



# Transient Simulation and its Post Processing

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# Content

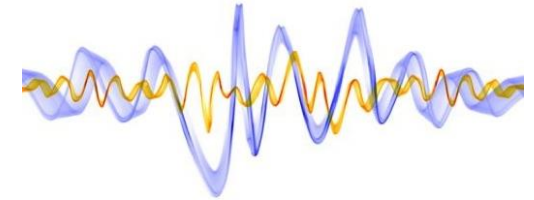
- 1 Why transient simulations can be important
- 2 What physics require transient simulations in FloEFD
- 3 What are the important settings for transient simulations
- 4 Various features explained
- 5 Get freaky with post processing



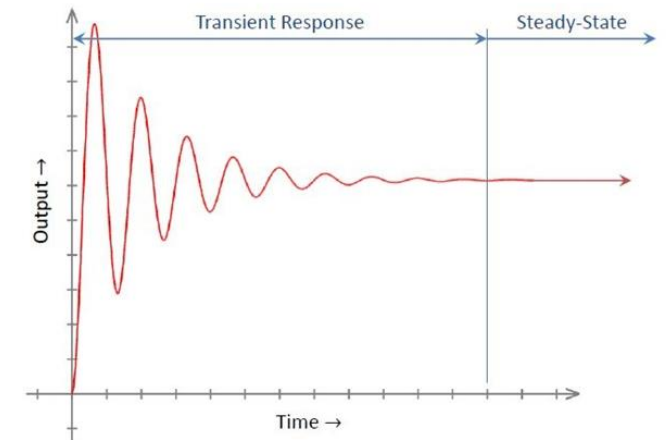
# Why transient simulations can be important

99% of nature is transient (and asymmetric)

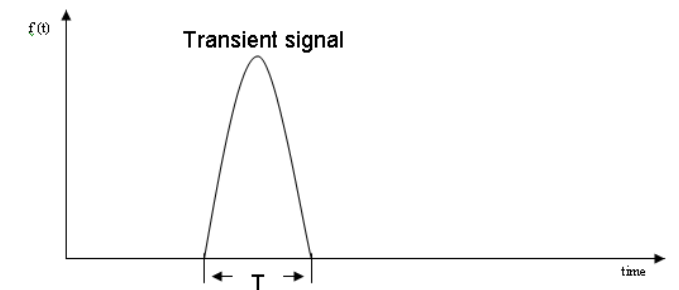
- Slow/marginal Changes
  - Temperature change over the day
  - Constant water stream
  - Idling computer processor
  - White noise
- Fast/big Changes
  - Moving Fan in the room
  - Filling of the tank
  - Fan cooling the processor
  - Noise frequency



Source: [Wildix Blog](#)



Source: [Electrical Engineering Community](#)

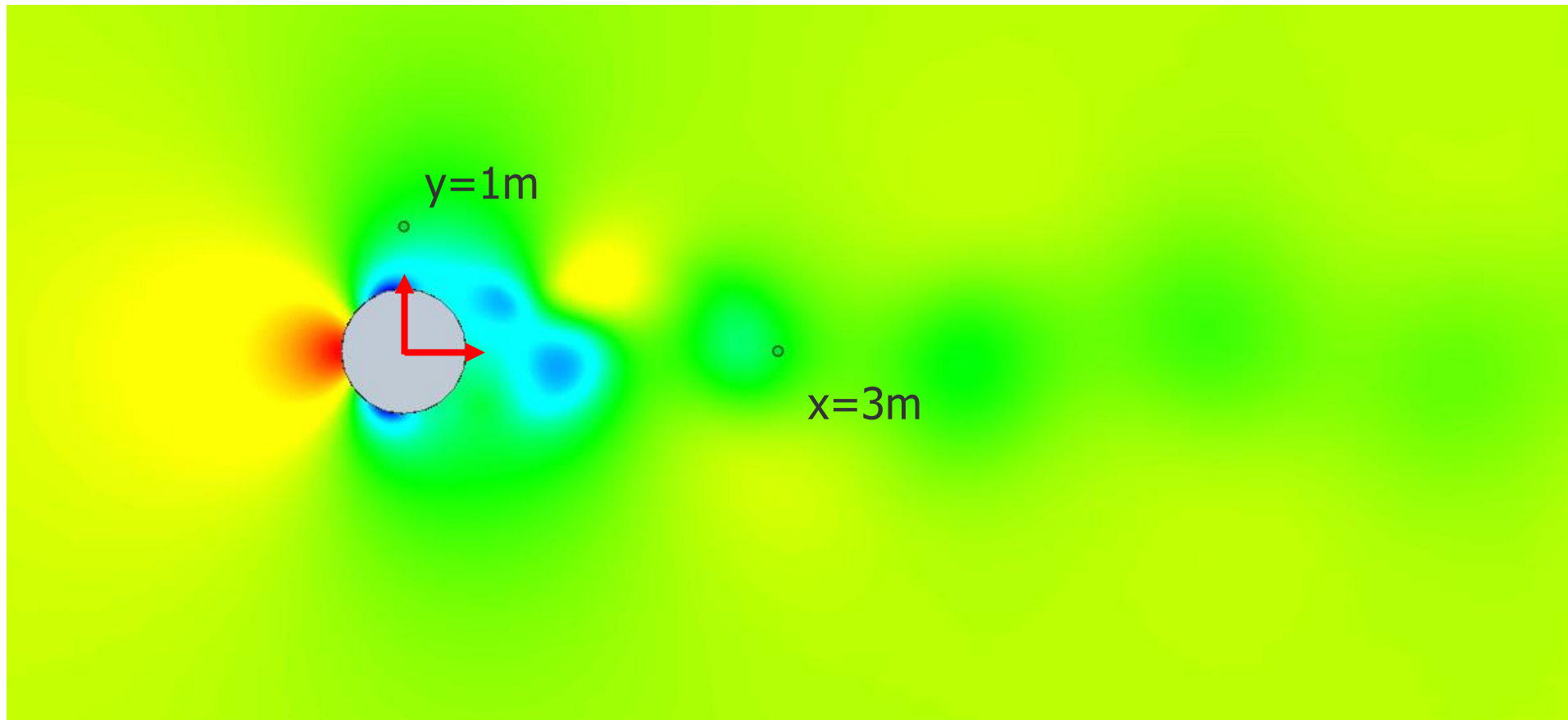


Source: [National Instruments](#)



# Why transient simulations can be important

## Karman Vortex Street



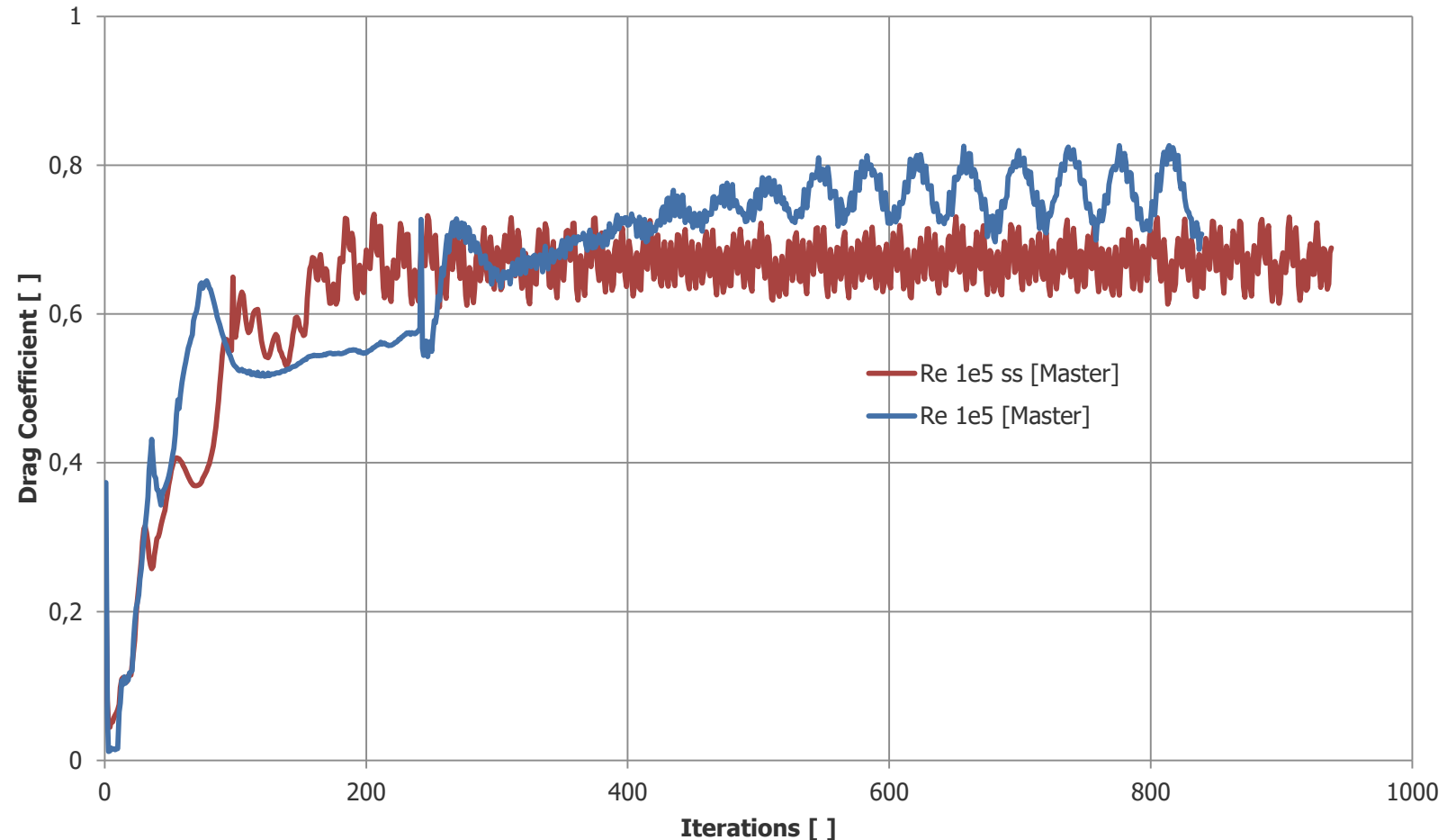


# Why transient simulations can be important

## Drag Coefficient

Average of the drag coefficient between iteration 700-800

- Transient CD=0.766
- Steady State CD=0.670







# Why transient simulations can be important

## PG Static Pressure x=3m

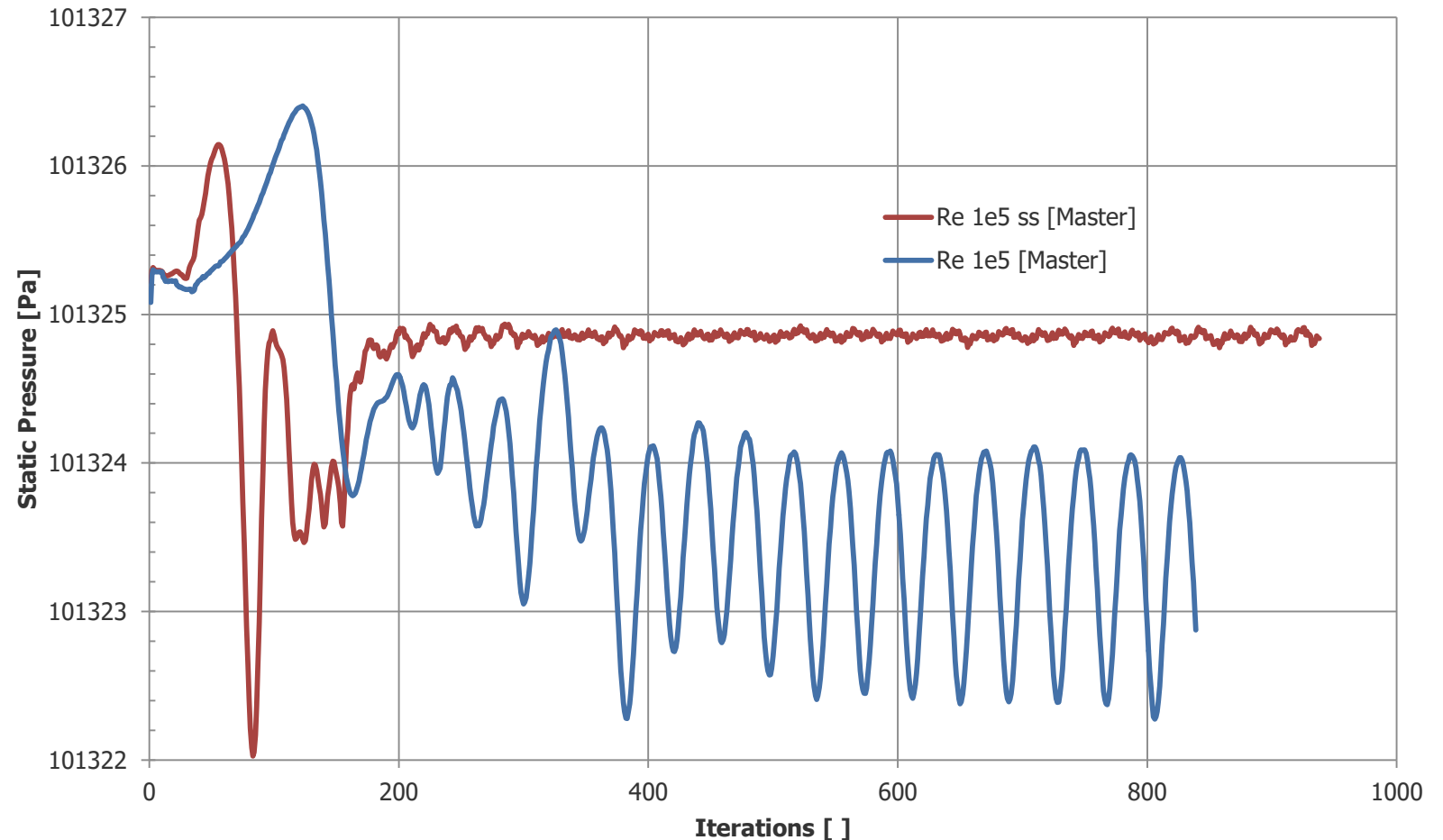
Static pressure between  
iteration 700-800 at x=3m

