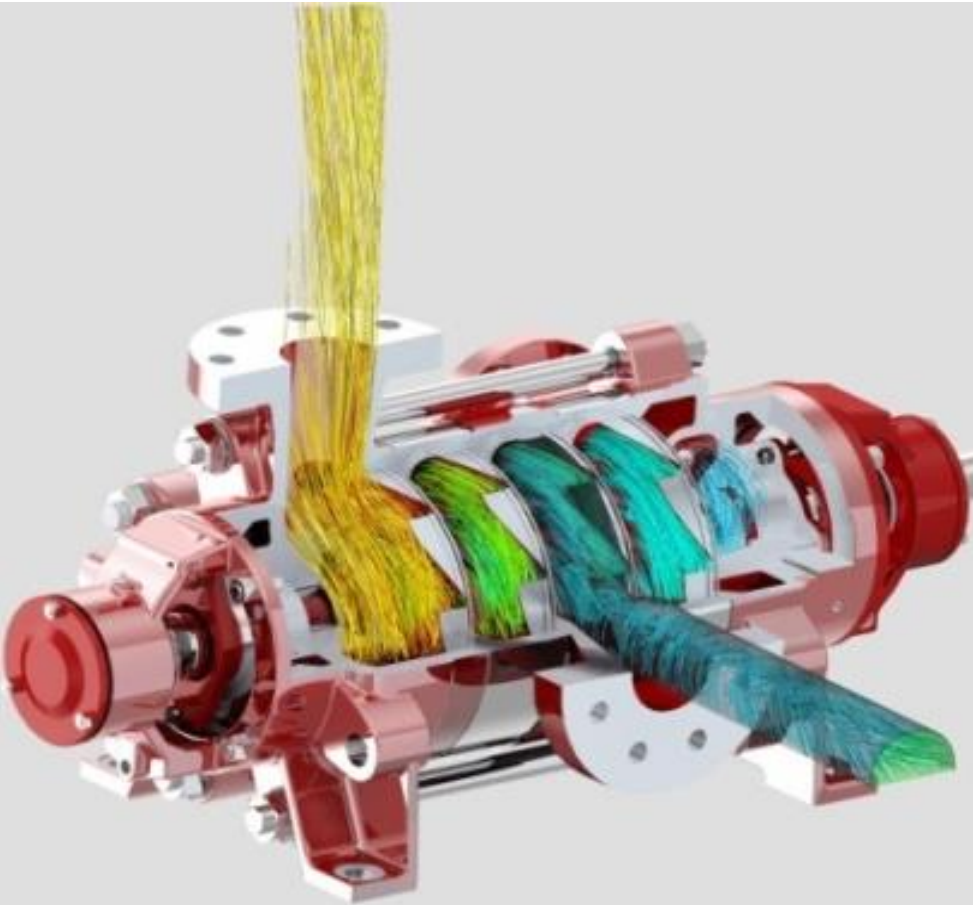
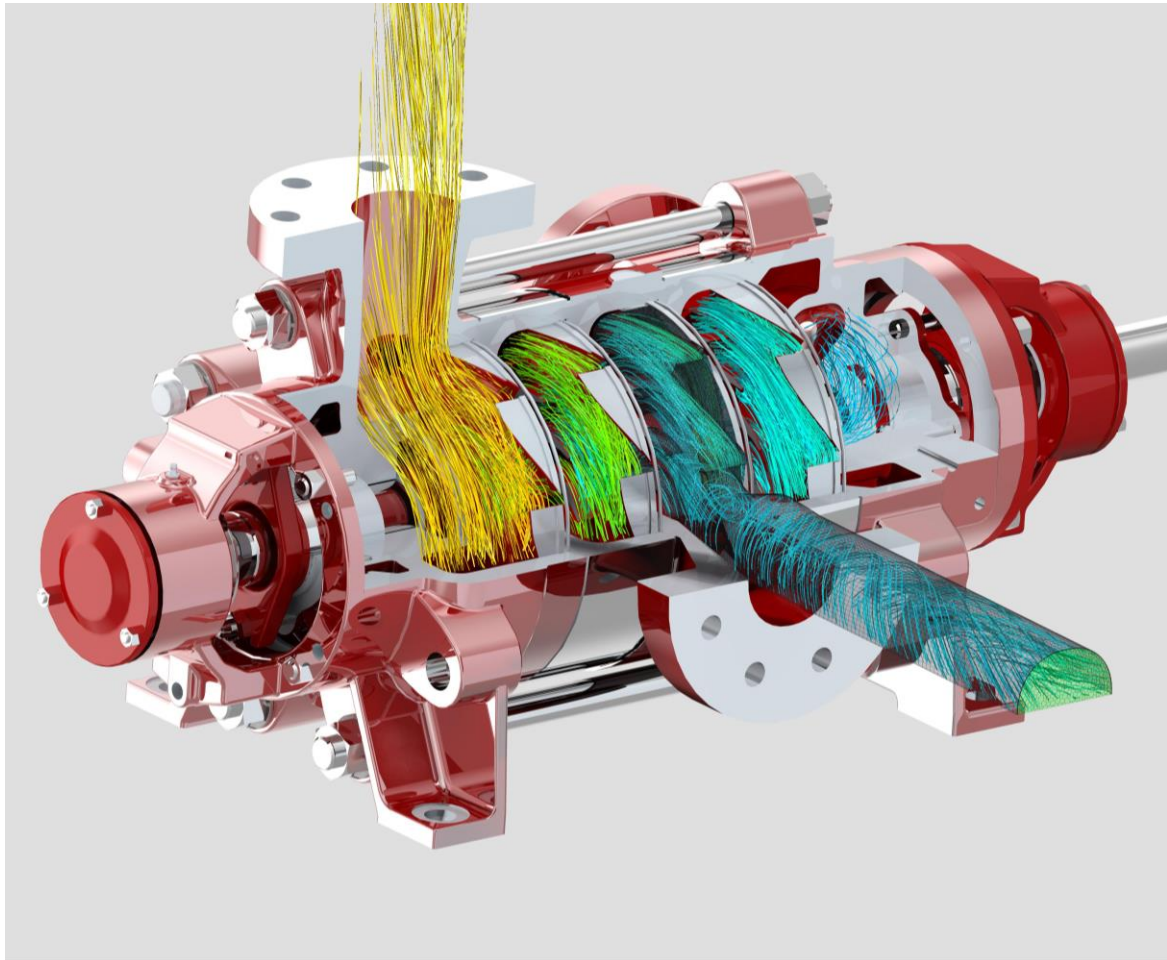


# Discovering Better Designs Faster for Centrifugal Pumps

兆水科技應用案例



- **Motivation for Modeling & Simulation**  
Improving pump performance within a short development cycle
- **The process/workflow and the tools involved**
  - Cfturbo for hydraulic design
  - STAR CCM+ for CFD simulation
  - HEEDS for design exploration and process automation
- **Review pump example based on specific objectives**
  - Accurately predict pump performance
  - Explore designs to increase pump efficiency



## Maximize pump efficiency

Meet hydraulics industry standards (ANSI, API, ISO)

Increase pump reliability  
& durability

Predict pump performance  
across wide-ranging operating conditions

Reduce cost,  
dependence on  
physical testing

Explore more  
design alternatives,  
earlier

Design, simulate, optimize pump ...  
run one test - built it

Discover better designs, faster

# Trends in Today's Pumps Market

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## Stricter Efficiency Regulations

