Simulation Projects in SE Europe with ANSYS Software Tools

Dimitrios Sofialidis
Technical Manager, SimTec Ltd.

Mechanical Engineer, PhD

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University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia

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Presentation Outline

- Simulation in SE Europe: *History & Trends*.
- Major Simulation Fields – Multiphysics.
- Categories of Simulations by Application Area.
- Presentation of SimTec Simulation Projects.
- Presentation of SimTec Customers Projects.

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Simulation in SE Europe – *History*

- **When SimTec was established in 2001, only a few companies in SE Europe were conducting simulation.**
  - ➢ High cost (& for hardware) – many applications not solvable.
  - ➢ Not a "mature" tool in many areas.
  - ➢ "Research culture" & "evidence proof" not fully deployed.
  - ➢ Lack of a "reliable solution" in the region.
- ***SimTec is proud for being a pioneer for more than 10 successful years and helped in the creation of an industrial community that uses simulation methods today as a standard tool for the design and optimization of products and processes.***

Simulation in SE Europe – *The People*

- **SimTec has trained +300 (mostly) engineers in +50 seminars, for the ANSYS software packages.**
  - Almost half of the trained continue today to use the software as commercial or academic users, supported technically by SimTec on a continuous basis.
  - Many were/are students, which had/will soon be recruited by companies with research activities to employ mathematical modeling with ANSYS.
  - At SimTec itself, Dimitris Papas is employed for 4 years now; he was trained in Fluent as a student originally in 2002.

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Simulation in SE Europe – *Trends*

- **Today:**
  - **Few** companies have introduced simulation in their daily routine.
  - **A significant number** of companies have used simulation services at some certain time in the past.
  - **A lot of** companies have shown interest in acquiring a permanent or occasional simulation solution, either in-house or out–sourced (consulting service).
  - **Almost all productive** companies of the region recognize that today simulation can offer a significant competitive advantage for products and services of high value–to–cost ratio.

Major Simulation Fields

- **Industrial simulation in engineering is divided today in the following major categories:**
  - **CSM** (Computational Structural Mechanics) or more commonly as **FEA** (Finite Element Analysis).
  - **CFD** (Computational Fluid Dynamics).
  - **EMag** (ElectroMagnetic) Analysis.
- **Each field has various categories:**
  - E.g. some categories of **CSM** are:
    - Static linear/non–linear analysis.
    - Transient analysis.
    - Modal analysis.
    - Harmonic analysis.
    - Static or Transient Thermal analysis.
    - Fatigue & failure analysis.
    - Explicit analysis.

Multiphysics

- **The last years significant progress and application are observed for simulations thatr cover more than one physical areas (multiphysics). And this because of the:**
  - Complexity of the real physical processes.
  - Available computing power.
- **All ANSYS solvers and supporting tools are ported in the same simualation environment: *ANSYS Workbench*.**
  - Support of Multiphysics capabilities, between all available solvers.
  - ANSYS Workbench is parametric, and supports persistent modeling, reproducibility and scalability.
  - Live parametric connection to all major CAD systems.
  - Statistical tools for automatic optimization.

Categories of Simulations by Application Area

- **Aerospace & Defense.**
- **Automotive.**
- **Power Generation & RES.**
- **Chemical and Process.**
- **Industrial Equipment.**
- **Consumer Goods.**
- **Turbomachinery.**
- **Food & Beverages.**
- **Pharmaceutical & Biomedical.**
- **Building Environment & Constructions.**
- **Electronics & Semiconductors.**
- **Electric Motors.**
- **Telecommunications.**
- **………..**

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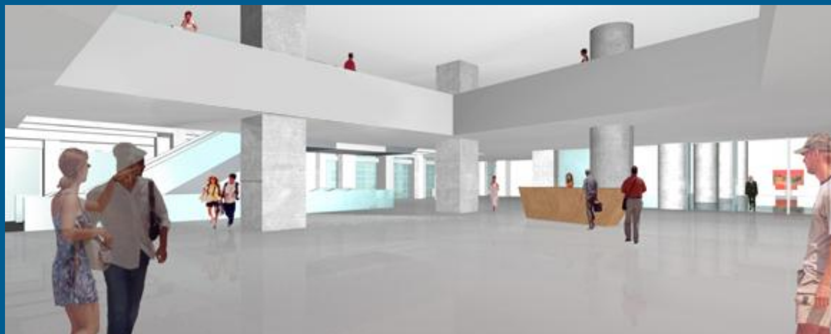
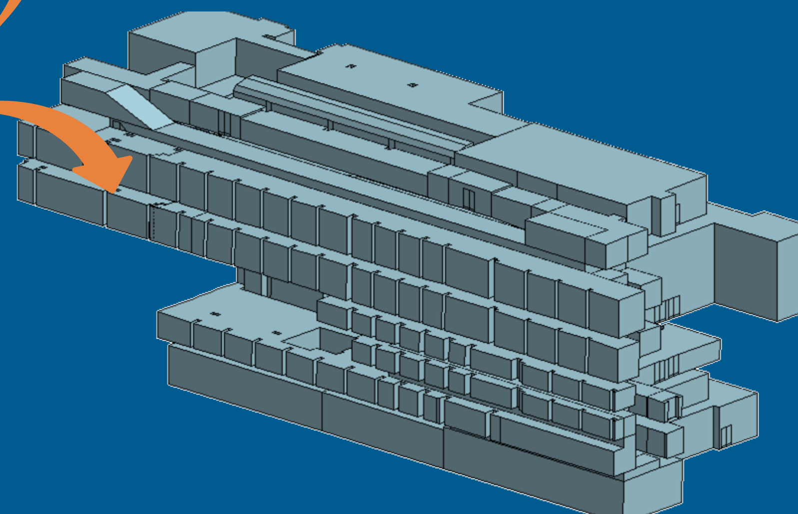
1. Finished Consulting Projects by SimTec

- ***2005. INSTA Consultants & Engineers. Greece.***
  CFD Model for the Smoke Extraction System in the National Museum of Modern Art in Athens.
- ***2005. LDK Consultants & Engineers. Libya.***
  CFD Model of the Ventilation/Cooling of a Power Generation Engine Hall.
- ***2008. LDK Consultants & Engineers. Greece.***
  CFD Simulation of the Ventilation of the Publicly–Used Spaces of a Mall in the City of Ioannina.
- ***2009–2011. AKTOR. Qatar.***
  CFD Simulation of the Ventilation & Air–Conditioning of the Heavy–Maintenance Hangar Bay of the New Doha International Airport.
  CFD Simulation of the Foam Spraying System of the Light–Maintenance Hangar Bay Floor of the New Doha International Airport.
- ***2011. J&P AVAX. Cyprus.***
  CFD Model of the Ventilation of the Steam Turbine Hall of Vassilikos Power Plant.
- ***2011. MELAMIN. Slovenia.***
  CFD Simulation of the Mixing Process Inside a Batch Reactor.
- ***2011. TERNA Energy. Greece.***
  Wind Power Production Evaluation in an Existing Wind Farm.
- ***2012. ELPEN. Greece/Germany.***
  CFD Simulation of the Air Flow and Particle Tracks Inside Elpenhaler® DPIs.

1a. Smoke Propagation in N.M.M.A.





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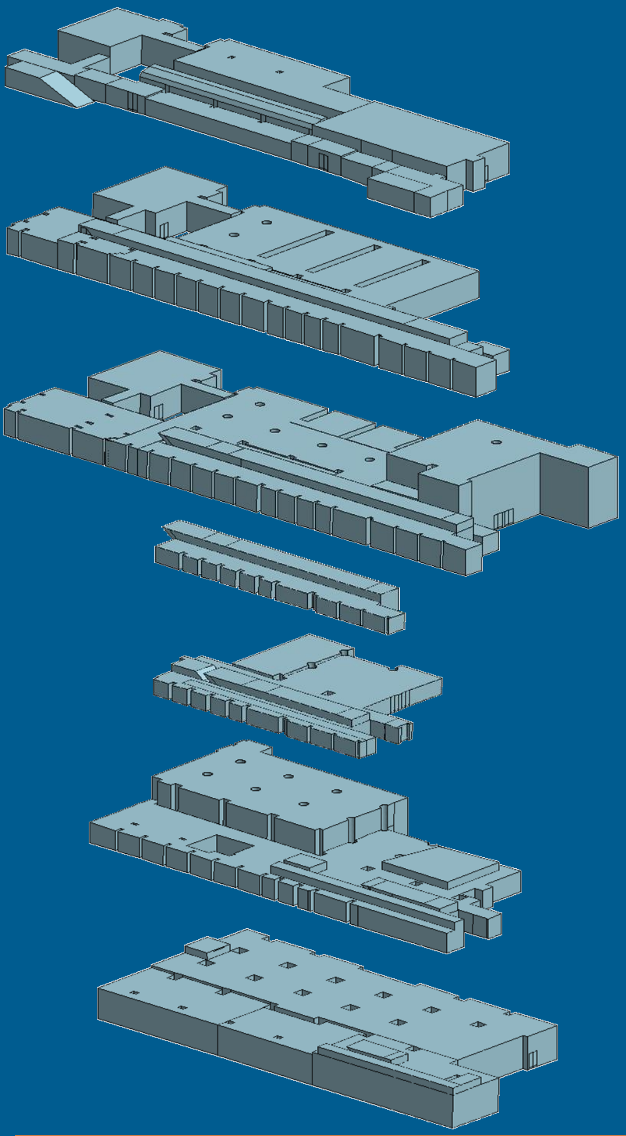

- ***7–storey old brewery. Six fire scenarios. Only public spaces.***
- ***Transient gases, heat and smoke release.***
- ***Sprinkler activation and fire–suppression.***
- ***Evacuation modeling through change of BCs.***
- ***Pressurization modeling (temperature increase and gases release).***
- ***Modeling of the smoke extraction system (supply and sucking of air from dedicated vents).***
- ***Turbulent flow, temperature-dependent properties, buoyant forces.***
- ***Calculation of visibility, lethality due to poisonous gases and heat stroke.***
- ***Calculation of smoke propagation.***

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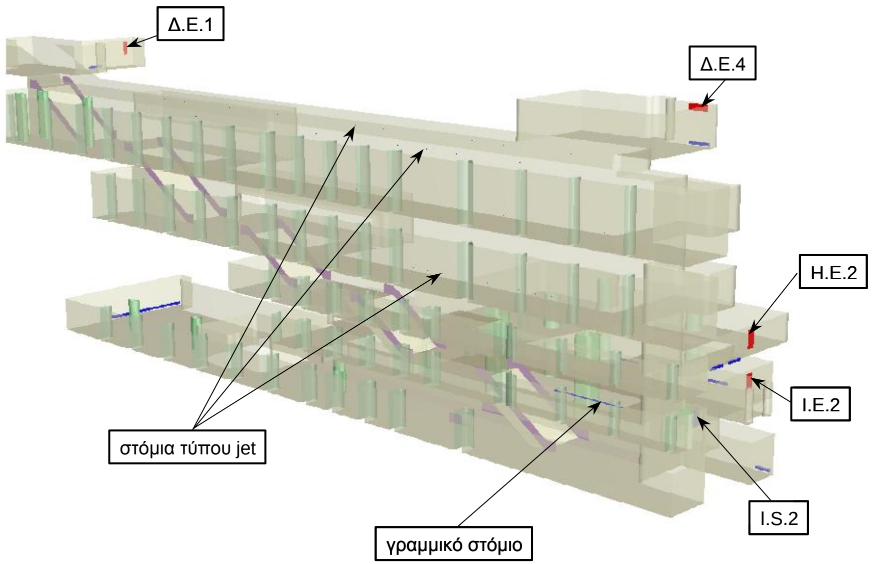

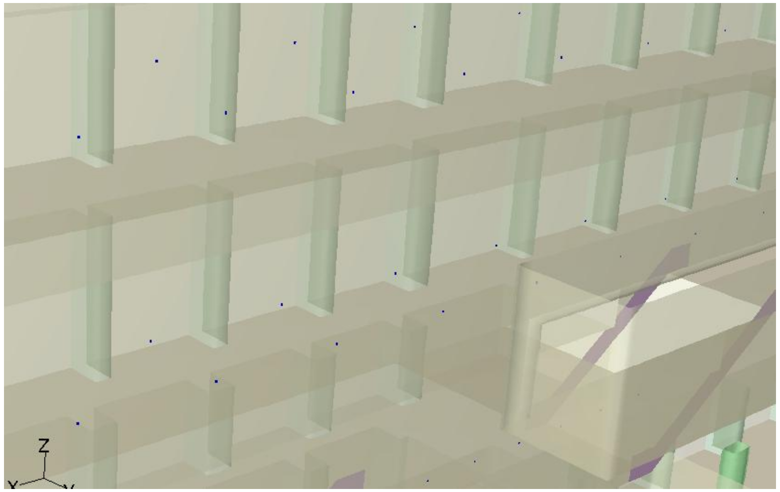

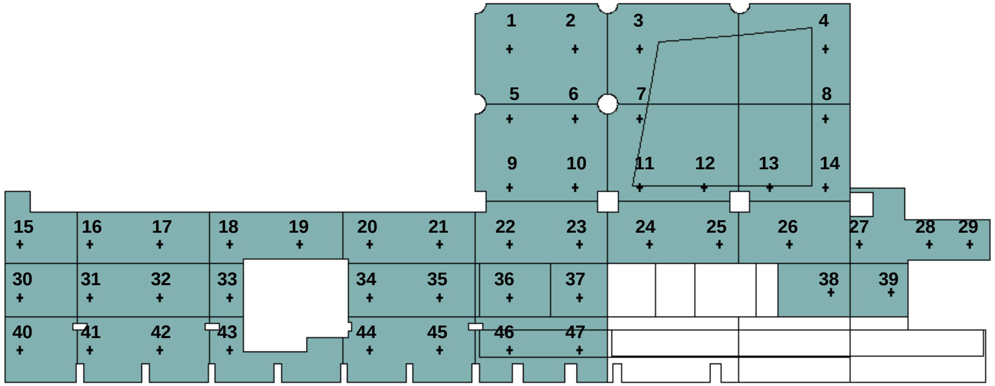

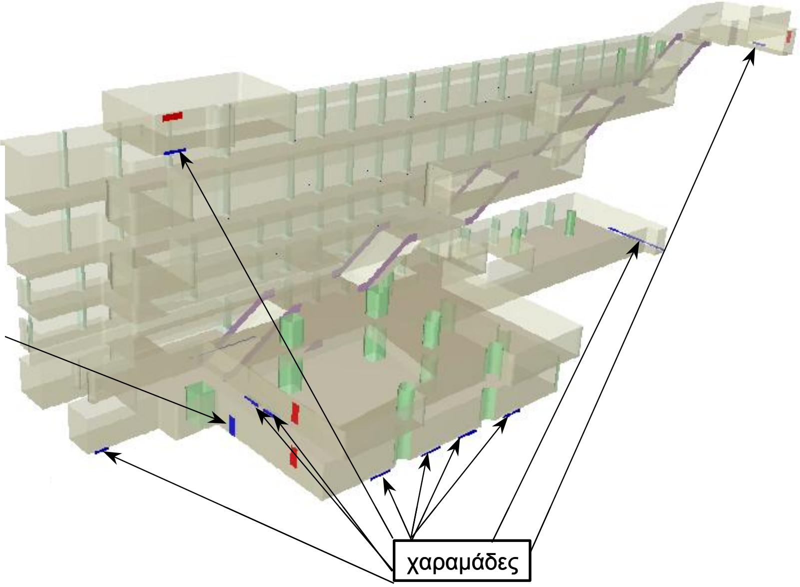

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1a. Smoke Propagation in N.M.M.A.

Stoichiometry (molar) CnHmOo		ΔHc [MJ/kg] - net (complete)
C (n):	6	17.5
H (m):	10	
O (o):	5	

% of C conversion to CO2	F (=CO/CO2 molar)
80	0.2500

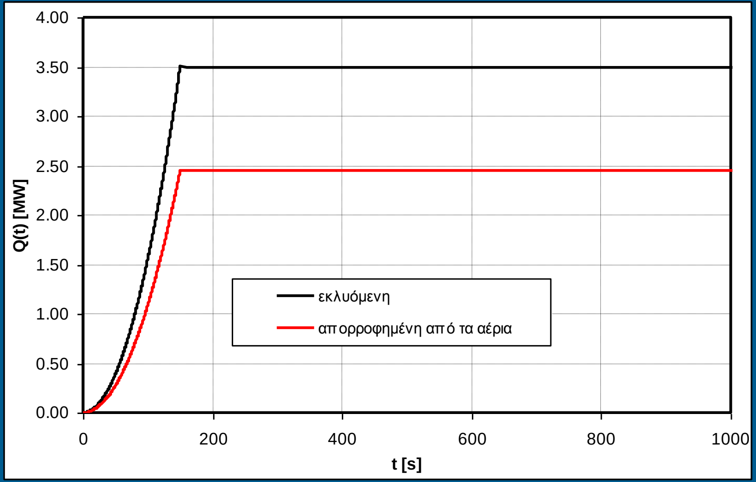
Reactants (molar)		Reactants (mass)		1129.50 per 1 [kg] fuel	Vol. Fract.	Mass Fract.
CnHmOo	1.25	CnHmOo	202.50	1.0000	-	-
O2	6.75	O2	216.00	1.0667	0.2100	0.2330
N2	25.39	N2	711.00	3.5111	0.7900	0.7670
Products (molar)		Products (mass)		1129.50 (yields)		
CO2	6.00	CO2	264.00	1.3037	0.1533	0.2337
CO	1.50	CO	42.00	0.2074	0.0383	0.0372
H2O	6.25	H2O	112.50	0.5556	0.1597	0.0996
N2	25.39	N2	711.00	3.5111	0.6487	0.6295

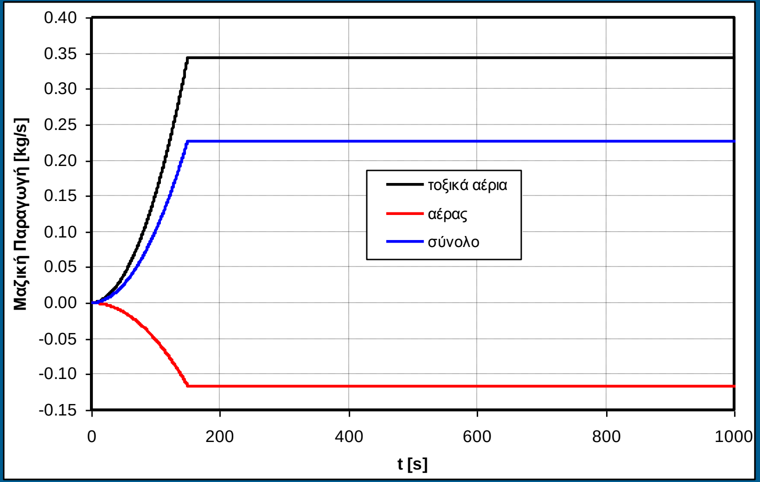
ΔHc [MJ/kg_fuel] - net (incomplete)	15.4038
ΔHc [MJ/kg_O2] - net (incomplete)	14.4410
CO yield [kgCO/kg_fuel]	0.2074
CO/gases [kgCO/kg_gases]	0.1373
"gases" yield [kg"gases"/kg_fuel]	1.5111

AW [kg/kmol]		N2-to-O2 molar ratio of air
C:	12	3.76
H:	1	
O:	16	CO--> CO2 [MJ/kmol]
N:	14	282.99
		CO--> CO2 [MJ/kg]
MW [kg/kmol]		10.11
CnHmOo	162	
O2	32	
N2	28	
CO2	44	
CO	28	
H2O	18	

"gases" PROPERTIES	
MW [kg/kmol]	40.80

Fire Combustion Model





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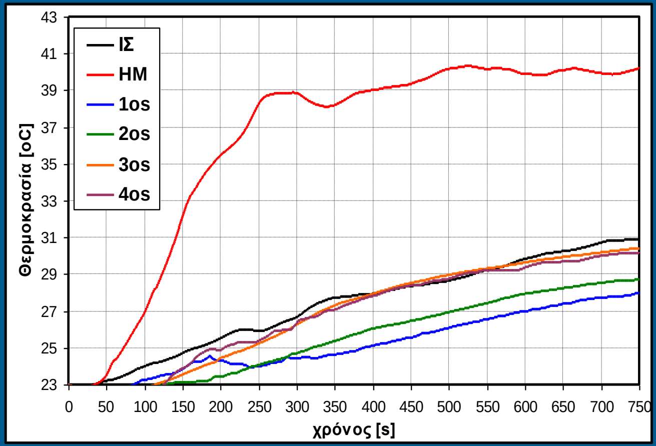
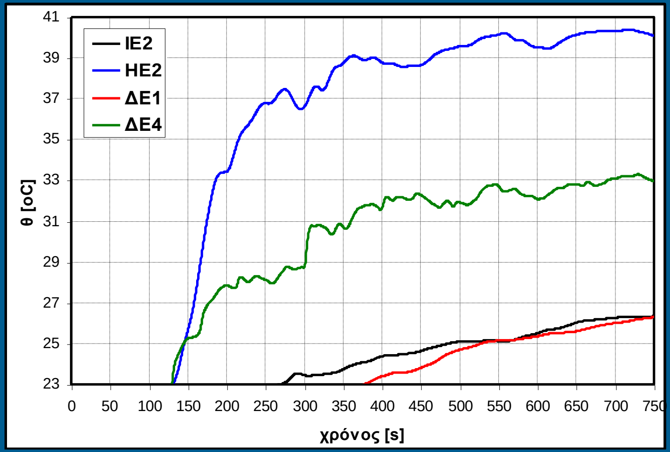
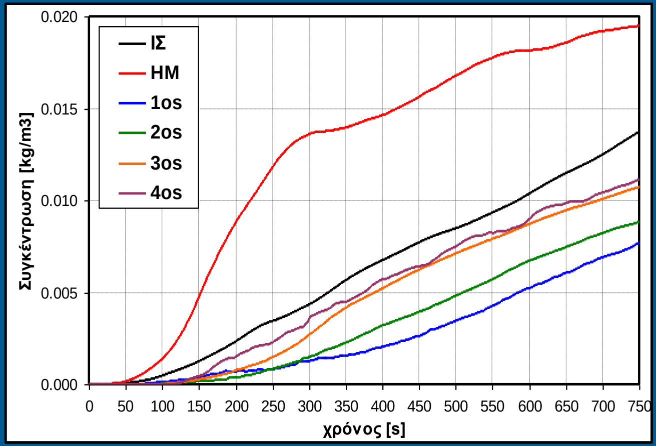


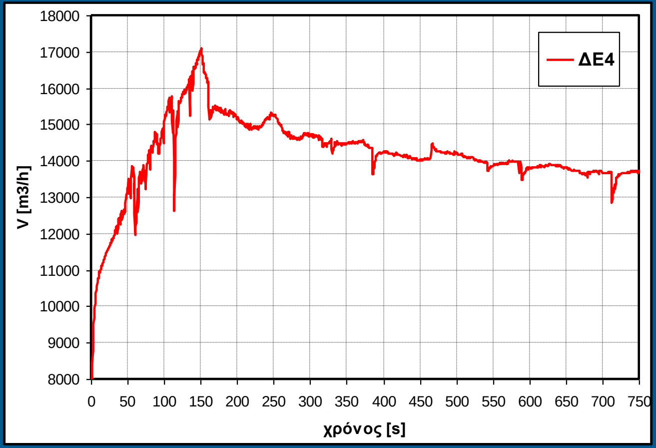
Air Average Space Temperature



Air Temperature at Exhaust Vents



Average CO_2 & CO Concentration



Air Flow at Exhaust Vents

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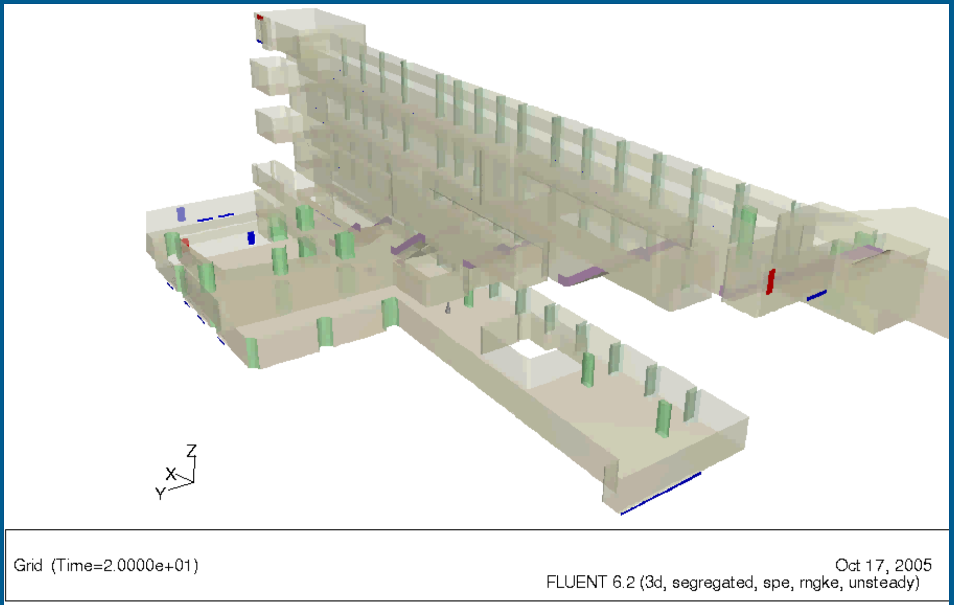
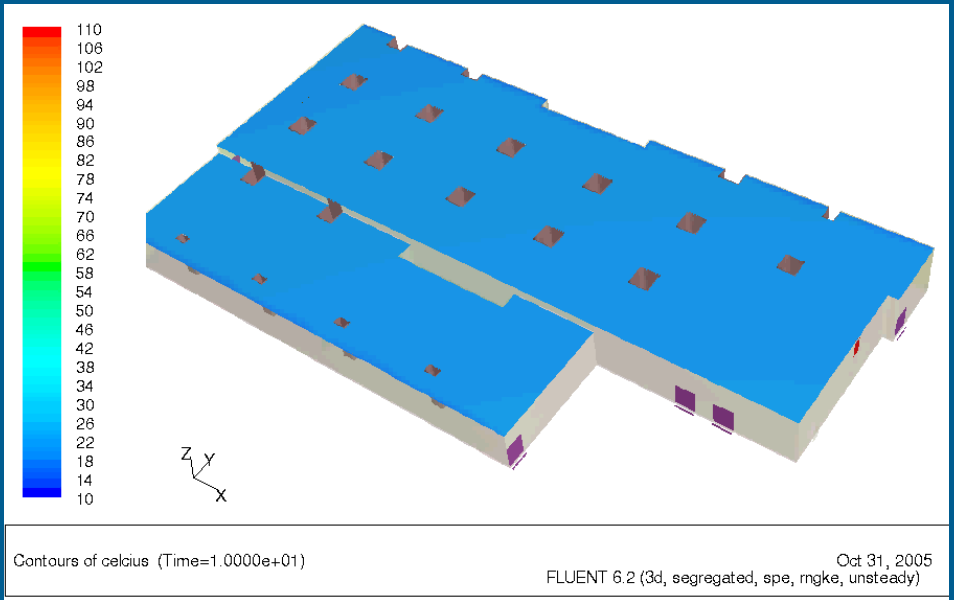
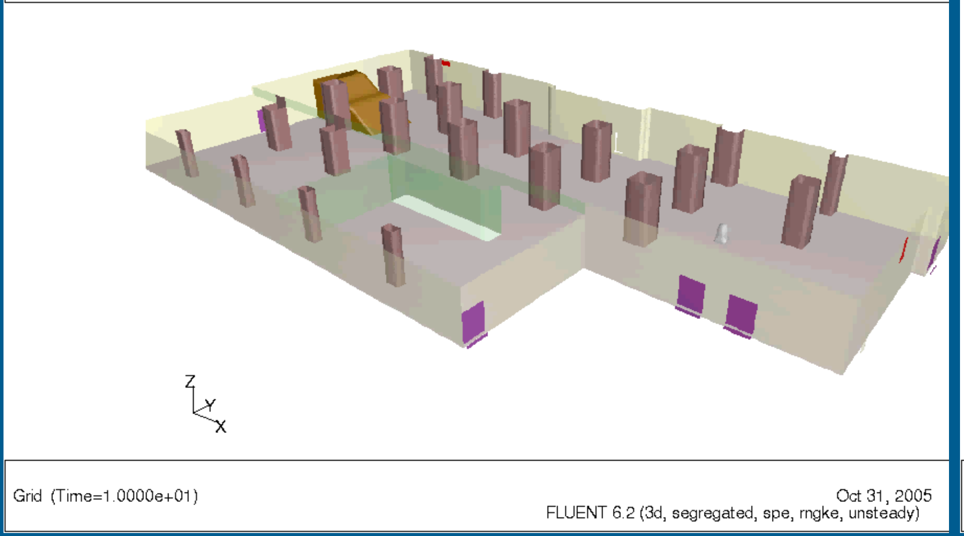
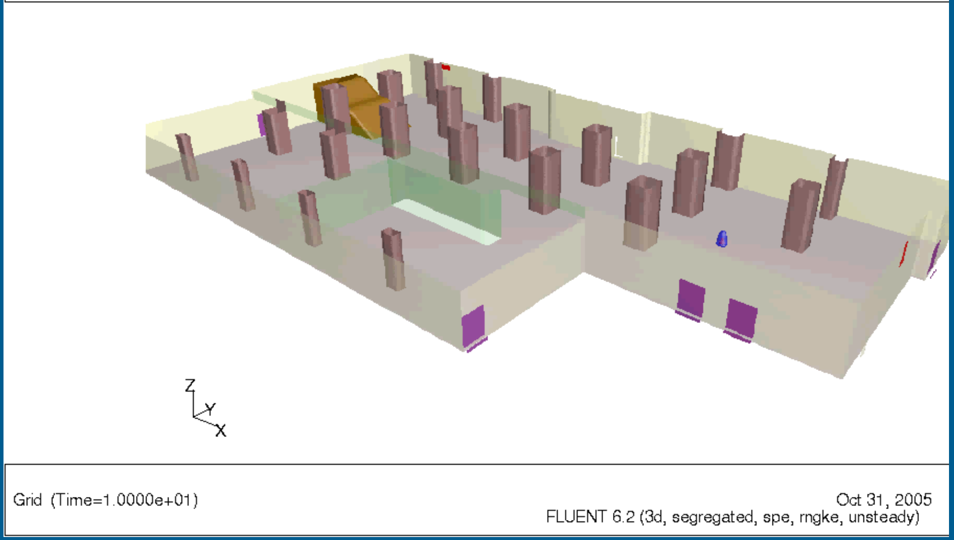
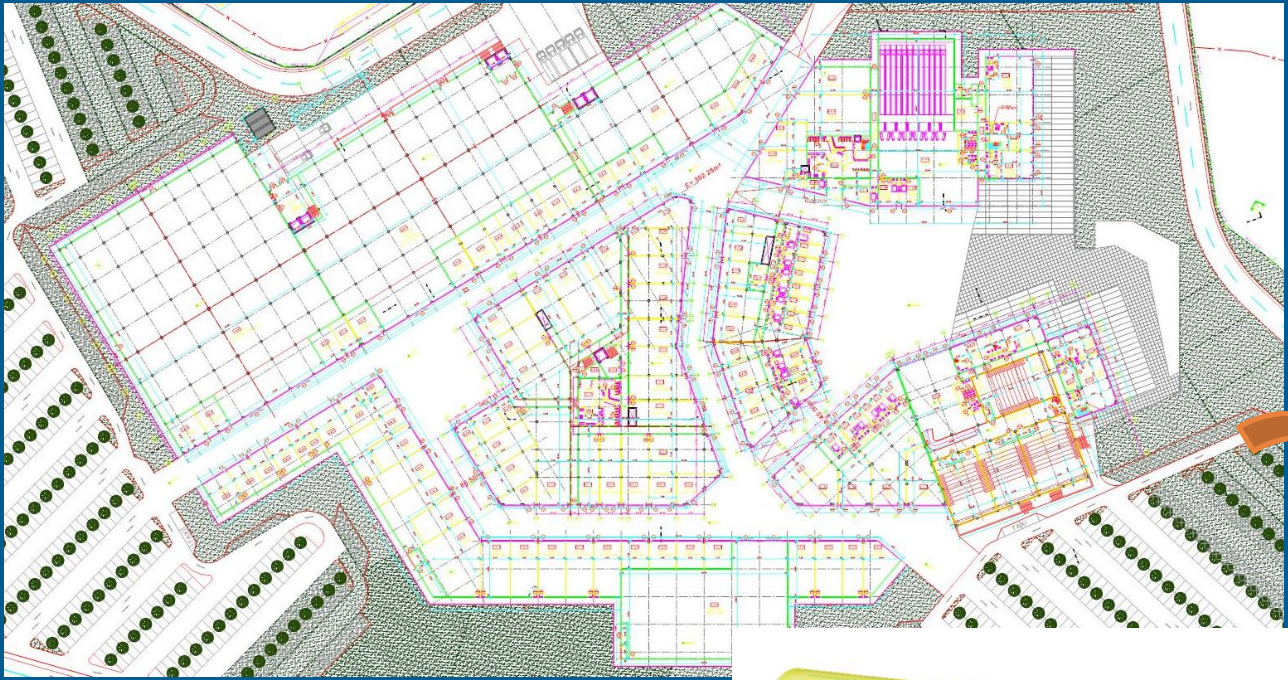