### Average:

- Transient  $P_S=101324.9$  Pa
- Steady State  $P_S=101323.5$  Pa

### Amplitude:

- Transient  $P_S=0.868$  Pa
- Steady State  $P_S=0.058$  Pa





# Why transient simulations can be important

**PG Static Pressure y=1m**

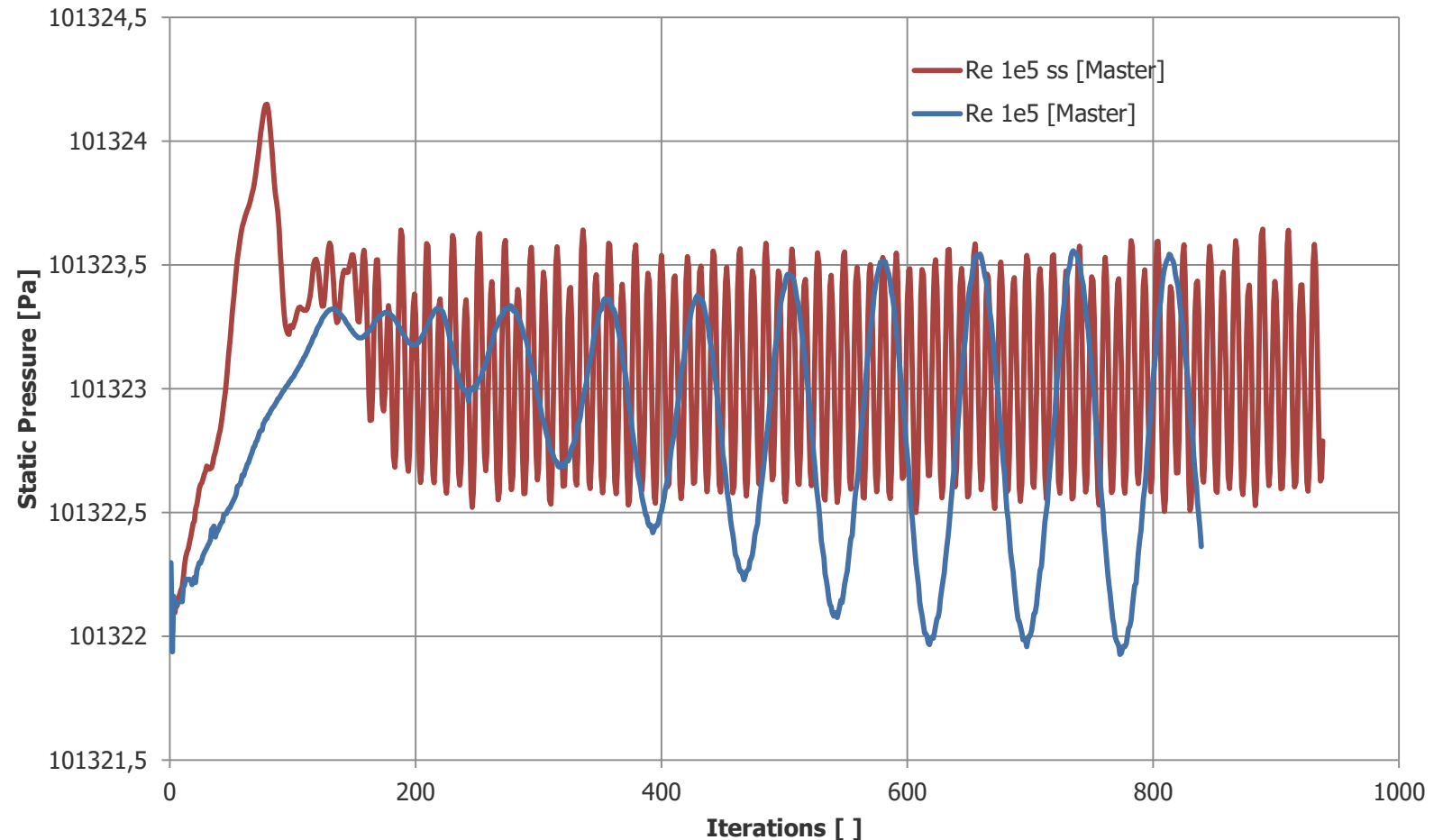
Static pressure between  
iteration 700-800 at y=1m

Average:

- Transient  $P_S=101322.7$  Pa
- Steady State  $P_S=101323.0$  Pa

Amplitude:

- Transient  $P_S=0.817$  Pa
- Steady State  $P_S=0.534$  Pa

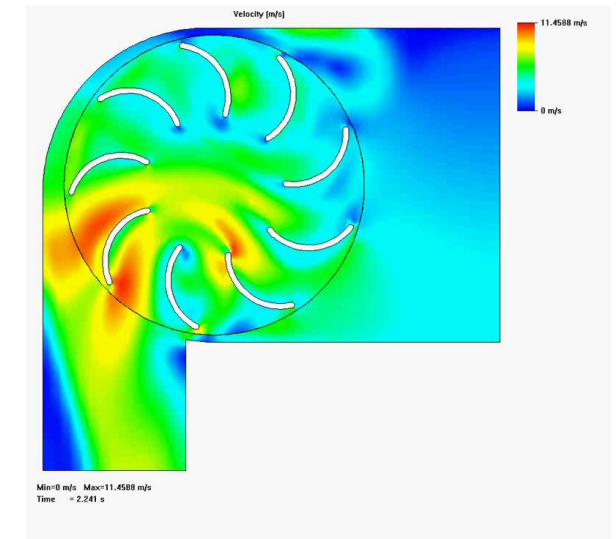
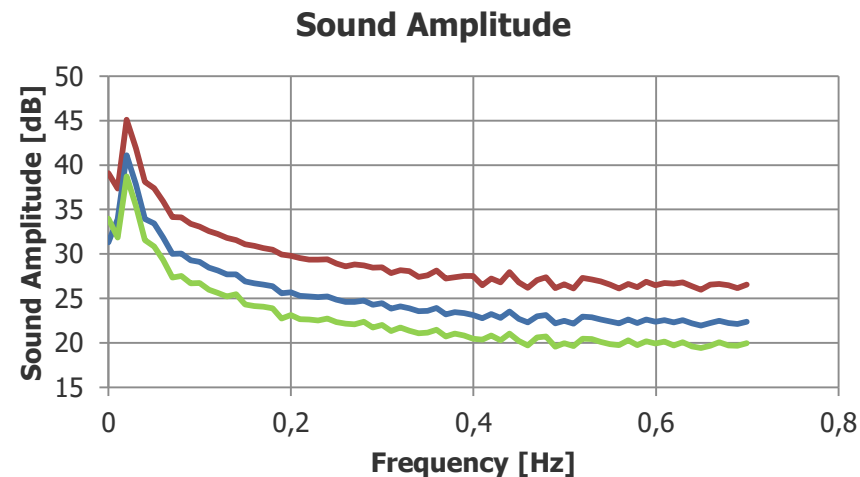
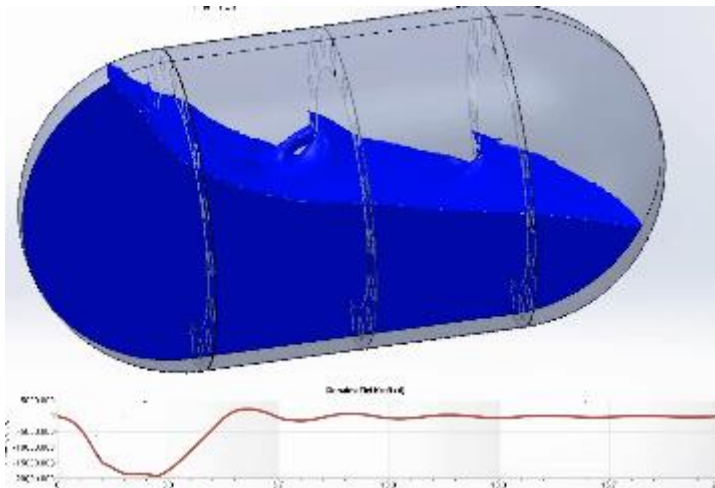
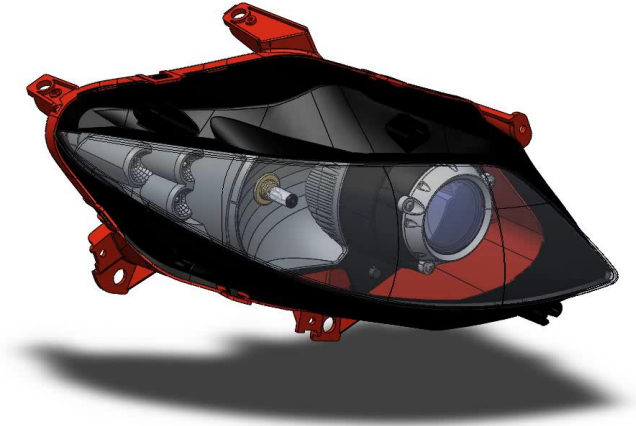






# What physics require transient simulations in FloEFD

- Condensation/Evaporation/Icing
- Water absorption in solids
- Sliding Mesh
- Fast Fourier Transformation (FFT) Noise Prediction
- Free Surface Flow

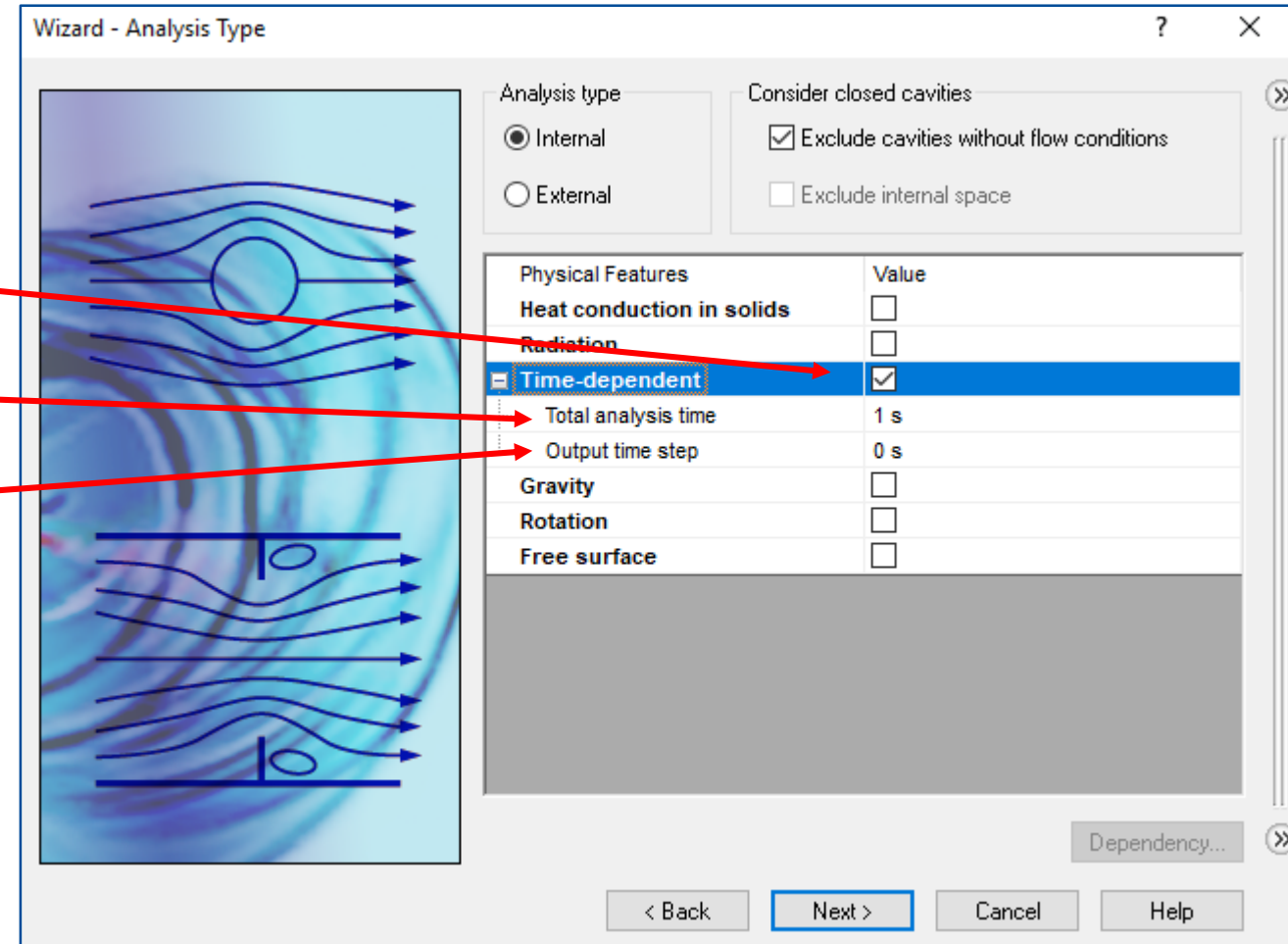




# What are the important settings for transient simulations

## Wizard & General Settings

- Activation of transient simulation
- Defining the total physical time
- Defining the result file interval





# What are the important settings for transient simulations

## Calculation Control Options

- Defining the total physical time
- Potentially deactivate other finishing criteria if a project is changed from steady state to transient and if not otherwise required
- Potentially activate **goal value criteria**

Parameter	Criteria	Value
<b>Finish Conditions</b>		
Criterion to stop	One satisfied	
<input type="checkbox"/> Goals convergence	For information only	
<input checked="" type="checkbox"/> Physical time	600 s	
<input type="checkbox"/> Iterations		
<input type="checkbox"/> Travels		
<input type="checkbox"/> Calculation time		
<input type="checkbox"/> Refinements		
<b>Goals Criteria</b>		
Analysis interval	[auto]	
<input checked="" type="checkbox"/> GG Force (X) 1	[auto]	
<input checked="" type="checkbox"/> PG Static Pressure x=3m	[auto]	
<input checked="" type="checkbox"/> PG Total Pressure x=3m	[auto]	
<input checked="" type="checkbox"/> PG Static Pressure x=4m	[auto]	
<input checked="" type="checkbox"/> PG Total Pressure x=4m	manual	
<input checked="" type="checkbox"/> PG Static Pressure x=5m	[auto]	
<input checked="" type="checkbox"/> PG Total Pressure x=5m	[auto]	
<input checked="" type="checkbox"/> PG Static Pressure x=6m	[auto]	
<input checked="" type="checkbox"/> PG Total Pressure x=6m	[auto]	
<input checked="" type="checkbox"/> PG Static Pressure x=7m	[auto]	
<input checked="" type="checkbox"/> PG Total Pressure x=7m	[auto]	



# What are the important settings for transient simulations

## Calculation Control Options

- Automatic/**manual definition of time step**
- Potentially activating the **Nested Iterations** and possibly also automatic/manual definition
- Select **time averaged results** for specific parameters and time interval
- Potentially activate a **freezing strategy** (radiation and flow calculation)

Parameter	Value
<b>Time Step Settings</b>	
Time step	manual 1 s
<input checked="" type="checkbox"/> Nested iterations	manual
Maximum number of nested iterations	25
Normalized mass residual	0.0015
Normalized momentum residual	0.0008
Normalized energy residual	0.0008
<b>Additional Parameters</b>	
<input checked="" type="checkbox"/> Time Averaged	
Parameters	...
Averaging interval	Full calculation
<input type="checkbox"/> Calculate Local Mean Age (LMA)	
<input type="checkbox"/> Calculate Comfort Parameters	
Results Processing Speed-up Data	Never
<b>Flow Freezing</b>	
Freezing strategy	Periodic
Start	0.25 Travels
Freezing period	20 Iterations
No freezing period	10 Iterations
Time step (Freezing)	manual 1 s



# What are the important settings for transient simulations

## Calculation Control Options

- Defining the result file interval
- Potentially activate the **Transient Explorer**, select the parameters to be saved and the interval

Calculation Control Options

Finishing Refinement Solving **Saving**

Parameter	Value
<b>Backup Files</b>	
<input checked="" type="checkbox"/> Save before refinement	
<input checked="" type="checkbox"/> Save backup every	100 Iterations
<b>Full Results</b>	
<input checked="" type="checkbox"/> Periodic	Physical time [s]
Start	0 s
Period	1 s
<input type="checkbox"/> Tabular	Iterations
<b>Selected Parameters (Transient Explorer)</b>	
<input checked="" type="checkbox"/> Periodic	Iterations
Start	0
Period	1
Parameters	...

OK Cancel Help

Reset...