*"Pumps that are not inherently efficient in their peer group ... will either be removed from the market or will require redesign in order to meet higher efficiency levels. Some estimates put this at up to 20% of the pumps on the market today."*

-- Empowering Pumps, 11-Sept-2015, "The Newly Proposed Pump Regulation by the Department of Energy"

## Faster-to-Market with Newer Products



## Increased Profitability; Cost Saving



Manage Risk;  
Ensure Up-Time; Longer Life

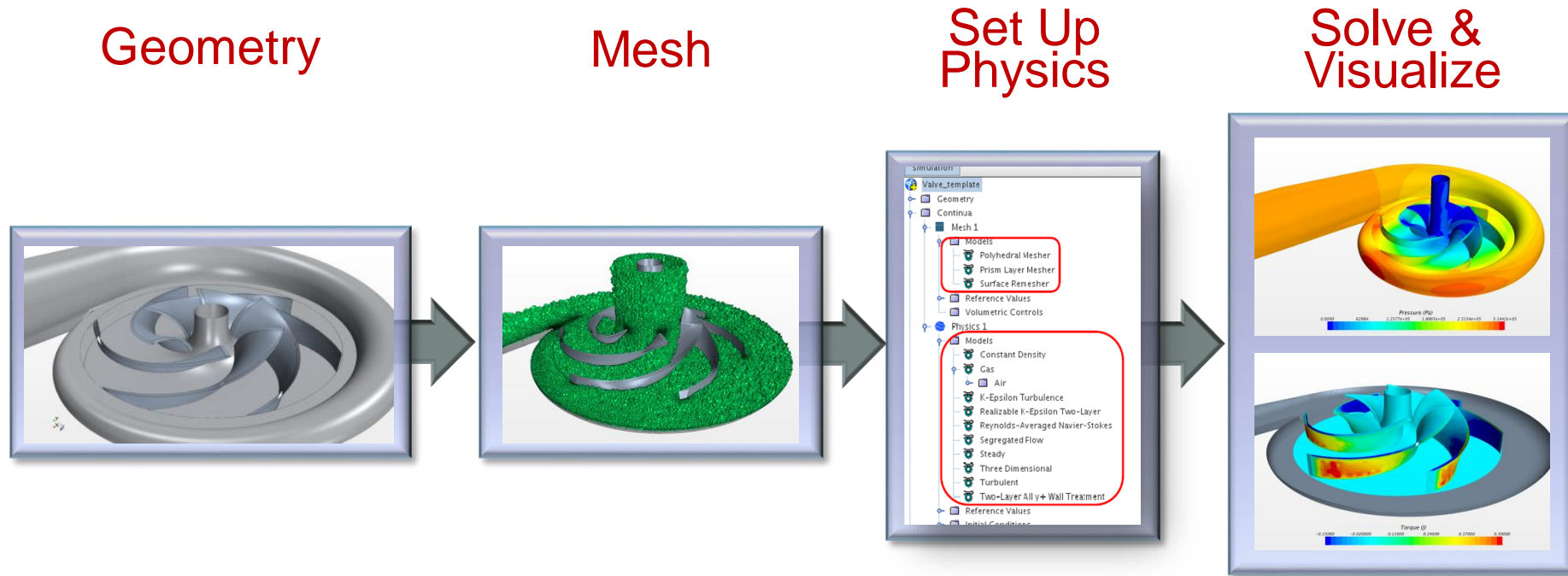


Rapidly Tailor to Customer Specifications

*"Operating conditions that were not mentioned in the pump's order document and were not considered in pump design have been responsible for more than 60% of all unscheduled shutdowns."*

-- Turbomachinery International,  
July/August 2015, page 14

Test More Designs  
and Operating Conditions

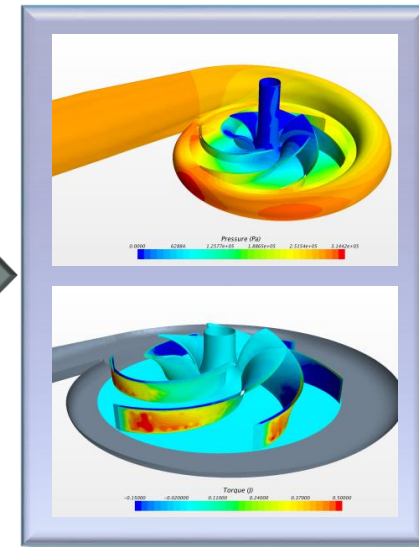
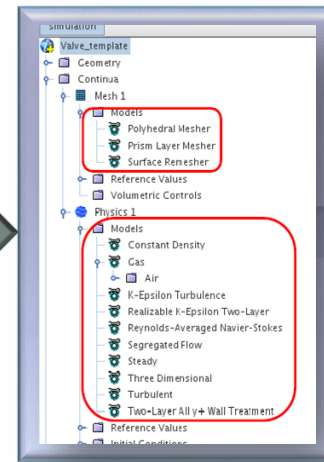
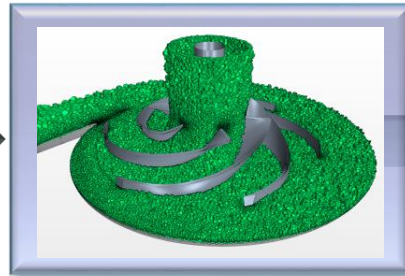
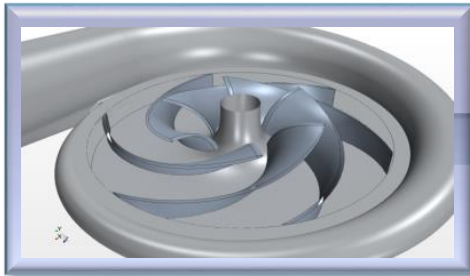