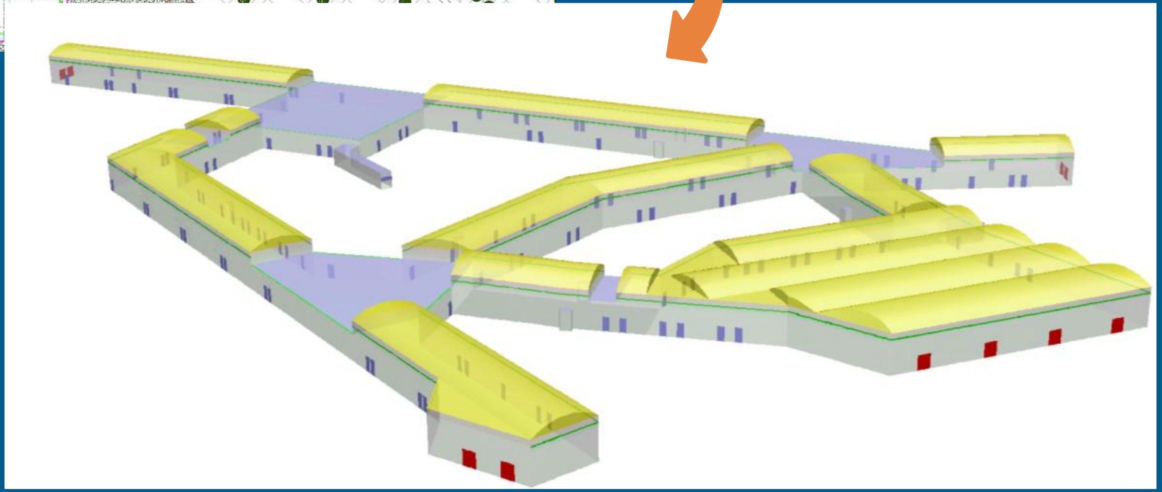






1b. CFD for the Ventilation of Public Spaces of a Mall





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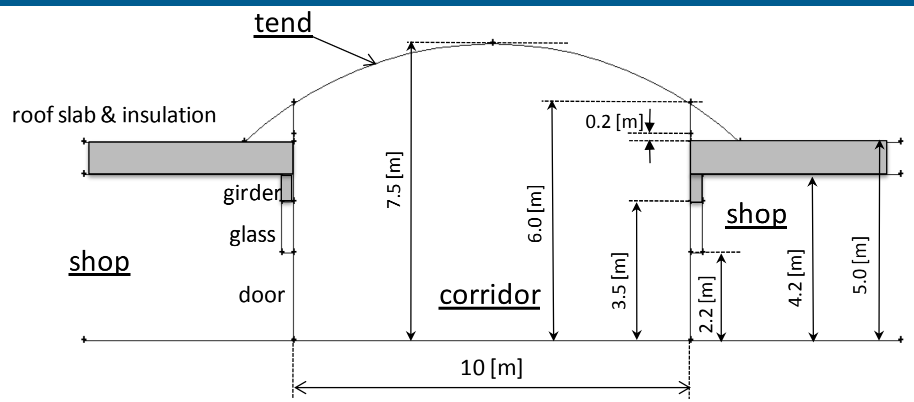
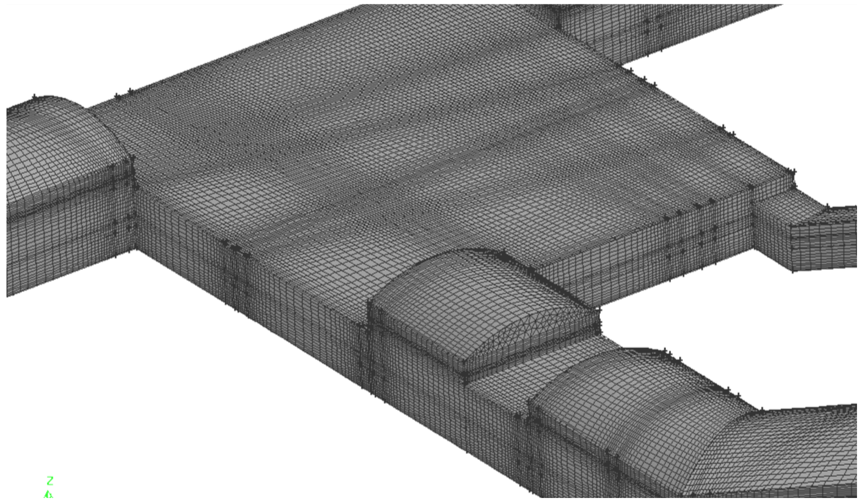
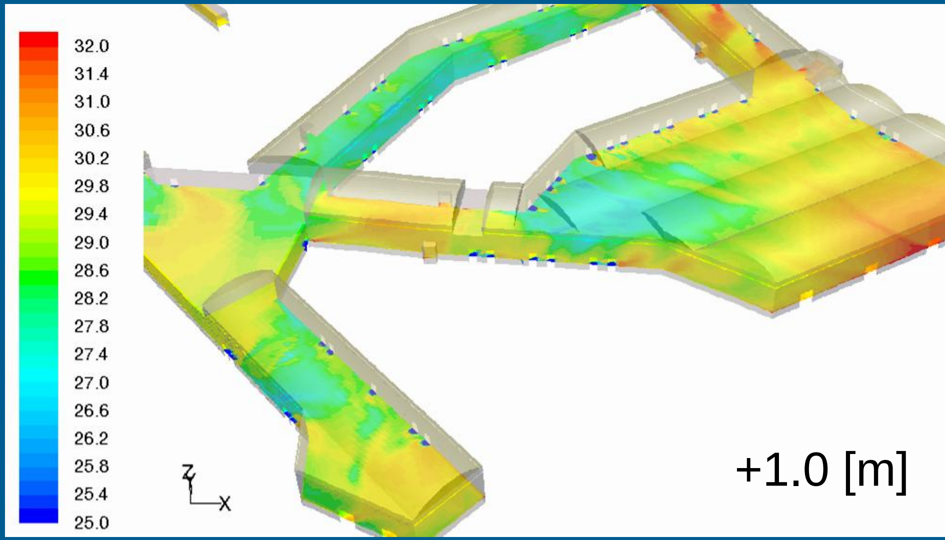
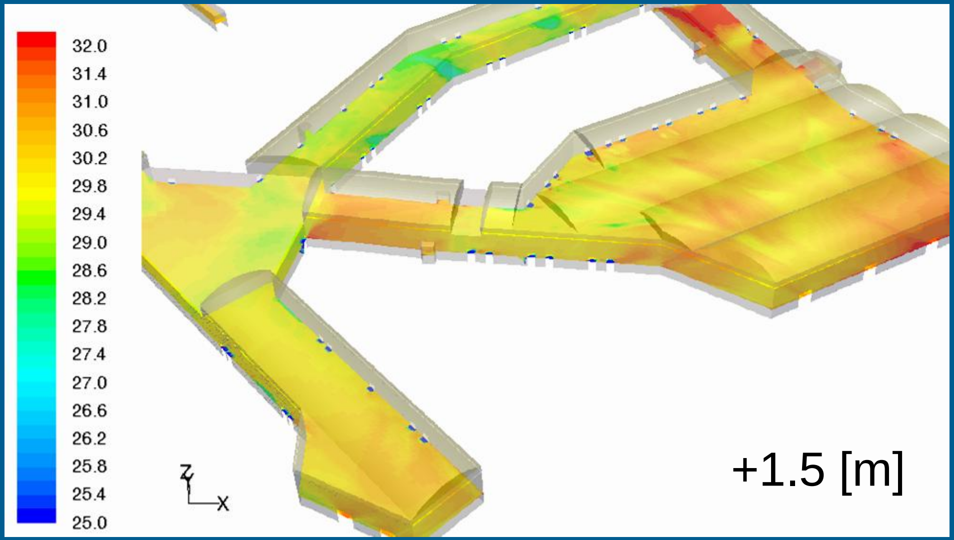


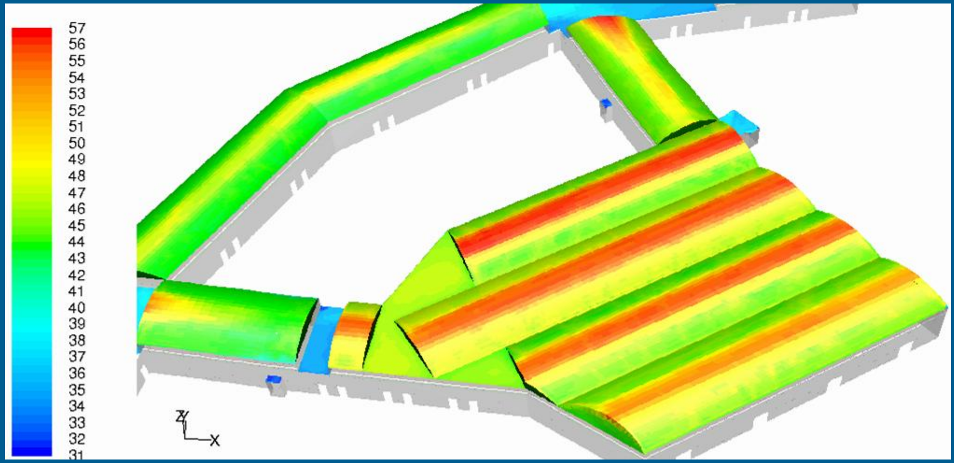


- *Modes: A/C (summer) and Underfloor Heating (winter).*
- *Calculation of heating/cooling loads for the public spaces.*
- *Calculation of solar load at the model envelope.*
- *Radiation modeling.*
- *Thermal loads from the shops, mall entrances and visitors.*
- *Turbulent flow, temperature-dependent properties, buoyant forces.*

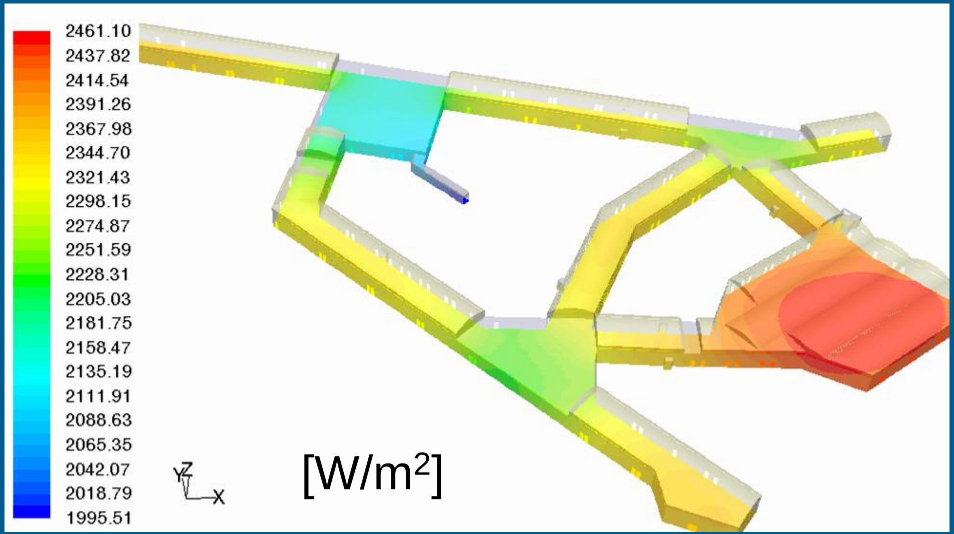
1b. CFD for the Ventilation of Public Spaces of a Mall



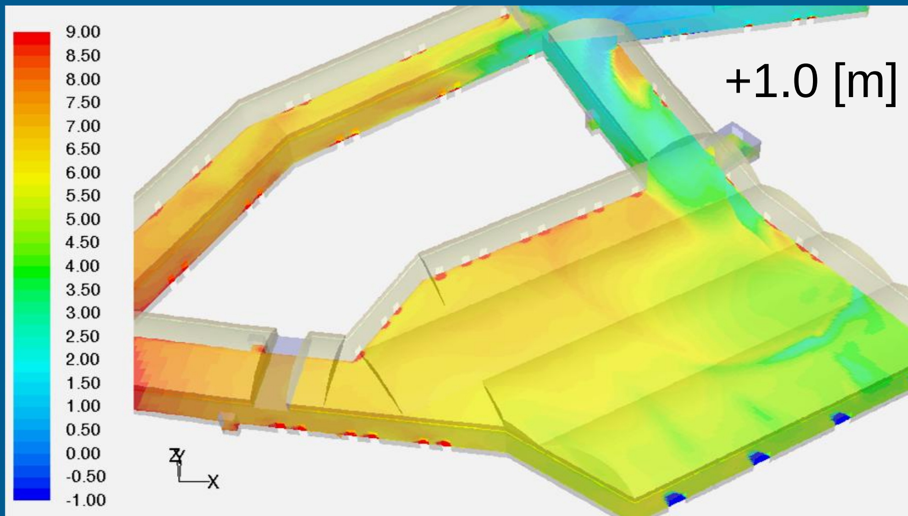


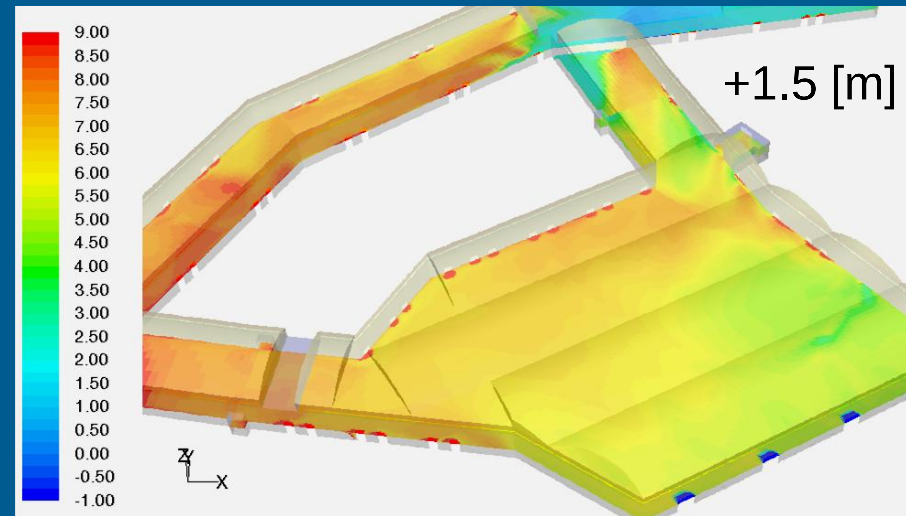


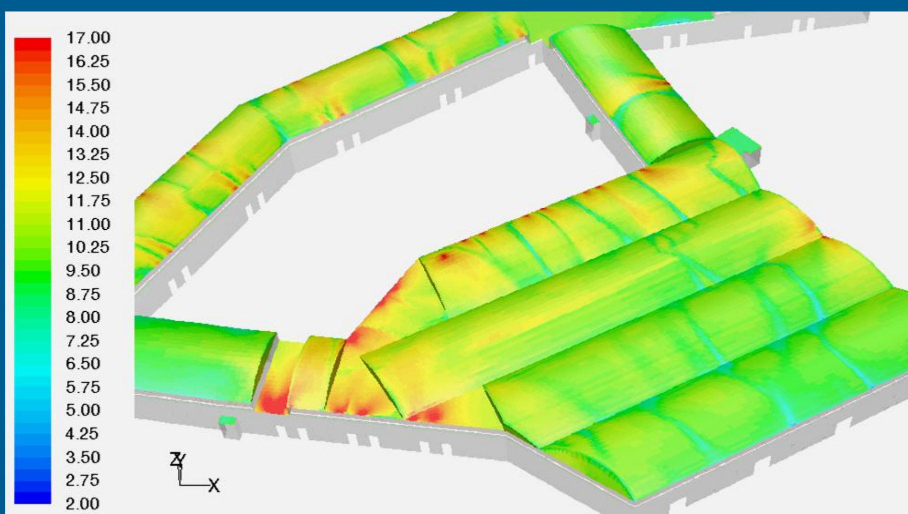
Cooling Mode

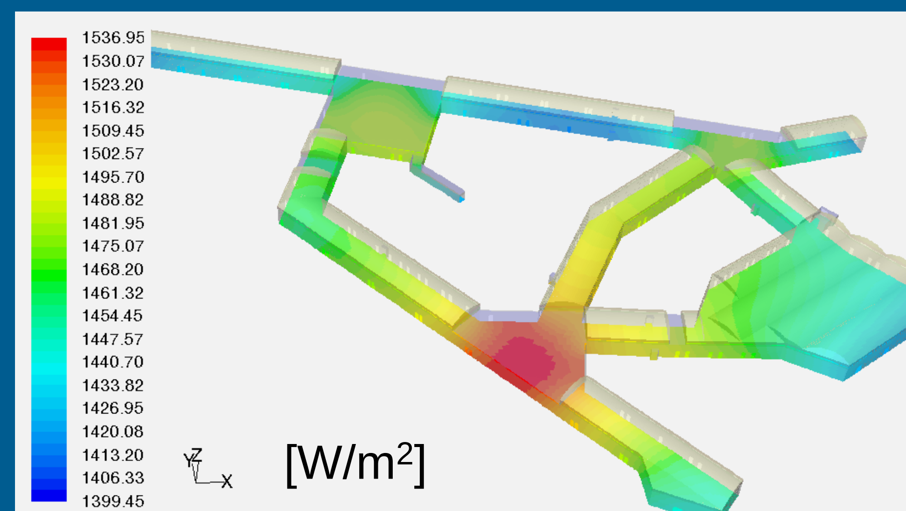


1b. CFD for the Ventilation of Public Spaces of a Mall







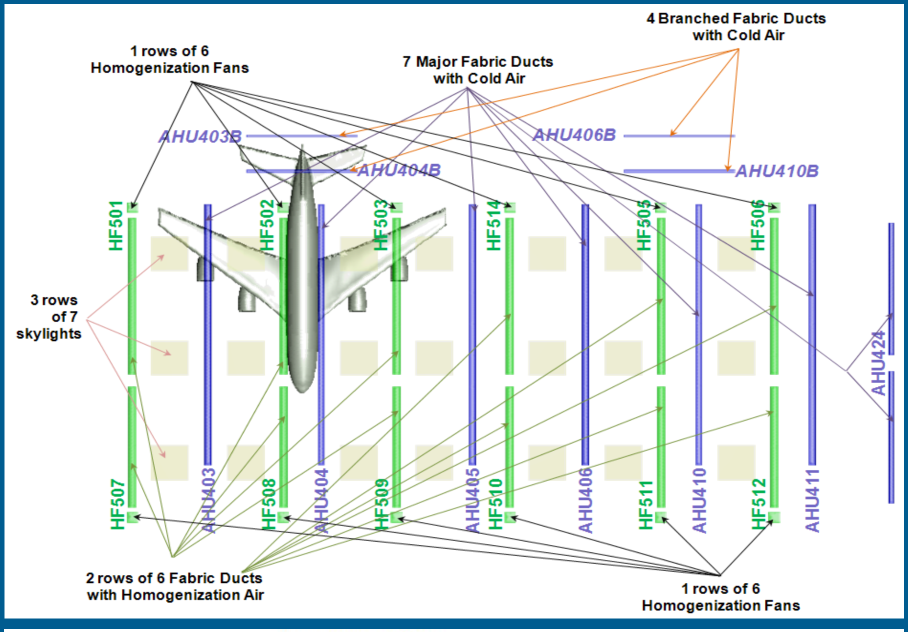


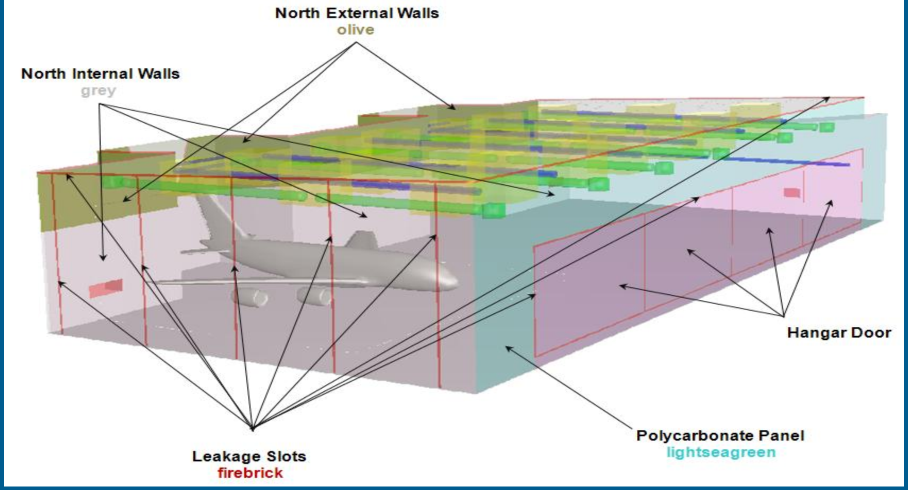
Heating Mode

1c. CFD for Ventilation & A/C of HVH of NDIA

Dimensions:
Length=220 [m]
Width=120 [m]
Height=45 [m]
Volume
~1.1×10^6 [m^3]

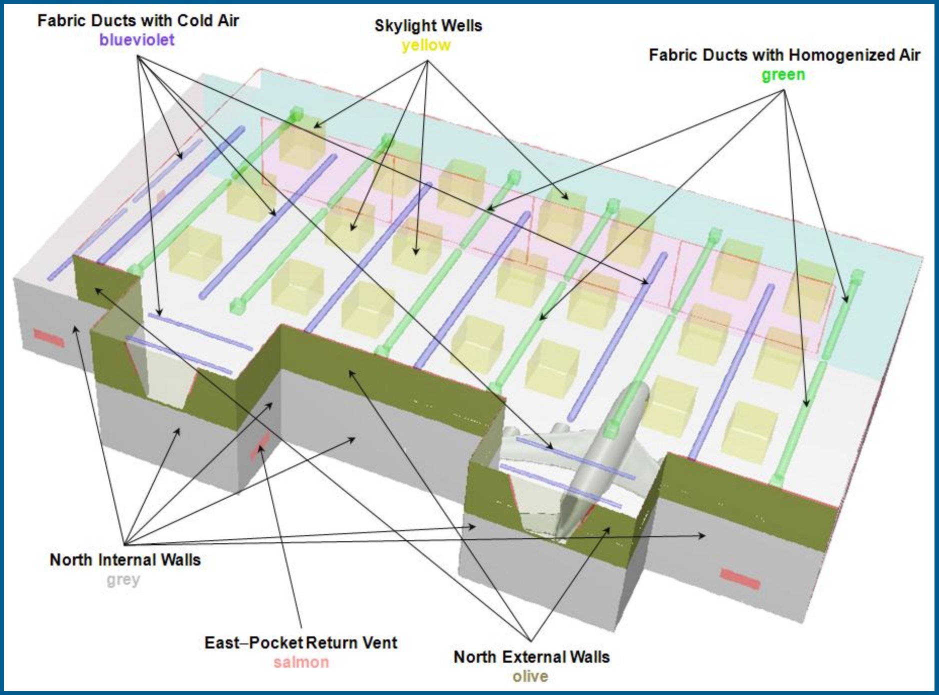
1c. CFD for Ventilation & A/C of HVH of NDIA

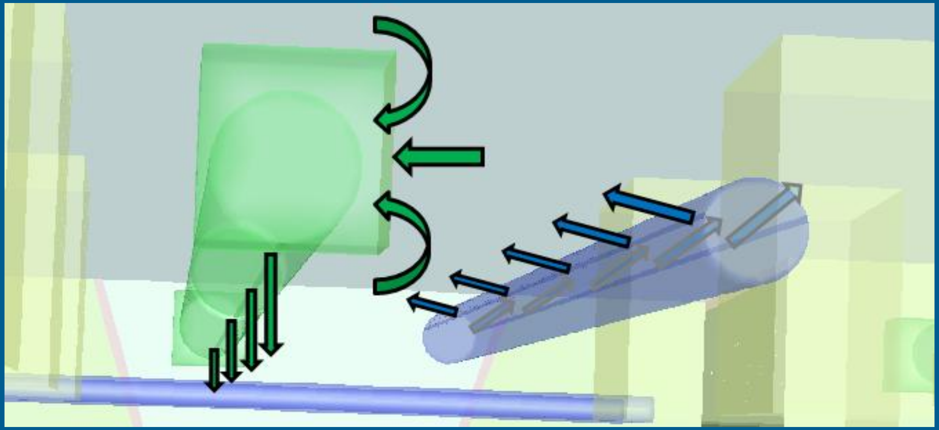




- ***Steady Thermal Conditions.***
- ***Transient coolling of an A380 aircraft after hours under the desert sun.***
- ***Thermal comfort conditions, sufficient air penetration through the large height.***
- ***Solar load calculation at the building envelope (2.9 [MW]). Worst day/hour, air temperature 46 °C.***
- ***Radiation modeling.***
- ***Heat released by A380 (1.5 [MW]), lighting, equipment, personnel (0.55 [MW]).***
- ***Turbulent flow, temperature-dependent properties, buoyant forces.***

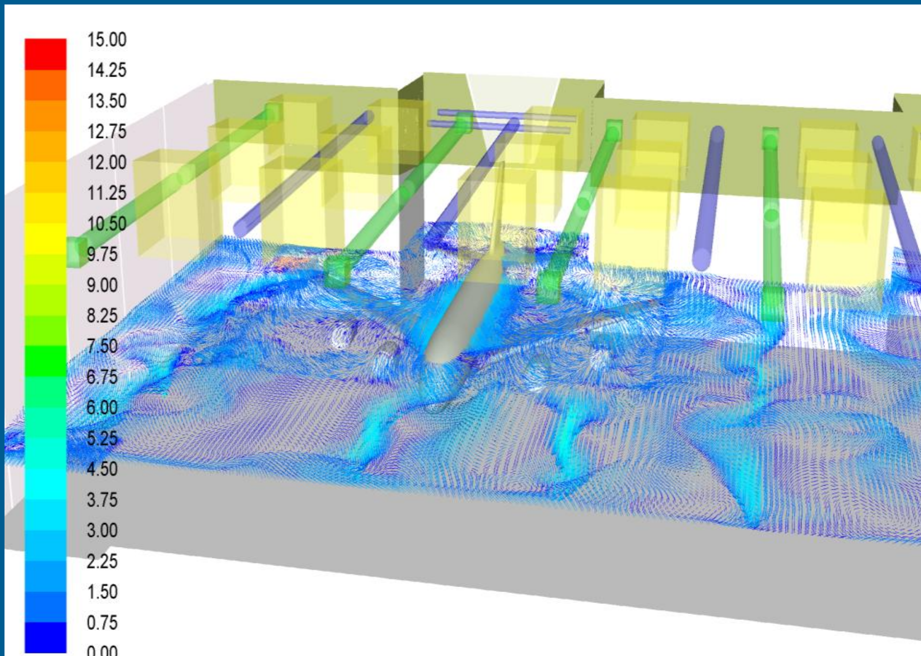
1c. CFD for Ventilation & A/C of HVH of NDIA