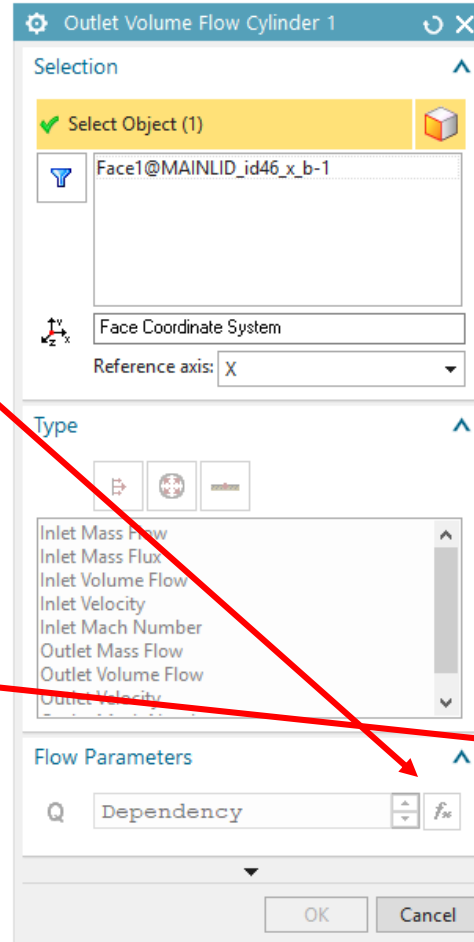




# What are the important settings for transient simulations

## Transient boundary conditions

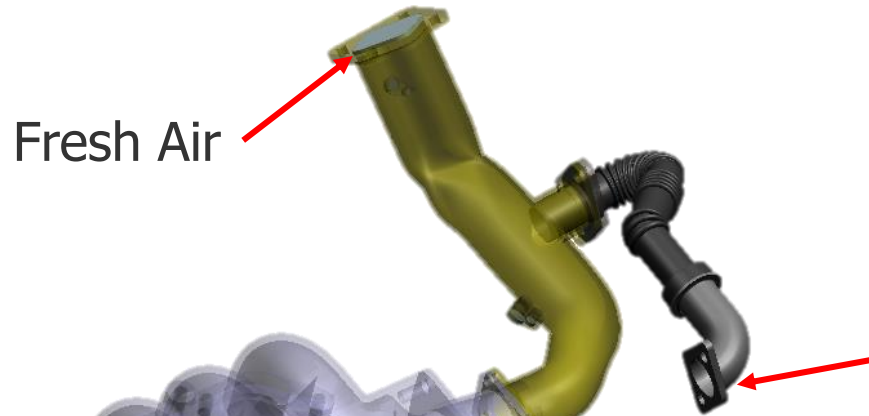
- Using the “Dependency”
- Defining  $F(\text{time})$ ,  $F(\text{txyz})$  or Formula Definition (with  $t$  as the variable)
- Use “Periodic” for repeating conditions







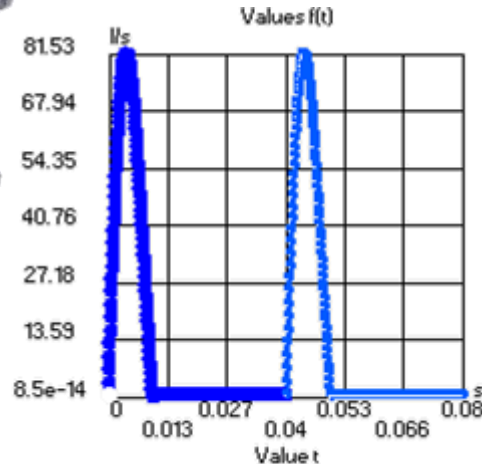
# What are the important settings for transient simulations



$T = 0.48 \text{ s}$   
 $t = 0.0001 \text{ s}$   
 $\Rightarrow 4800 \text{ Iterations}$

Cycle = 0.04 s (400 Iterations)  
Full Results 100 Files  $\Rightarrow$  11.5 GB  
(every 4<sup>th</sup> iteration)  
Transient Explorer  $\Rightarrow$  2.22 GB  
(every iteration, 8 parameters)

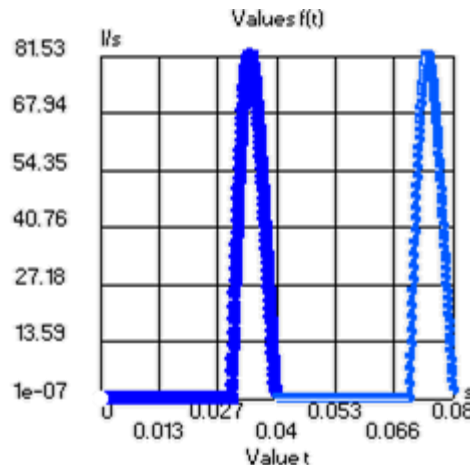
Cylinder 1



Order:

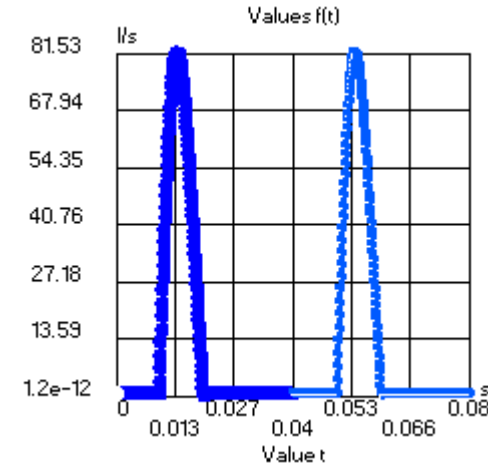
1

Cylinder 2



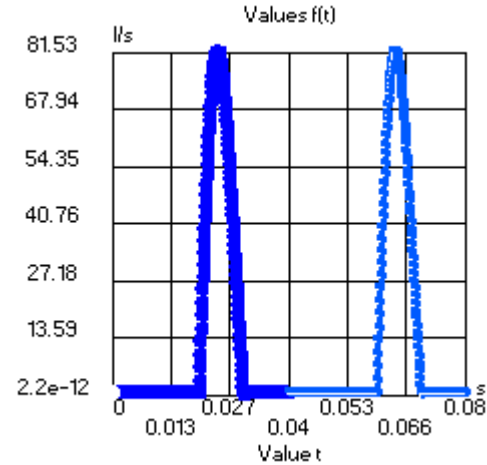
4

Cylinder 3



2

Cylinder 4



3



# What are the important settings for transient simulations

Transient  
boundary  
conditions

- Heat source, Radiation source, LED & Fan “Toggle” condition
- Transient values

**Volume Source**

Selection

Select Body (0)

Global Coordinate System  
Reference axis: X

Toggle

Always ON

Parameter

Q 0 W

Options

☐ Create associated goals

OK Cancel

**Dependency**

Dependency type:  
F(time) - table

Table of values:

Value t	Toggle
0 s	Off
1 s	On
5 s	Off
10 s	On

Periodic

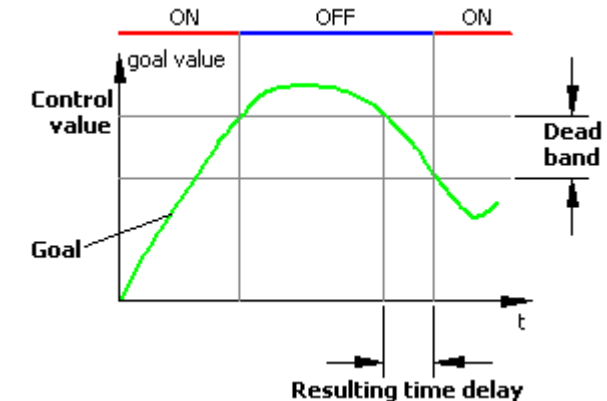
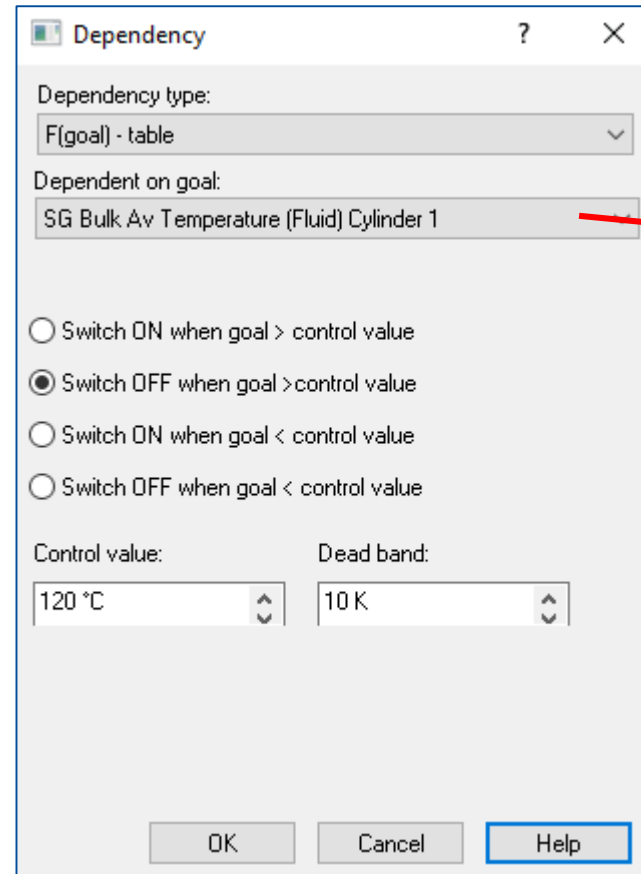
OK Cancel Help



# What are the important settings for transient simulations

## Other “Toggle” options

- Time or goal controlled devices
  - Heaters
  - Irons
  - Ovens
  - CPU Fans
  - A/C fans





# Manual Definition of Time Step

Important to note:

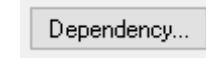
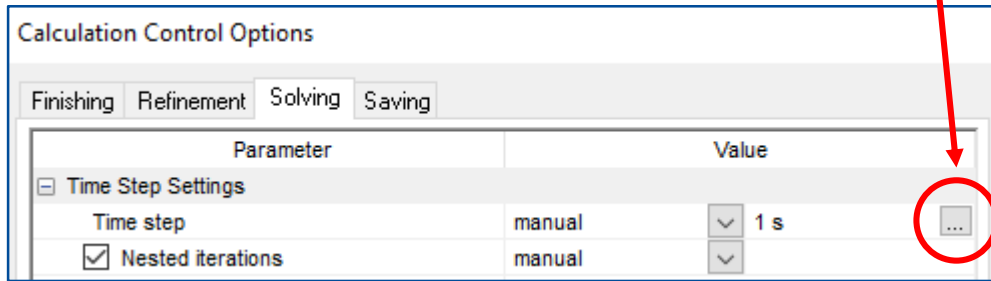
- Automatic time step can be micro seconds
- **Classic solver** uses 1 iteration per 1 time step
  - For short physical times suggested (10s for instance)
- **Nester solver** uses x iterations per 1 time step
  - For long physical times suggested (10.000s for instance)
- Physics needs to be resolved in time (not only space => mesh)
  - Sudden jumps in a boundary condition need to be resolved for accurate resolution of it effect.



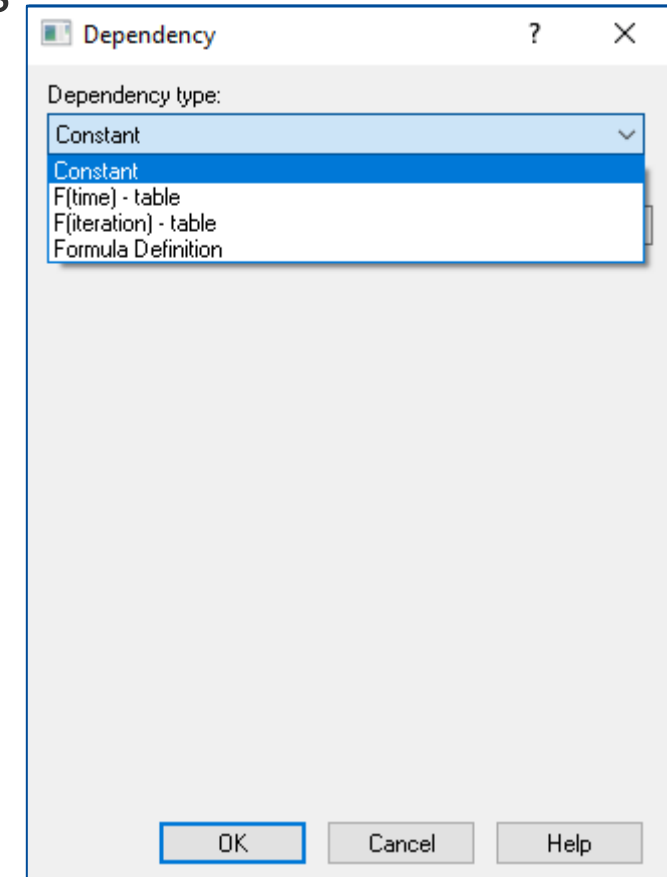
# Manual Definition of Time Step

Calculation Control Options &  
Engineering Database

Wizard &  
General Settings



Boundary Conditions





# Manual Definition of Time Step

Dependency

Dependency type:

F(time) - table

Table of values:

Start	Value	Type	Definition
0 s	0.001 s	Linear Joint	
0.01 s	0.005 s	Linear Joint	
0.1 s	0.008 s	Linear Joint	
1 s	0.01 s	Linear Joint	
2 s	0.05 s	Linear Joint	
3 s	0.1 s	Linear Joint	
10 s	0.1 s	Linear Joint	

☐ Periodic

OK

Cancel

Help

☐ True scale





# Manual Definition of Time Step

Dependency

Dependency type:

F(time) - table

Table of values:

Start	Value	Type	Definition
0 s	0.001 s	Linear Joint	
0.01 s	0.005 s	Linear Joint	
0.1 s	0.008 s	Linear Joint	
1 s	0.01 s	Linear Joint	
2 s	0.05 s	Linear Joint	
3 s	0.1 s	Linear Joint	
10 s	0.1 s	Linear Joint	