Geometry

Mesh

Set Up  
Physics

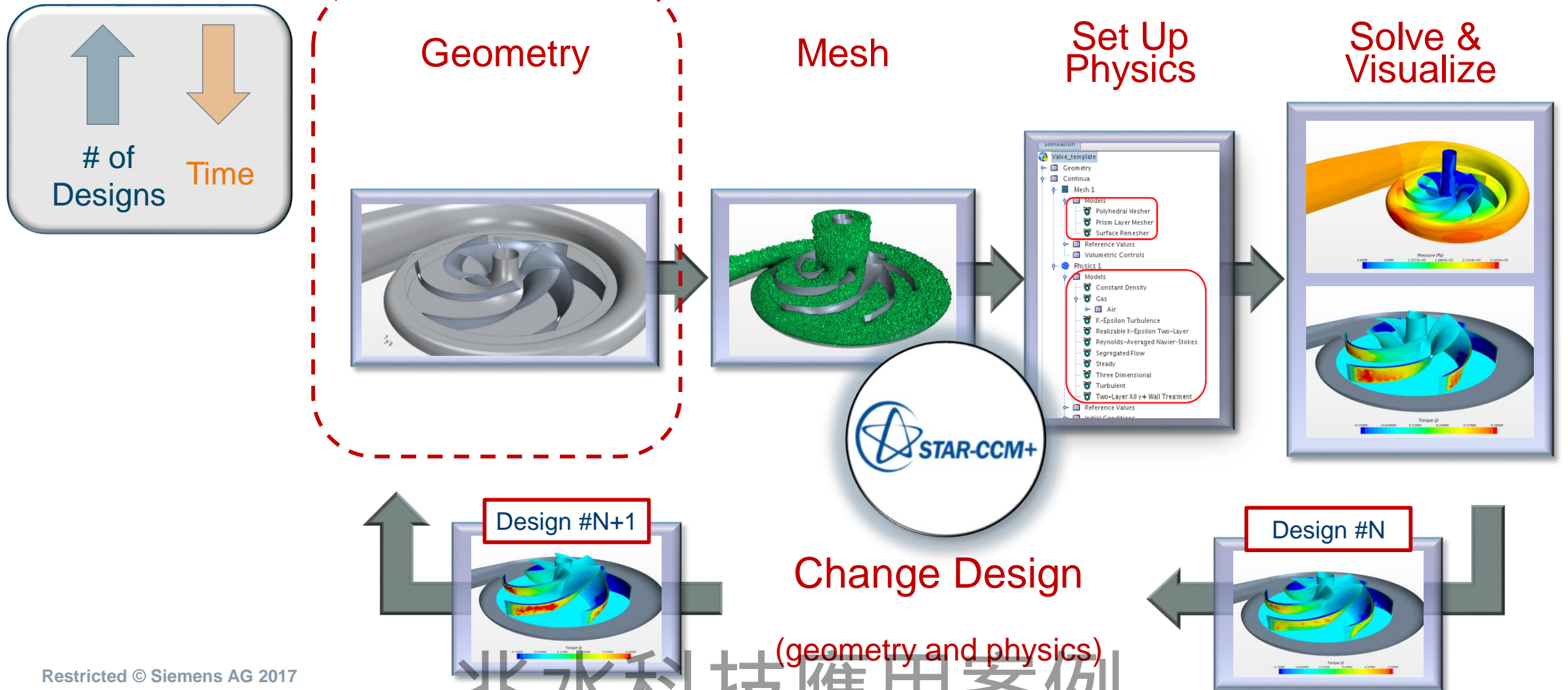
Solve &  
Visualize



Manual Interaction  
(geometry + physics)

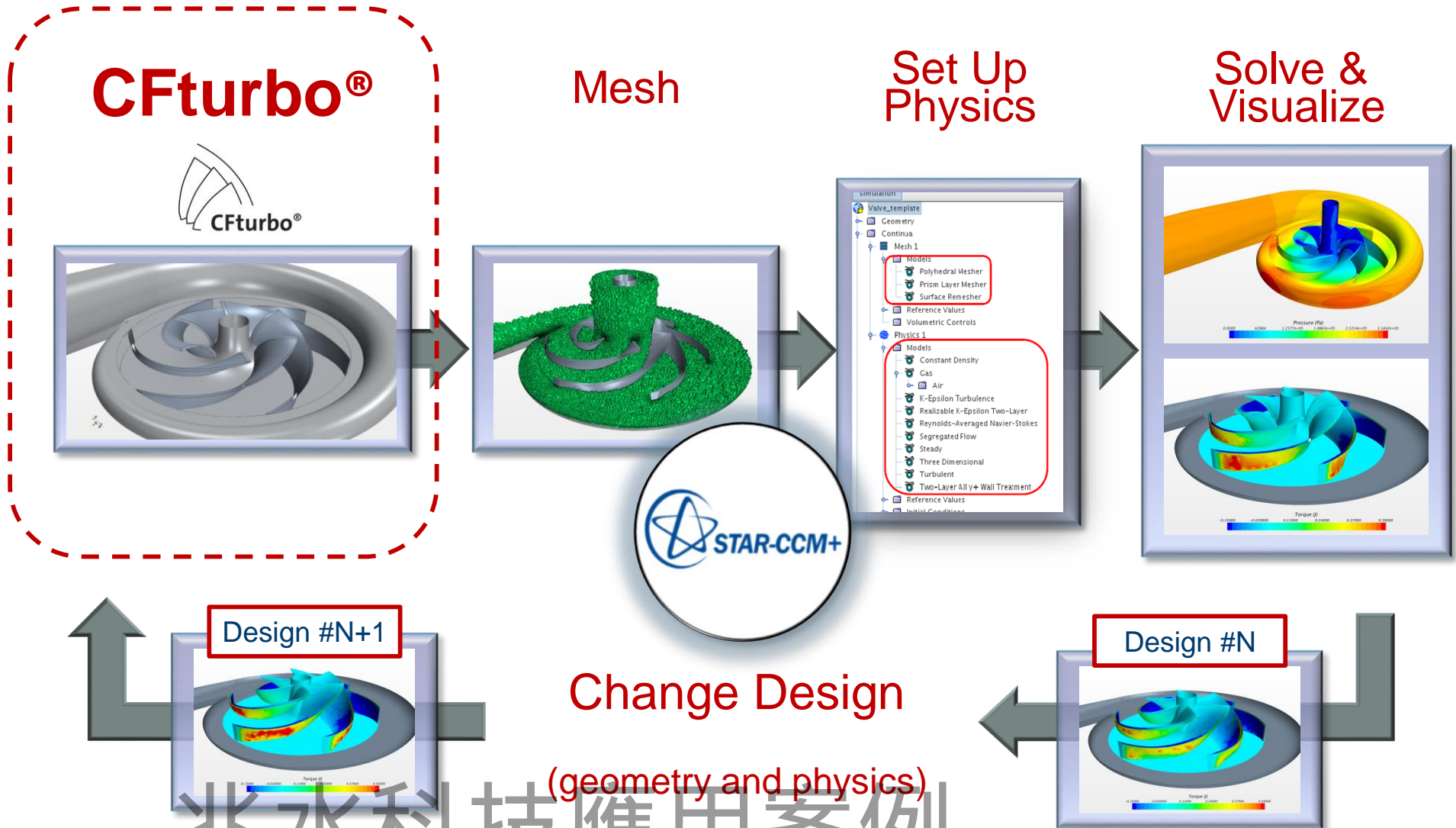
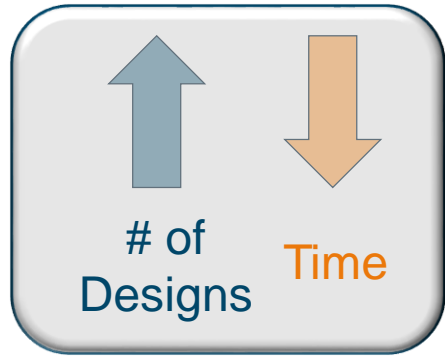
# Automated Design Space Exploration

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# Automated Design Space Exploration

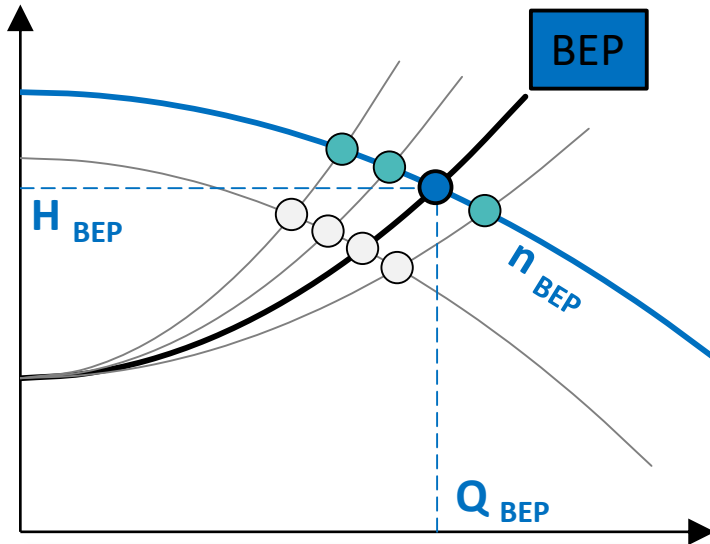
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# CFturbo® for Direct Turbomachinery Design