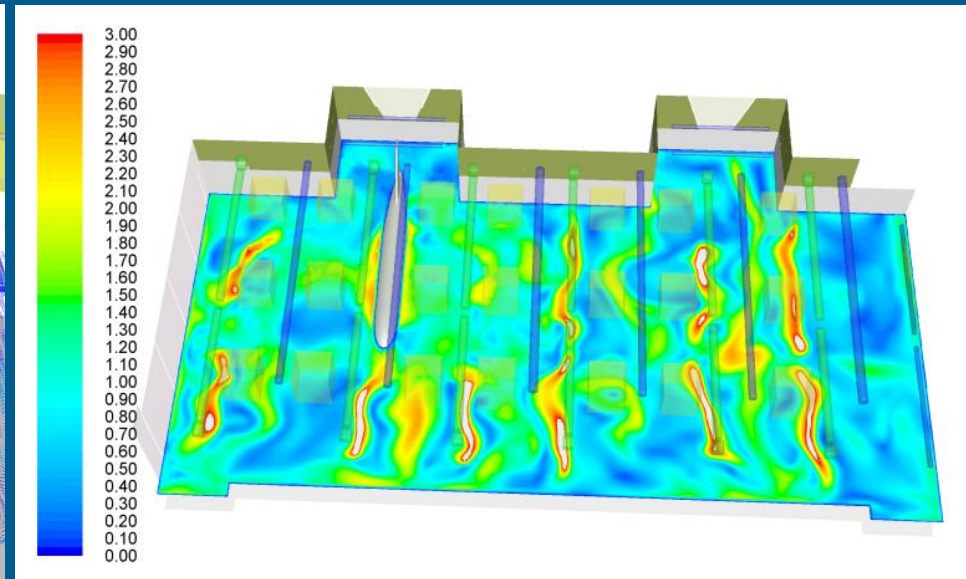


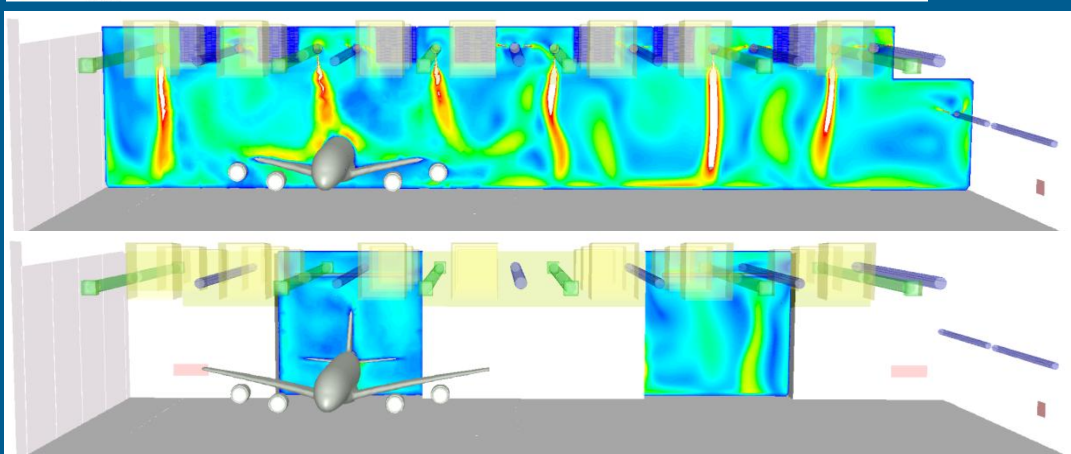


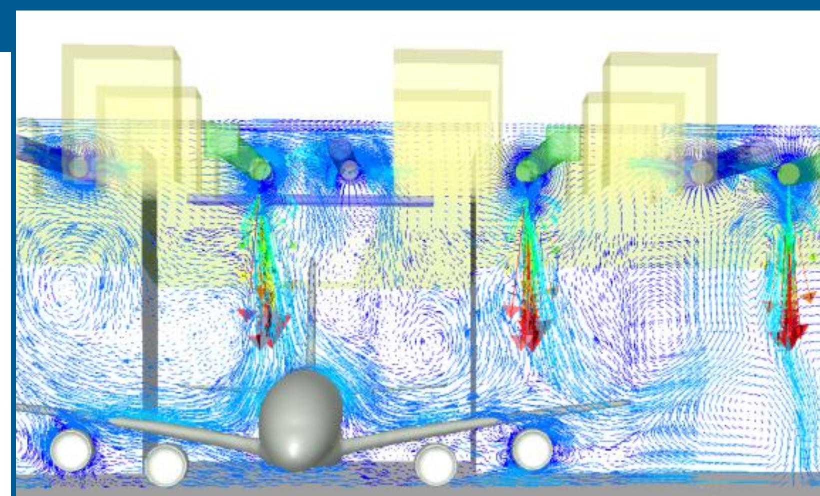
- *Fabric ducts (D=2.1 [m]). Cooling air 10^6 [m^3/h]. Recirculation air 1.8×10^6 [m^3/h]. Entrainment air 0.15×10^6 [m^3/h].*
- *Momentum sources to reproduce the (measured by the duct manufacturer) air velocities at various radial distances.*
- *4 large extract vents (return air to AHUs).*
- *The A380 was "naturally" modeled as solid body with reference to the individual properties (density, Cp, thermal conductivity) of fuselage/wings and engines.*

1c. CFD for Ventilation & A/C of HVH of NDIA









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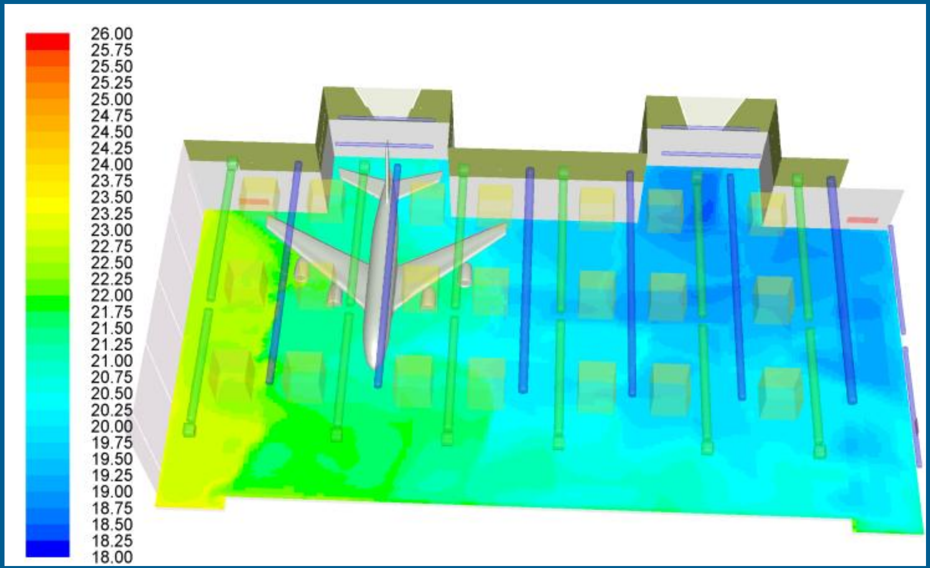
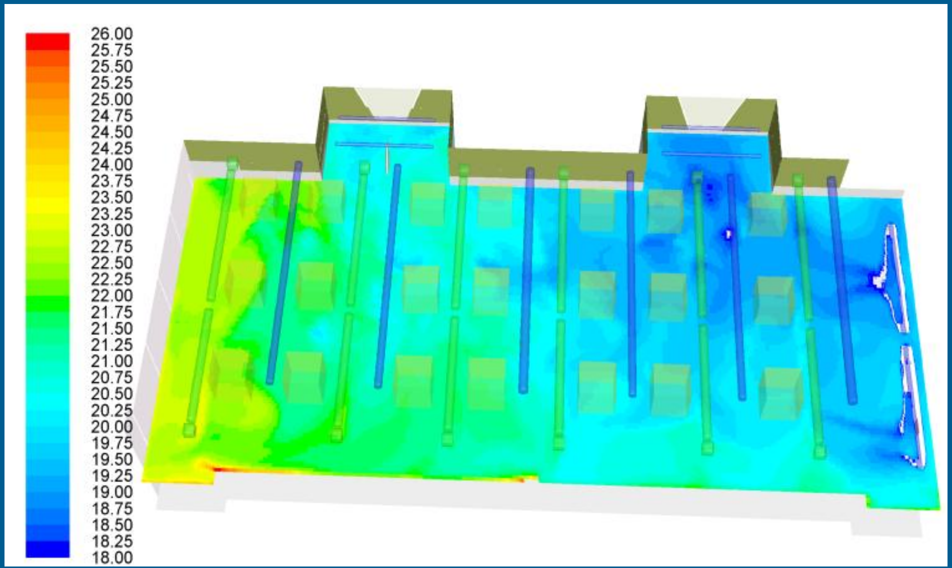
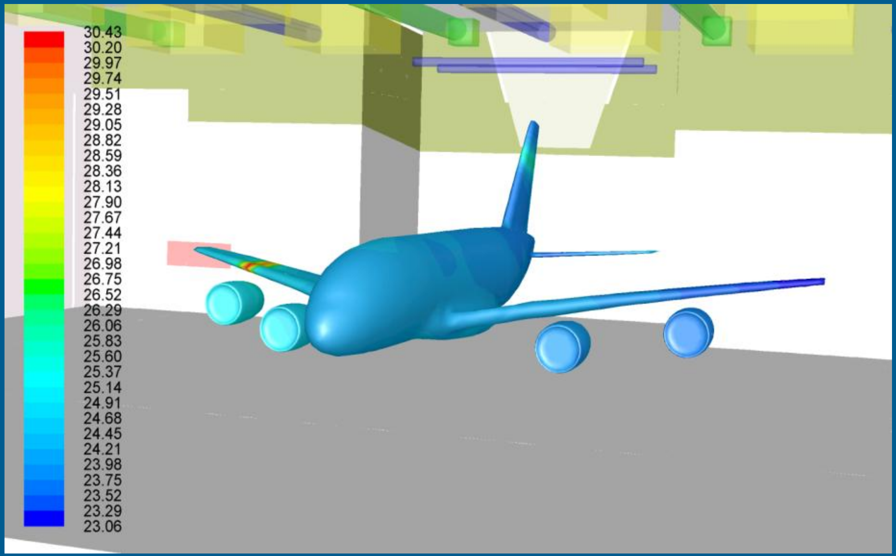
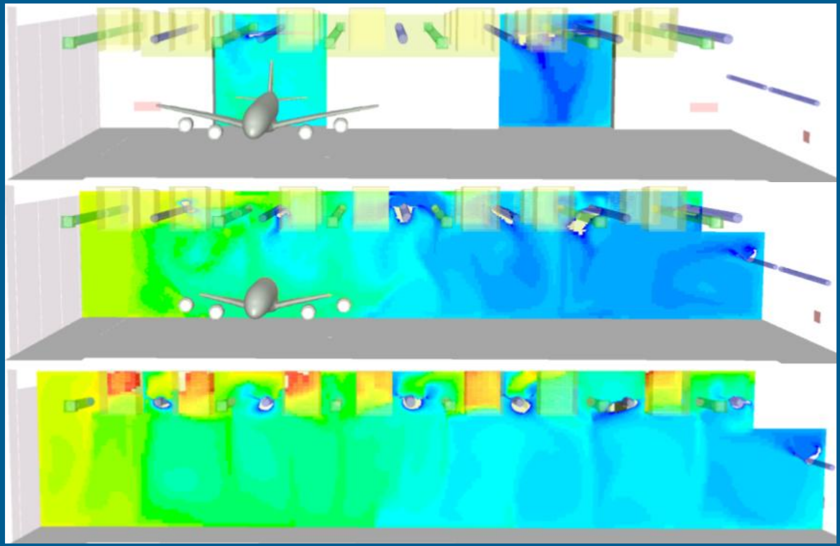
1c. CFD for Ventilation & A/C of HVH of NDIA









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1c. CFD for Ventilation & A/C of HVH of NDIA

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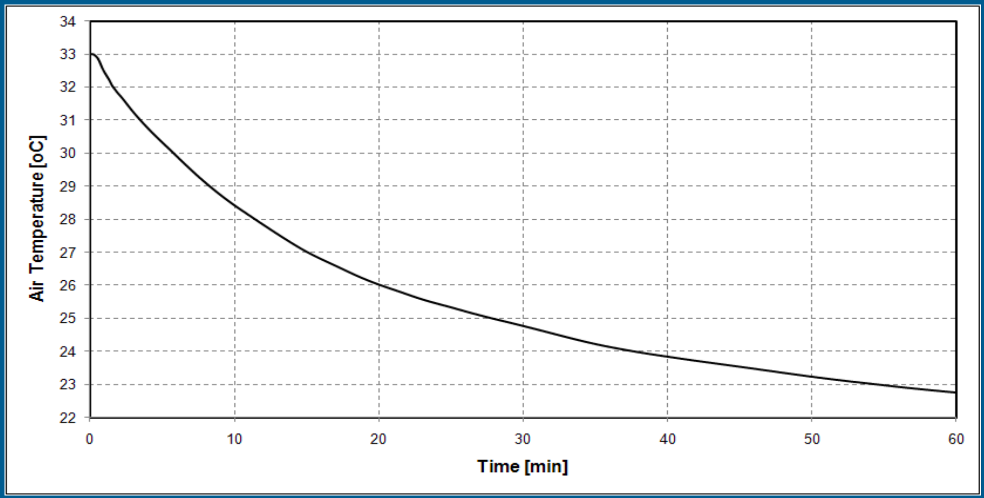

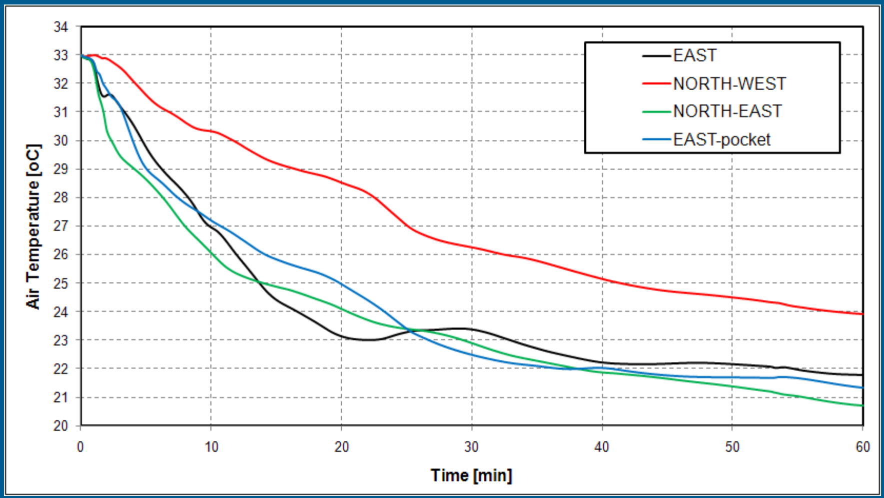

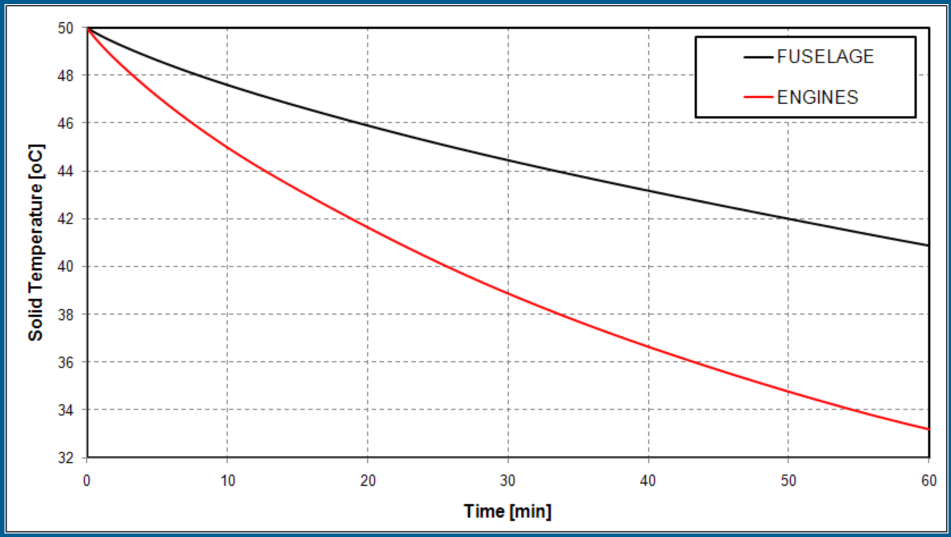

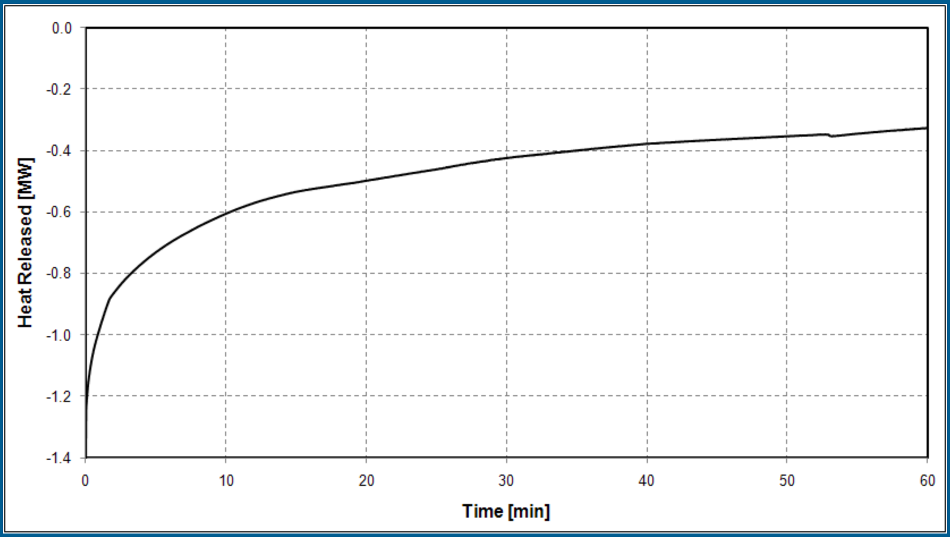

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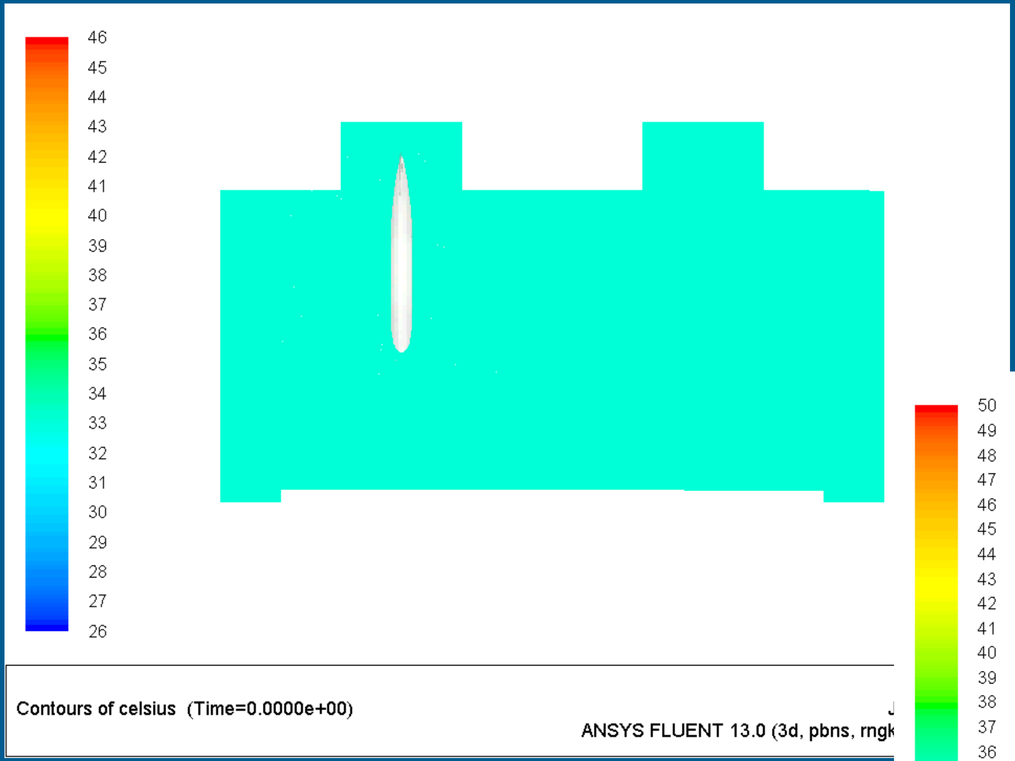
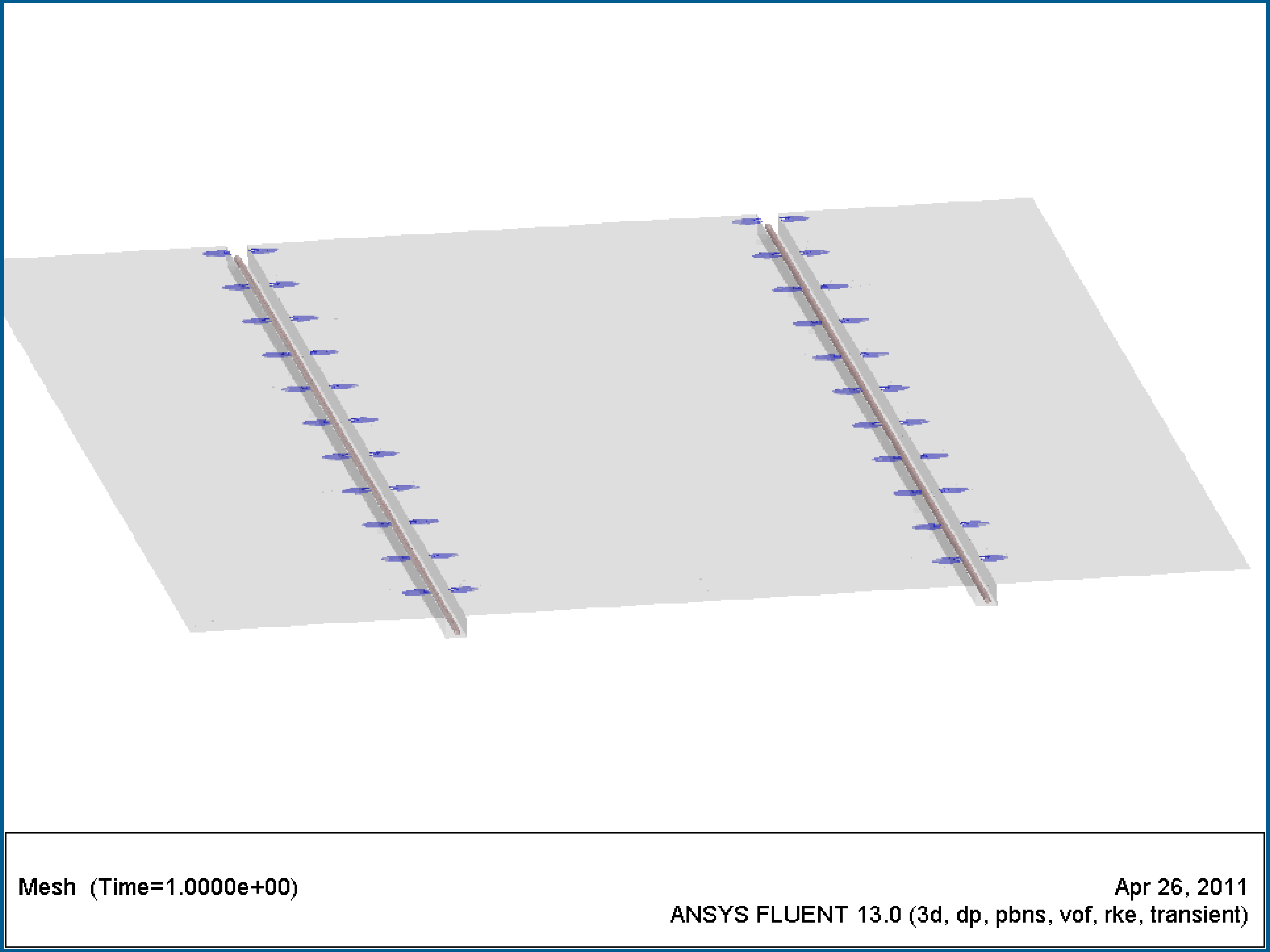


Contours of celsius (Time=0.0000e+00)
ANSYS FLUENT 13.0 (3d, pbns, rngk

Contours of celcius-wall (Time=0.0000e+00)
Jan 05, 2011
ANSYS FLUENT 13.0 (3d, pbns, rngke, transient)

1d. CFD of Floor Fire Suppression of HVH of NDIA



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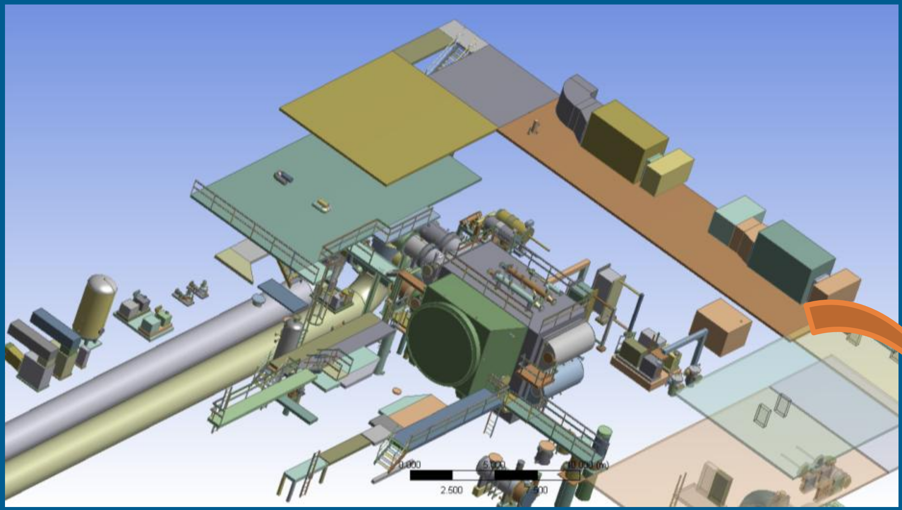
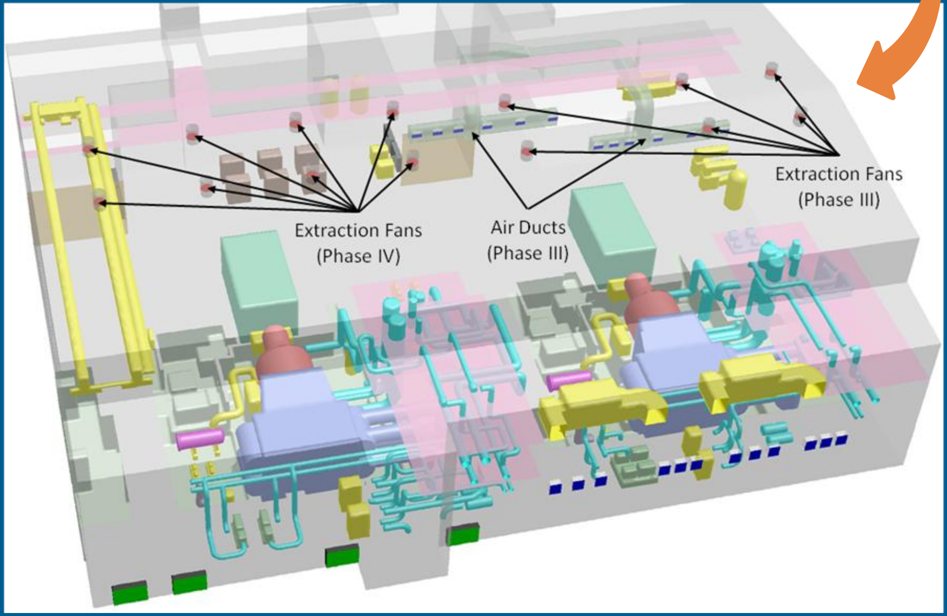
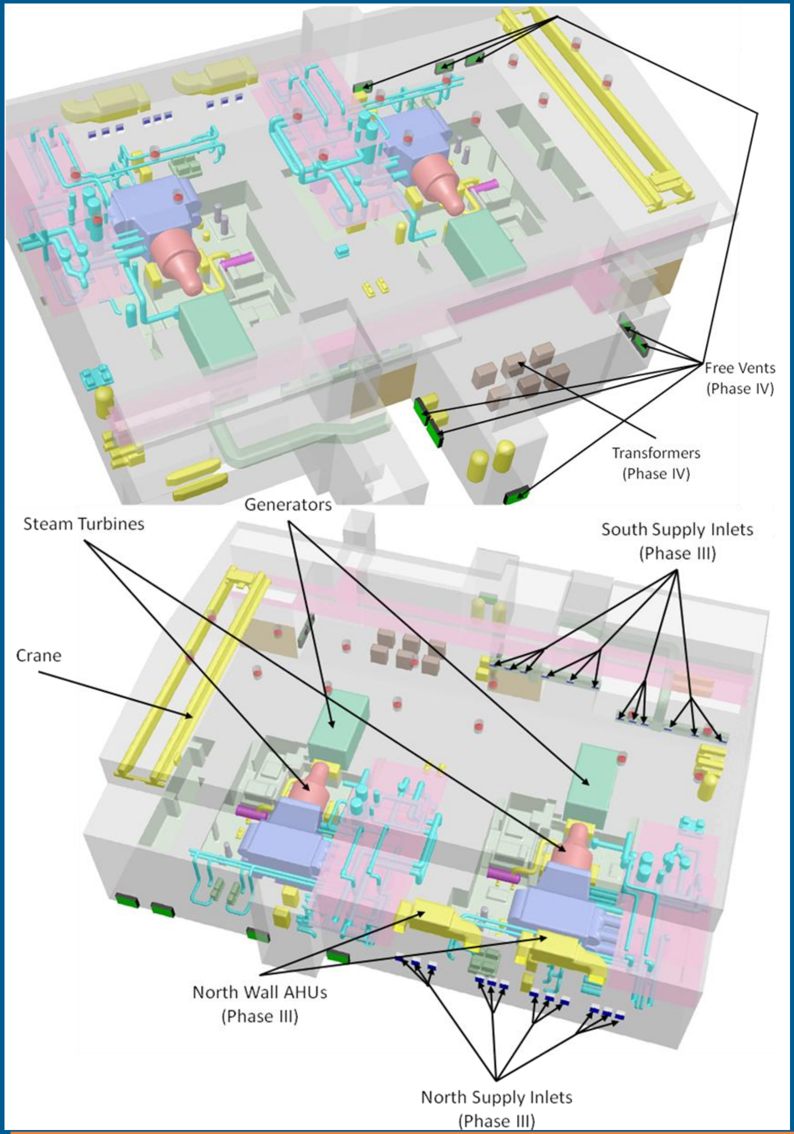
1e. CFD Model for Ventilation of Steam Turbine Hall





1e. CFD Model for Ventilation of Steam Turbine Hall

SimTec Software & Services



- ***Expansion of Phase III, in the same building (PhaseIV).***
- ***Confirmation of temperatures & overpressure.***

- ***Solar load calculation at the building envelope.***
- ***Specific weather conditions (38 °C).***
- ***Heat release from equipment (turbines, generators, etc.) of 307 [kW].***
- ***Cool air supply from 24 nozzles at low height, extraction by 14 roof fans and 9 free vents at the floor level.***
- ***Turbulent flow, temperature-dependent properties, buoyant forces.***