☐ Periodic

OK

Cancel

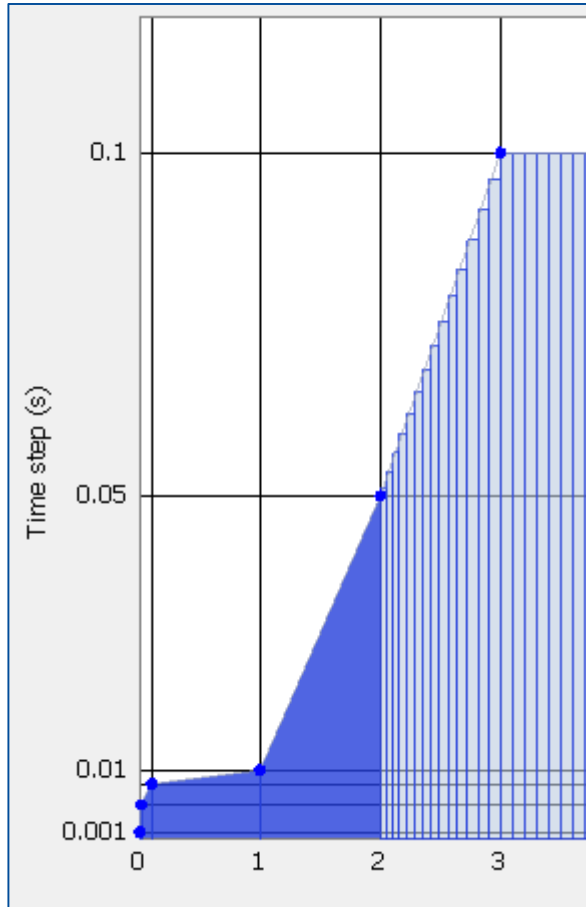
Help

☒ True scale

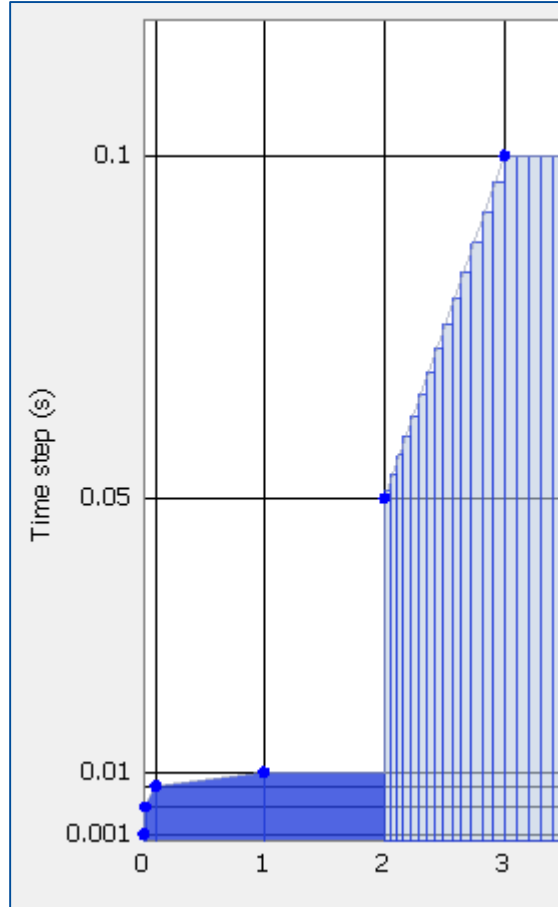


# Manual Definition of Time Step

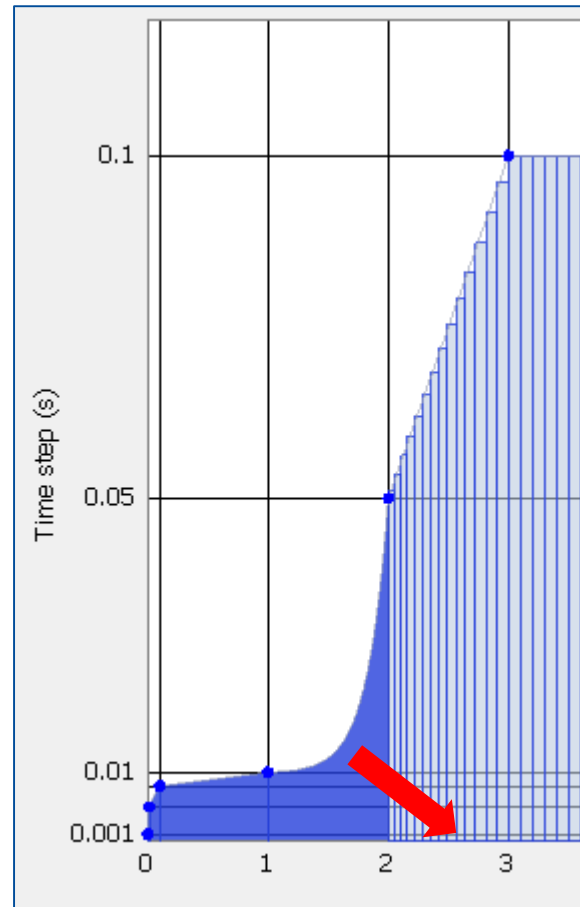
Linear Joint



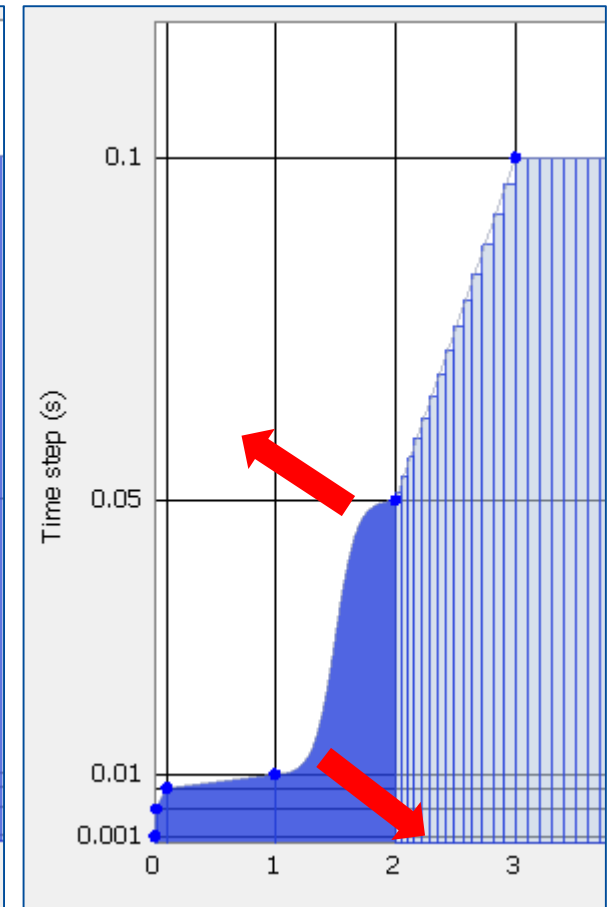
Constant Joint



Exponential Joint



Logistic Joint





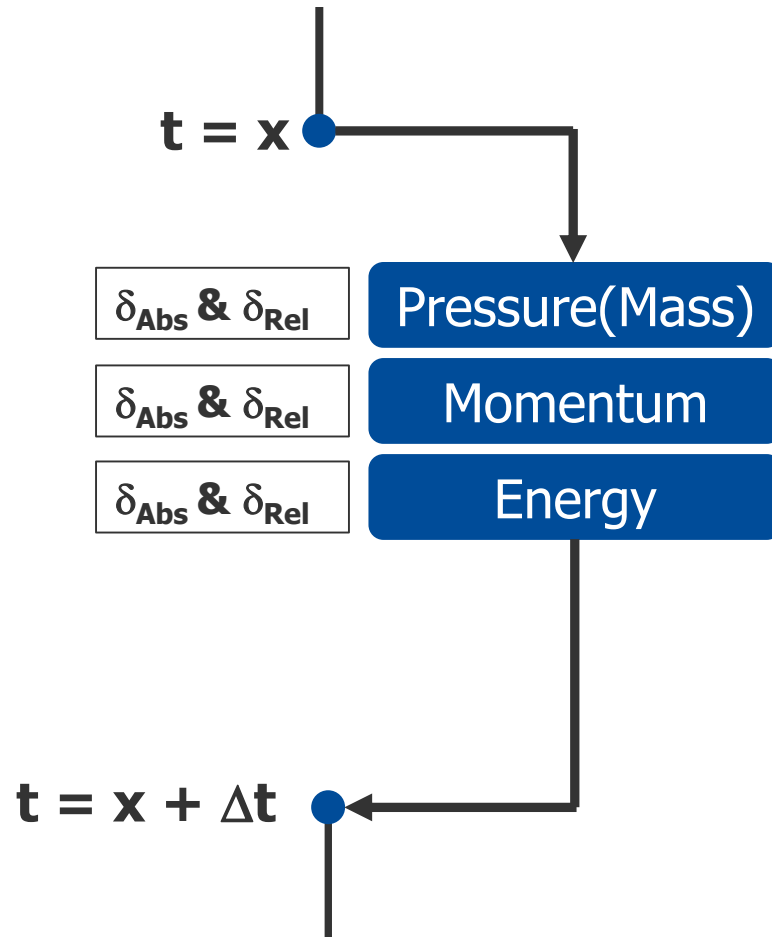
## Nested Iteration Solver

- Physical time of simulation is long (10.000 s for instance)
- Calculation with small time step can be very long
- Big time step should be used in this case to decrease the calculation time
- Transient solver with nested iterations allows increasing time step significantly (up to 100 s or even more) without deterioration in accuracy.
- The optimum time step is from 10 to 50 s depending on physical processes and the total physical time

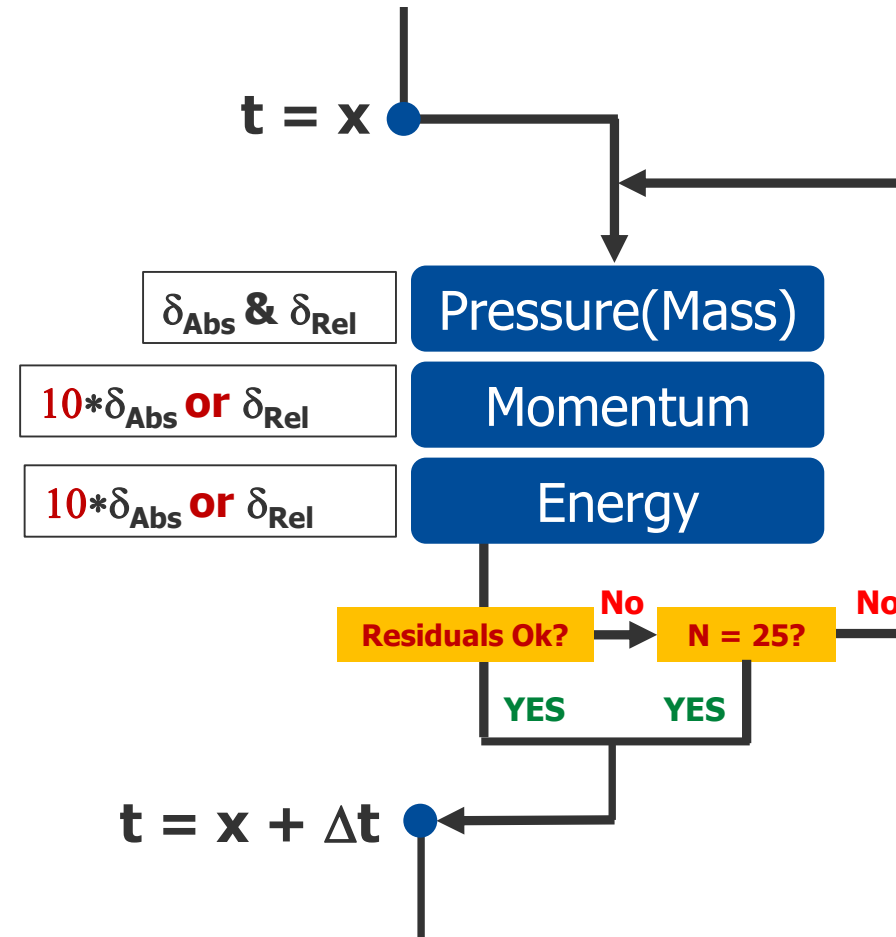


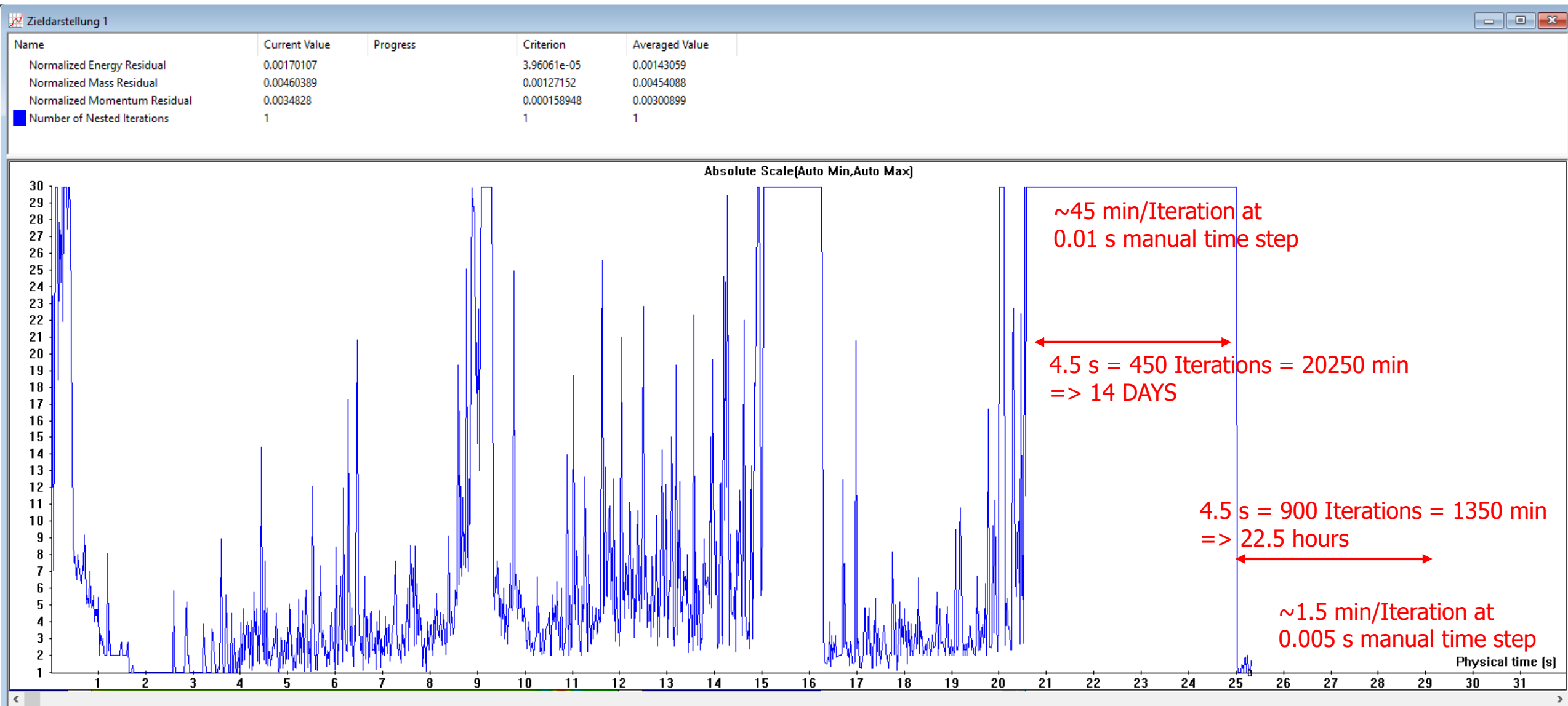
# Nested Iteration Solver

## Classical (Old)



## Nested



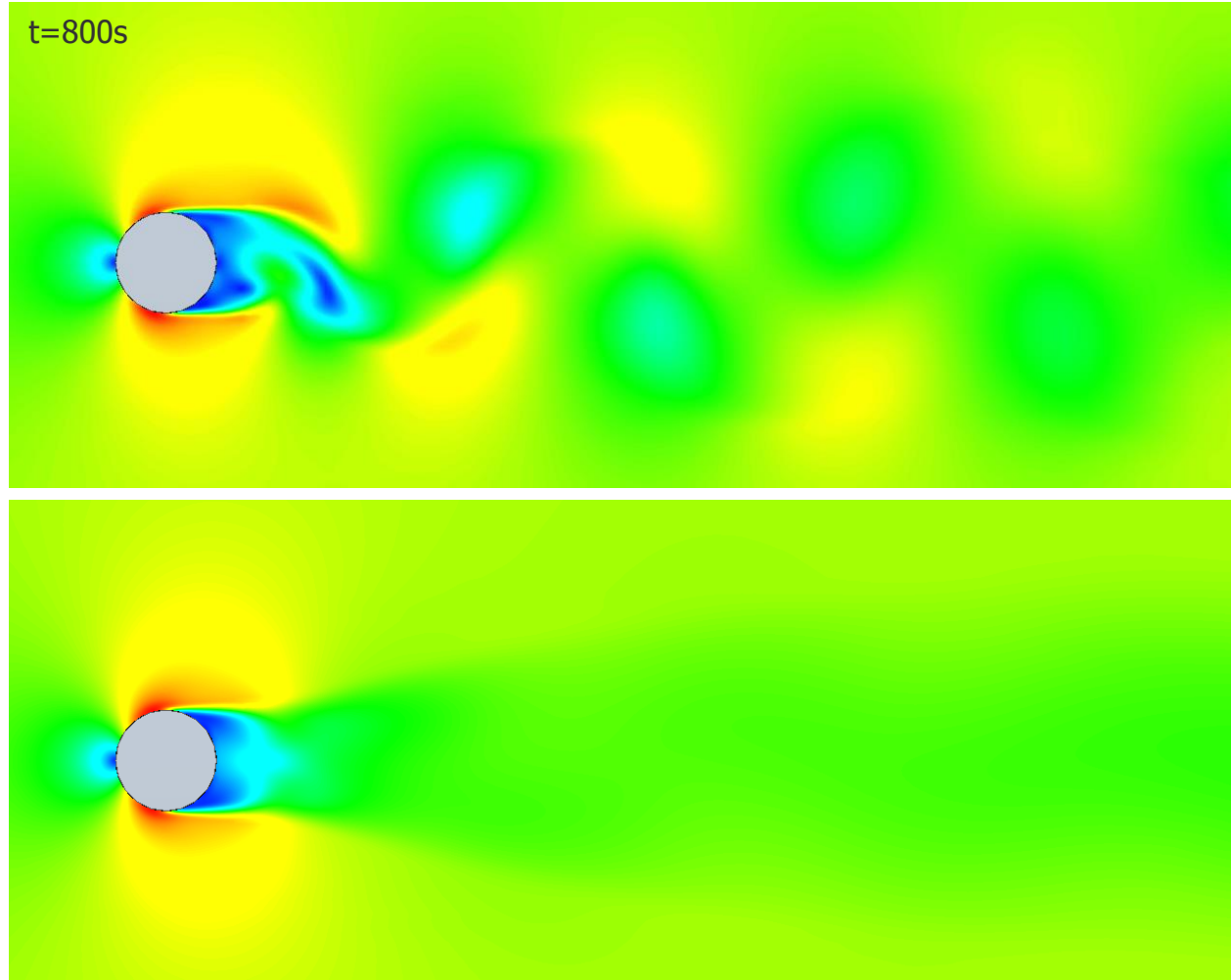




# Time Averaging Plots

## Time averaged plots

- Specify averaging interval in the Calculation Control Options (CCO)
- Selecting the averaged parameter in the plot settings/color bar