## Initial Design Process for a New Pump

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### Define operating point (BEP)

Q,  $\Delta p$ , Speed, Fluid properties,  
Inlet conditions

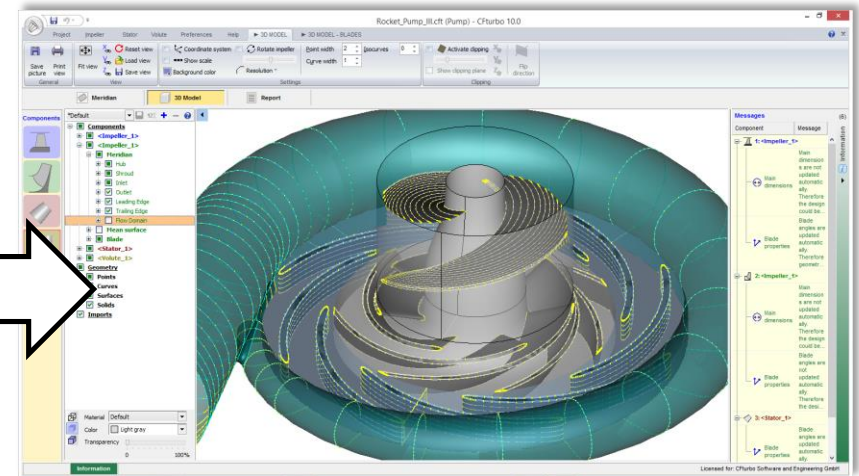
### Fundamental equations

Bernoulli-, Euler equation,  
Mass-, Momentum- and  
Energy conservation, ...