Partnership for Advanced Computing in Europe

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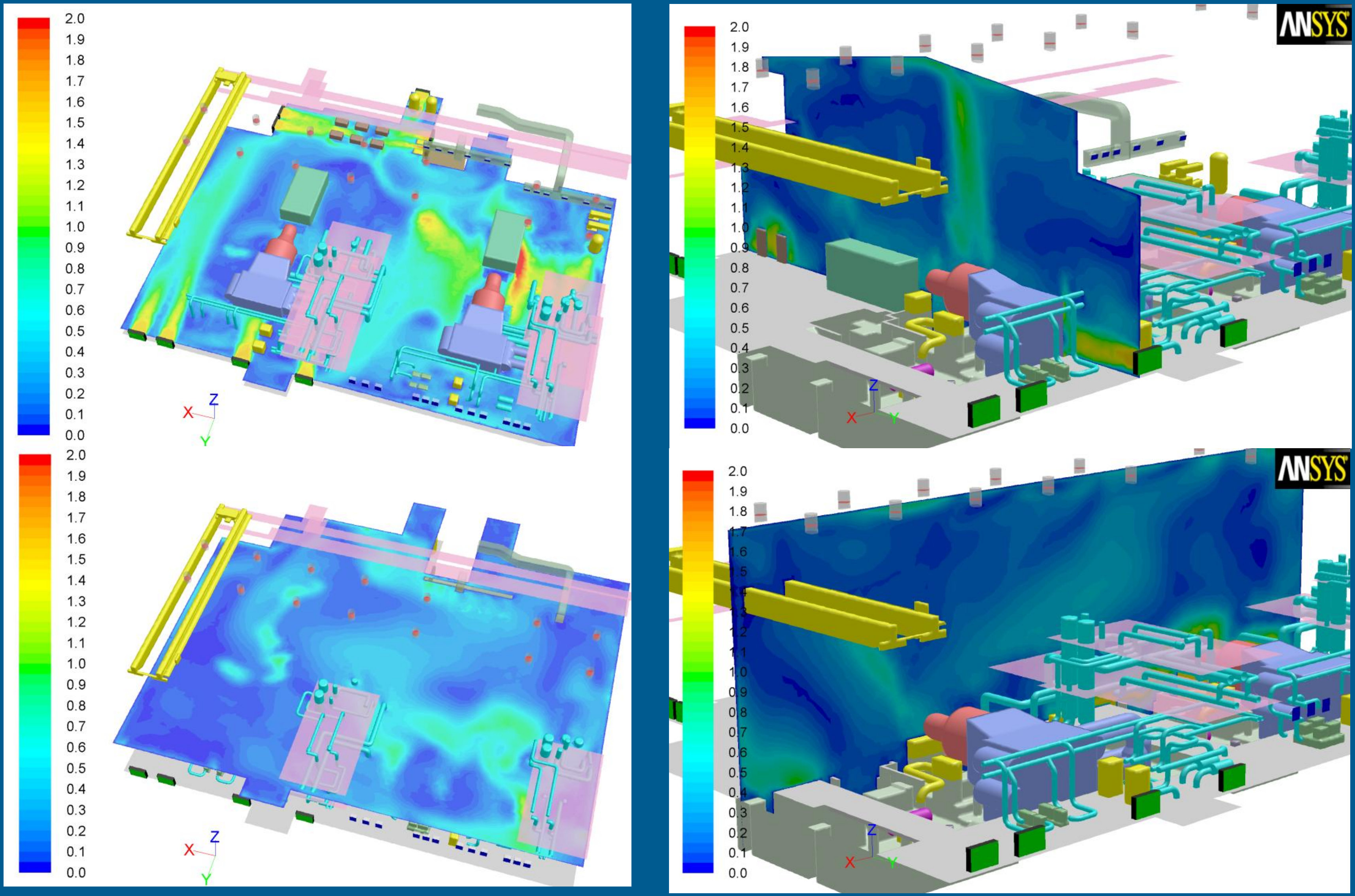

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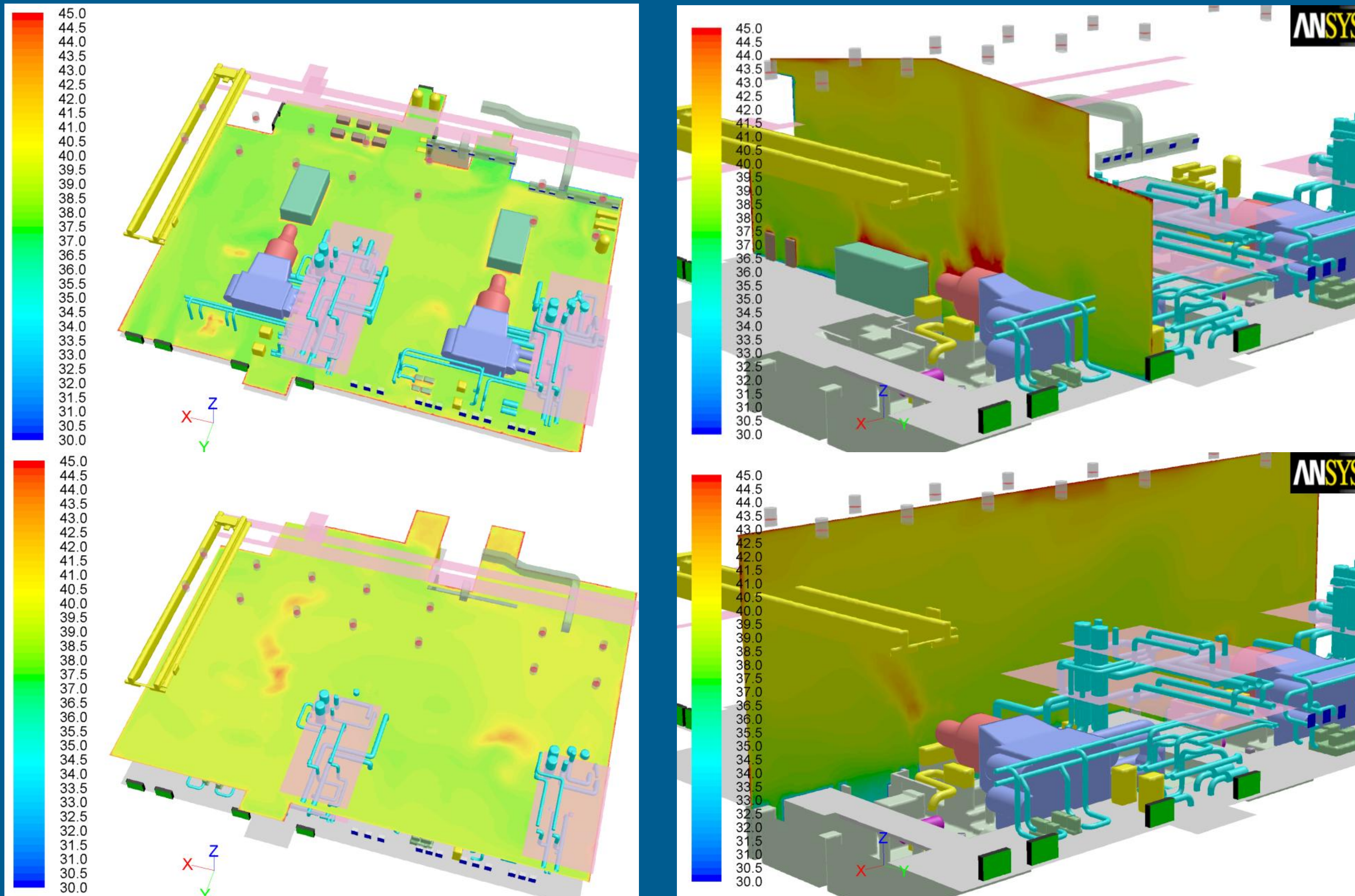

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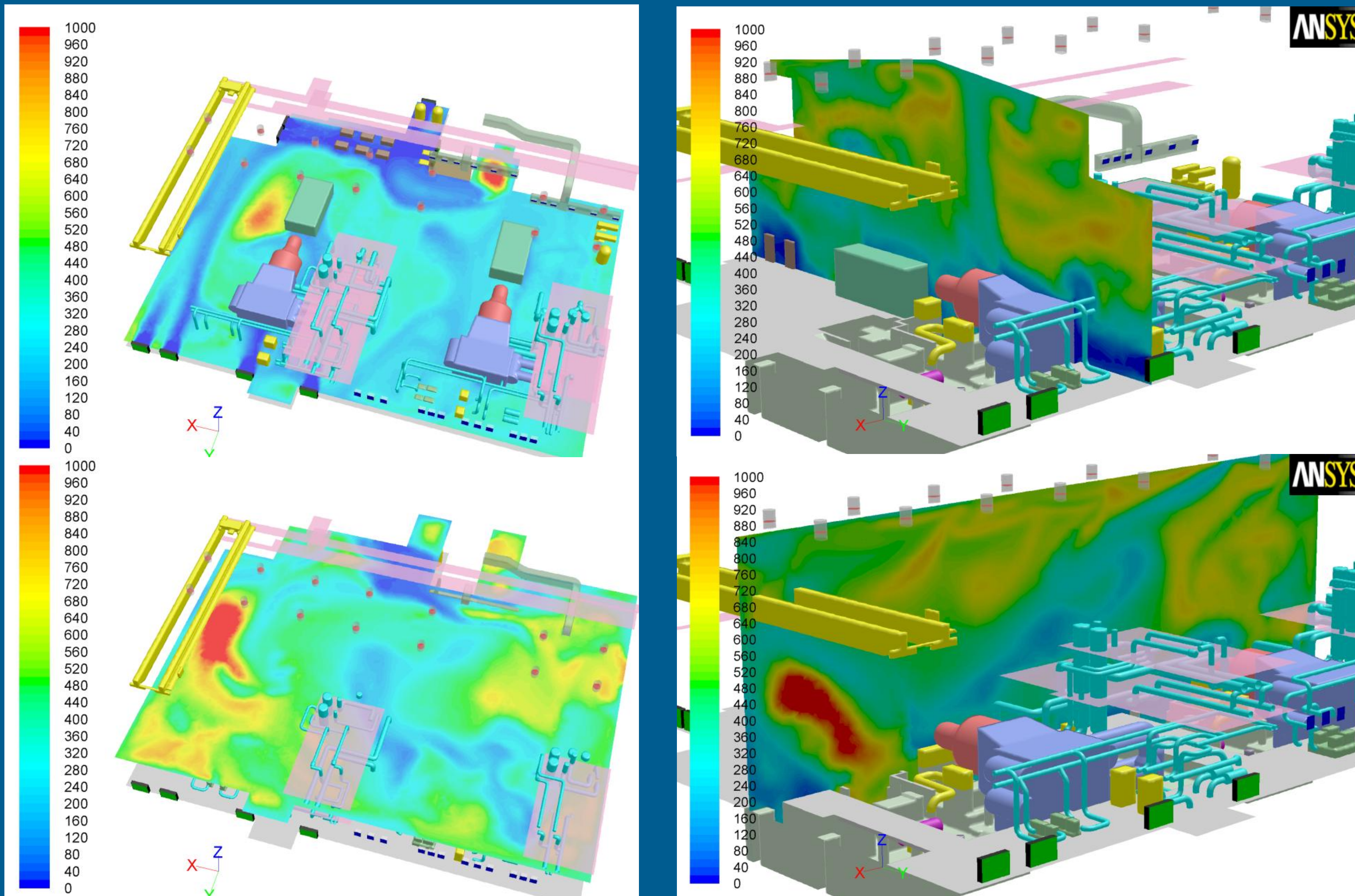
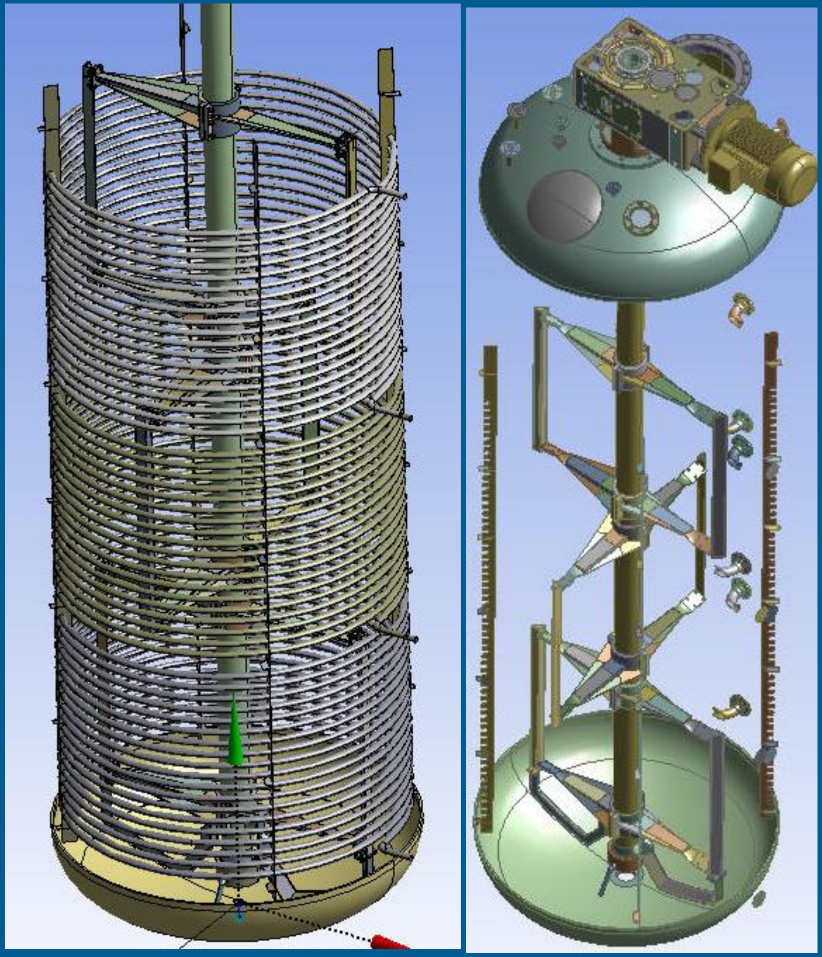
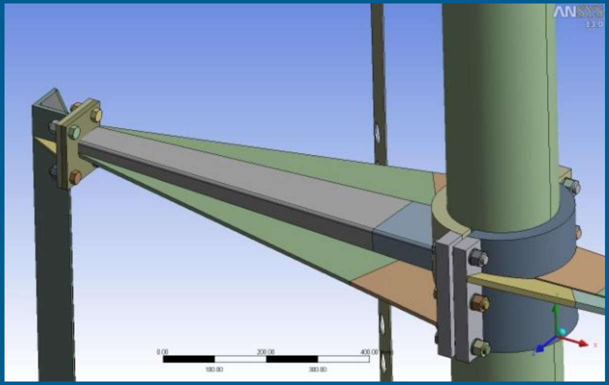
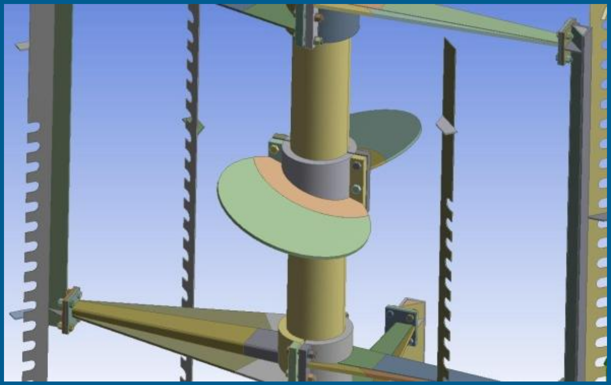
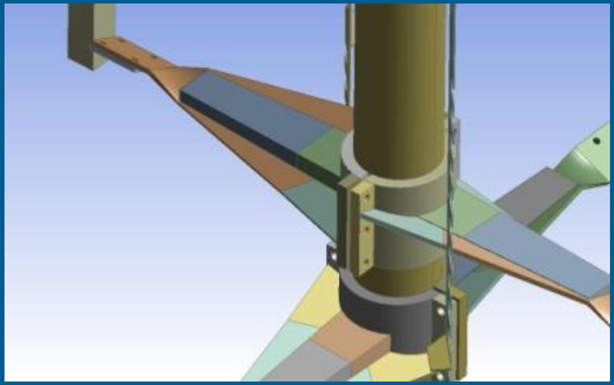
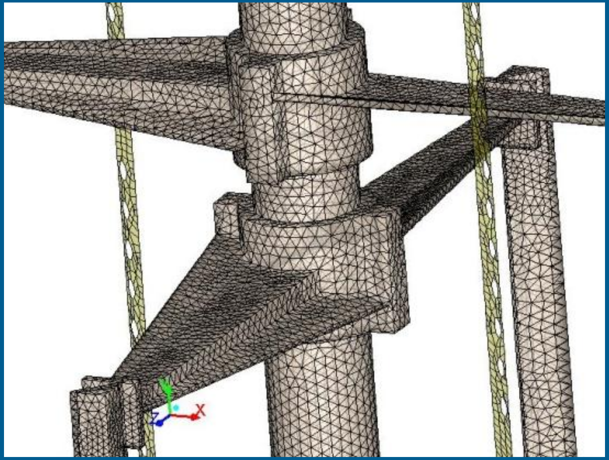
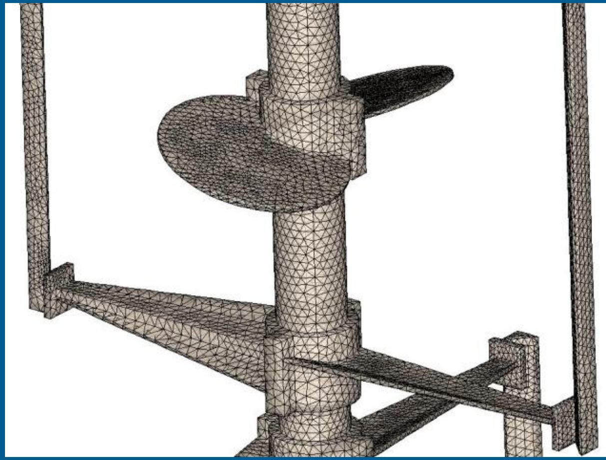
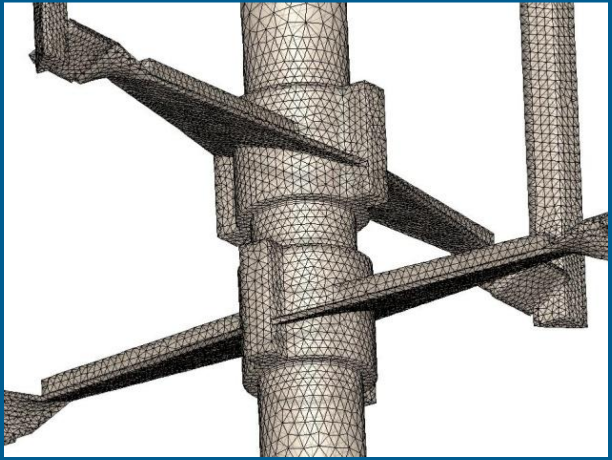


1f. CFD Analysis of a Batch Reactor

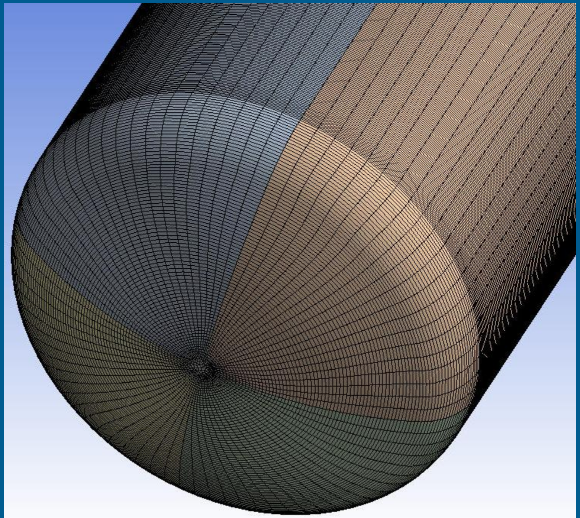
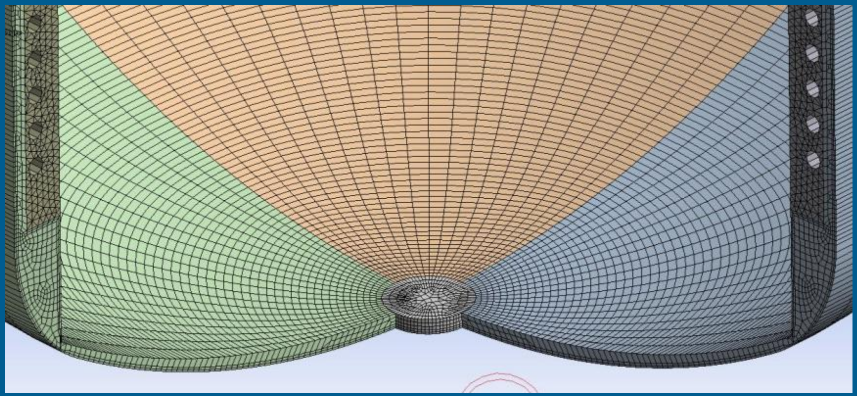
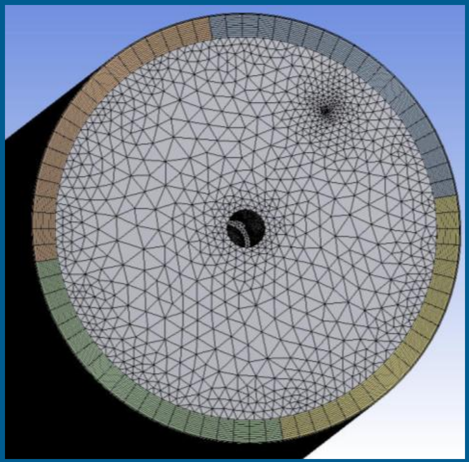


3 Blades in 90º Staggered Configuration

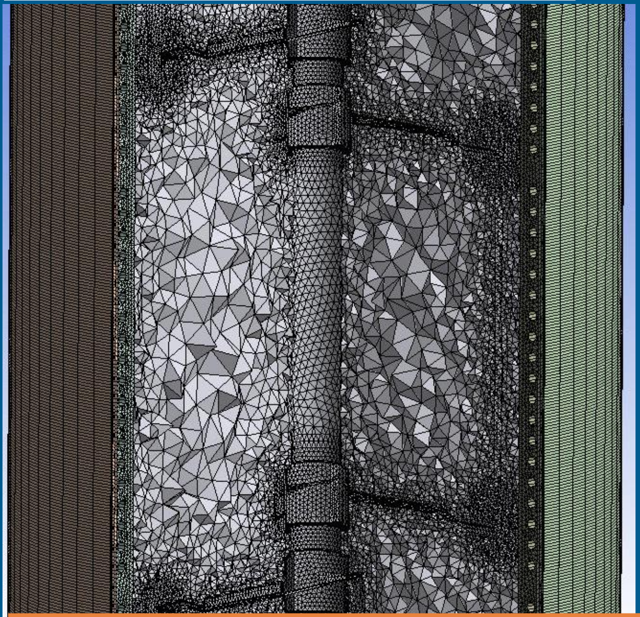
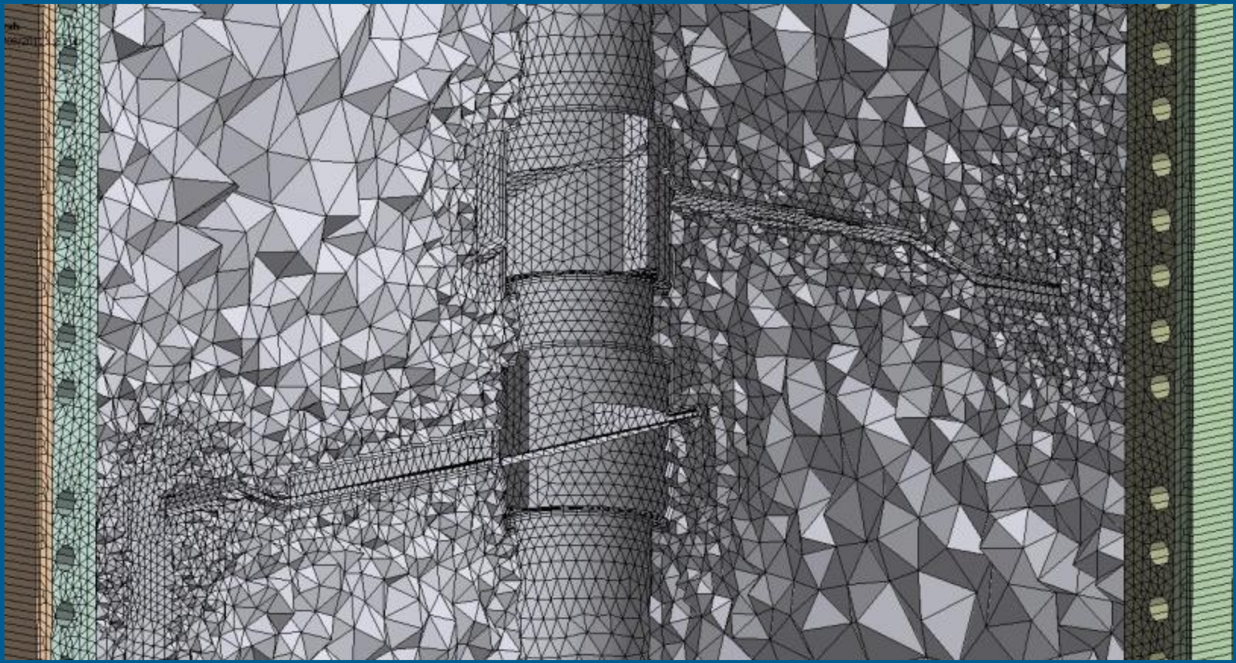
- ***Scale–Up of an existing reactor 10 [m³] to one of 30 [m³].***
- ***Evaluation of 3 alternative impellers for faster mixing.***
- ***Fluid injection into a water solution from the top. Injection duration 20 [s].***
- ***Free surface modeled as symmetry plane. Injection modeled as mass and momentum sources.***
- ***Rotation speed 44 [rpm].***
- ***Turbulent flow, mixture of 2 liquids (equivalent to water).***
- ***Simplification of the solution by 4 solution stages.***

Impeller #1	Impeller #2	Impeller #3
		
		
2.2M cells	2.1M cells	3.0M cells

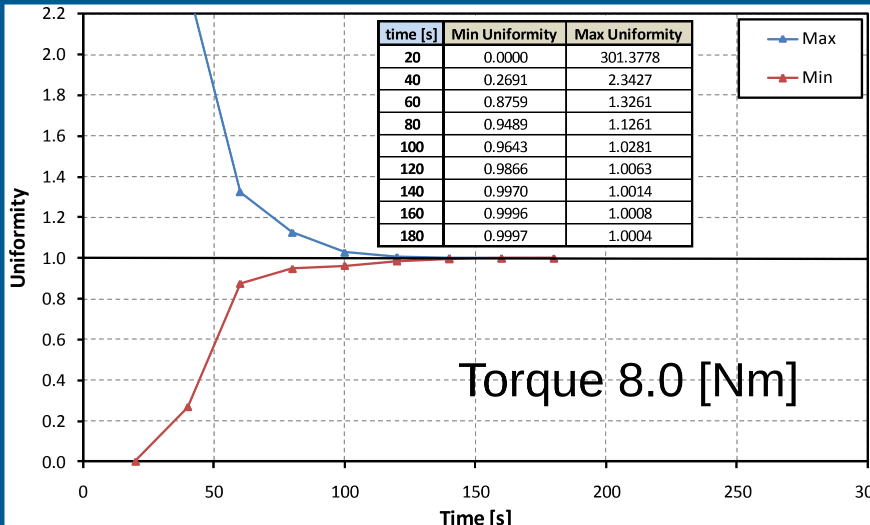
1f. CFD Analysis of a Batch Reactor

Impeller #3

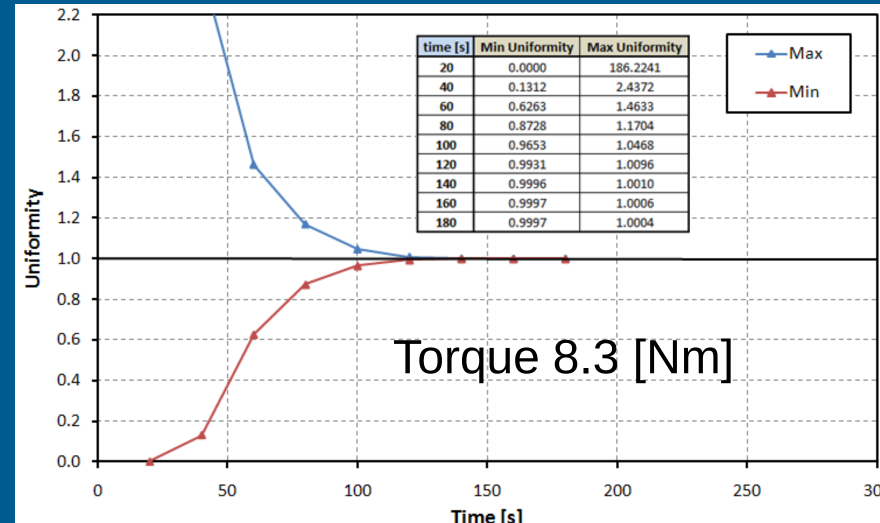



1f. CFD Analysis of a Batch Reactor



time [s]	Min Uniformity	Max Uniformity
20	0.0000	301.3778
40	0.2691	2.3427
60	0.8759	1.3261
80	0.9489	1.1261
100	0.9643	1.0281
120	0.9866	1.0063
140	0.9970	1.0014
160	0.9996	1.0008
180	0.9997	1.0004

Impeller #1

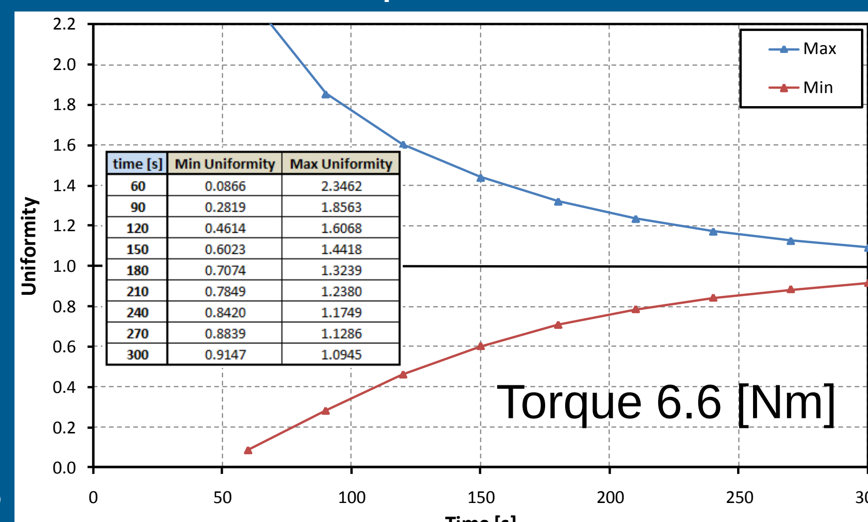


time [s]	Min Uniformity	Max Uniformity
20	0.0000	186.2241
40	0.1312	2.4372
60	0.6263	1.4633
80	0.8728	1.1704
100	0.9653	1.0468
120	0.9931	1.0096
140	0.9996	1.0010
160	0.9997	1.0006
180	0.9997	1.0004