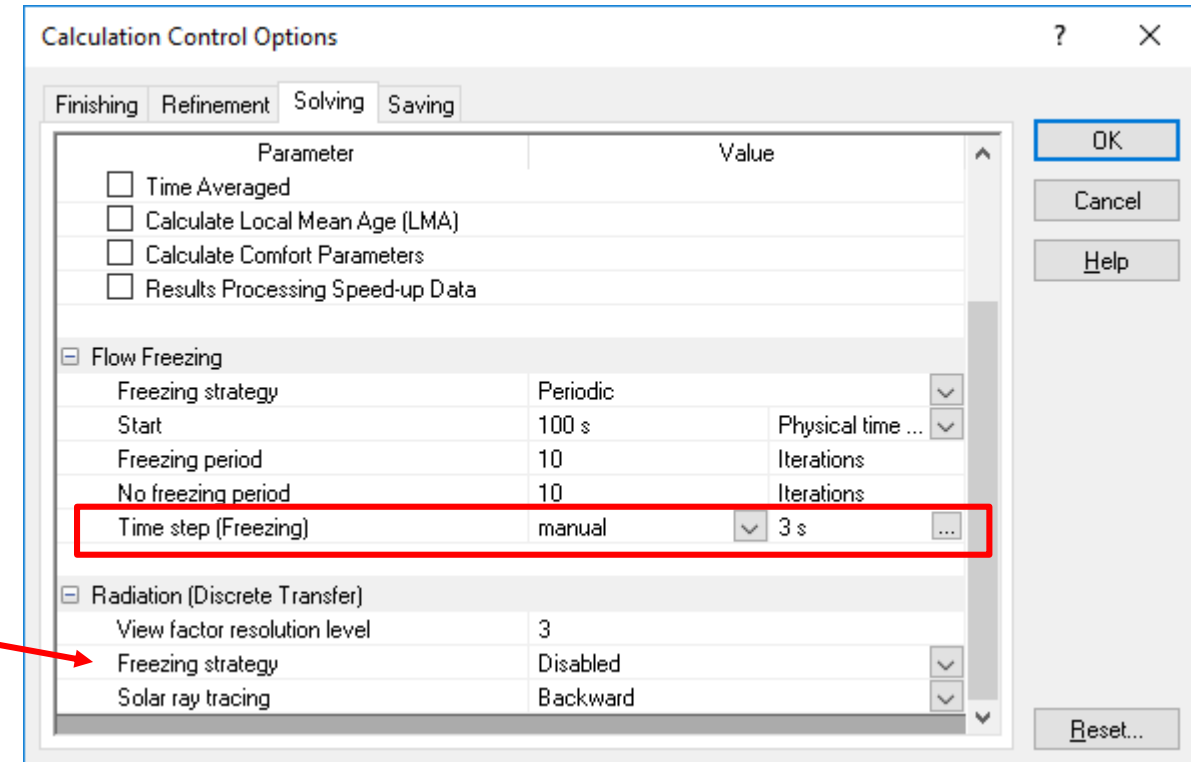




# Flow Freezing Strategy

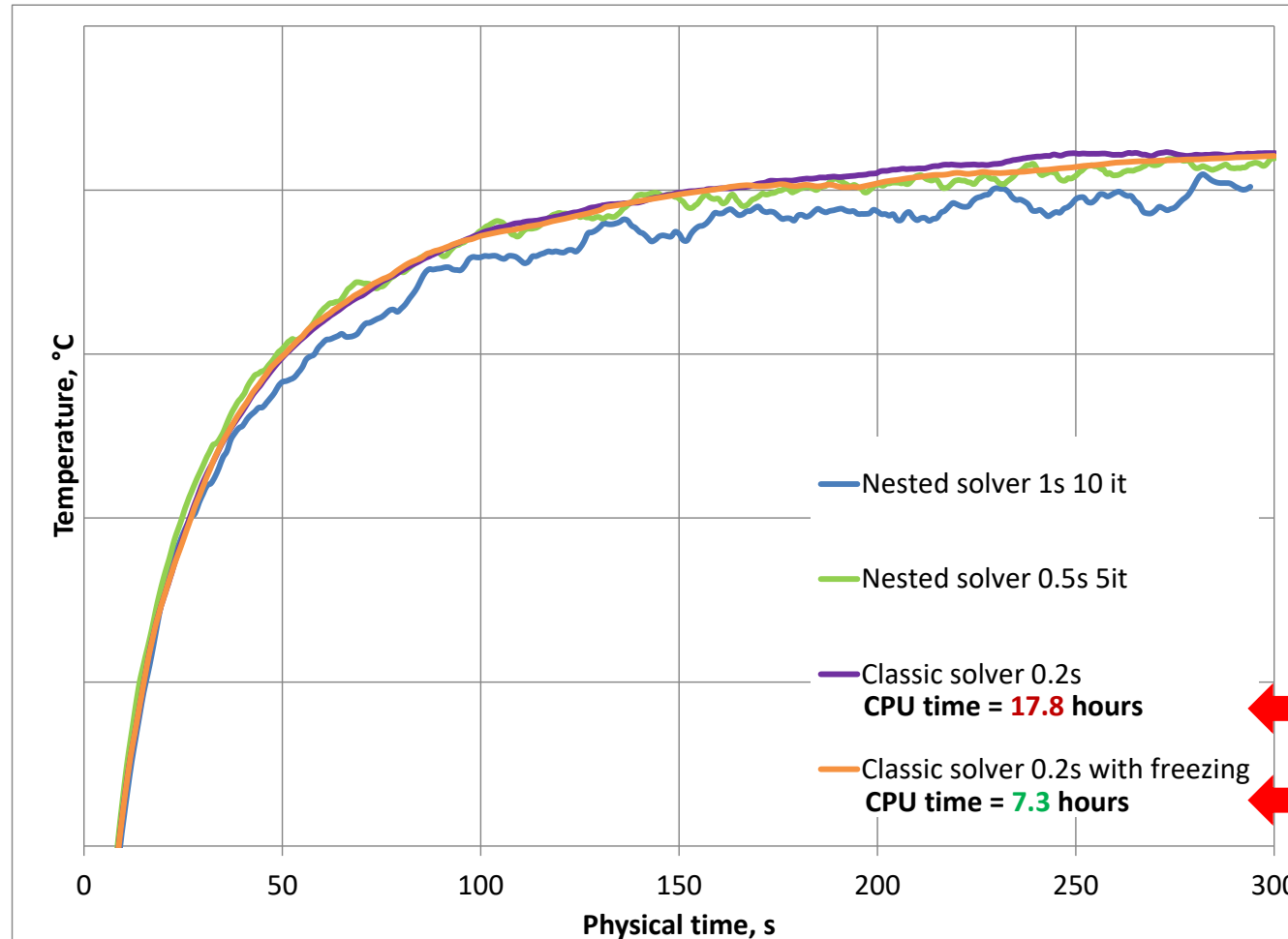
How and why flow freezing:

- Heat conduction inside solids without flow consideration
- Heat transfer in the solid and into the fluid, but fluid flow properties are frozen
- Freezing ray calculation for radiation to every x iterations
- Solver speedup due to lower CPU use by the solver on flow or radiation calculation





# Flow Freezing Strategy

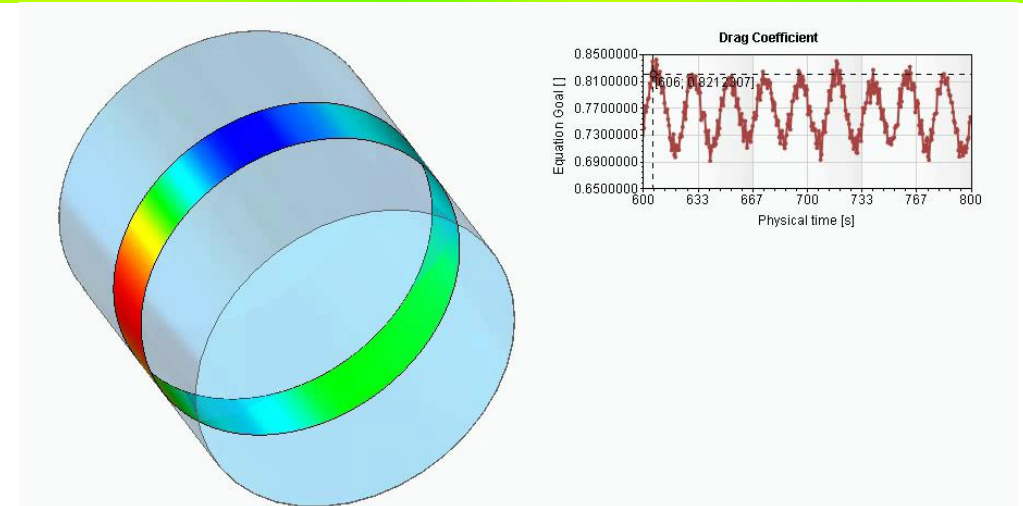
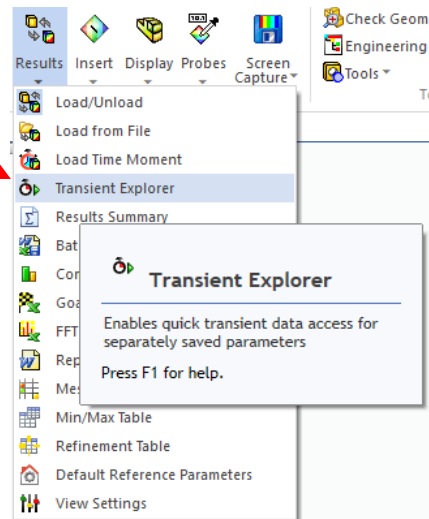
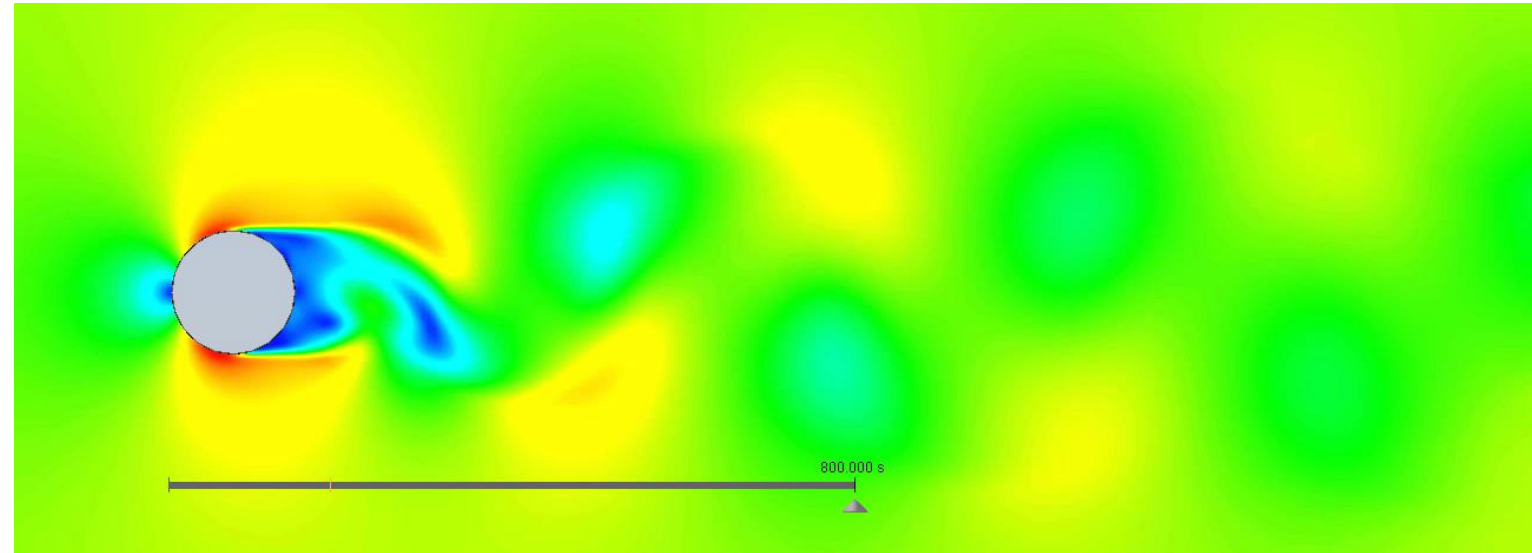


x2.4 speedup

# Transient Explorer

## Transient Explorer

- Specify the Transient Explorer settings in the CCO
- Right-click on the result tree or from the menu and load Transient Explorer
- Manipulate and right-click the timeline options
- Possible for Surface, Cut, XY and Goal plot