**CFturbo®**

### Empirical correlations

Use of publicly available  
functions, or integrate own  
proprietary data



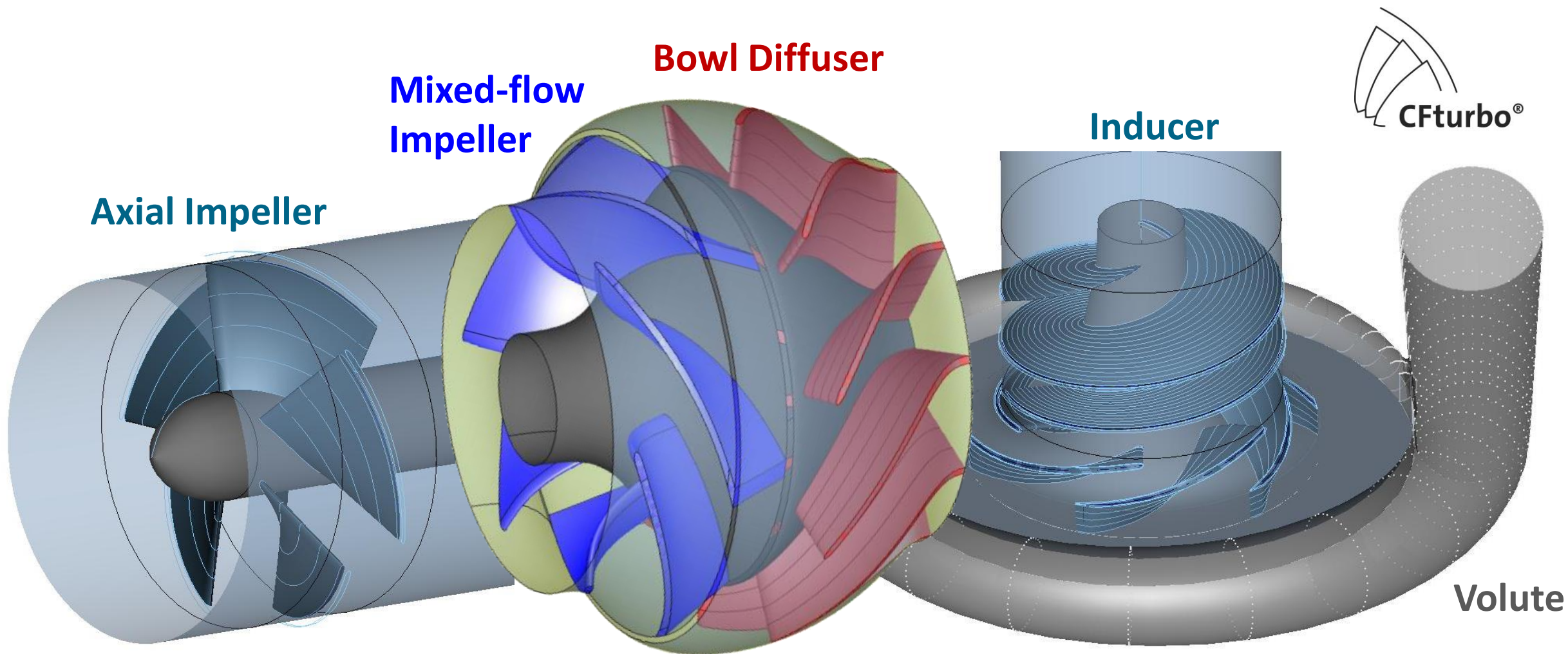
### Get a (reasonable) 3D-model

CAD/CFD/FEA export formats,  
+ batch-mode capability

# CFturbo® for Turbomachinery Design

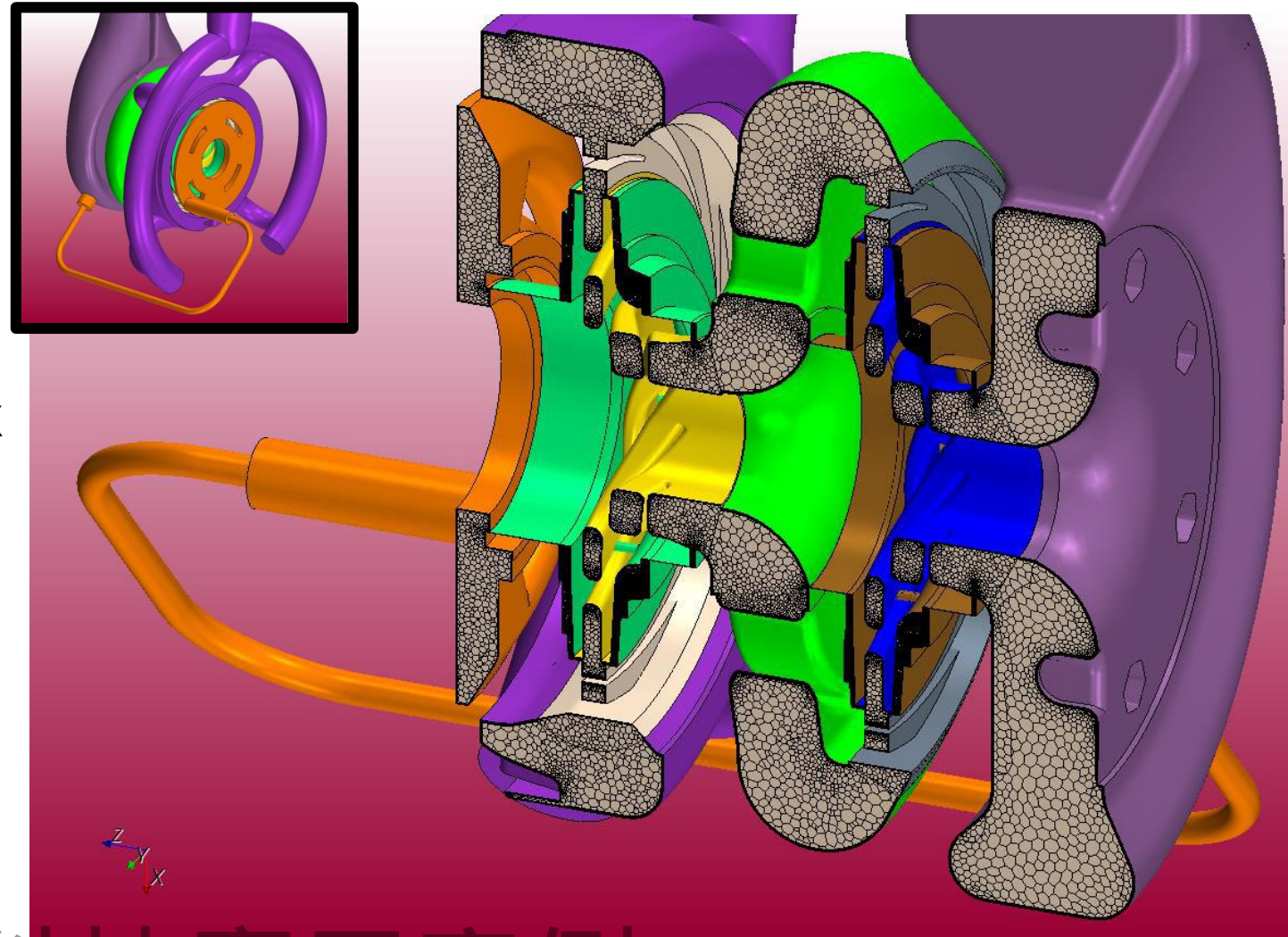
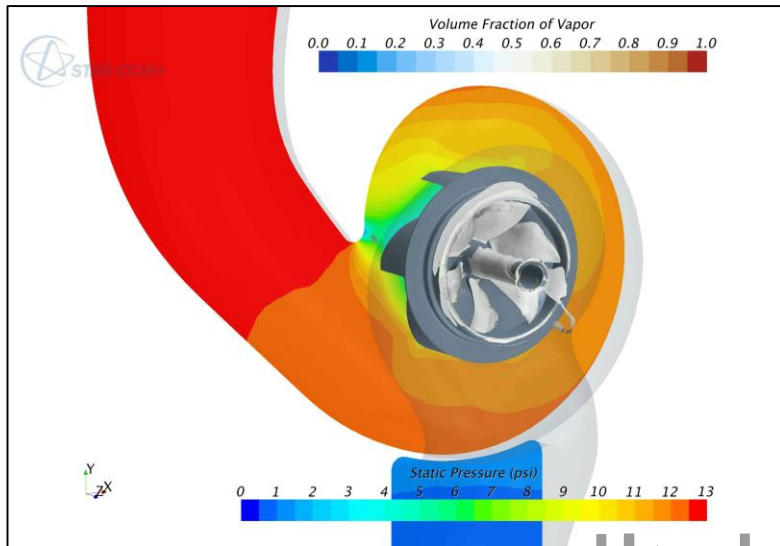
## Pump Impeller Types and Components

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## Strengths for pump simulations:

- Connectivity to 3<sup>rd</sup>-party geometry codes
- Robust meshing of complete geometry
- Fast transient solution; cavitation
- Rapid design iteration ability
- Connectivity to Design Exploration codes
- Licensing that enables cost-affordable DX



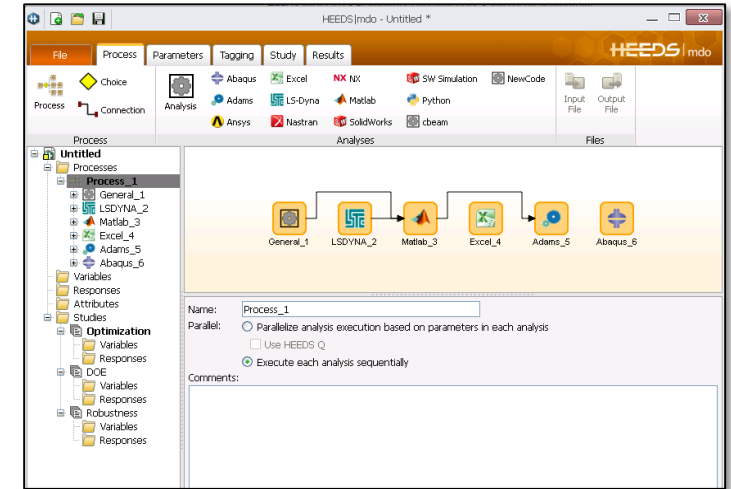
# Design Exploration with HEEDS



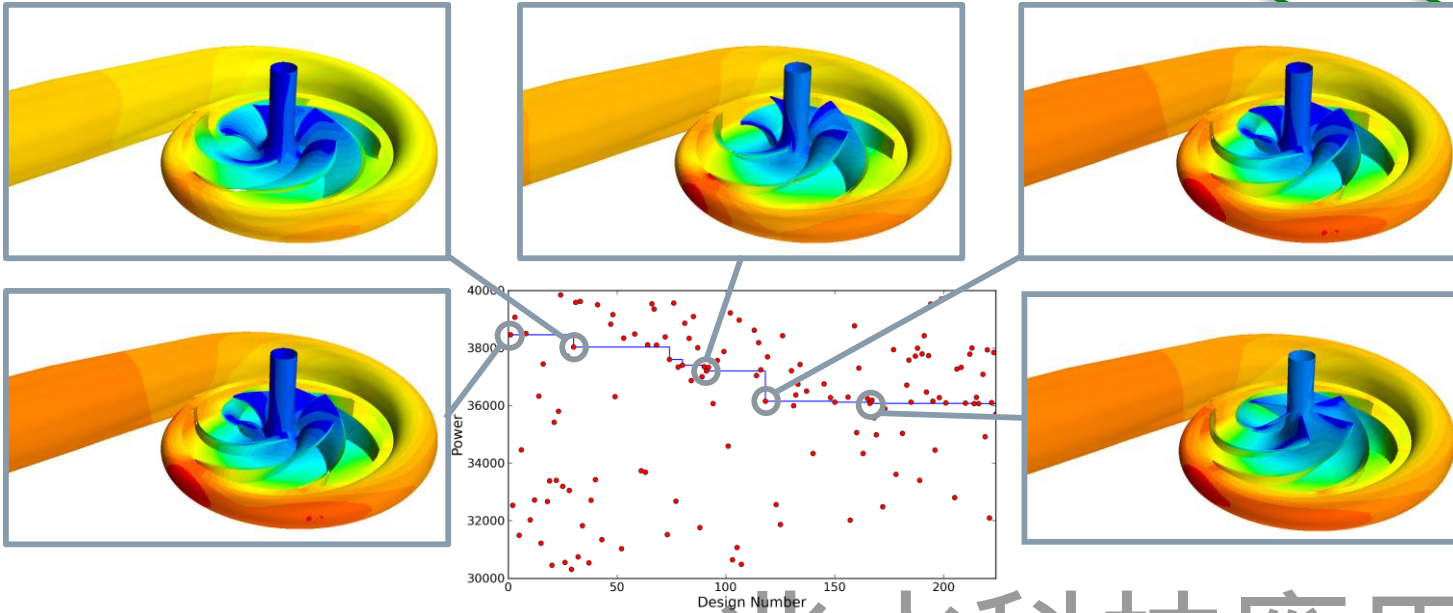
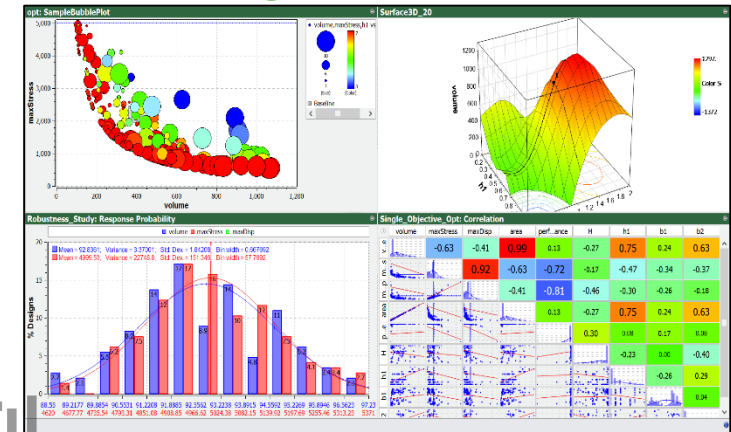
## Strengths for pump simulations:

- Tool-neutral process automation (CFturbo, STAR-CCM+, etc.)
- Scalable high performance computing
- Efficient exploration (optimization, DOE)
- Sensitivity & robustness assessment

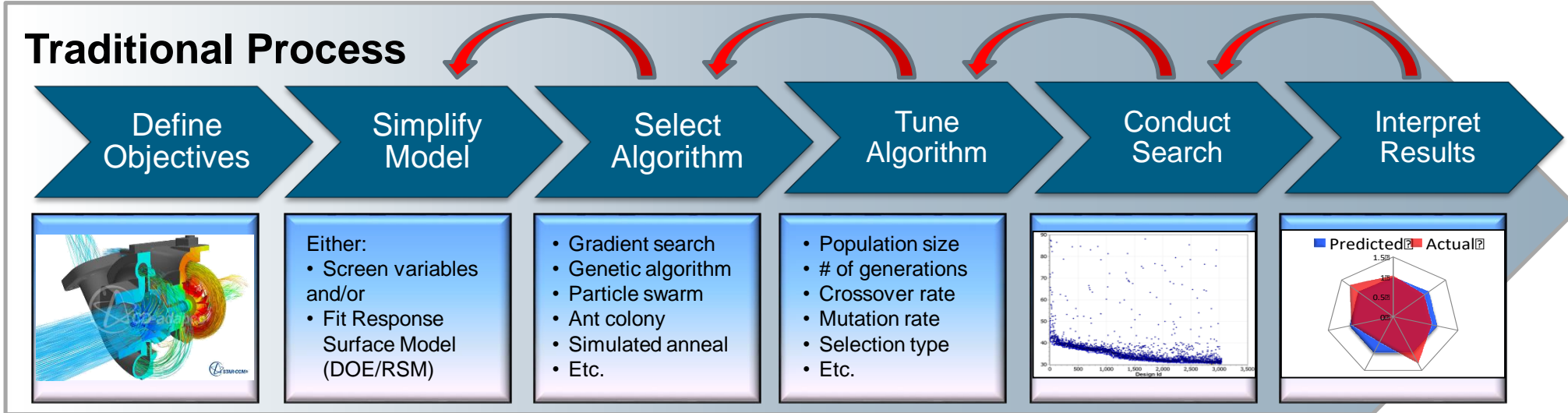
## Process Automation



## Design Exploration



# Traditional Process for Design Exploration



**Problems Encountered**

*Reactions:*

**Introduces Errors**

*“Too Error-Prone”*

**Requires Iteration**

*“Too Costly”*

**Requires Expertise**

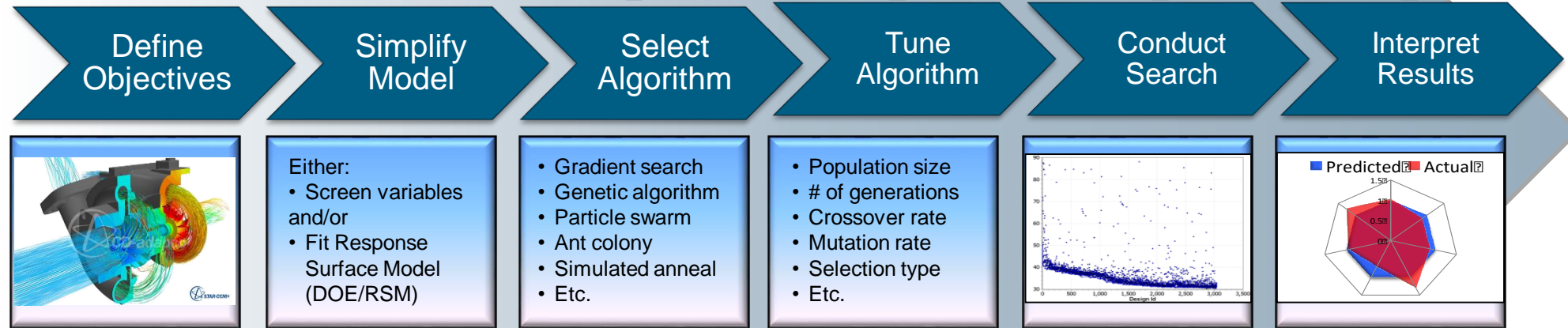
*“Too Difficult”*

**Result:**

Design Exploration

- *Used sparingly*
- *Only by experts*
- *Only for toughest “optimization” problems*
- ***Delivers limited innovation***

## Traditional Process



## Modern Process (HEEDS)



*“HEEDS surpasses anything on the market in its ability to help us drive innovation.”*