Impeller #2

Uniformity

$$U(t) = 1 - \frac{\left[C_\infty - C(t)\right]}{C_\infty}$$

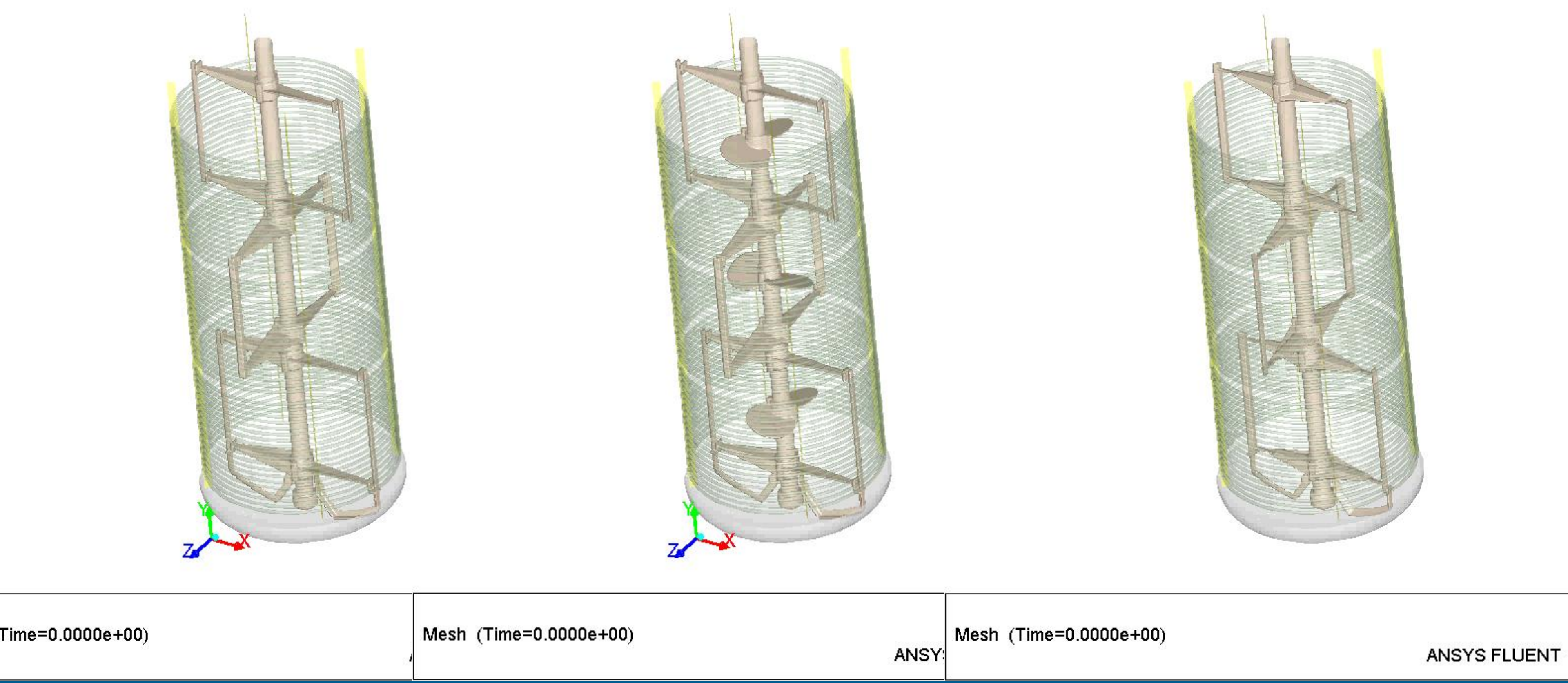


time [s]	Min Uniformity	Max Uniformity
60	0.0866	2.3462
90	0.2819	1.8563
120	0.4614	1.6068
150	0.6023	1.4418
180	0.7074	1.3239
210	0.7849	1.2380
240	0.8420	1.1749
270	0.8839	1.1286
300	0.9147	1.0945

Impeller #3

1f. CFD Analysis of a Batch Reactor

Impeller #1 | Impeller #2 | Impeller #3



Red: U=0.95
Green: U=0.97
Blue: U=1.00

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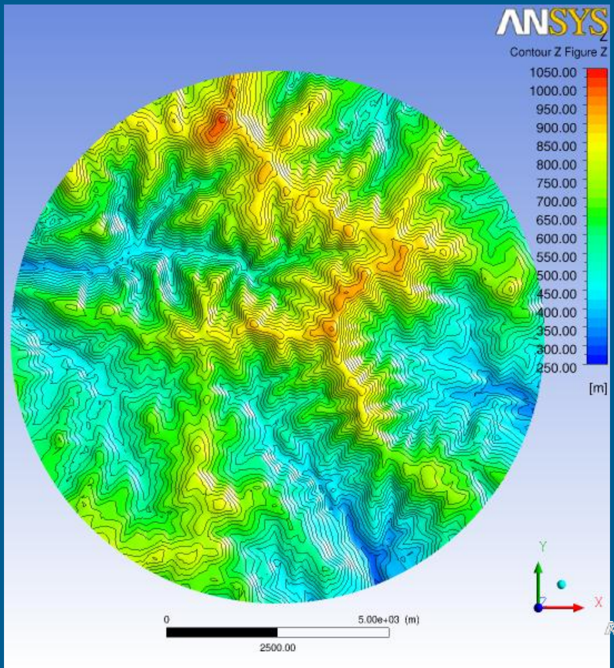
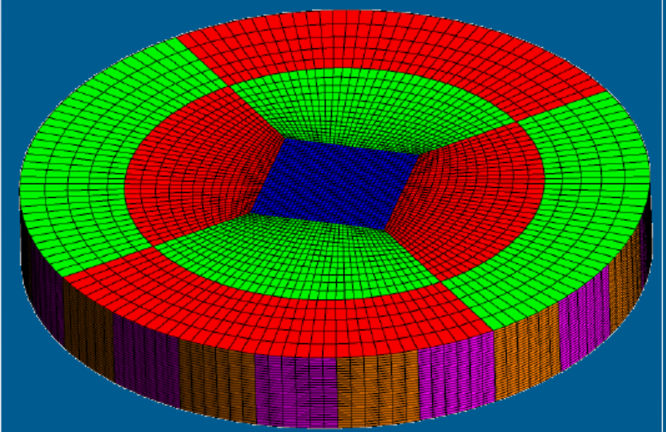
1g. Power Assessment of an Operating Wind Farm.



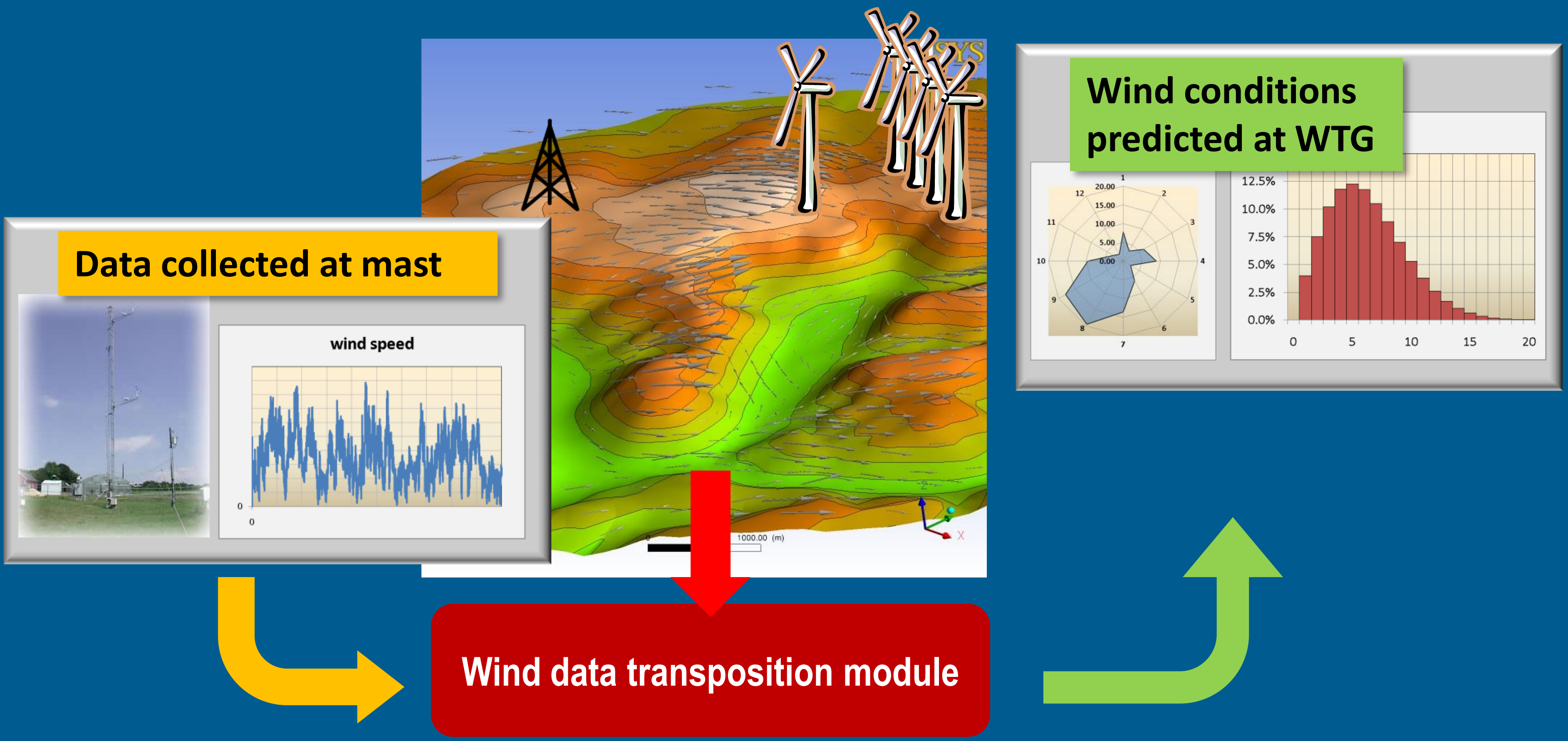


- ***Operating farm with 18 W/T in operation.***
- ***Available measurements at mast and power production for 1 year.***

- ***Domain radius=6000 [m], height=4000 [m]. Outer radial extend=1500 [m].***
- ***First cell at 2 [m], 1.42M cells. Automatic refinement around the W/T.***
- ***Division in 16 sectors (wind directions). Automatic alignment of W/T with the wind.***
- ***W/T modeled as negative momentum sources. W/T shadowing effects included.***
- ***Terrain roughness and forest model (porous medium).***
- ***Atmospheric boundary layer conditions at inlet, zero or no thermal gradient.***

1g. Power Assessment of an Operating Wind Farm.

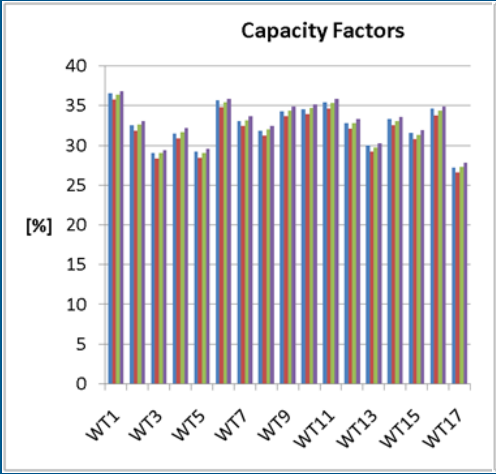
Transposition Method

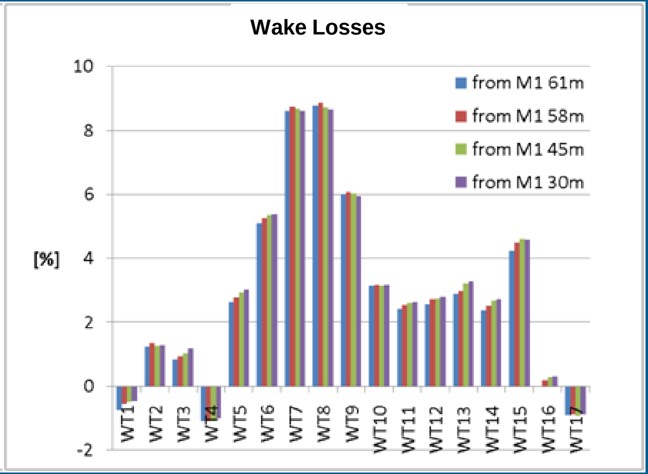


1g. Power Assessment of an Operating Wind Farm.

- ***64 automatically performed simulations (scripting) for 4 wind speeds (5, 10, 15 & 20 [m/s] at mast top height=60 [m]) and for 16 wind directions.***
- ***Self–correlation of the mast measurements.***
- ***W/T capacity factors were calculated, with reference to the predictions at the 4 mast heights, with statistical projection for the whole year of operation.***
- ***The same procedure was performed without shadowing effect. The difference of the two calculations is an estimate of the shadowing losses.***

Relative error	Wind speed predicted at			
Reference Mast	M1m61	M1m58	M1m45	M1m30
M1m61	0.00%	0.86%	–0.29%	–1.17%
M1m58	–0.99%	0.00%	–1.30%	–2.20%
M1m45	0.28%	1.29%	0.00%	–0.88%
M1m30	1.13%	2.01%	0.87%	0.00%





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1g. Power Assessment of an Operating Wind Farm.

- *Annual and monthly averages for the wind speed at the W/T hub height.*
- *Annual averages of the capacity factors per wind direction for each W/T.*
- *Annual averages κfor each wind speed range of the turbulence intensity at the W/T hub height.*
- *Wind speed, wind angle, turbulence intensity, shear factor at the W/T hub height per wind direction and wind speed range*
- *Power in [kW] in 10 [min] intervals for each W/T for the whole year of operation.*

Average wind speed at wind

	mast	WT1	WT
over all data	**7.07**	**7.97**	**7.5**
Jun	5.79	6.65	6.1
Jul	5.85	6.61	6.1
Aug	7.64	8.61	7.9
Sep	6.49	7.36	6.8
Oct	7.50	8.77	8.0
Nov	7.30	8.32	7.8
Dec	8.62	9.21	8.9
Jan	7.98	8.96	8.5
Feb	8.30	8.99	8.6
Mar	6.71	7.58	7.2
Apr	7.16	8.12	7.5
May	6.11	7.02	6.5

Capacity factors predicted from

Wind Direction	0	22.5	
WT1	22.86	53.38	2
WT2	25.61	47.16	1
WT3	23.48	43.14	1
WT4	31.01	47.66	1
WT5	35.06	40.11	1
WT6	29.11	50.39	2
WT7	26.25	49.01	3
WT8	21.81	48.75	2
WT9	20.17	54.18	2
WT10	22.25	54.66	2
WT11	31.53	53.78	1
WT12	28.73	47.56	1
WT13	20.94	42.38	1
WT14	26.16	50.42	1
WT15	32.61	43.86	1
WT16	33.71	50.15	2
WT17	32.23	38.11	9

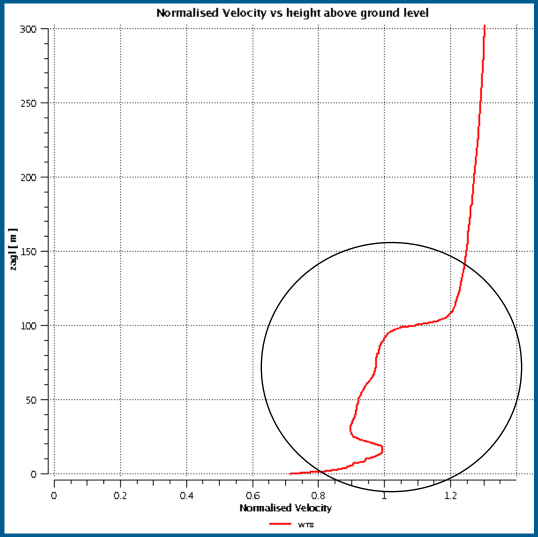
TI predicted from anemometer M1m61

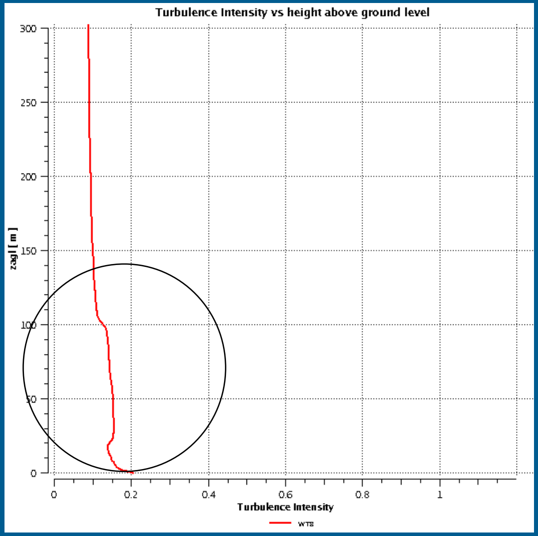
Class	Speed [m/s]	mean TI at WT1	repr TI at WT1	mean TI at WT2	repr TI at WT
Yearly-Average		0.146	0.249	0.153	0.26
0	0.25	0.657	0.951	0.619	0.90
1	1	0.322	0.519	0.321	0.51
2	2	0.228	0.387	0.233	0.39
3	3	0.197	0.328	0.198	0.33
4	4	0.177	0.294	0.180	0.30
5	5	0.173	0.281	0.169	0.27
6	6	0.156	0.257	0.163	0.26
7	7	0.146	0.236	0.159	0.24
8	8	0.147	0.228	0.156	0.23
9	9	0.145	0.218	0.154	0.22
10	10	0.144	0.211	0.152	0.21
11	11	0.143	0.206	0.146	0.20
12	12	0.138	0.197	0.141	0.19
13	13	0.135	0.184	0.137	0.18
14	14	0.130	0.175	0.132	0.17
15	15	0.126	0.167	0.129	0.16
16	16	0.124	0.162	0.127	0.16
17	17	0.122	0.159	0.125	0.16
18	18	0.119	0.153	0.117	0.14
19	19	0.115	0.146	0.112	0.14
20	20	0.110	0.136	0.115	0.14
21	21	0.111	0.136	0.118	0.14
22	22	0.114	0.140	0.113	0.13
23	23	0.108	0.130	0.111	0.13
24	24	0.107	0.132	0.108	0.13
25	25	0.100	0.112	0.107	0.11
26	26	0.099	0.107	0.104	0.11
27	27	0.101	0.109	0.100	0.10
28	28	0.101	0.114	0.000	0.00
29	29	0.096	0.096	0.000	0.00

Table 26. Upflow Angle at wind turbine locations for each direction

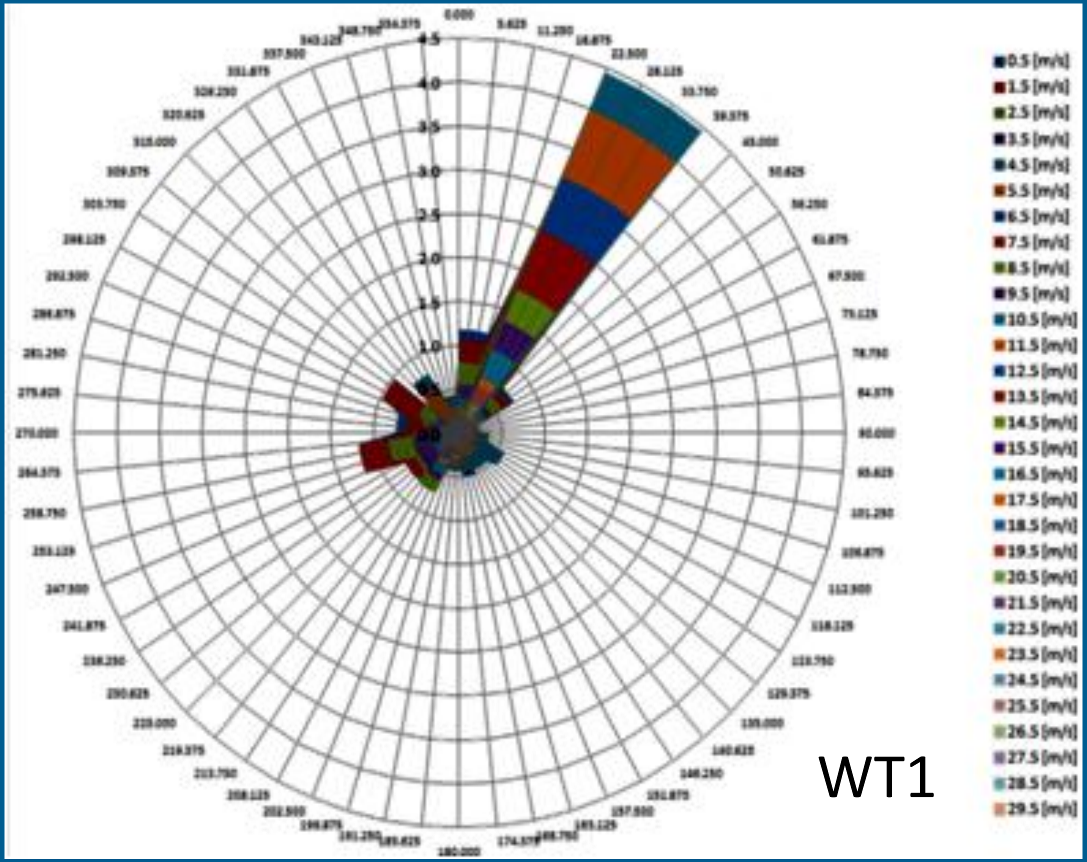
Reference speed	10															
Location / Direction	**0**	**22**	**45**	**67**	**90**	**112**	**135**	**157**	**180**	**202**	**225**	**247**	**270**	**292**	**315**	**337**
WT1	5.720	3.568	1.663	-0.396	-1.936	-3.767	-2.031	-1.148	-0.204	0.939	2.550	4.718	5.836	6.531	6.027	5.384
WT2	2.912	2.993	3.130	1.987	1.639	1.663	2.302	2.272	2.201	2.683	2.940	2.668	1.776	2.285	2.140	2.879
WT3	4.096	3.757	3.679	0.372	-1.078	-1.958	-1.424	-0.702	-0.167	0.959	2.514	5.293	5.863	7.191	7.780	4.996
WT4	3.434	3.847	3.632	1.927	1.251	0.333	0.098	0.130	0.644	0.610	1.277	2.238	2.909	5.194	4.752	3.270
WT5	2.168	1.714	-0.818	-1.413	-0.421	0.975	2.835	2.952	3.752	3.355	4.245	5.009	4.745	3.718	3.599	2.639
WT6	4.614	3.988	2.629	1.045	-0.032	-1.894	1.051	4.638	5.805	4.974	4.441	4.888	5.454	5.801	5.076	4.289
WT7	3.648	6.047	5.470	4.693	3.844	4.170	5.140	7.705	10.215	9.589	6.586	3.031	-0.763	-2.643	-0.813	0.132
WT8	8.837	8.214	5.125	4.059	1.520	1.891	2.363	4.504	8.461	7.754	6.125	3.974	1.873	3.140	3.153	4.019
WT9	7.121	6.622	3.252	2.618	-0.047	0.419	2.066	3.355	7.027	8.034	6.695	5.368	3.004	2.601	3.172	3.492
WT10	6.967	5.111	4.799	3.909	2.217	1.077	0.450	-0.399	-0.022	0.370	0.862	1.681	1.076	1.880	3.512	4.824
WT11	0.866	-0.759	-2.270	-4.216	-2.567	-2.433	-0.874	1.526	2.505	4.918	5.796	6.126	8.316	5.330	4.582	2.533
WT12	-0.543	-2.784	-5.034	-5.040	-2.759	-0.731	0.644	2.789	3.836	5.390	6.213	5.693	6.742	3.948	2.974	1.237
WT13	-0.938	-1.317	-0.539	1.087	3.184	7.392	4.454	3.776	4.238	4.864	4.684	4.370	5.528	3.368	2.723	1.253
WT14	0.574	1.062	1.695	3.401	4.075	5.899	7.554	8.202	5.265	4.546	2.101	0.181	0.812	0.050	0.839	0.822
WT15	-0.938	-0.373	1.820	3.970	5.177	6.960	7.165	8.494	5.889	4.704	0.434	-1.668	-1.475	-1.725	-0.487	-0.676
WT16	1.996	2.632	3.436	3.121	3.506	2.851	2.894	3.362	1.629	0.367	0.341	1.243	2.019	1.402	2.473	1.352
WT17	-1.605	-0.259	-0.427	1.160	4.374	4.266	5.165	4.912	5.116	5.108	4.773	3.295	1.277	0.772	-1.164	-1.704

1g. Power Assessment of an Operating Wind Farm.



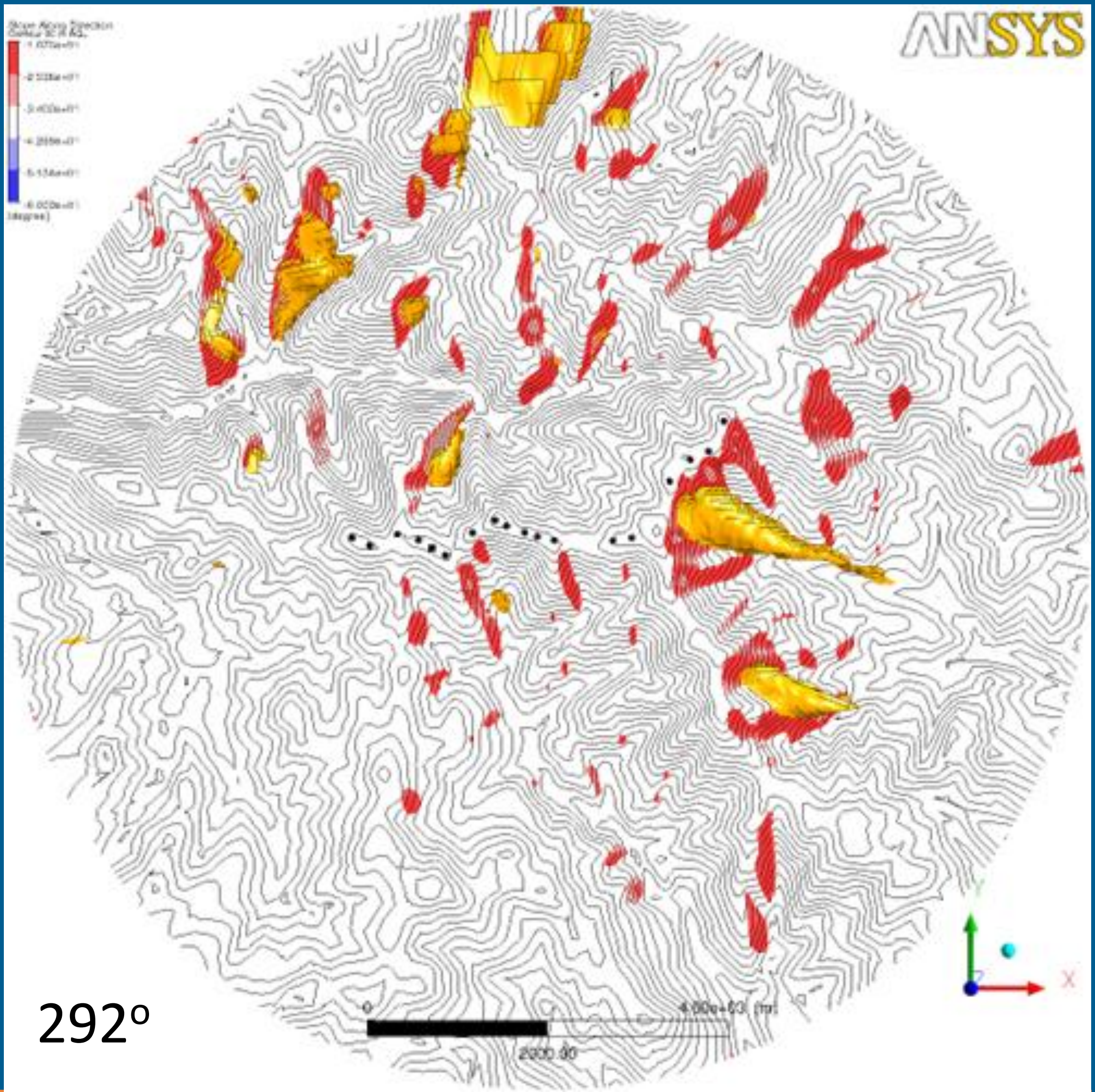


Automatic Production of Graphs.



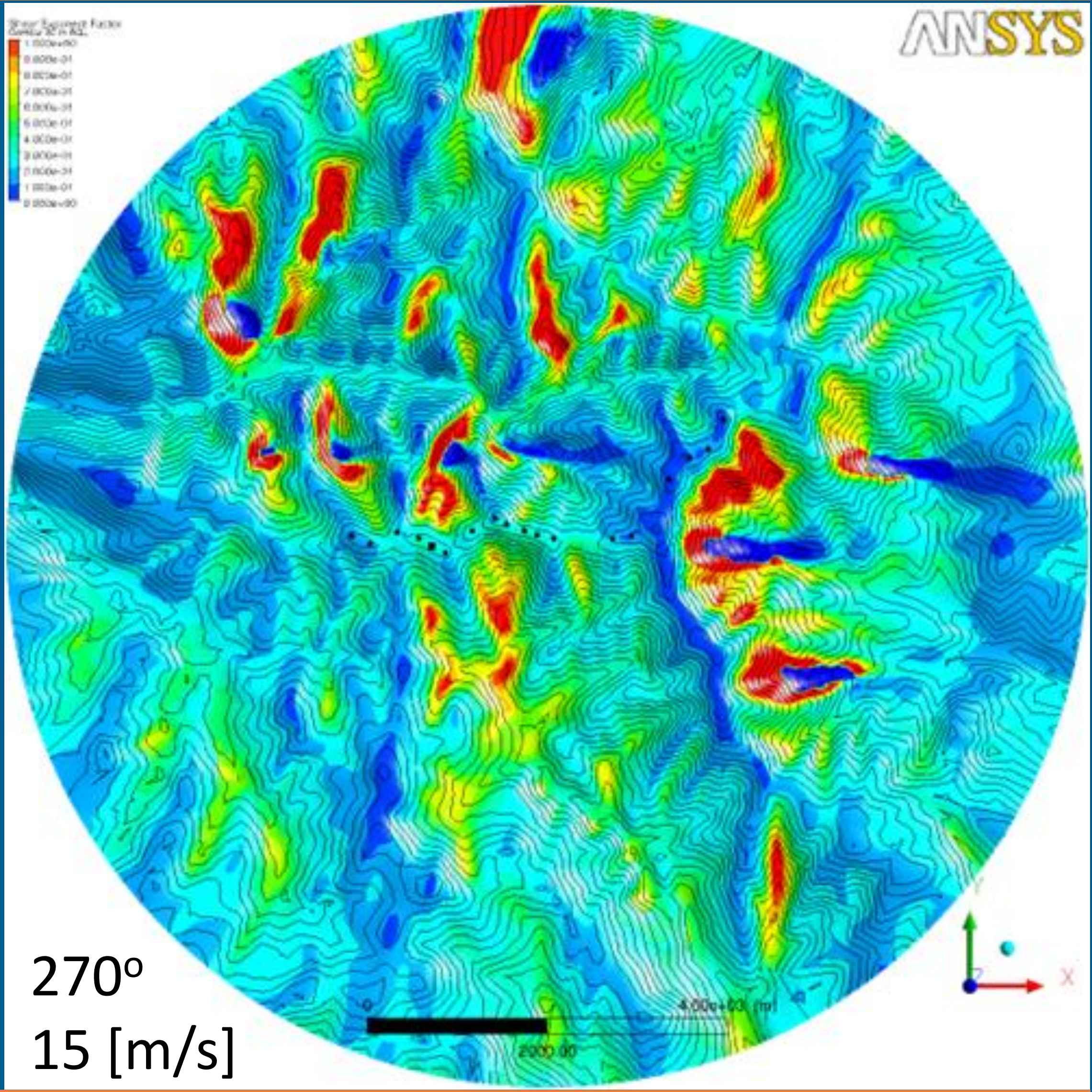
1g. Power Assessment of an Operating Wind Farm.