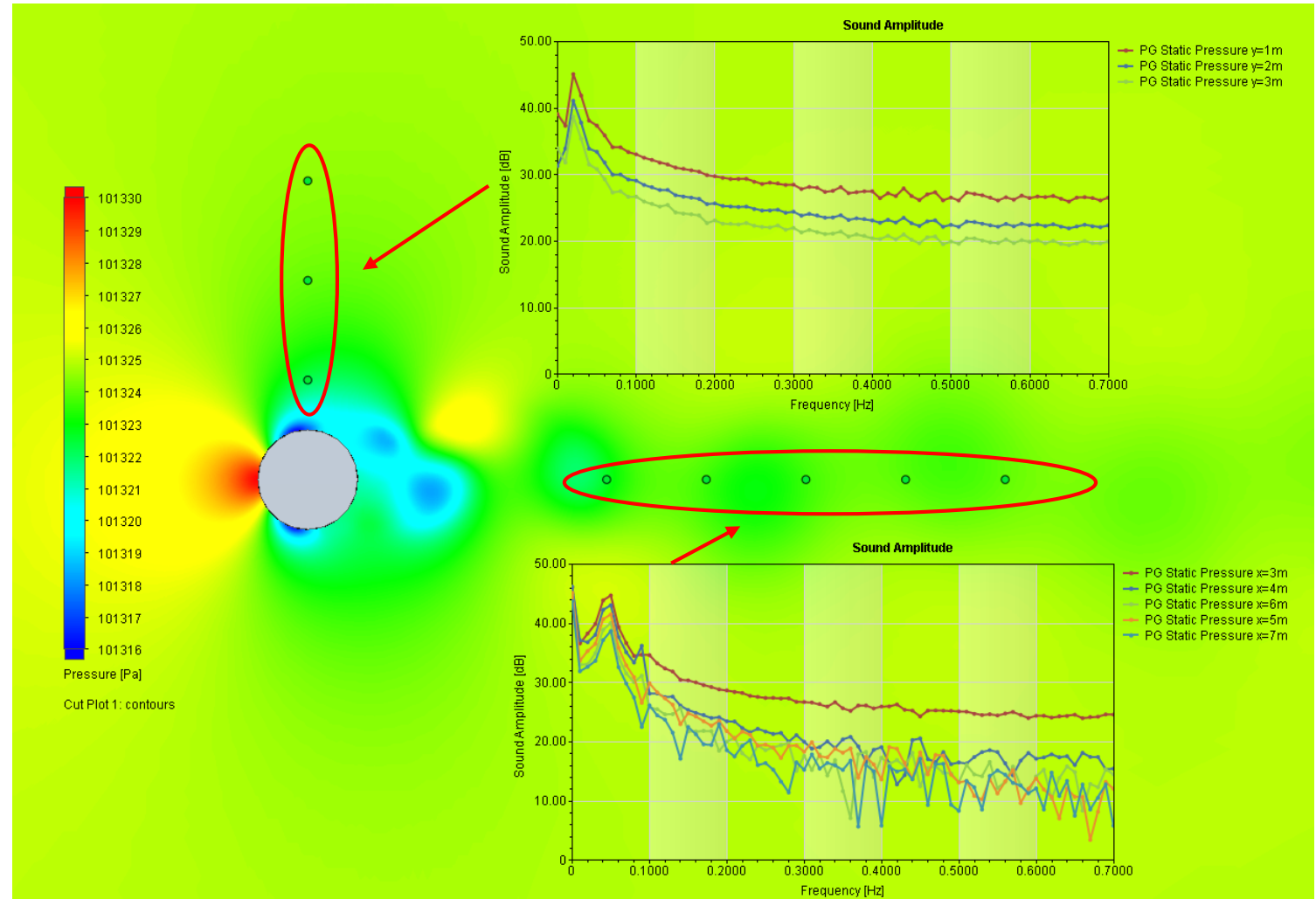




# Get freaky with post processing

## Fast Fourier Transformation

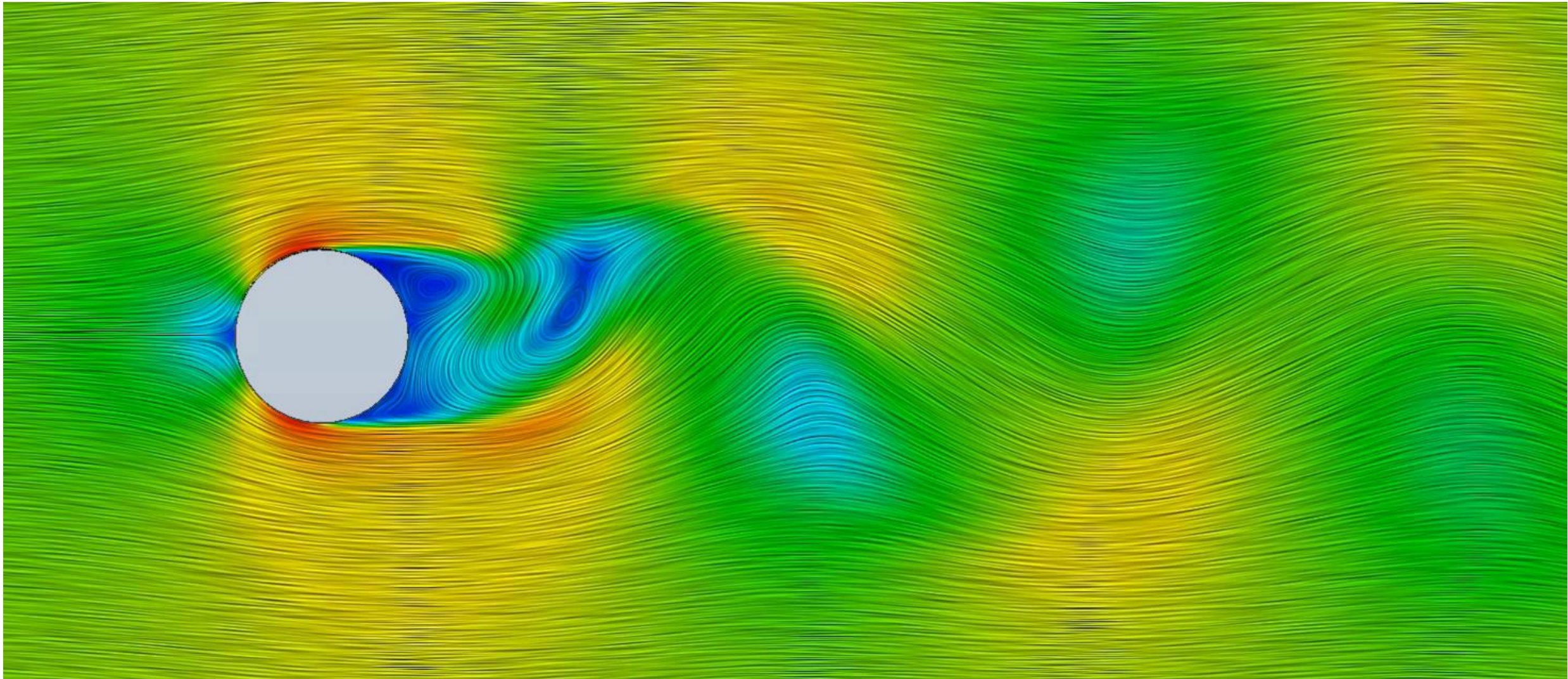
- Transient Static Pressure
- Point Goals
- Human Hearing range  
20 - 20,000 Hz  
(peak here: 0.02 Hz)







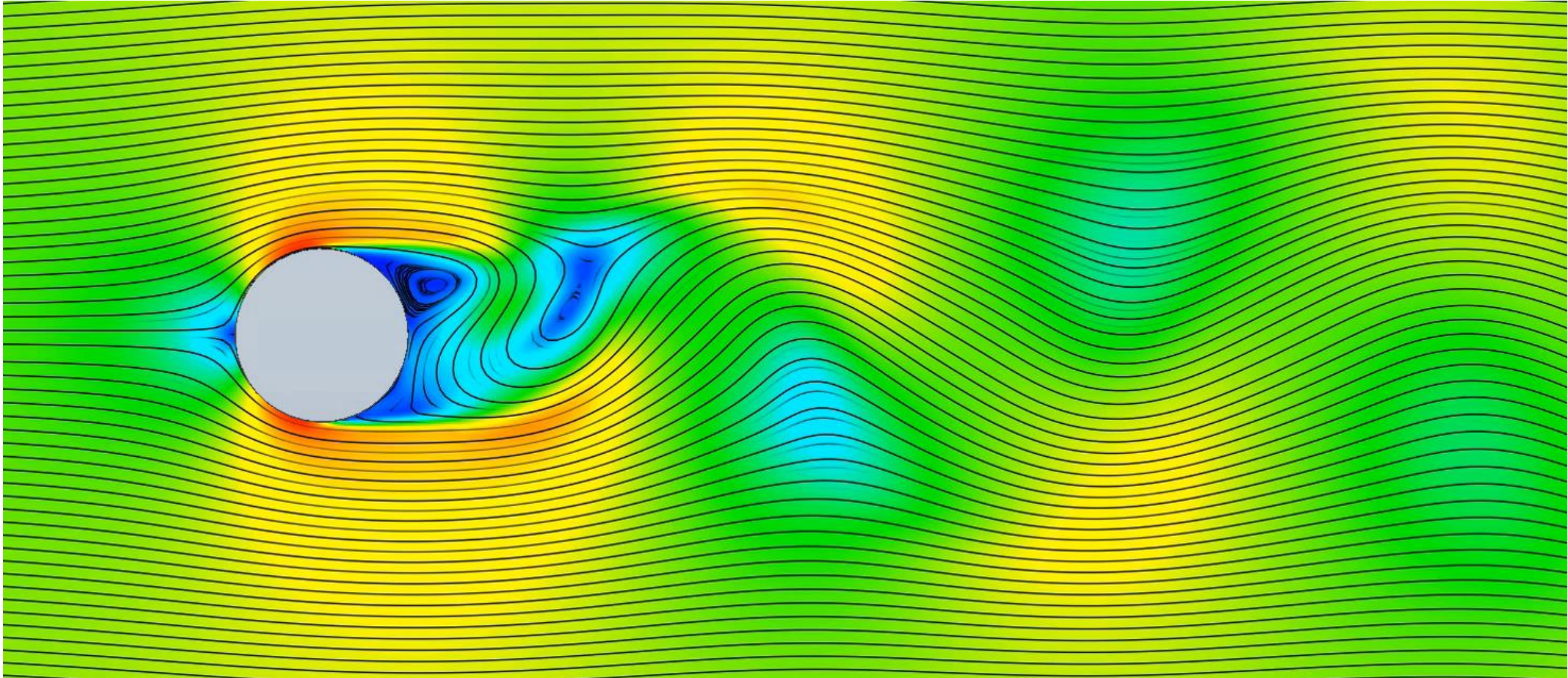
## Get freaky with post processing







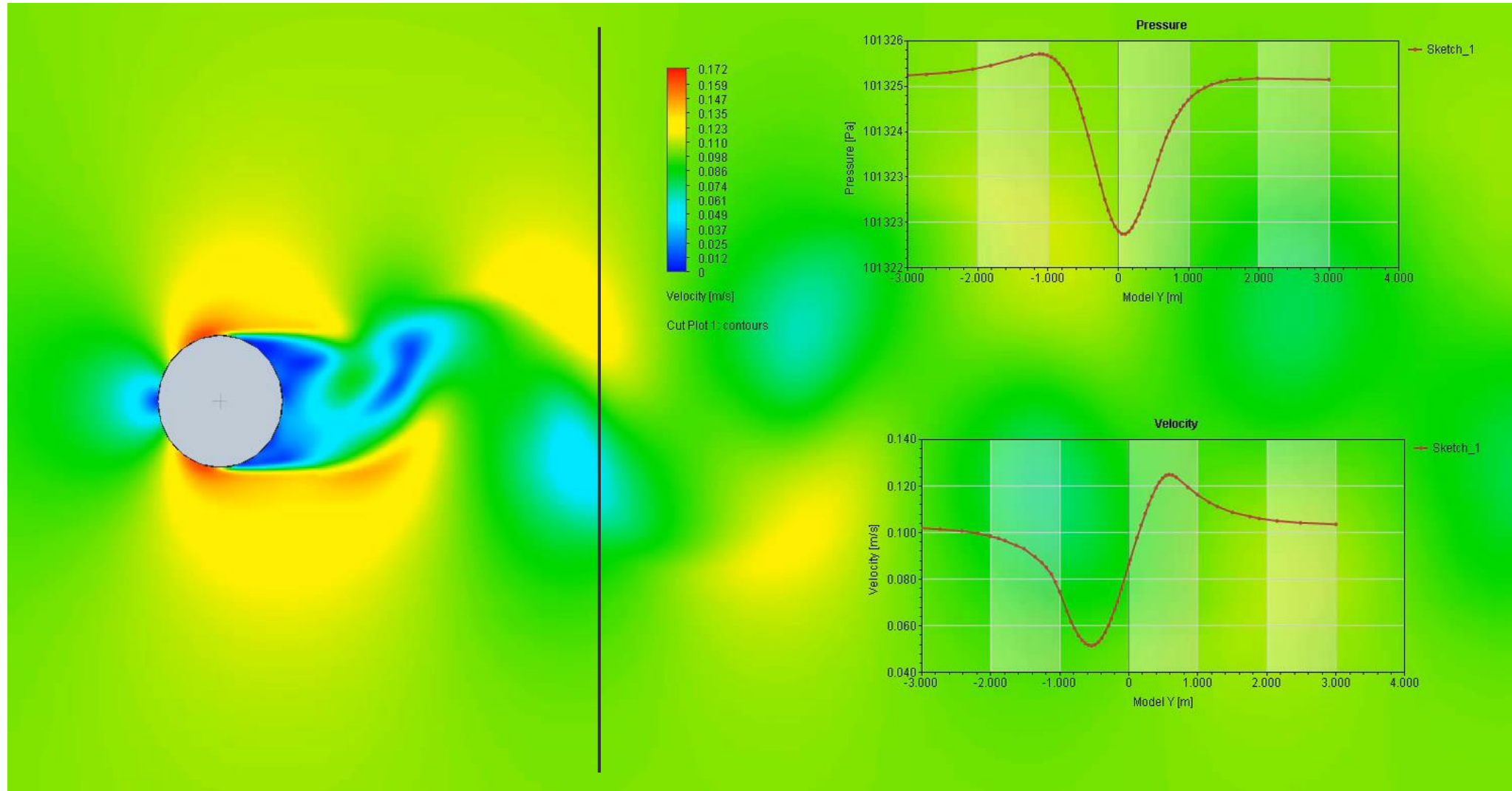
## Get freaky with post processing





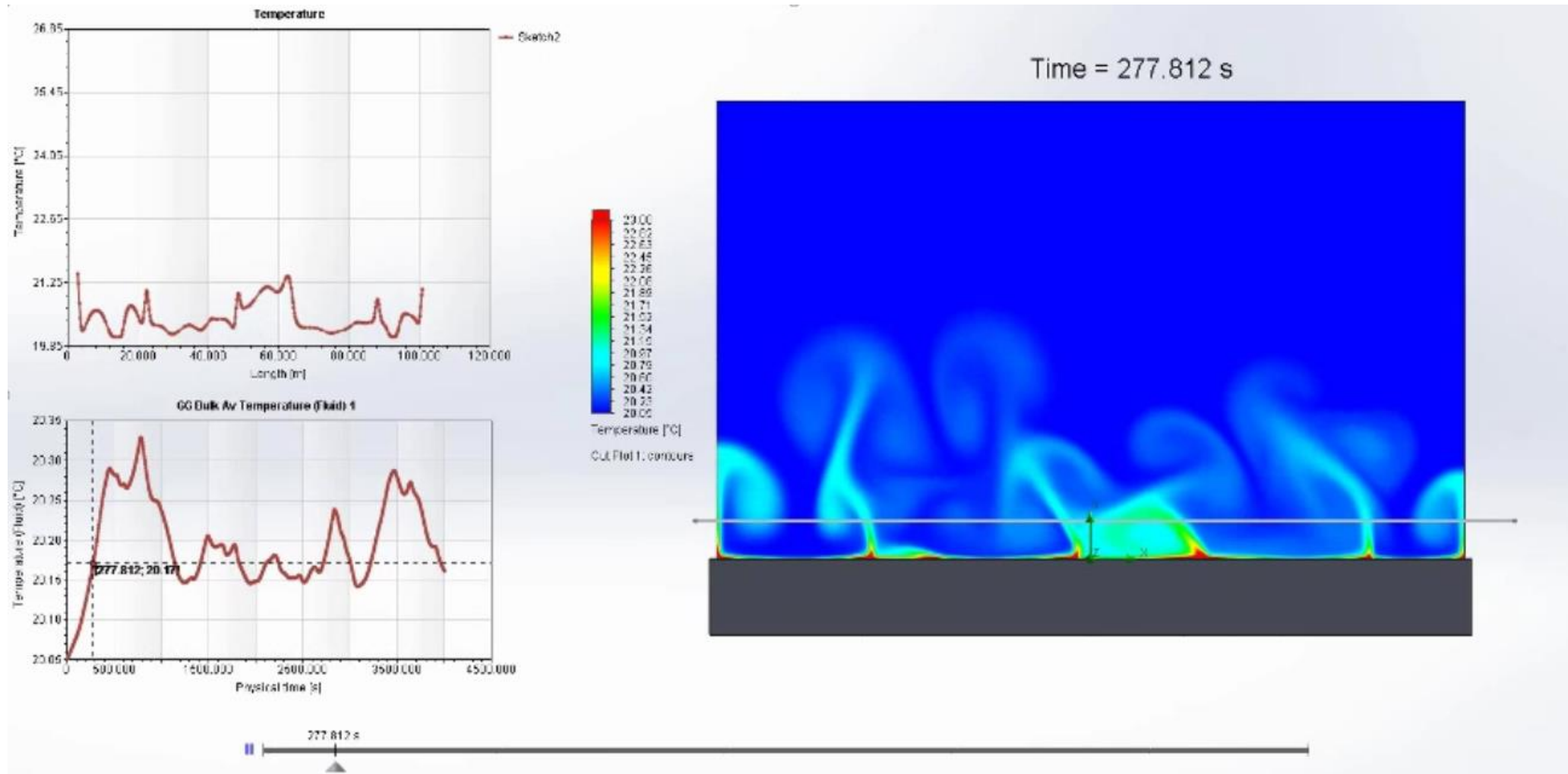


# Get freaky with post processing



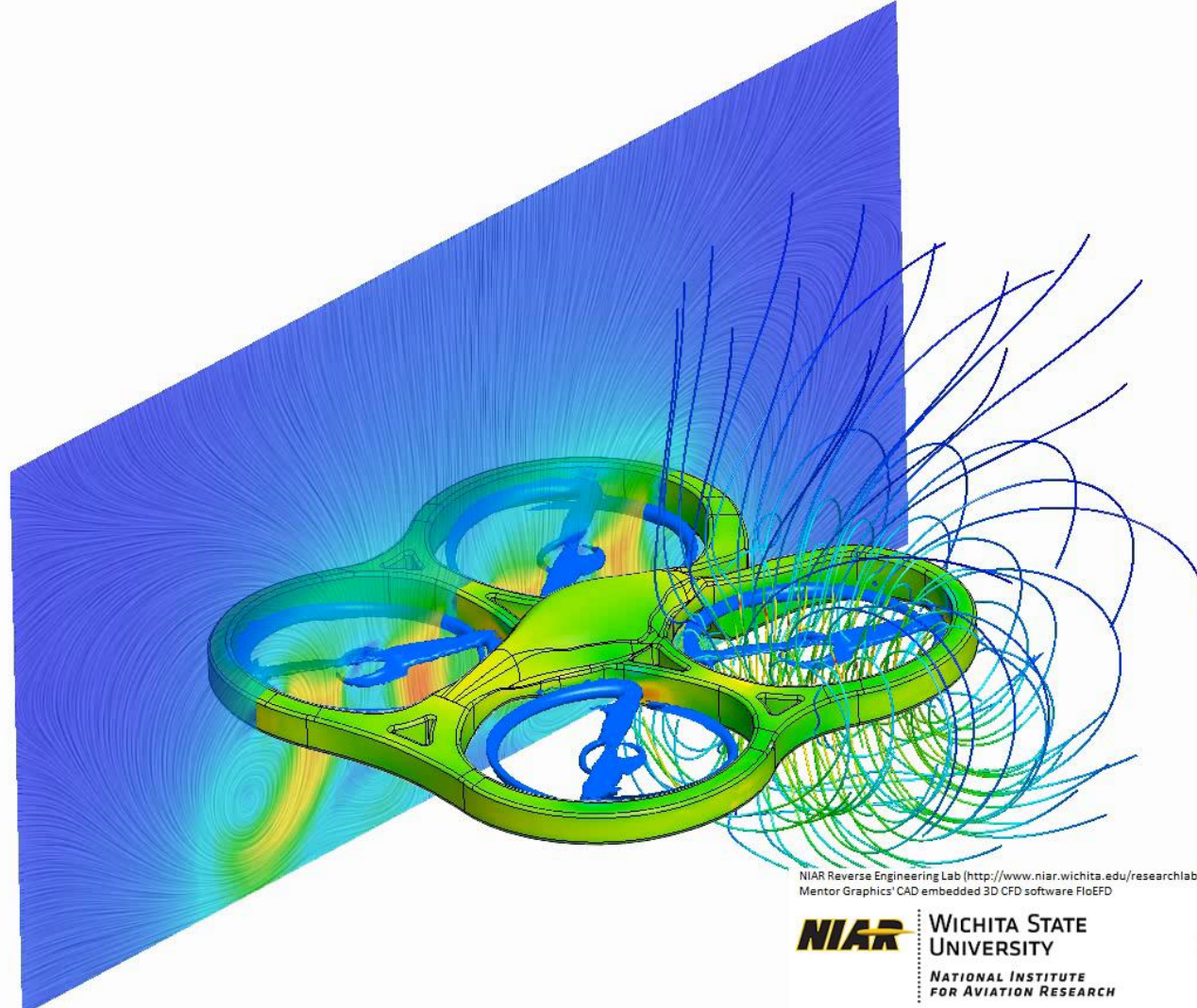


# Get freaky with post processing





# Get freaky with post processing



NIAR Reverse Engineering Lab ([http://www.niar.wichita.edu/researchlabs/re\\_overview.asp](http://www.niar.wichita.edu/researchlabs/re_overview.asp)) and  
Mentor Graphics' CAD embedded 3D CFD software FloEFD