-- Anders Ahlström , Scania Truck

Time Savings

Discover Better Designs, *Faster*

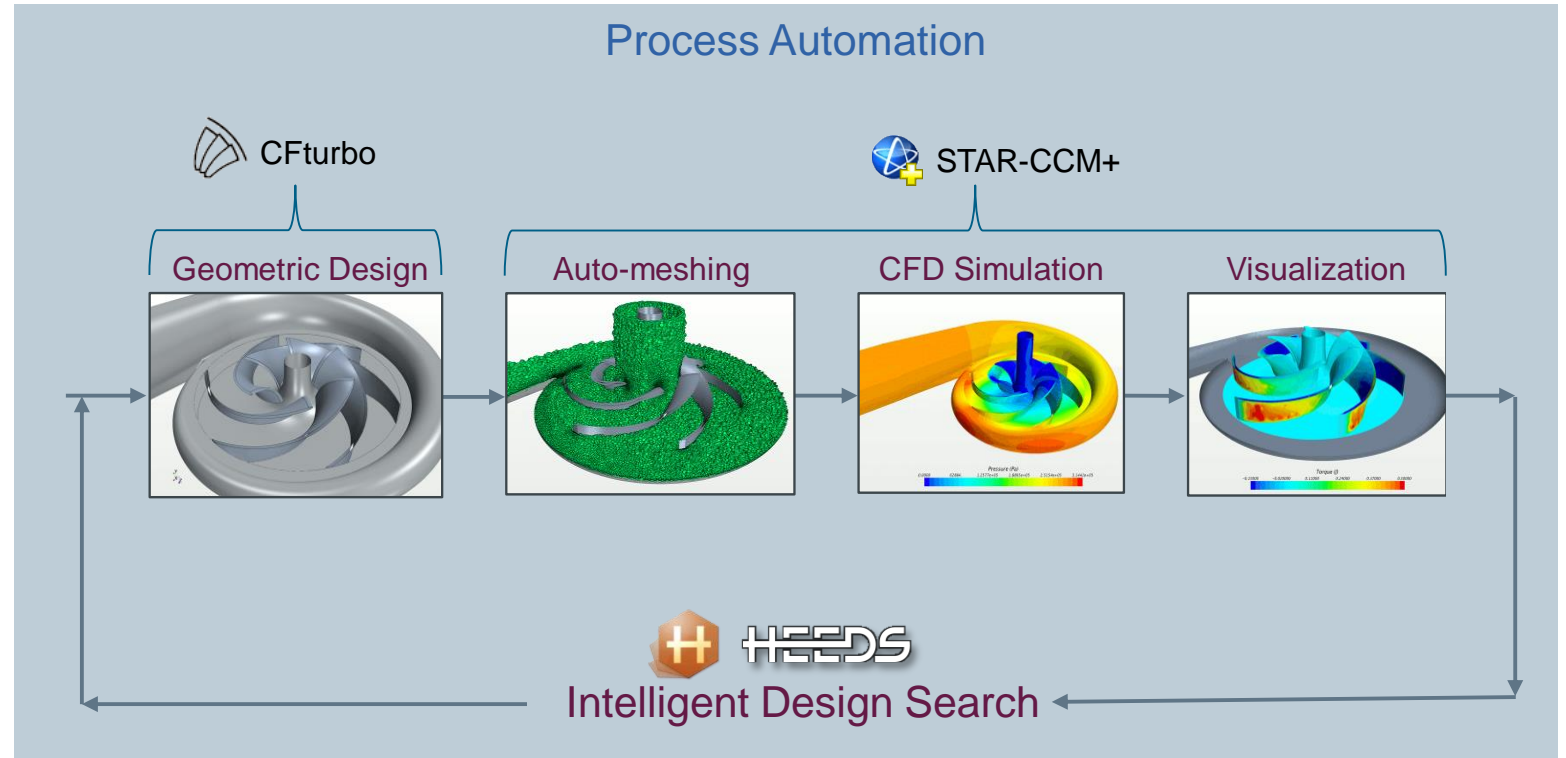
# Mechanical Solutions Inc. (MSI)

## Designing More Efficient Centrifugal Pumps

SIEMENS



- Power required reduced by 6%
- Found 33 improved designs; not just 1 that is “good enough”
- Scalable platform for affordable simulation-driven design exploration



*“I can now obtain better pump designs faster by spending more time on engineering decision-making, and less time on model setup & data transfer.”*