Contours of critical terrain (>16.7º) along the wind direction.



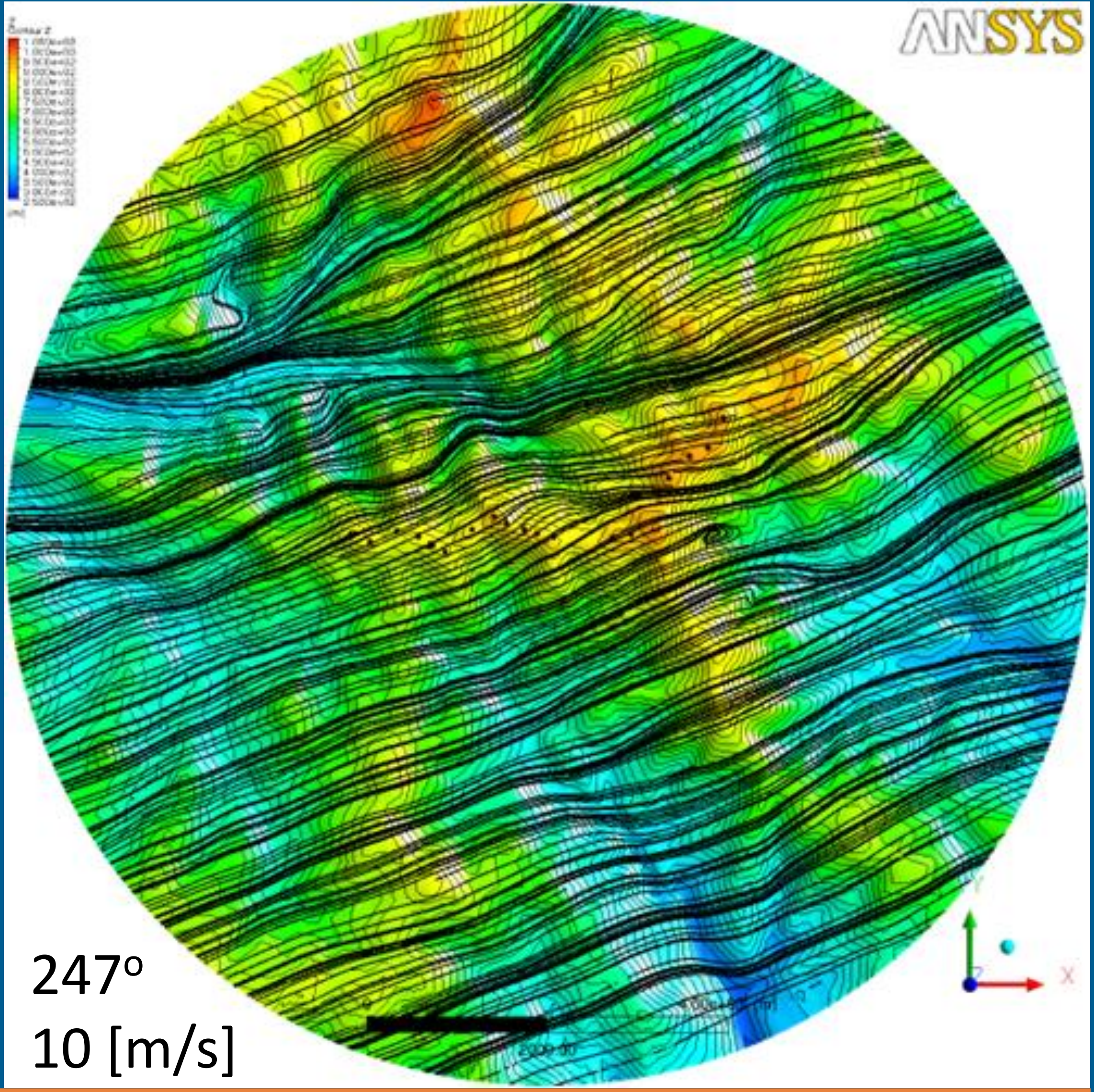
1g. Power Assessment of an Operating Wind Farm.

Contours of the shear factor at the W/T hub height, per wind speed range and wind direction.



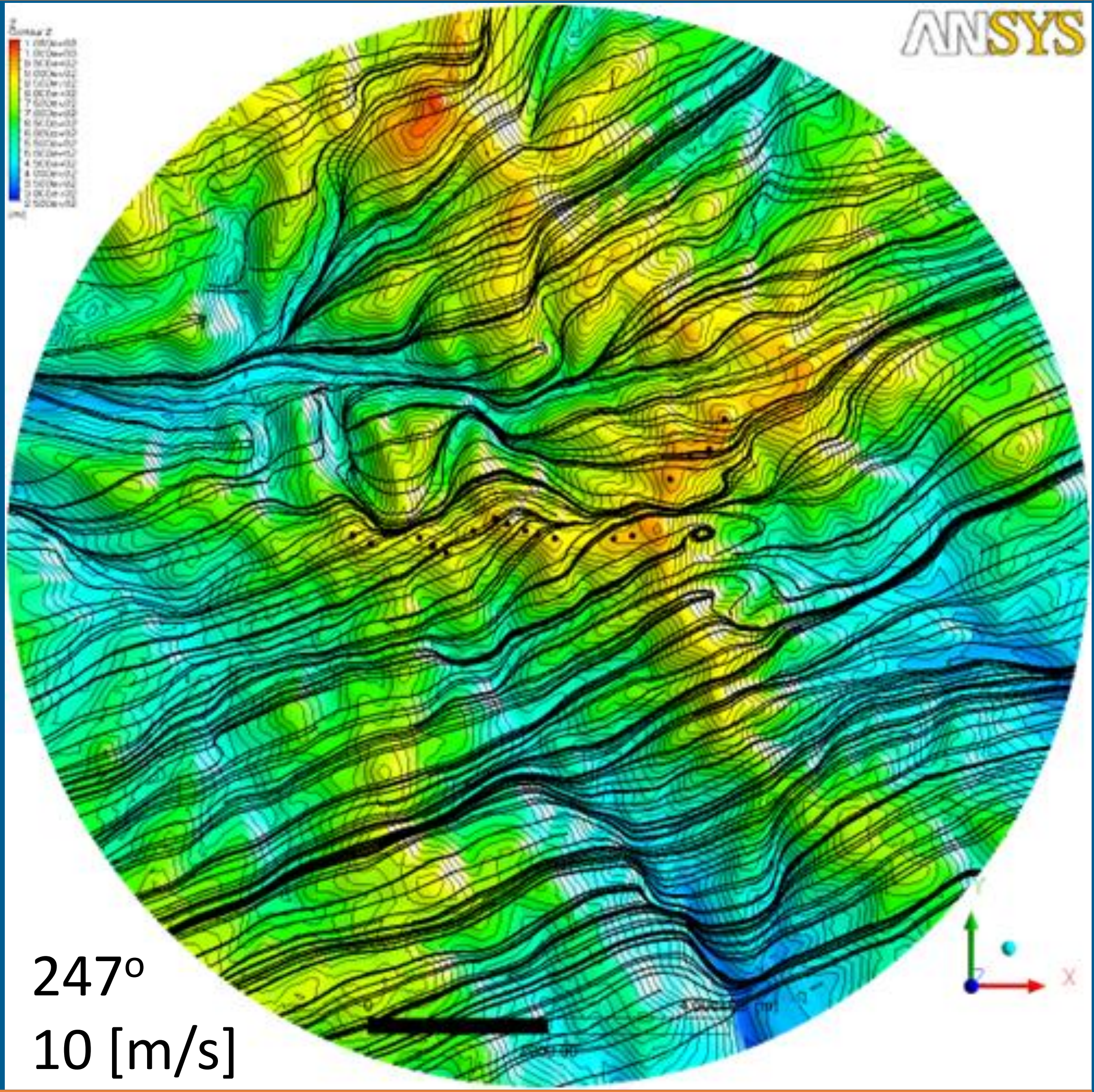
1g. Power Assessment of an Operating Wind Farm.

Pathlines at W/T hub height, per wind speed range and wind direction.



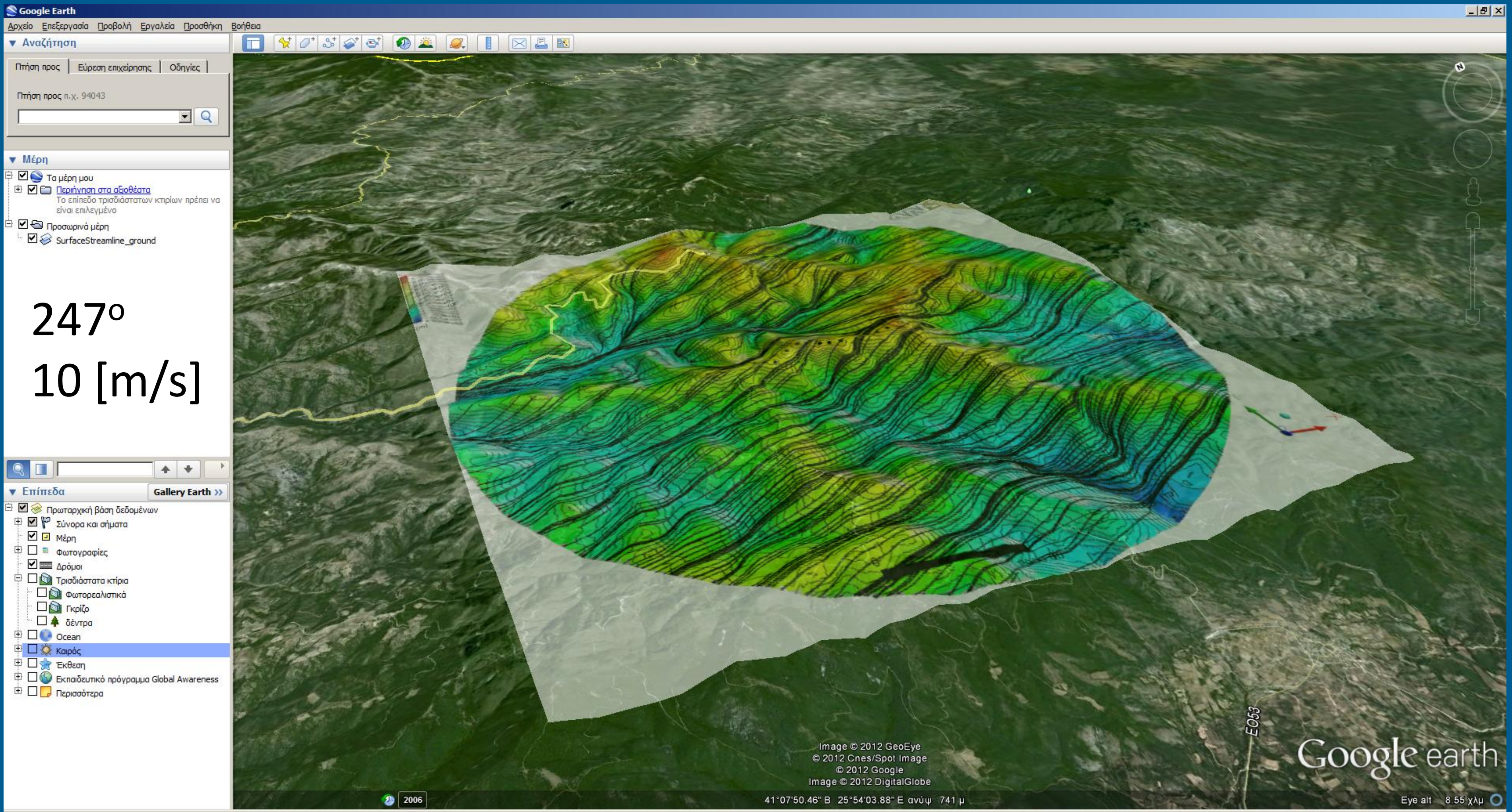
1g. Power Assessment of an Operating Wind Farm.

Pathlines on the ground , per wind speed range and wind direction.

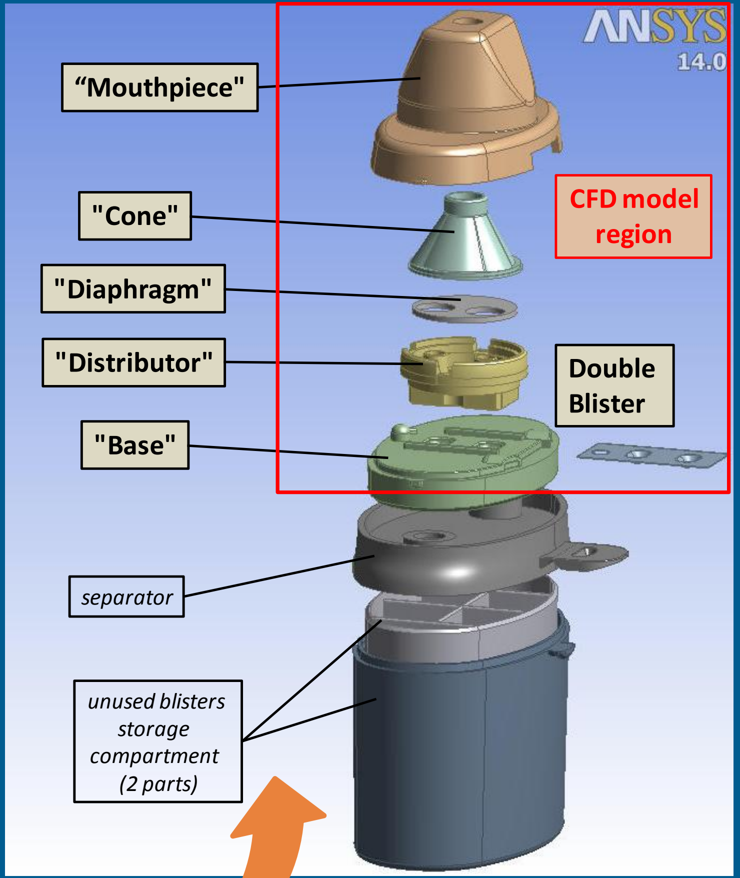


1g. Power Assessment of an Operating Wind Farm.

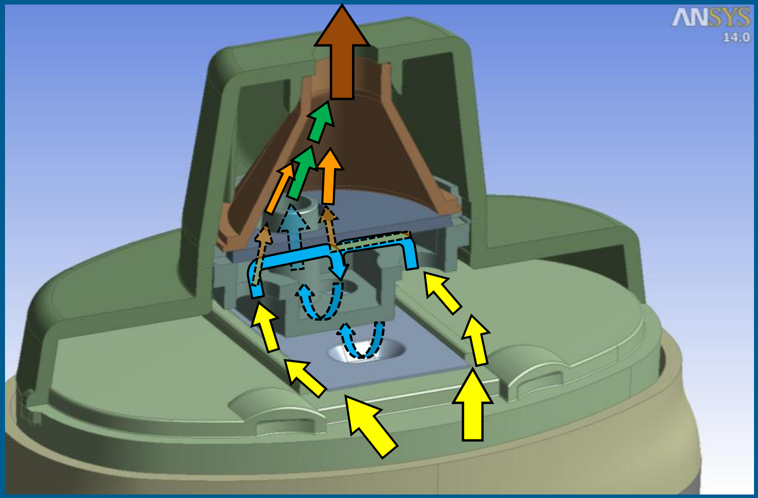
All graphs available on GoogleEarth!

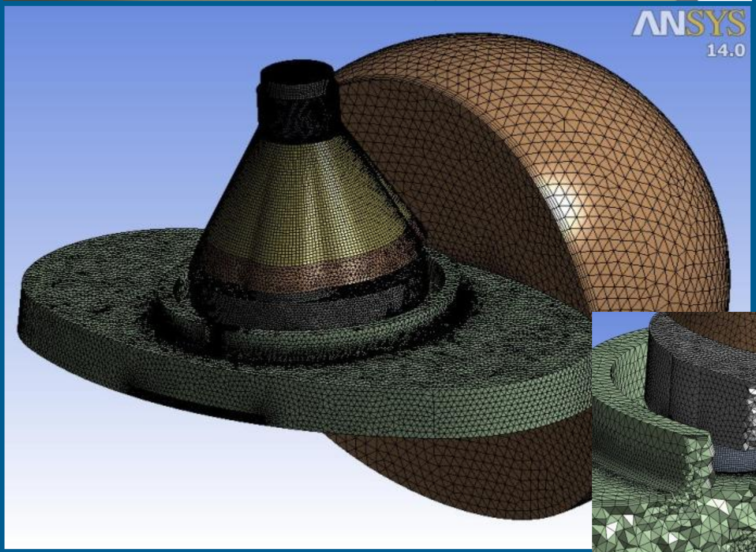


1h. CFD Study of a Drag Inhaler (Elpenhaler®)



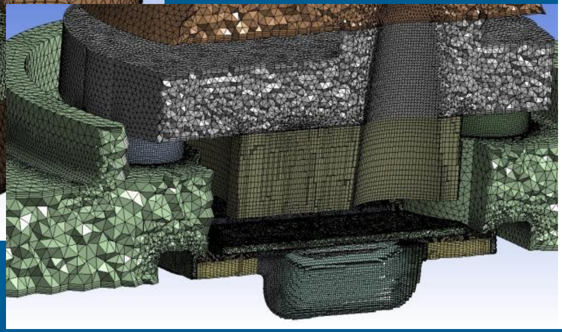
1h. CFD Study of a Drag Inhaler (Elpenhaler®)

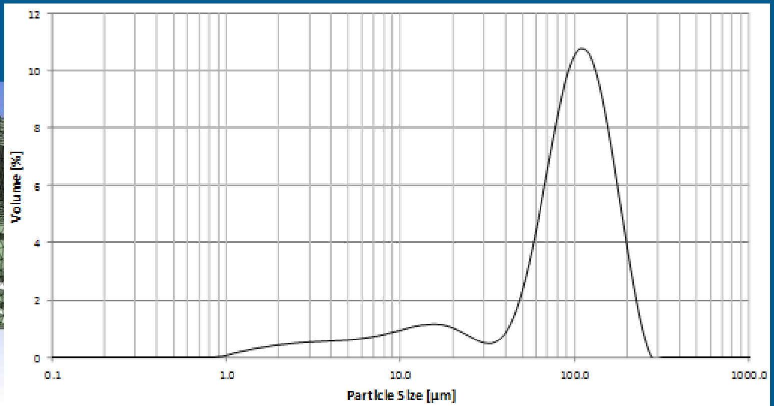




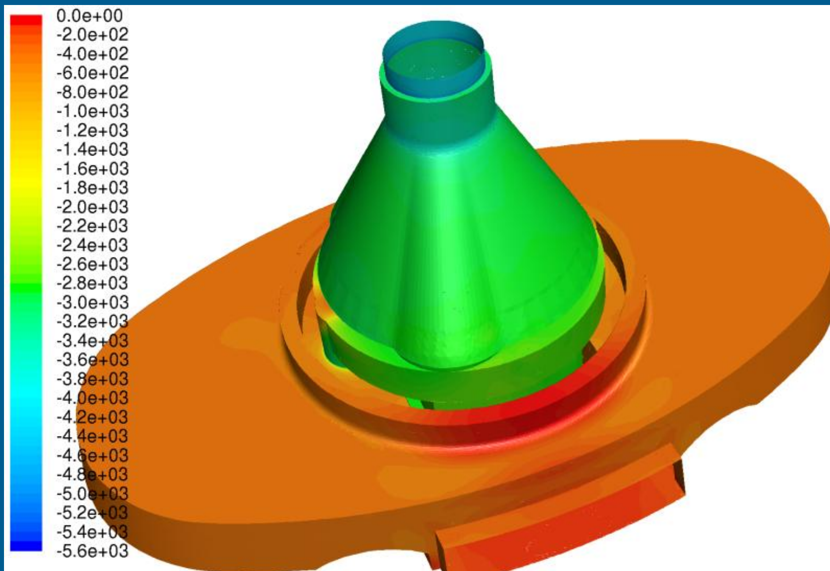
- ***Confirmation of efficient operation.***
- ***Further optimization.***

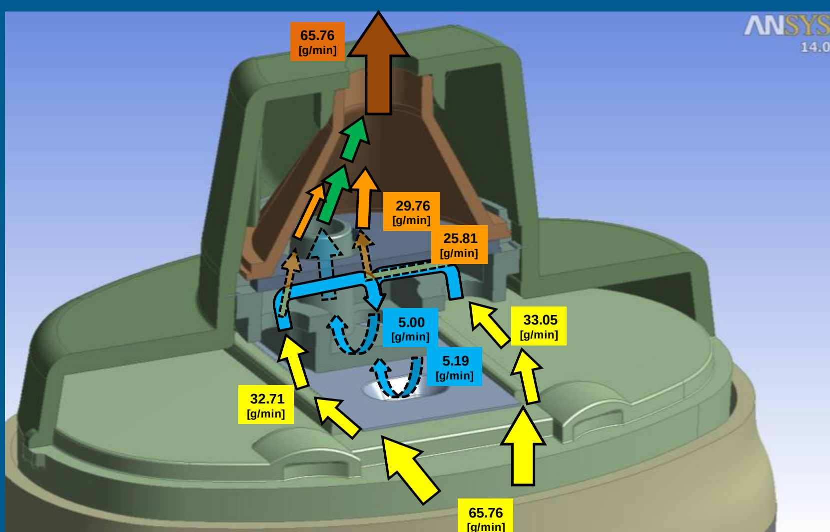
- ***Underpressure from patient's inhaling.***
- ***Turbulent, compressible air flow, which carries the particles to the exit.***
- ***Very small gaps, mesh of 7.7M cells.***
- ***Steady conditions (assumption).***
- ***Particle tracking without effect on the air flow (uncoupled) for specific size distribution.***

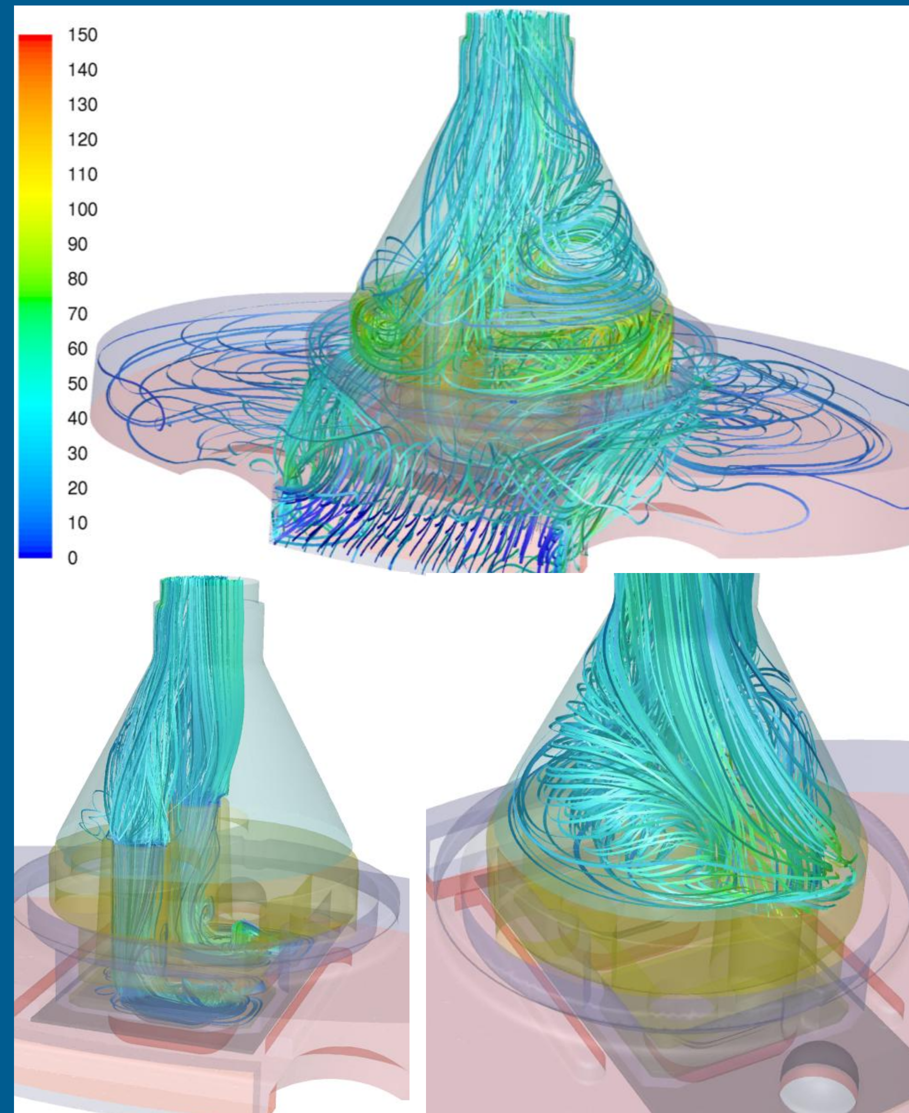




1h. CFD Study of a Drag Inhaler (Elpenhaler®)







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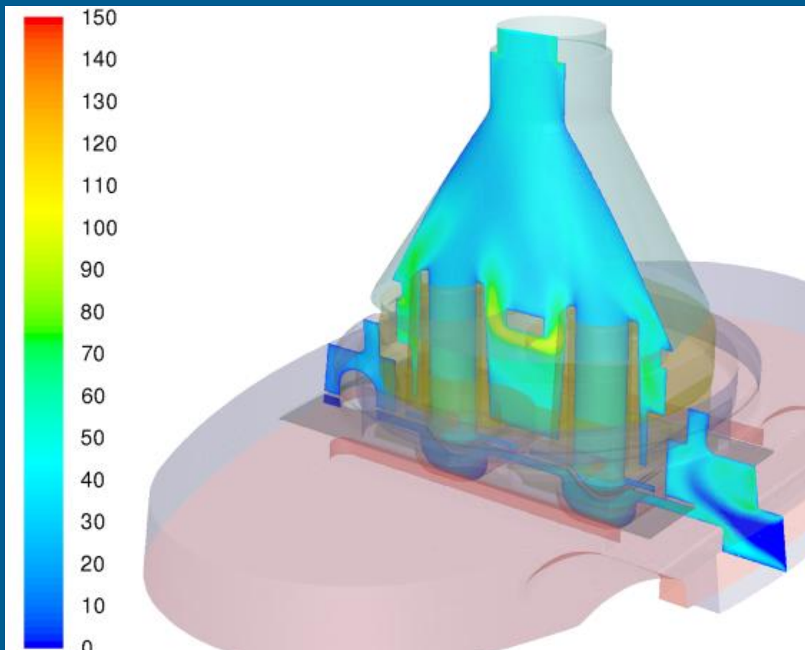
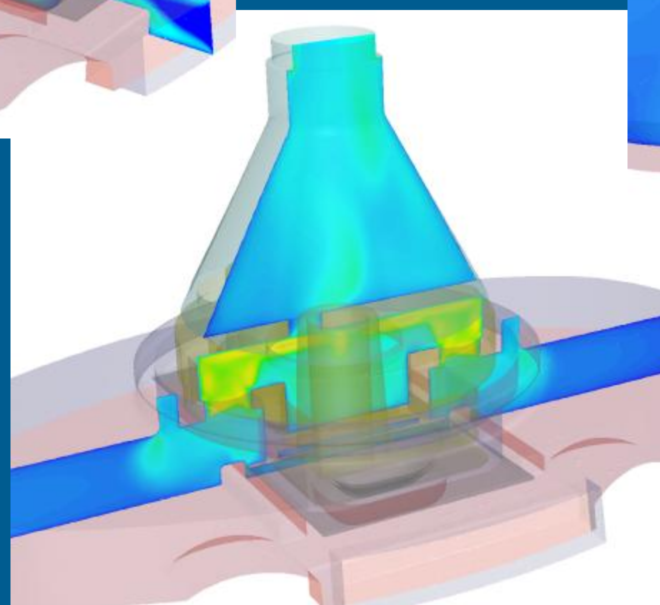
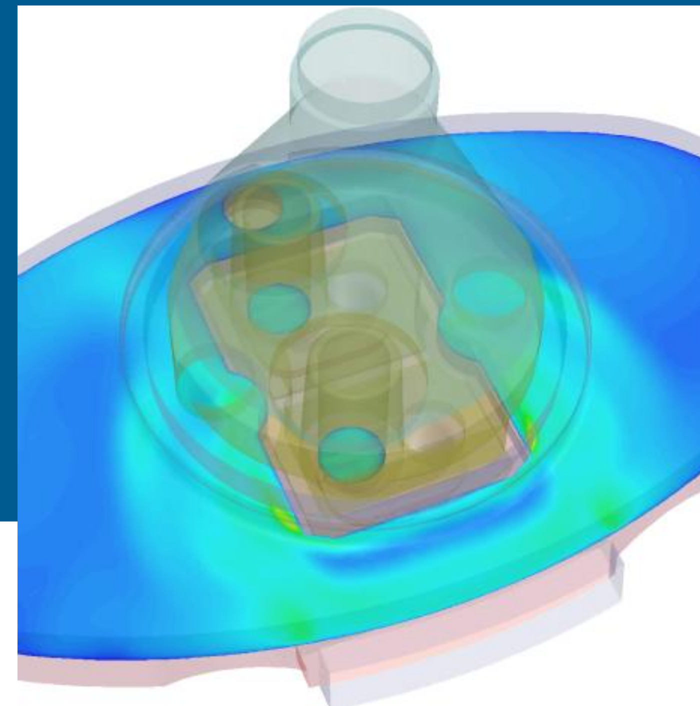
1h. CFD Study of a Drag Inhaler (Elpenhaler®)







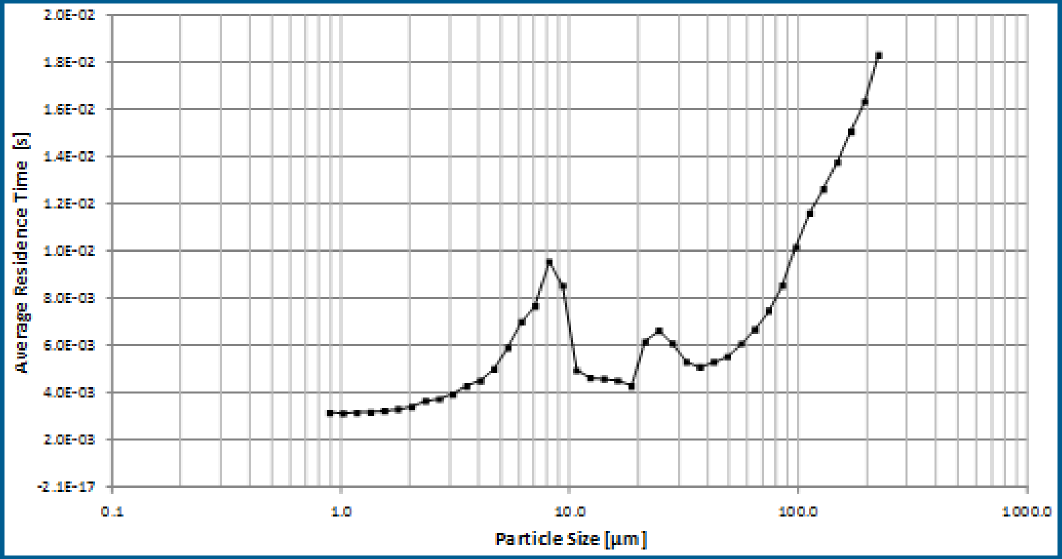
Turbulence Intensity

1h. CFD Study of a Drag Inhaler (Elpenhaler®)