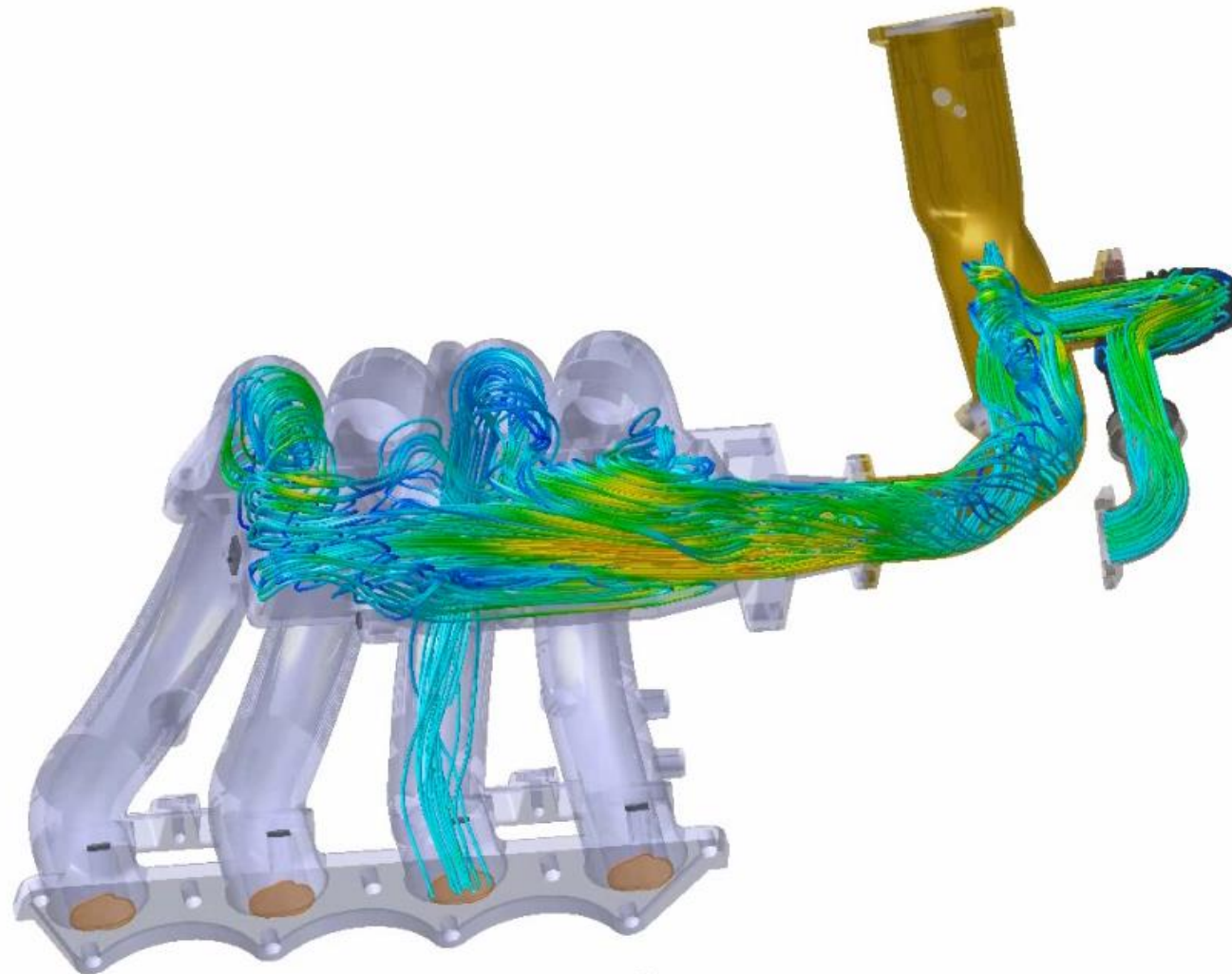
**NIAR** WICHITA STATE  
UNIVERSITY  
NATIONAL INSTITUTE  
FOR AVIATION RESEARCH

**Mentor  
Graphics**  
— Mechanical Analysis



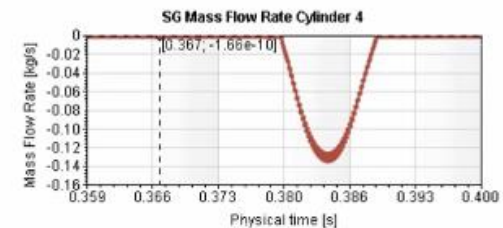
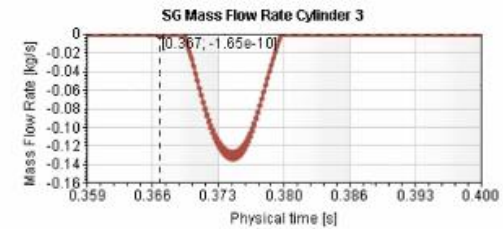
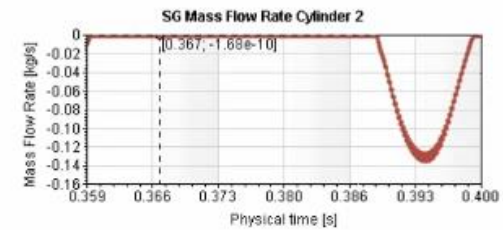
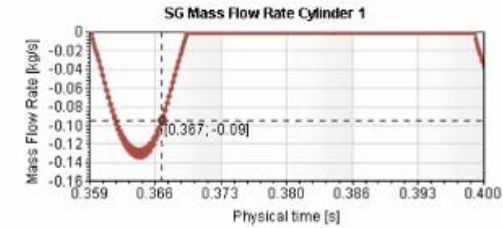
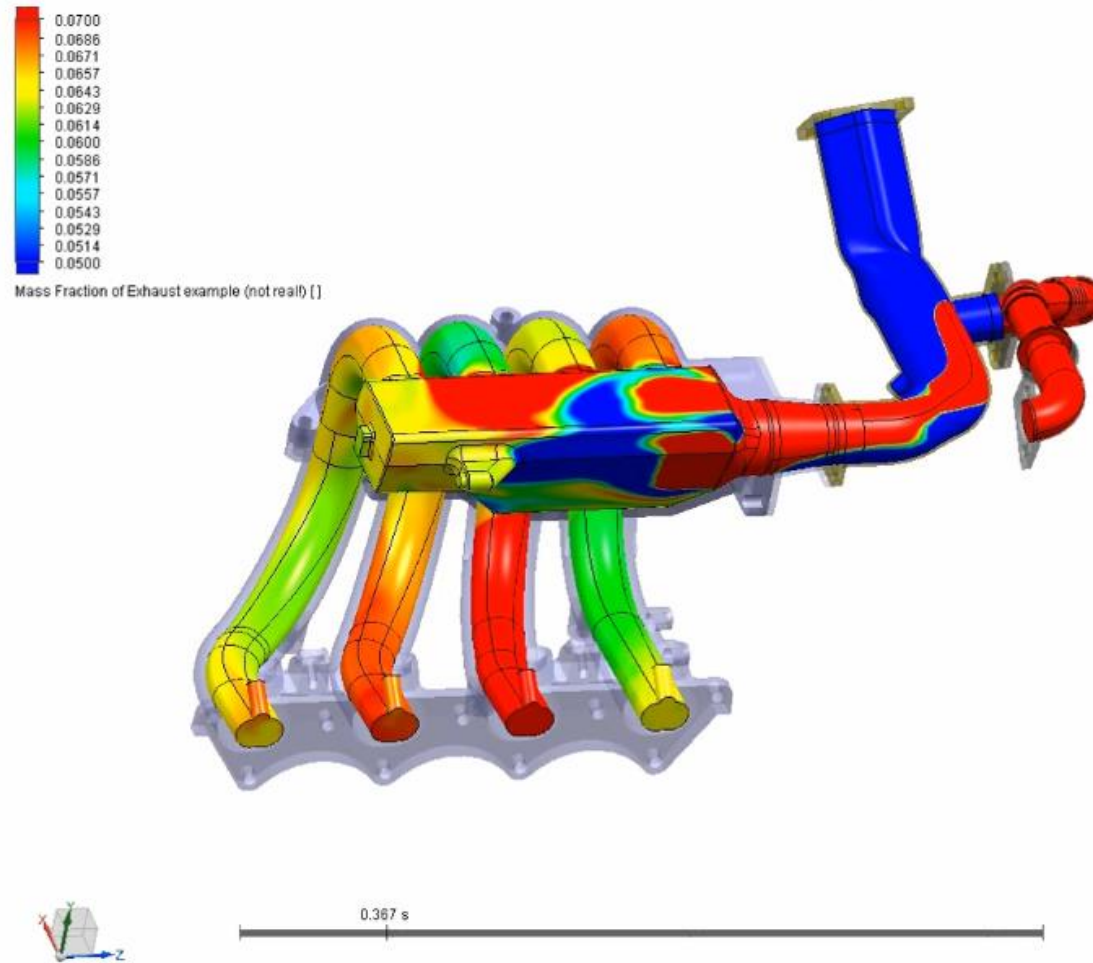


# Get freaky with post processing



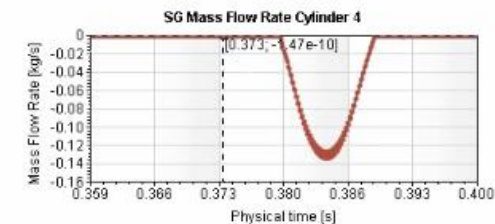
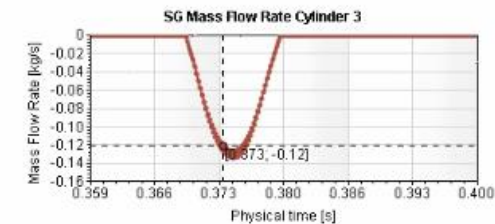
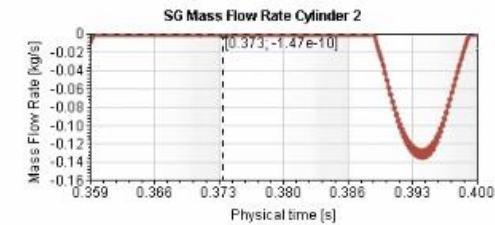
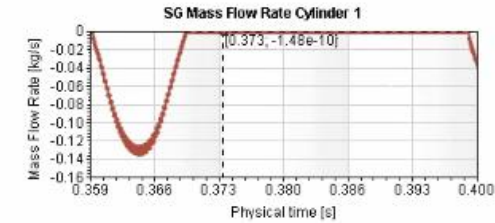
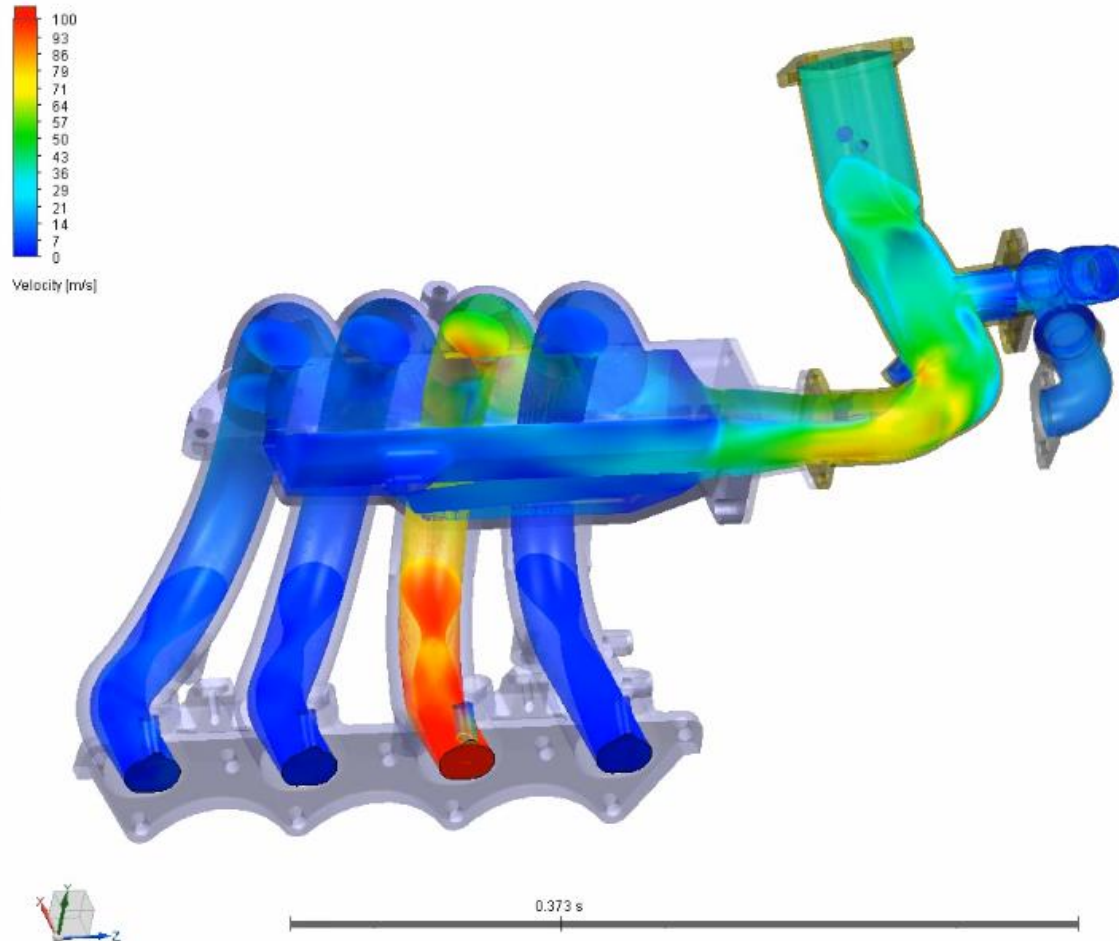