– Ed Bennett, VP of Fluids Engineering

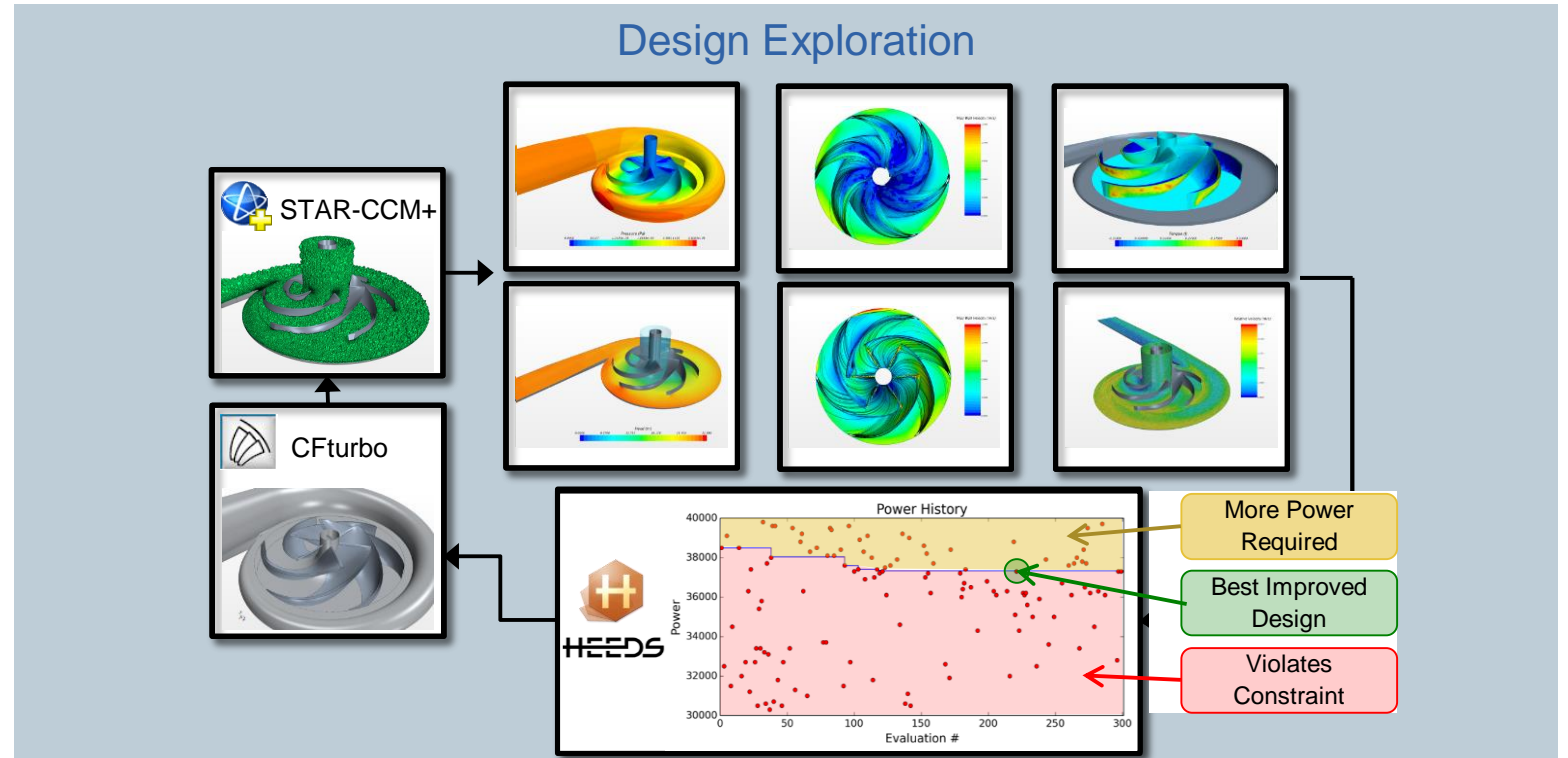
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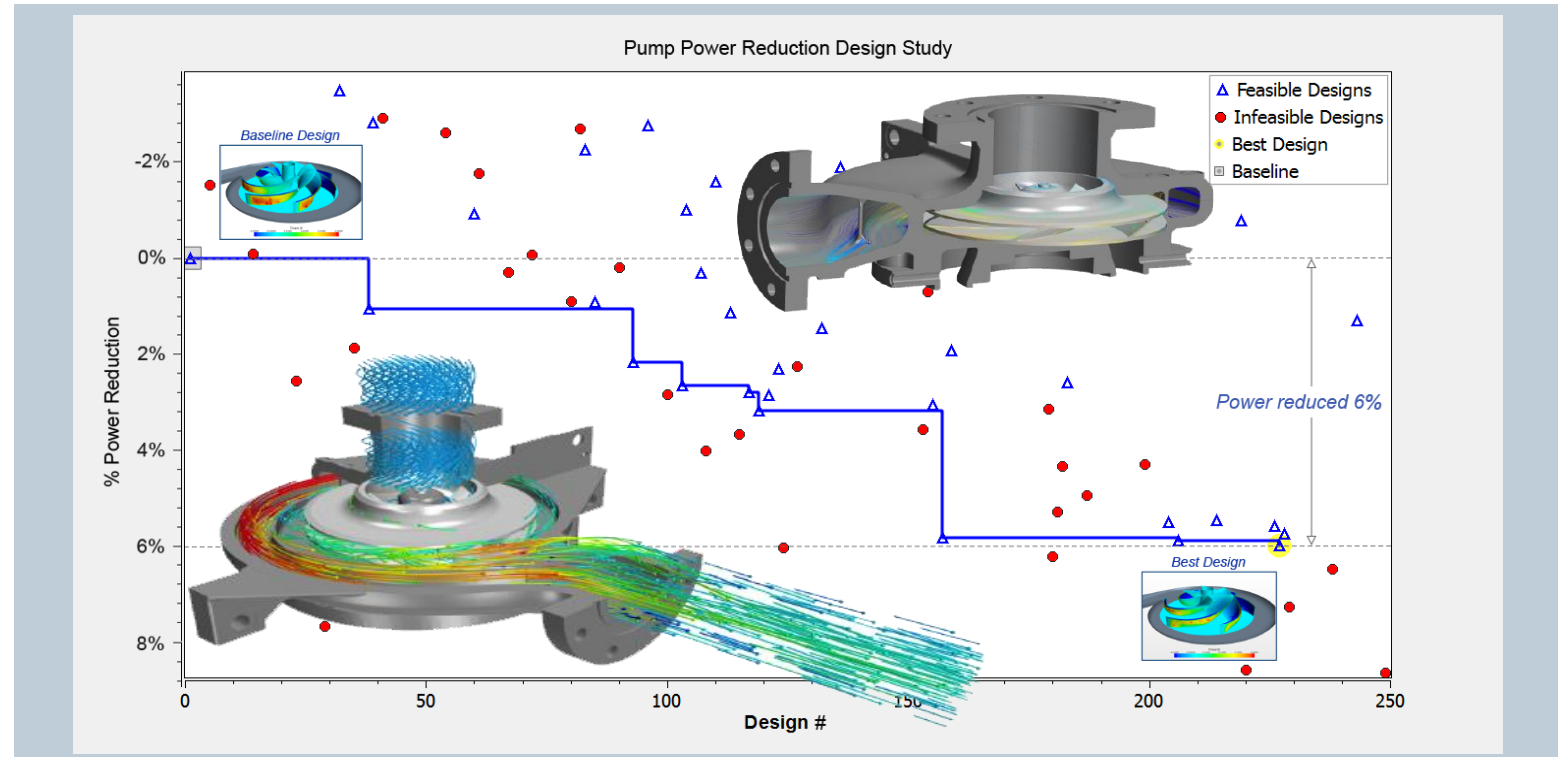
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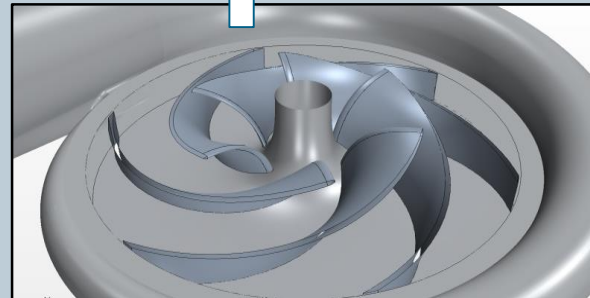
SIEMENS



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### Design Exploration

Power reduced by 6%

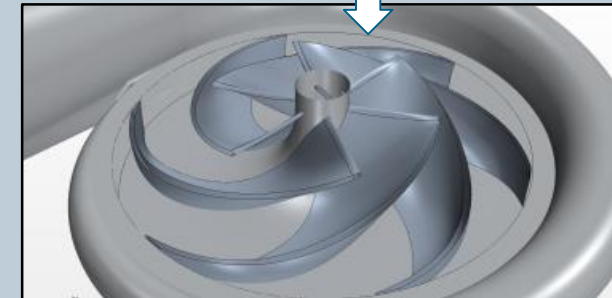


#### Baseline Design

Flow rate = 400 m<sup>3</sup>/h

Head = 30 m

Power required = 38.4 kW



#### Improved Design

Flow rate = 400 m<sup>3</sup>/h

Head = 30 m

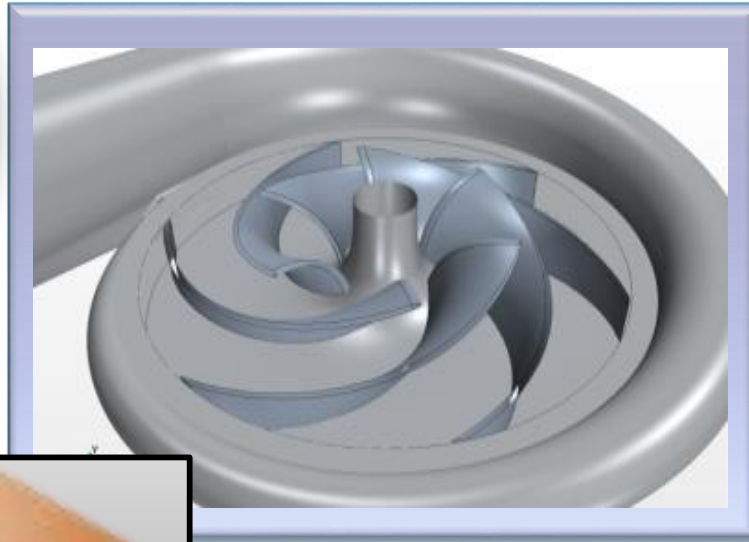
Power required = 36.0 kW

*“I can now obtain better pump designs faster by spending more time on engineering decision-making, and less time on model setup & data transfer.”*

– Ed Bennett, VP of Fluids Engineering

# To Design New or To Improve Your Pumps ... Blowers, Compressors, Turbines

SIEMENS



 **Mechanical Solutions, Inc.**  
Engineering Analysis, Test & Technology 