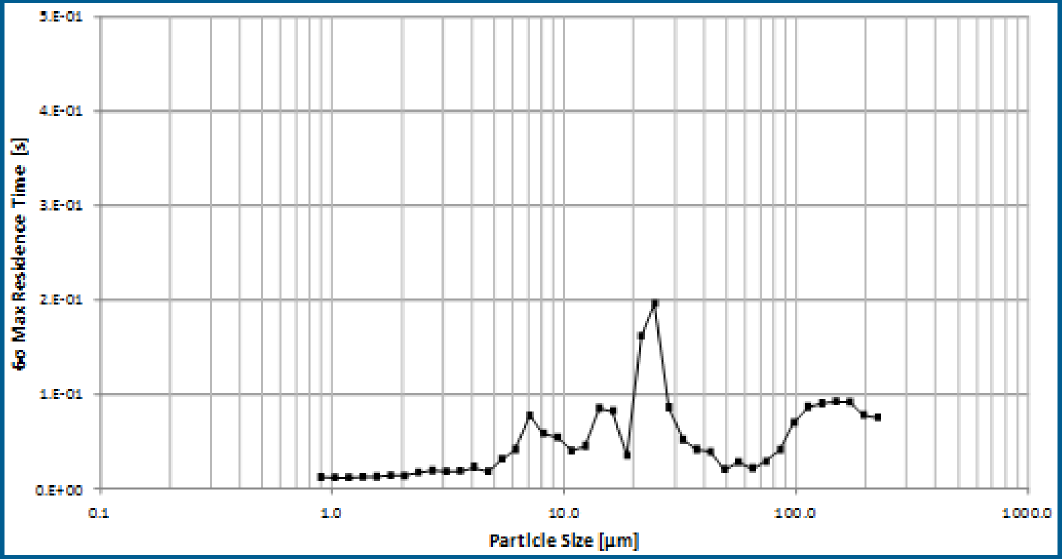
Class	Size [μm]	Volume [%]	Escaped [particles]	Incomplete [particles]	Escaped Particles: Min Time [s]	Max Time [s]	Average Time [s]	STD [s]	6σ Max Time	Incomplete Volume [%]
1	0.894	0.04	28257	111	1.504E-03	5.164E-02	3.153E-03	2.814E-03	1.160E-02	0.000157
2	1.026	0.14	28263	105	1.505E-03	5.155E-02	3.140E-03	2.742E-03	1.137E-02	0.000518
3	1.178	0.22	28258	110	1.506E-03	5.572E-02	3.154E-03	2.777E-03	1.149E-02	0.000853
4	1.352	0.30	28262	106	1.508E-03	1.049E-01	3.178E-03	2.928E-03	1.196E-02	0.001121
5	1.553	0.36	28253	115	1.511E-03	8.252E-02	3.239E-03	3.000E-03	1.224E-02	0.001459
6	1.783	0.42	28264	104	1.515E-03	1.614E-01	3.299E-03	3.351E-03	1.335E-02	0.001540
7	2.047	0.46	28219	149	1.525E-03	7.399E-02	3.406E-03	3.223E-03	1.308E-02	0.002416
8	2.350	0.50	28184	184	1.535E-03	1.563E-01	3.650E-03	4.419E-03	1.691E-02	0.003243
9	2.698	0.53	28099	269	1.551E-03	2.268E-01	3.730E-03	5.011E-03	1.876E-02	0.005026
10	3.098	0.55	28062	306	1.566E-03	2.726E-01	3.945E-03	4.670E-03	1.796E-02	0.005933
11	3.557	0.57	28111	257	1.578E-03	1.871E-01	4.280E-03	4.707E-03	1.840E-02	0.005164
12	4.084	0.59	28147	221	1.593E-03	4.830E-01	4.507E-03	6.023E-03	2.258E-02	0.004596
13	4.689	0.61	28274	94	1.618E-03	1.048E-01	5.000E-03	4.334E-03	1.800E-02	0.002021
14	5.383	0.65	28109	259	1.649E-03	4.740E-01	5.902E-03	8.338E-03	3.092E-02	0.005935
15	6.181	0.70	28169	199	1.654E-03	5.138E-01	7.007E-03	1.129E-02	4.088E-02	0.004910
16	7.097	0.77	27906	462	1.662E-03	2.794E+00	7.682E-03	2.303E-02	7.677E-02	0.012540
17	8.148	0.86	27711	657	1.675E-03	1.570E+00	9.555E-03	1.622E-02	5.822E-02	0.019918
18	9.355	0.95	27872	496	1.698E-03	1.126E+00	8.532E-03	1.507E-02	5.374E-02	0.016610
19	10.741	1.06	27992	376	1.748E-03	1.135E+00	4.946E-03	1.157E-02	3.966E-02	0.014050
20	12.333	1.13	27821	547	1.771E-03	1.260E+00	4.630E-03	1.338E-02	4.477E-02	0.021789
21	14.160	1.16	27656	712	1.820E-03	2.136E+00	4.581E-03	2.676E-02	8.486E-02	0.029114
22	16.257	1.14	27476	892	1.885E-03	2.077E+00	4.514E-03	2.583E-02	8.200E-02	0.035846
23	18.666	1.03	27540	828	1.969E-03	7.740E-01	4.282E-03	1.009E-02	3.455E-02	0.030063
24	21.431	0.85	27606	762	2.069E-03	4.158E+00	6.159E-03	5.172E-02	1.613E-01	0.022832
25	24.606	0.65	27918	450	2.160E-03	6.926E+00	6.630E-03	6.298E-02	1.956E-01	0.010311
26	28.252	0.50	28199	169	2.254E-03	2.305E+00	6.087E-03	2.647E-02	8.550E-02	0.002979
27	32.437	0.53	28315	53	2.390E-03	1.974E+00	5.302E-03	1.534E-02	5.132E-02	0.000990
28	37.243	0.86	28348	20	2.545E-03	1.715E+00	5.082E-03	1.198E-02	4.102E-02	0.000606
29	42.760	1.63	28359	9	2.736E-03	1.405E+00	5.313E-03	1.105E-02	3.846E-02	0.000517
30	49.095	2.87	28365	3	2.953E-03	5.506E-01	5.534E-03	4.777E-03	1.987E-02	0.000304
31	56.369	4.55	28365	3	3.187E-03	8.409E-01	6.075E-03	7.239E-03	2.779E-02	0.000481
32	64.720	6.49	28366	2	3.444E-03	1.455E-01	6.673E-03	4.813E-03	2.111E-02	0.000458
33	74.308	8.40	28368	0	3.727E-03	1.713E-01	7.474E-03	6.919E-03	2.823E-02	0.000000
34	85.317	9.94	28368	0	4.038E-03	3.069E-01	8.542E-03	1.076E-02	4.062E-02	0.000000
35	97.957	10.73	28365	3	4.376E-03	5.146E-01	1.016E-02	1.977E-02	6.947E-02	0.001135
36	112.470	10.60	28311	57	4.743E-03	5.194E-01	1.160E-02	2.481E-02	8.603E-02	0.021299
37	129.132	9.49	28252	116	5.147E-03	6.791E-01	1.262E-02	2.574E-02	8.984E-02	0.038806
38	148.264	7.61	28265	103	5.598E-03	9.317E-01	1.375E-02	2.603E-02	9.184E-02	0.027631
39	170.230	5.33	28327	41	6.101E-03	1.083E+00	1.506E-02	2.535E-02	9.111E-02	0.007703
40	195.450	3.07	28355	13	6.659E-03	8.645E-01	1.633E-02	2.041E-02	7.756E-02	0.001407
41	224.407	1.16	28366	2	7.267E-03	4.706E-01	1.829E-02	1.884E-02	7.481E-02	0.000082
	SUM	100.00							SUM	0.362

Results for the path and fate of the particles.

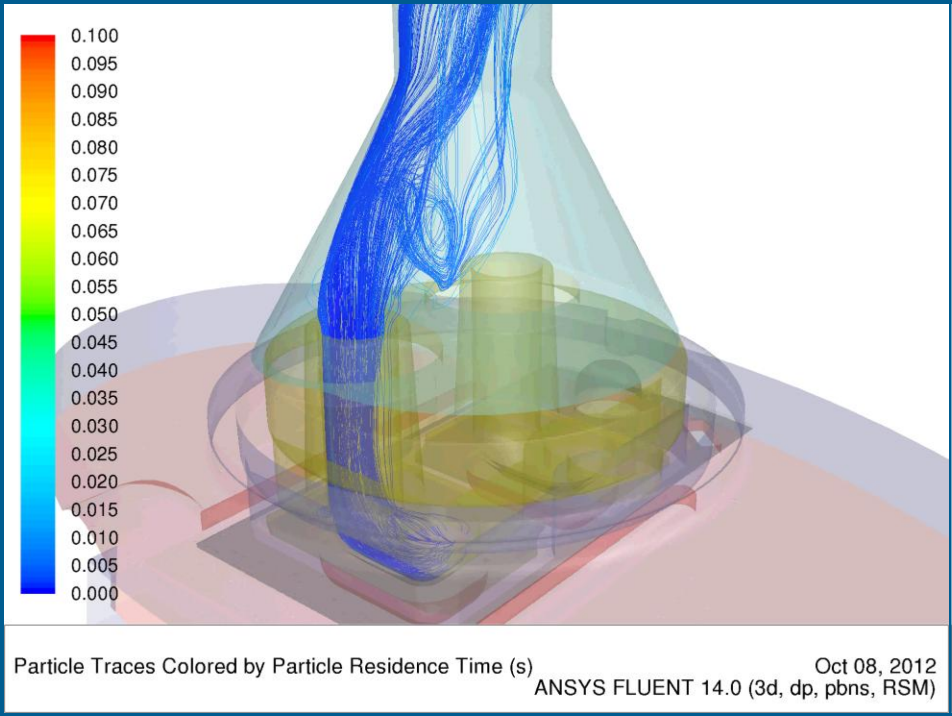
1h. CFD Study of a Drag Inhaler (Elpenhaler®)

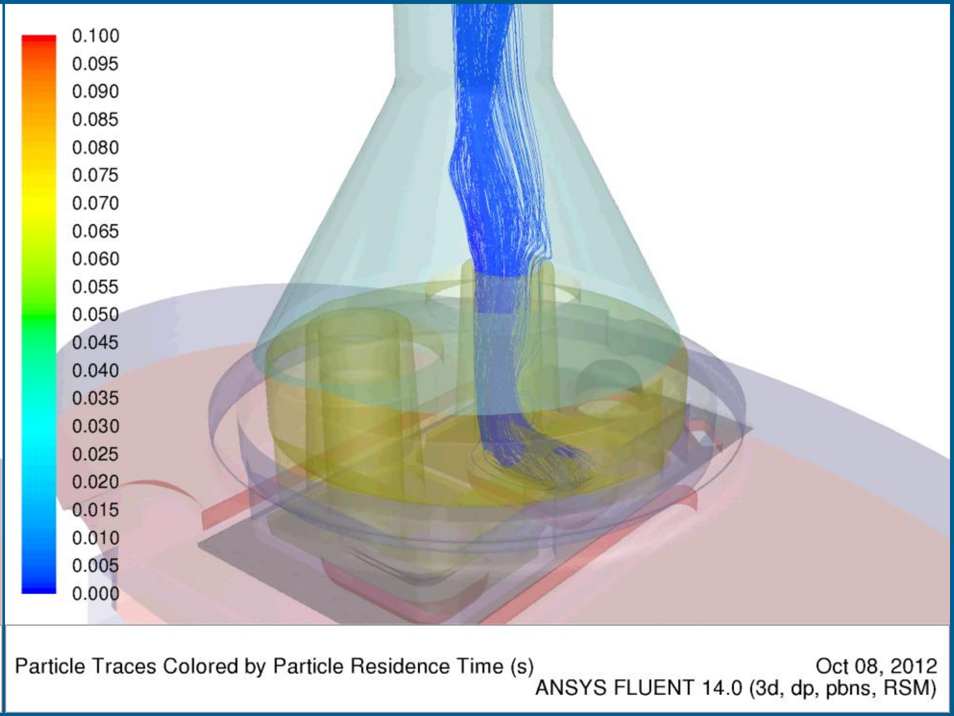


Residual time of particles vs diameter



1h. CFD Study of a Drag Inhaler (Elpenhaler®)





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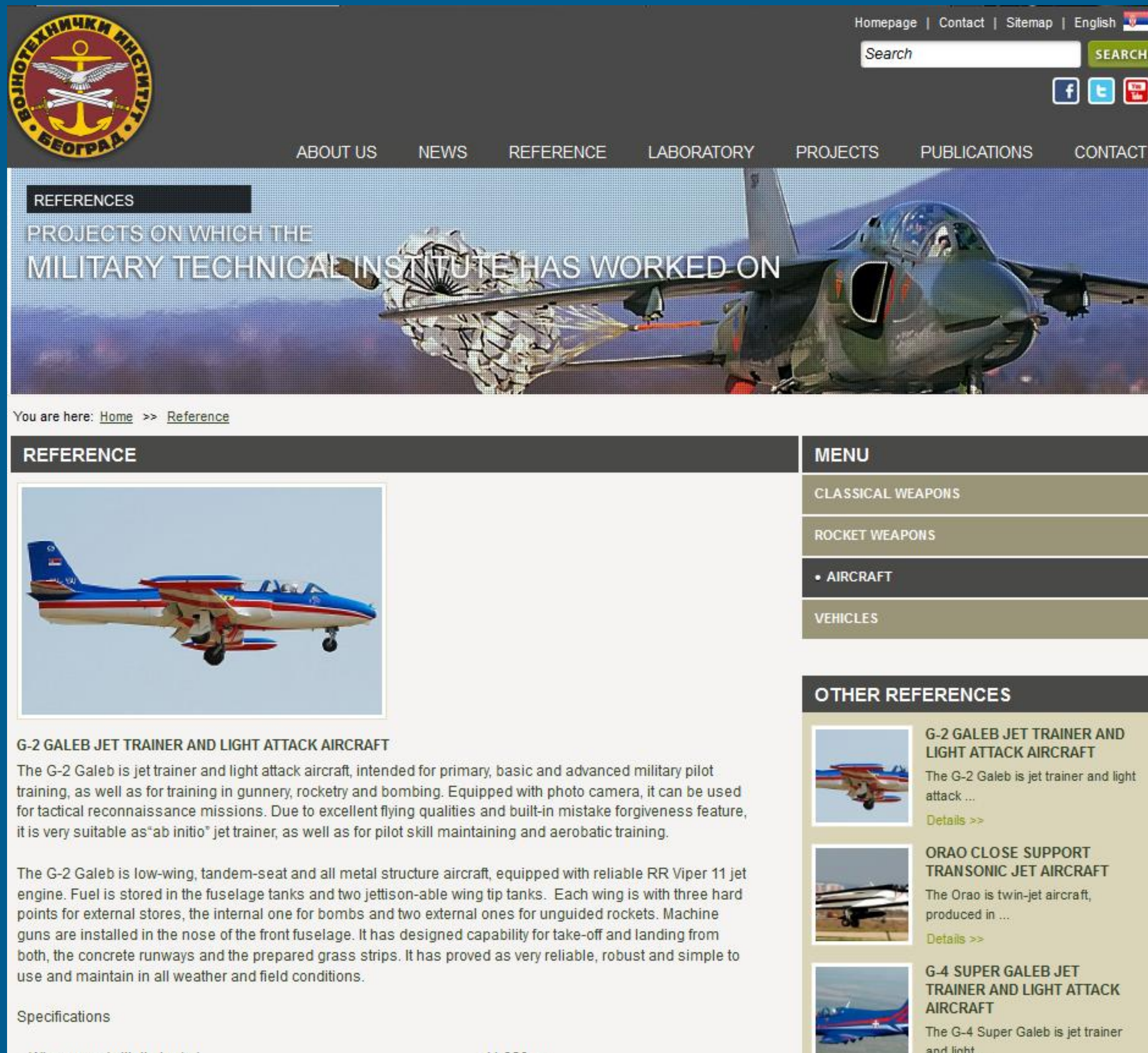
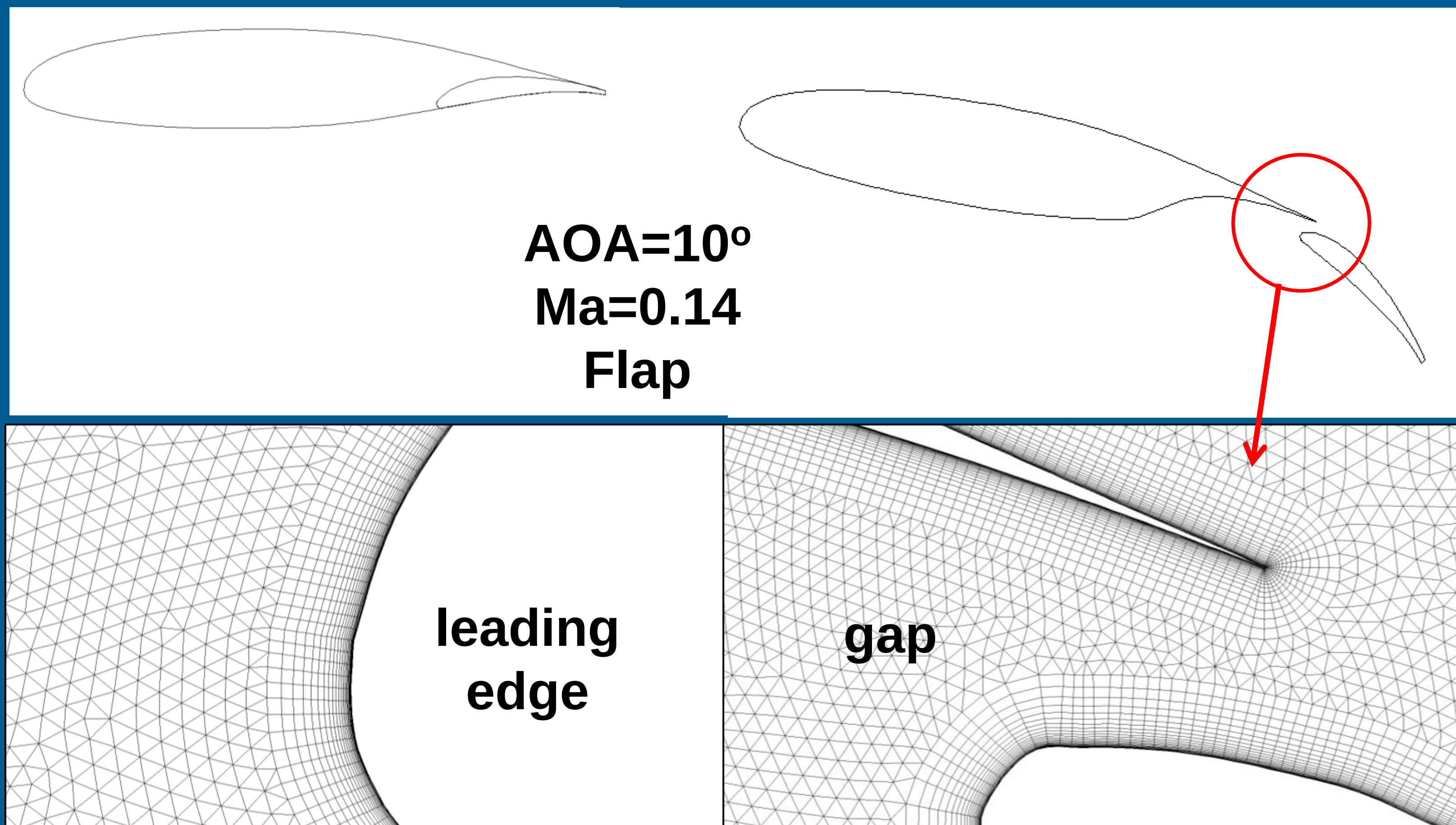
2α. Military Technical Institute of Serbia



Modeling the Aerodynamic Behavior of a High–Lift Airfoil (HLA)



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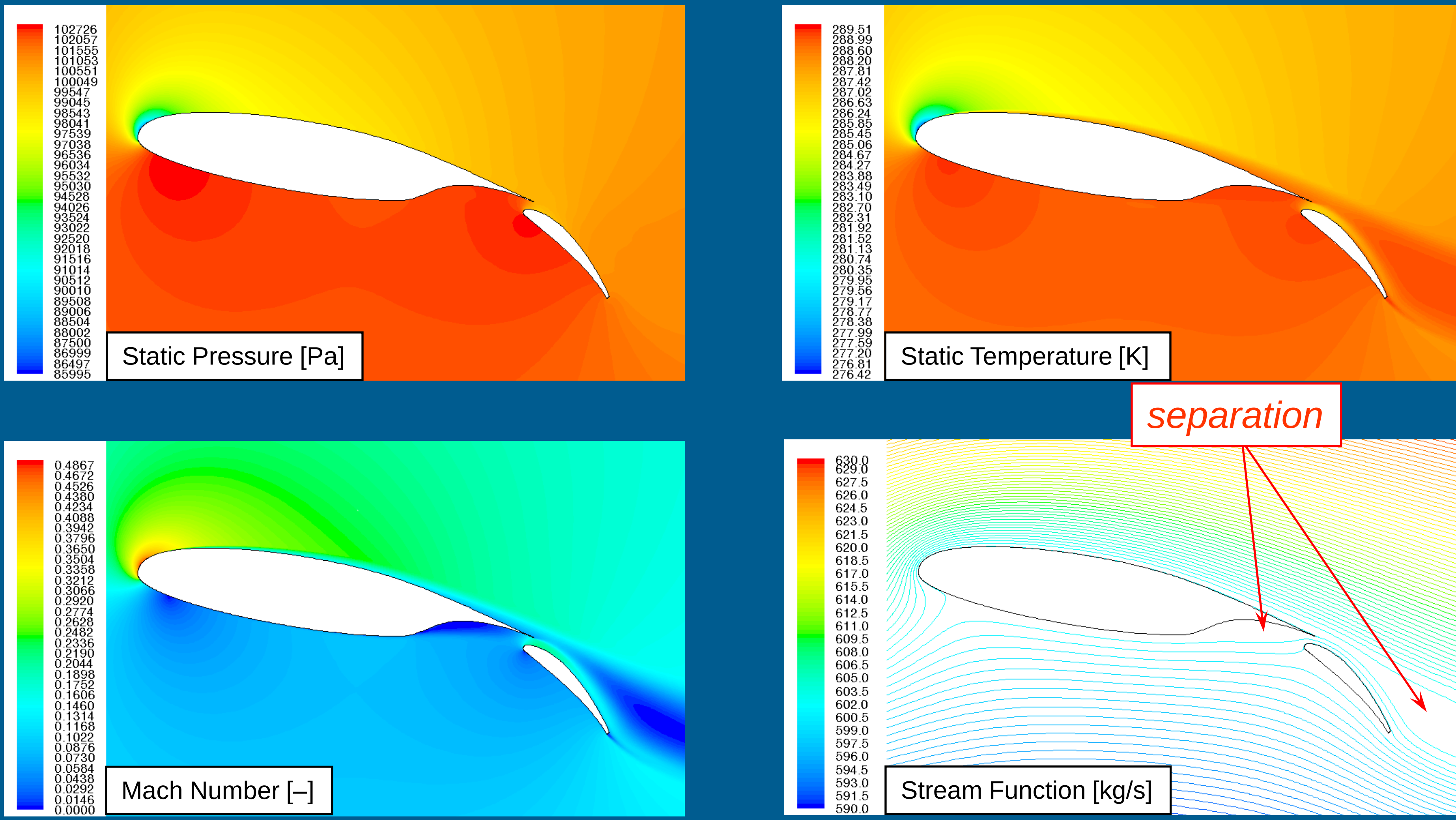
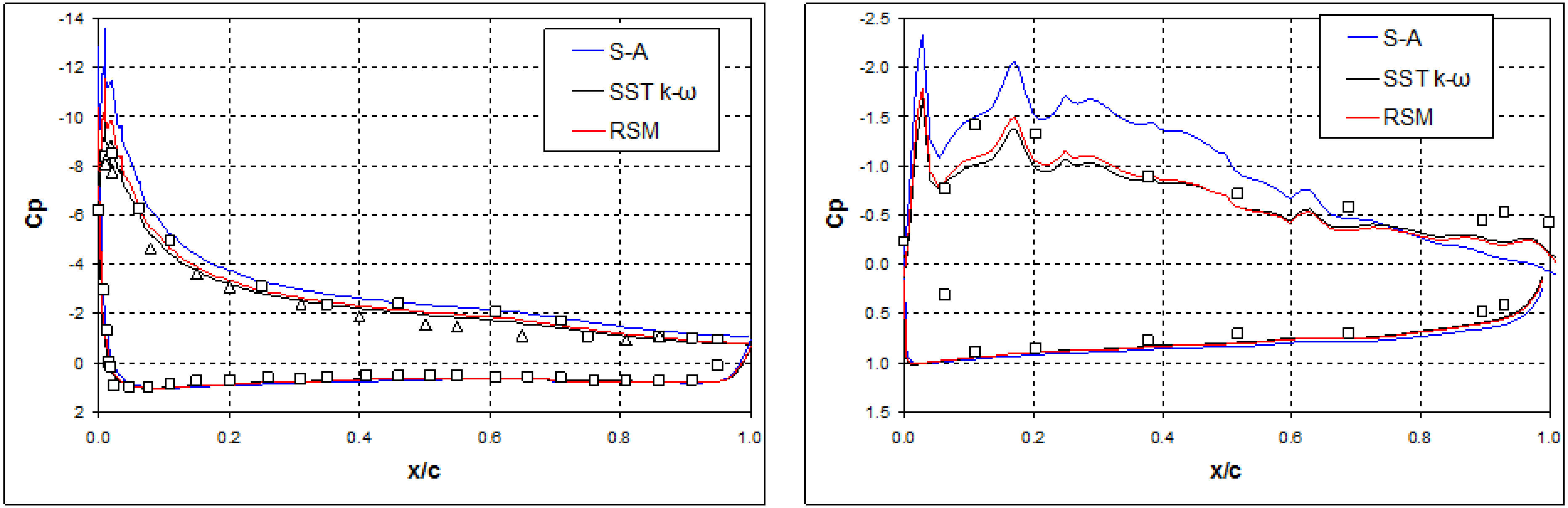


2α. Military Technical Institute of Serbia

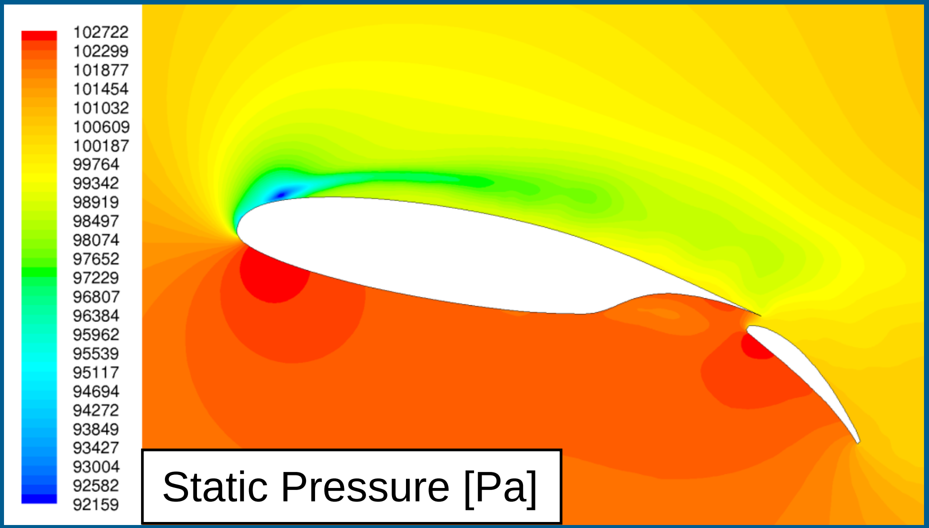


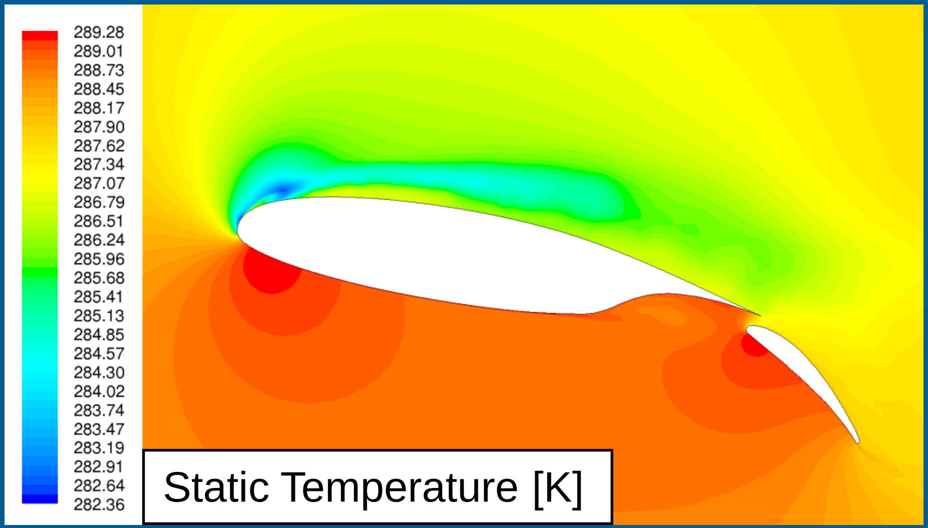
Airfoil

Flap

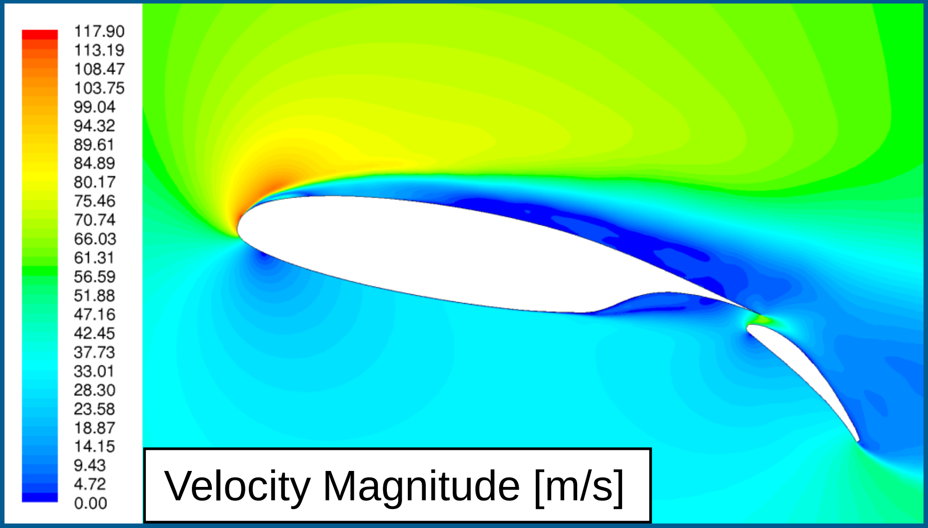
Surface Pressure Coefficient Profiles

2a. Military Technical Institute of Serbia

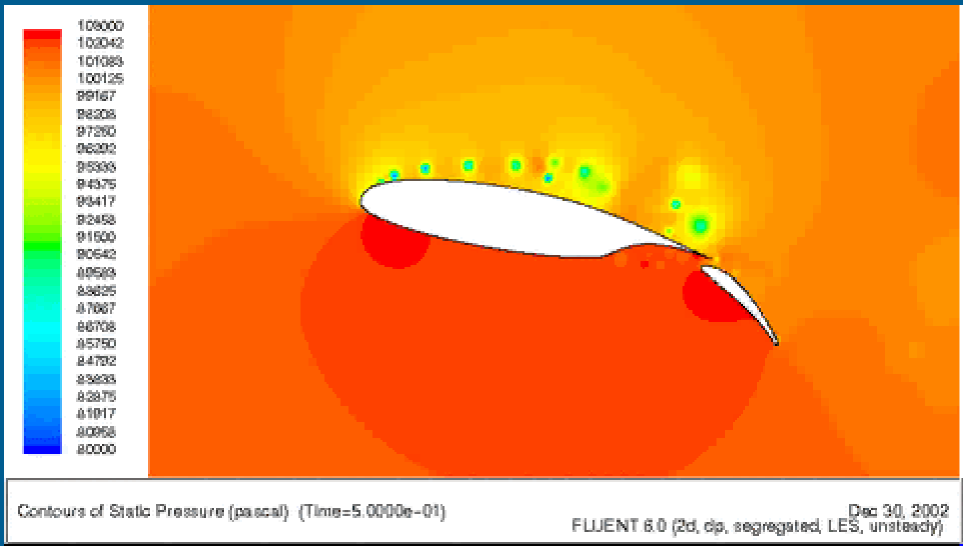




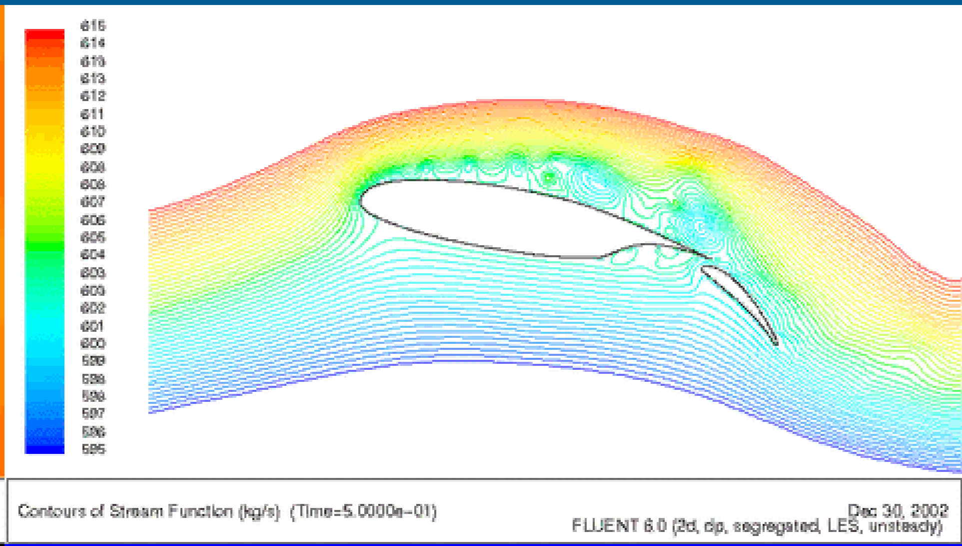
Time–averaged contours from the transient LES solution.