# Get freaky with post processing





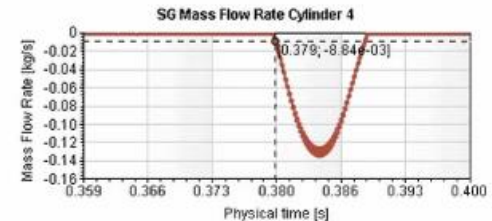
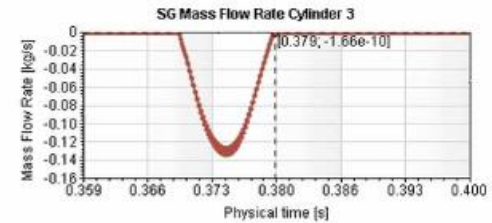
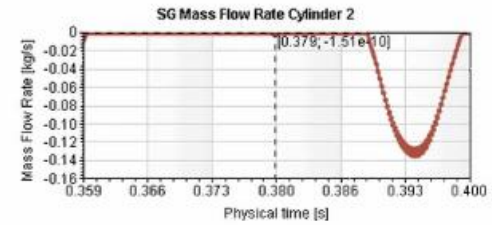
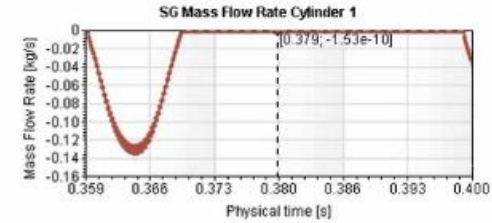
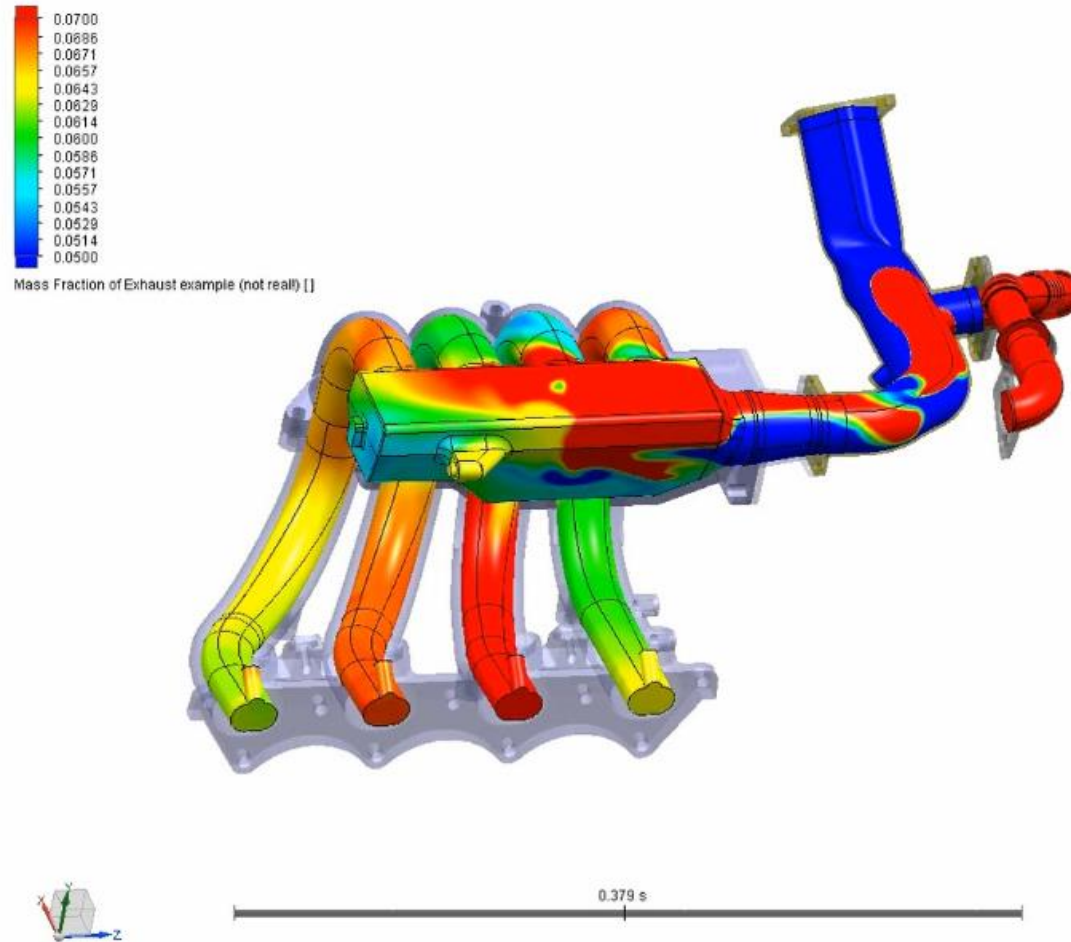
# Get freaky with post processing





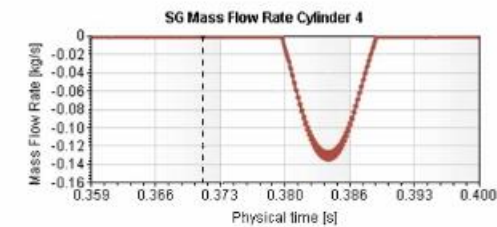
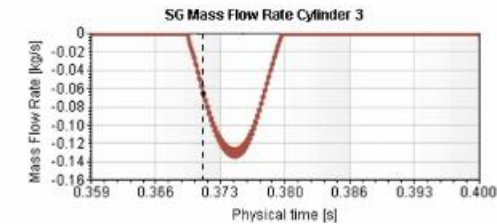
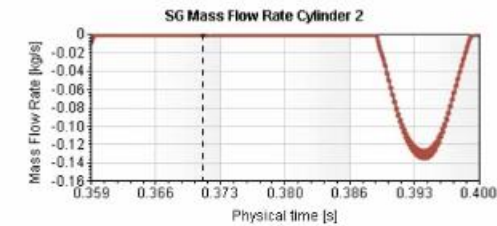
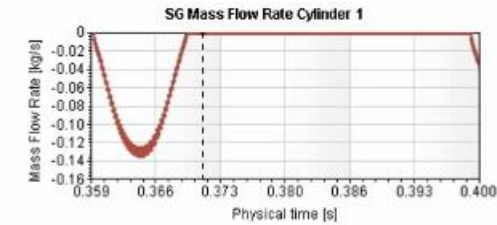
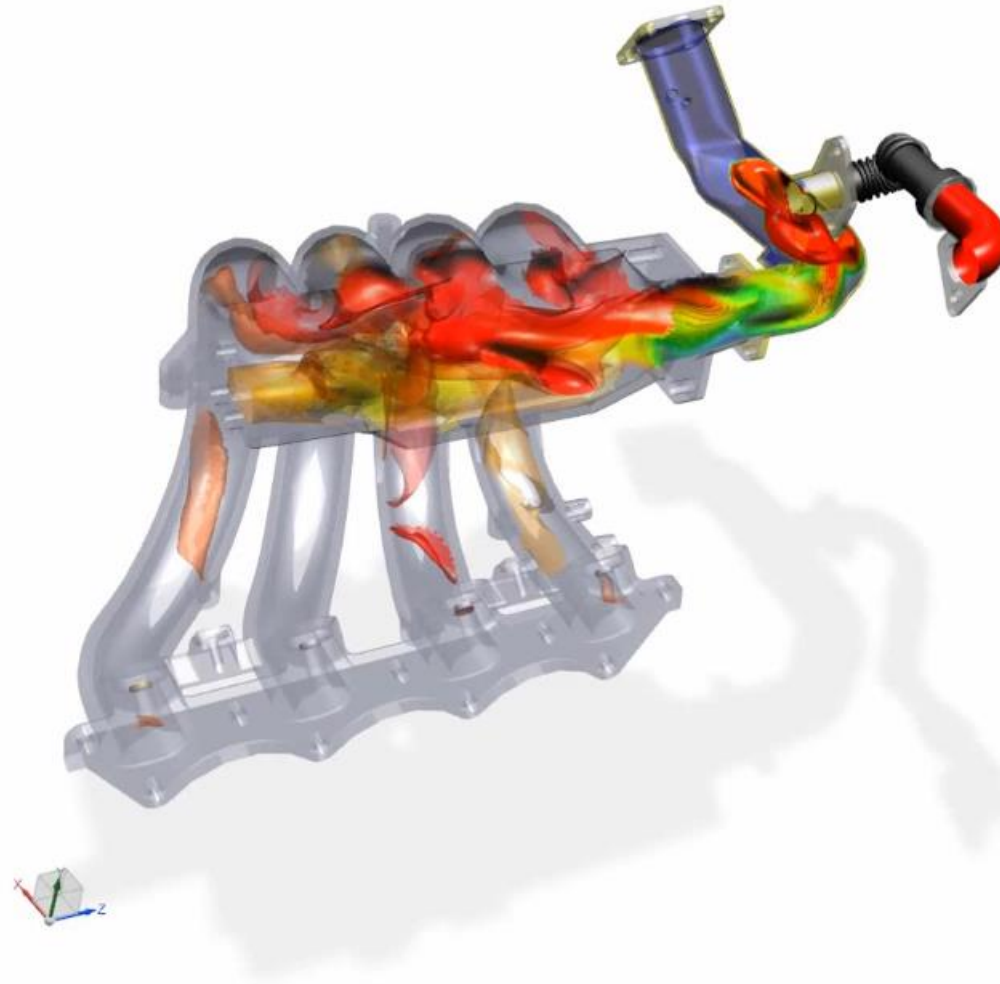


# Get freaky with post processing



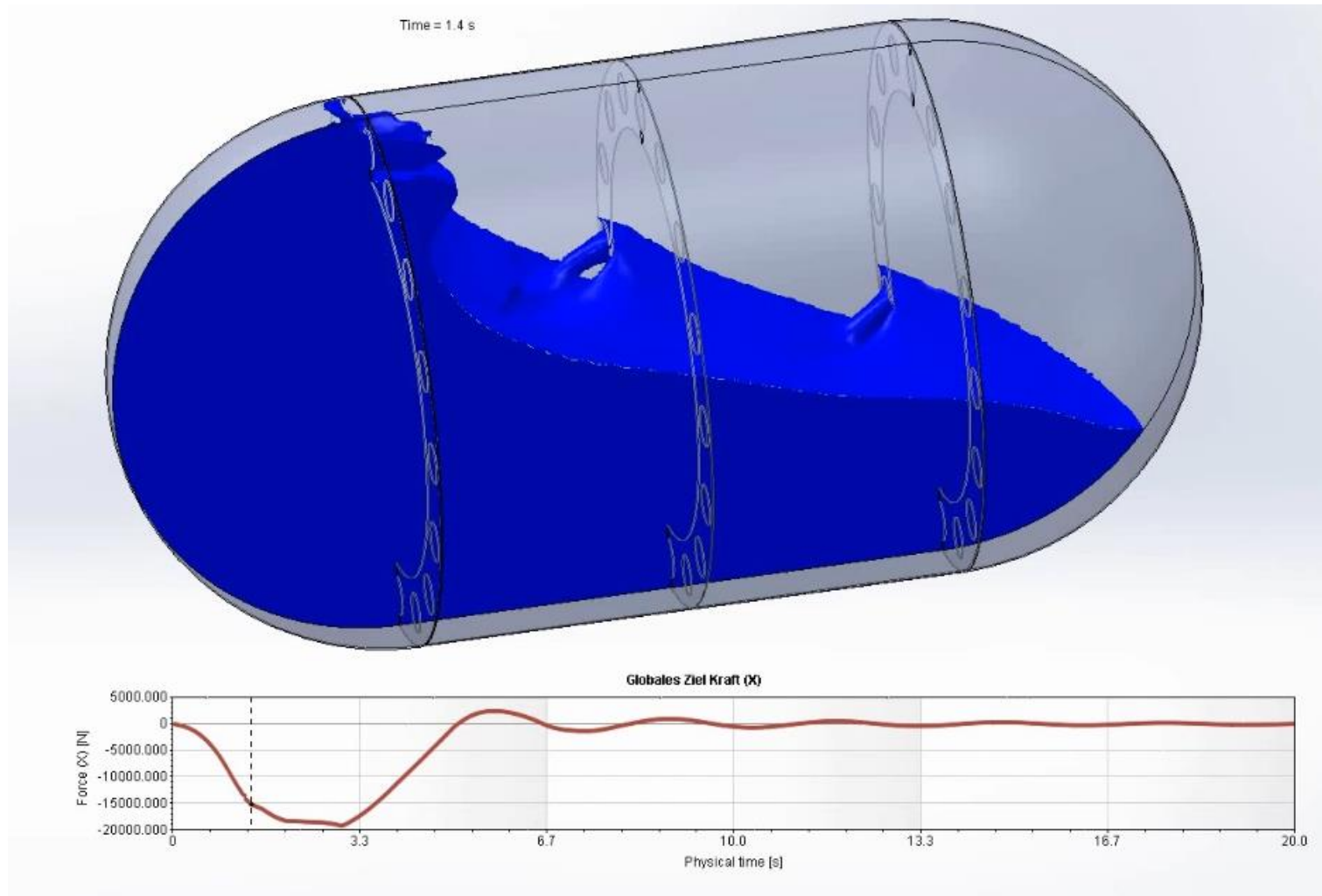


# Get freaky with post processing





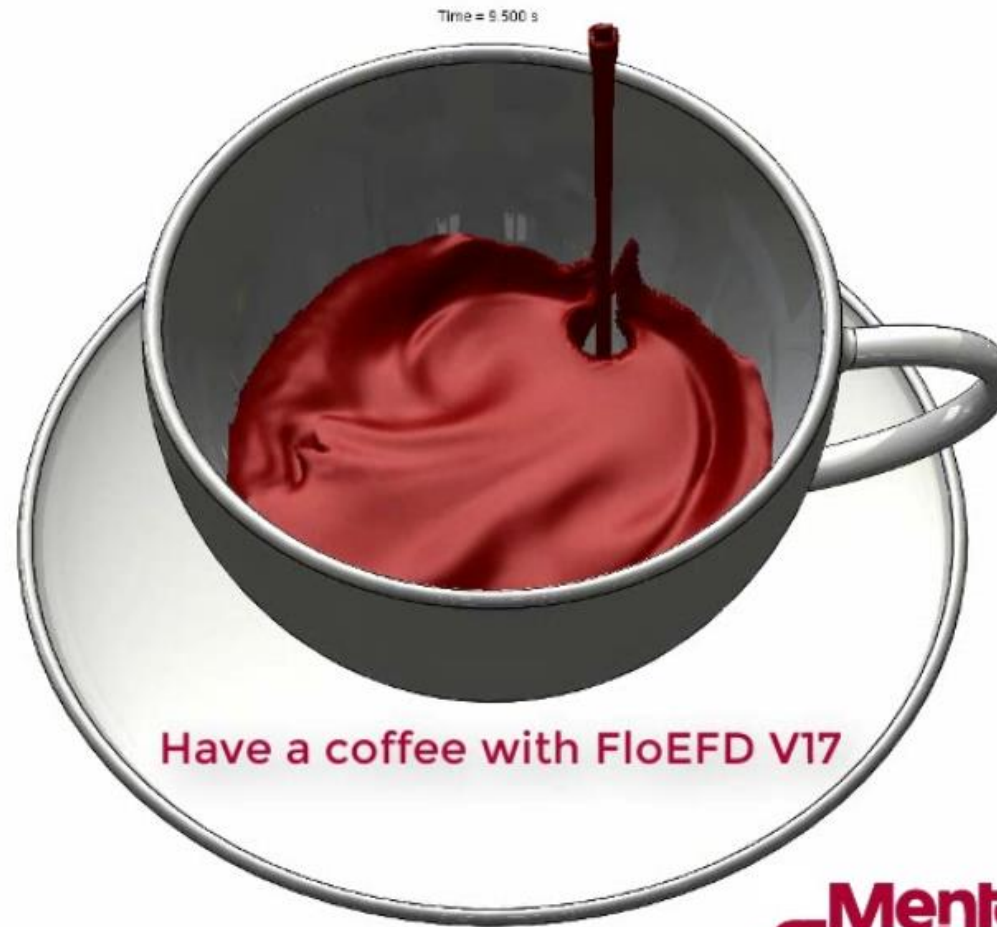
# Get freaky with post processing







# Get freaky with post processing



# HOEFD

# Thank you!

