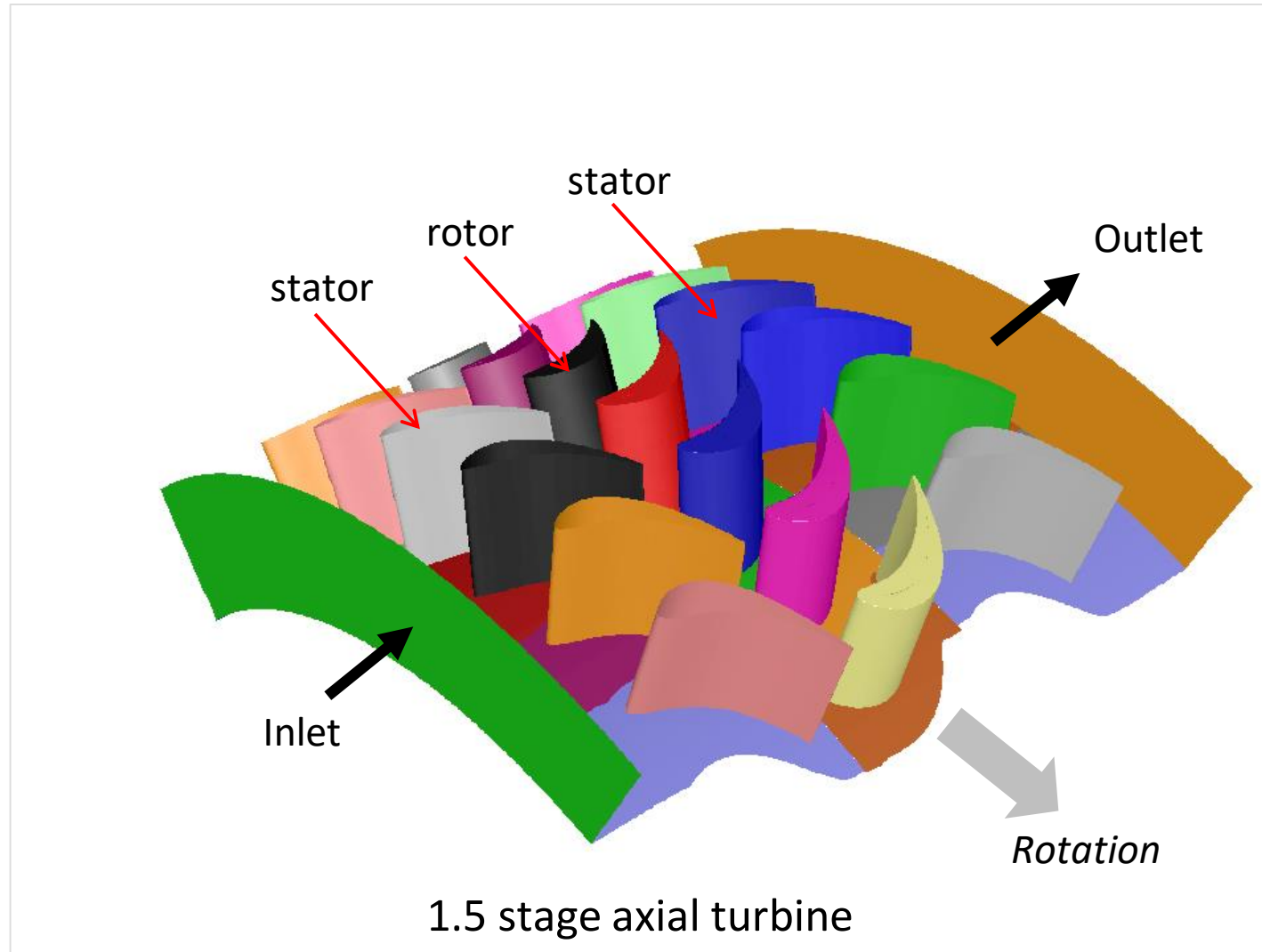
Various Modelling Approaches

- Single Rotating Component Analysis (Steady-State)
  - Entire domain in a single moving reference frame
  - Steady-state solution

- Multiple Component Analysis (Steady-State)
  - Multiple components are required (e.g. additional blade rows, volutes, baffles, struts, etc.),
    - ➢ Frozen Rotor Model, Mixing Plane Model

- Multiple Component Analysis (Unsteady)
  - Transient full-annulus
  - Transient pitch change

Increasing complexity
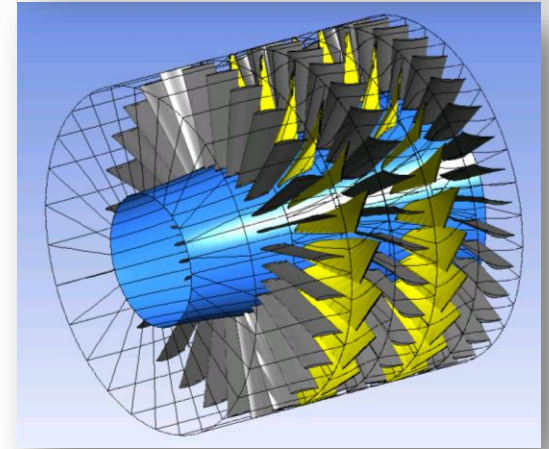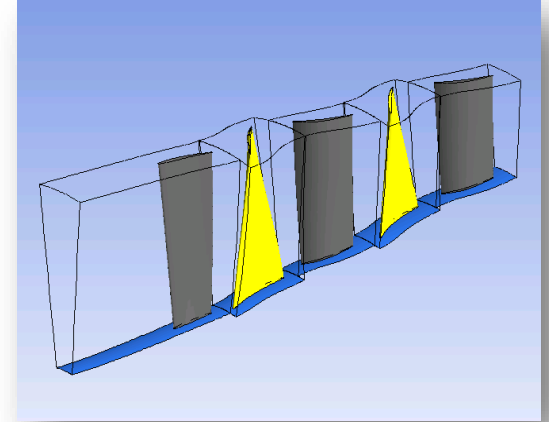
Summary

- Various rotating machine types
  - Turbomachinery, mixing, other…
  - Axial, centrigugal, mixed

- Various Modelling Approaches
  - Single Rotating Component Analysis (Steady-State)
  - Multiple Component Analysis (Steady-State)
  - Multiple Component Analysis (Unsteady)