2a. Military Technical Institute of Serbia

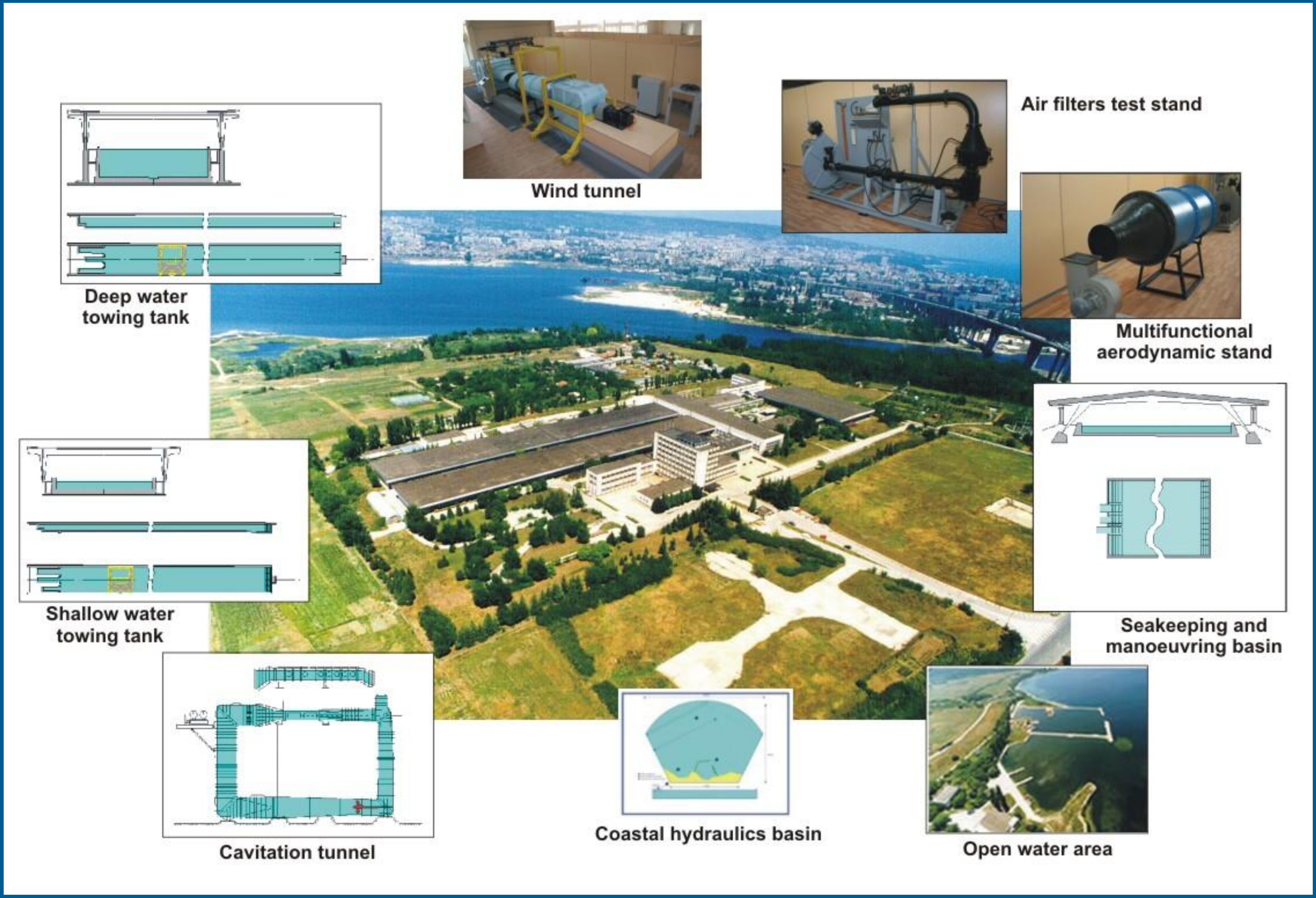


Static Pressure



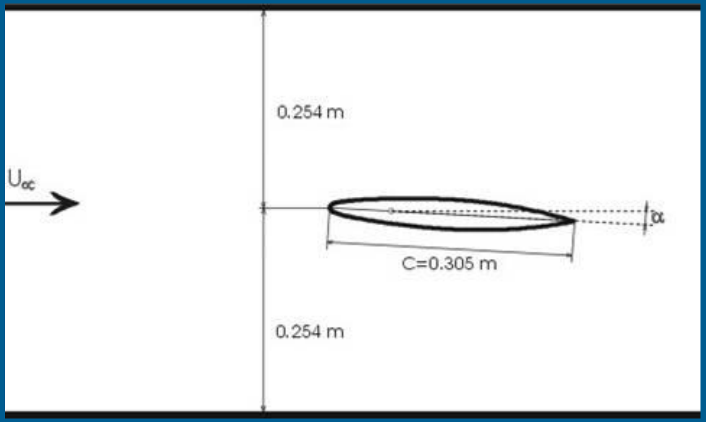
Stream Function

2b. Bulgarian Ship Hydrodynamics Center

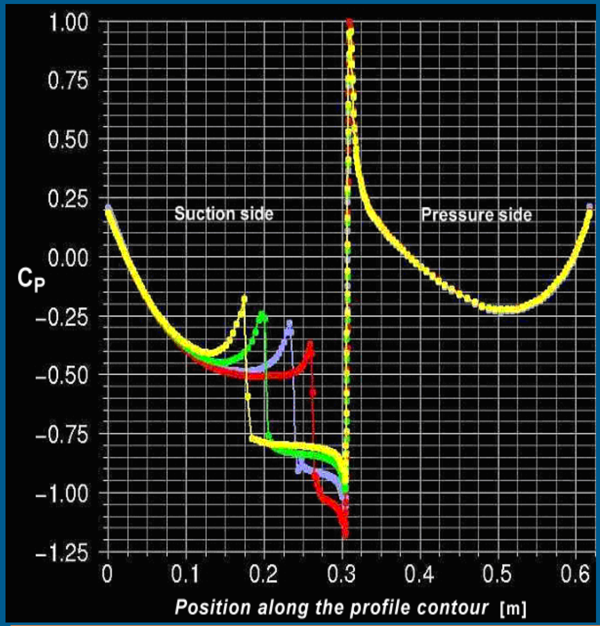


2b. Bulgarian Ship Hydrodynamics Center

I. Steady–State Sheet Cavitation over a 2D hydrofoil

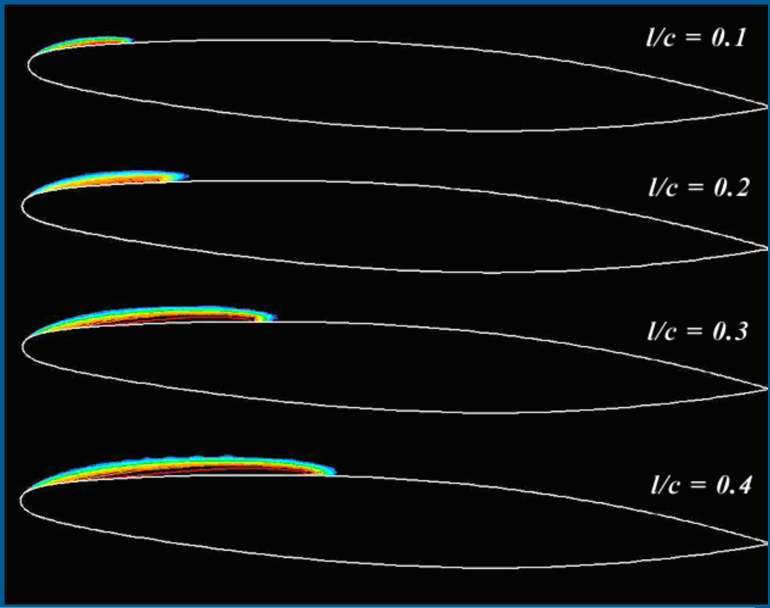


l/c	σ	C_L		C_D	
		Experiment	Present study	Experiment	Present study
1	2	3	4	5	6
0.0	---	0.3619	0.3671	0.0119	0.0131
0.1	1.020	0.4064	0.3811	0.0164	0.0175
0.2	0.905	0.4036	0.3910	0.0190	0.0204
0.3	0.836	0.4225	0.4185	0.0208	0.0241
0.4	0.813	0.4621	0.4206	0.0261	0.0248

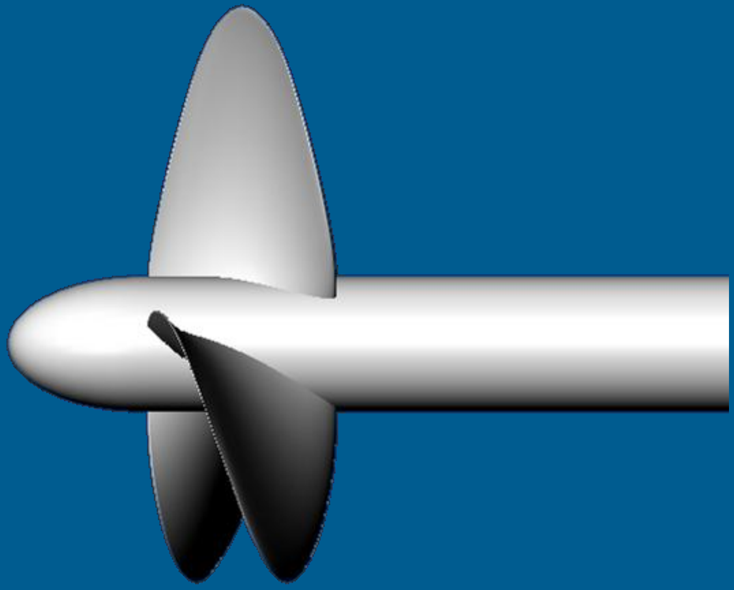


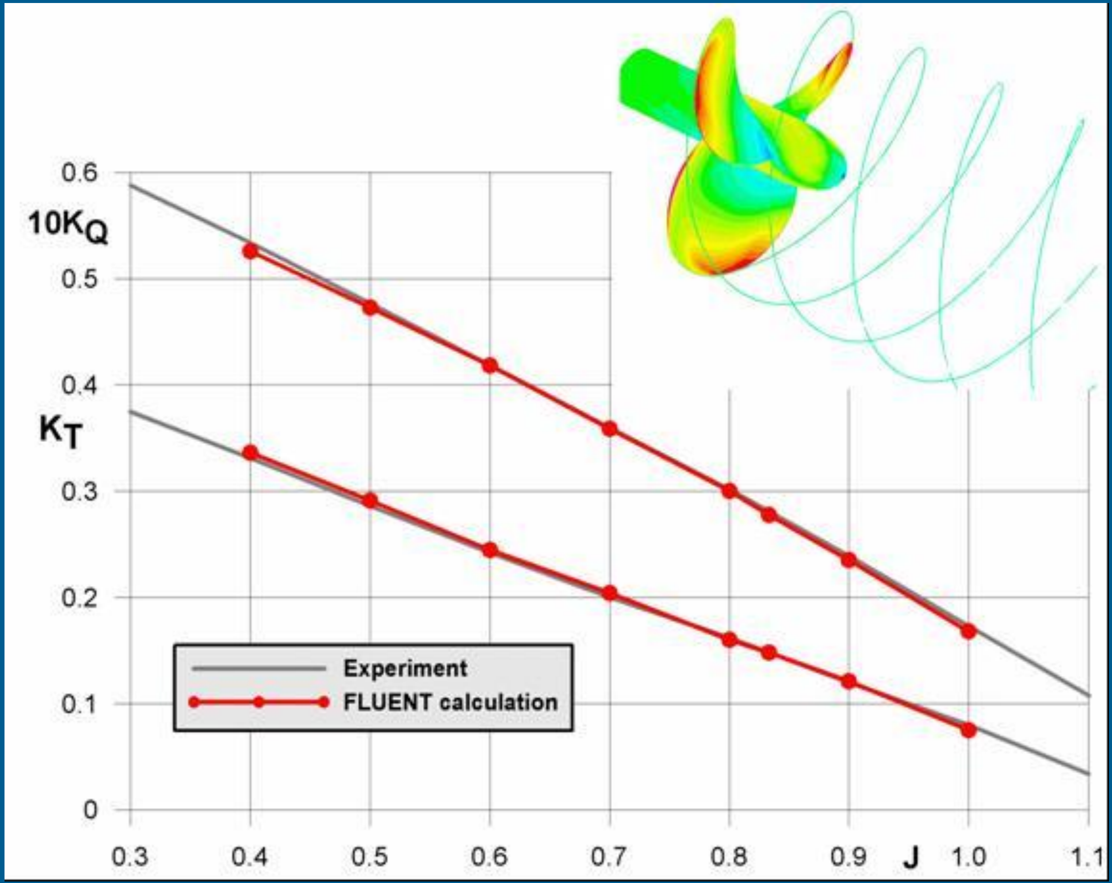
Pressure Coefficient

Cavity Extent



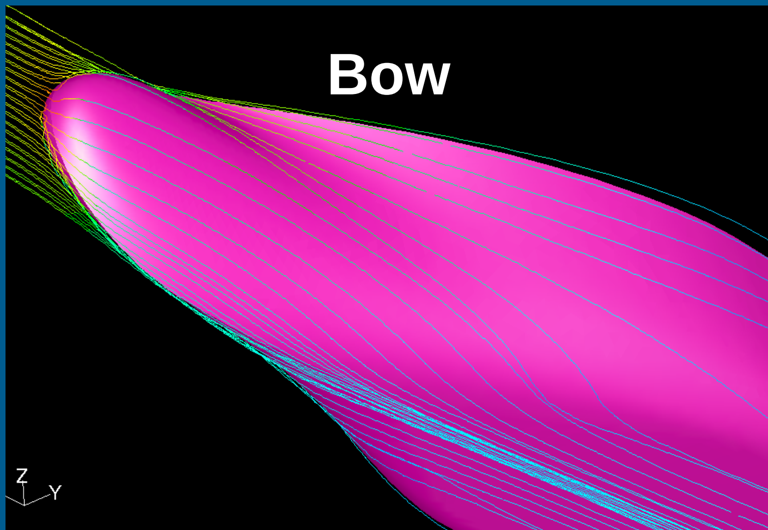
II. Flow about the ITTC Test Screw Propeller No.4119

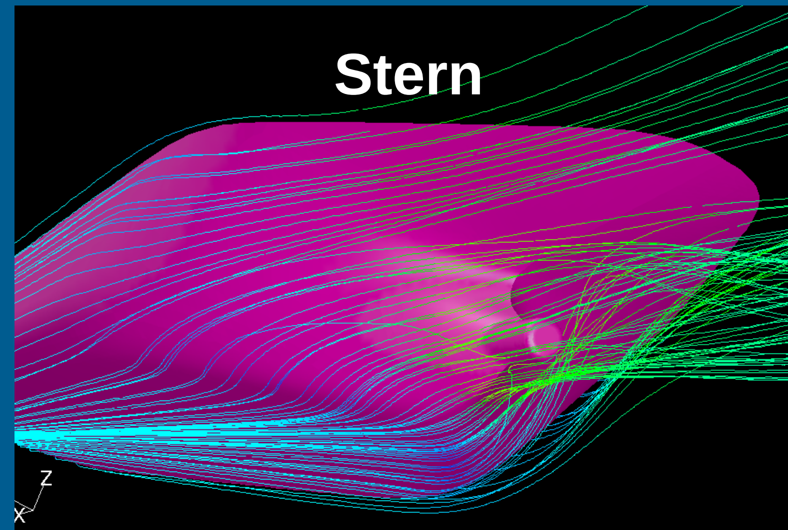


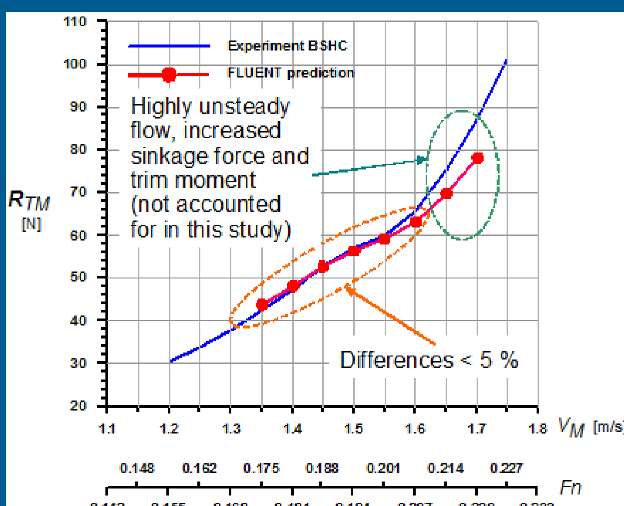


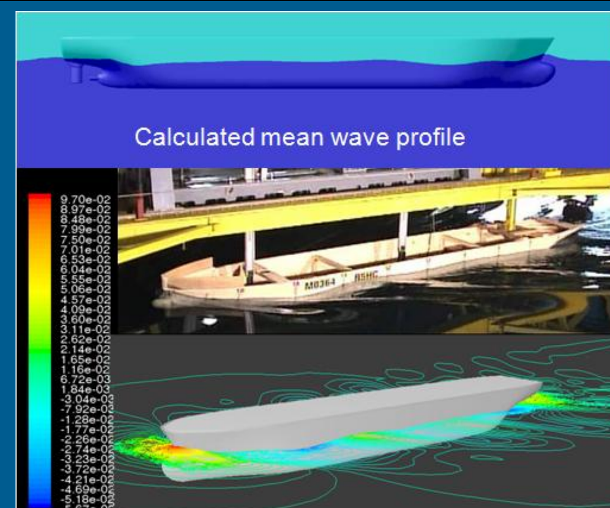
Thrust & Torque Coefficients

III. Flow about a model 6000t cement carrier









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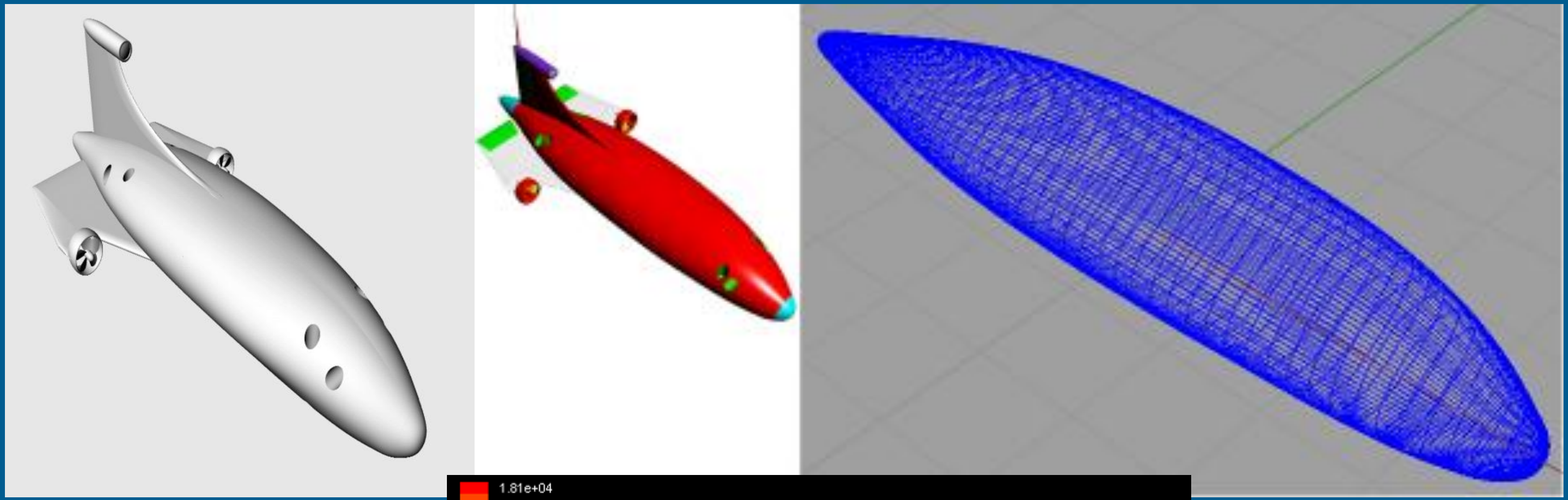
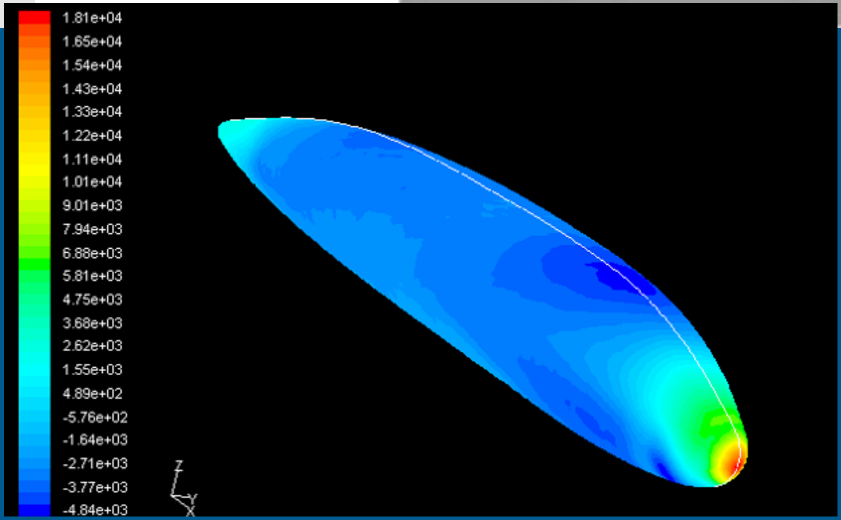
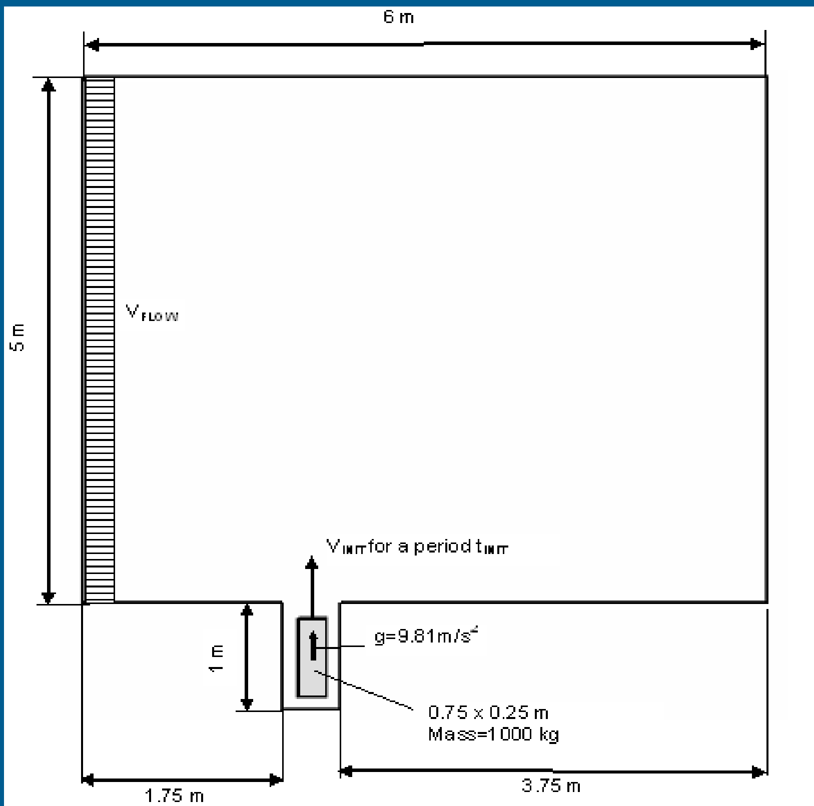
2b. Bulgarian Ship Hydrodynamics Center

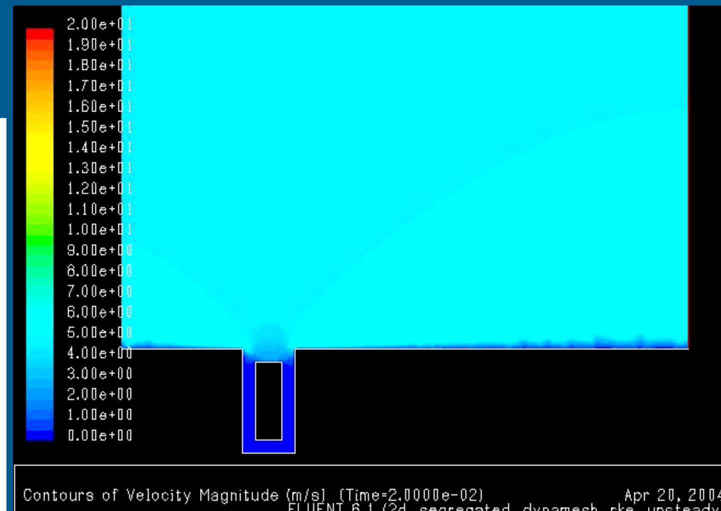
IV. Hydrodynamic Study of an UUV



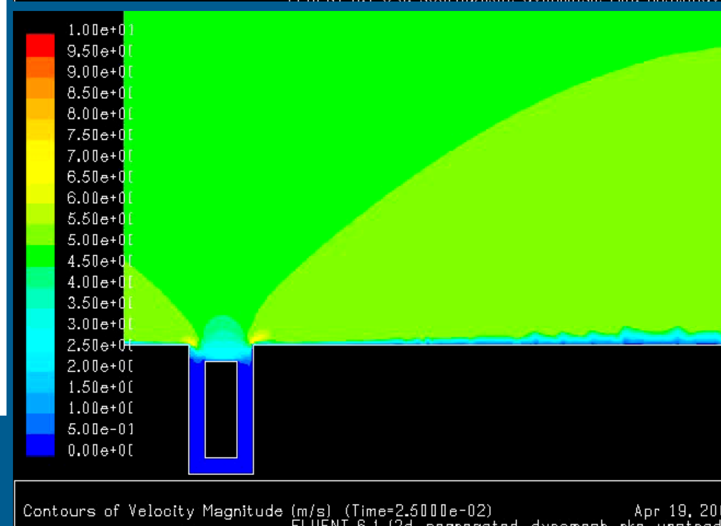


V. Store Separation in Water





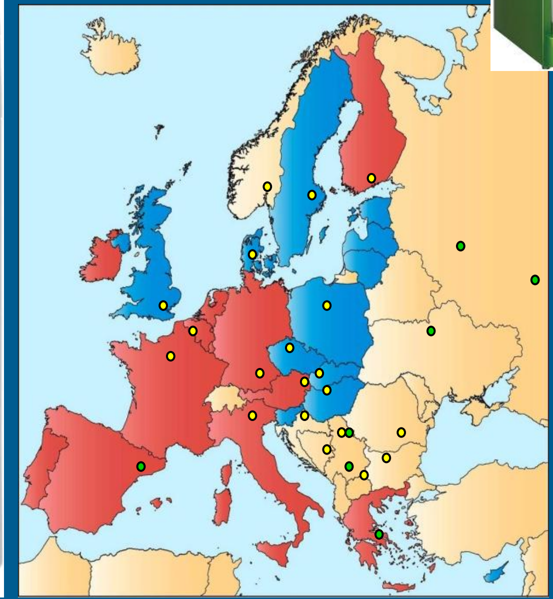
U_∞=5 [m/s]
V_{init}=10 [m/s]



U_∞=5 [m/s]
V_{init}=5 [m/s]

2c. Gorenje d.d.

gorenje



gorenje

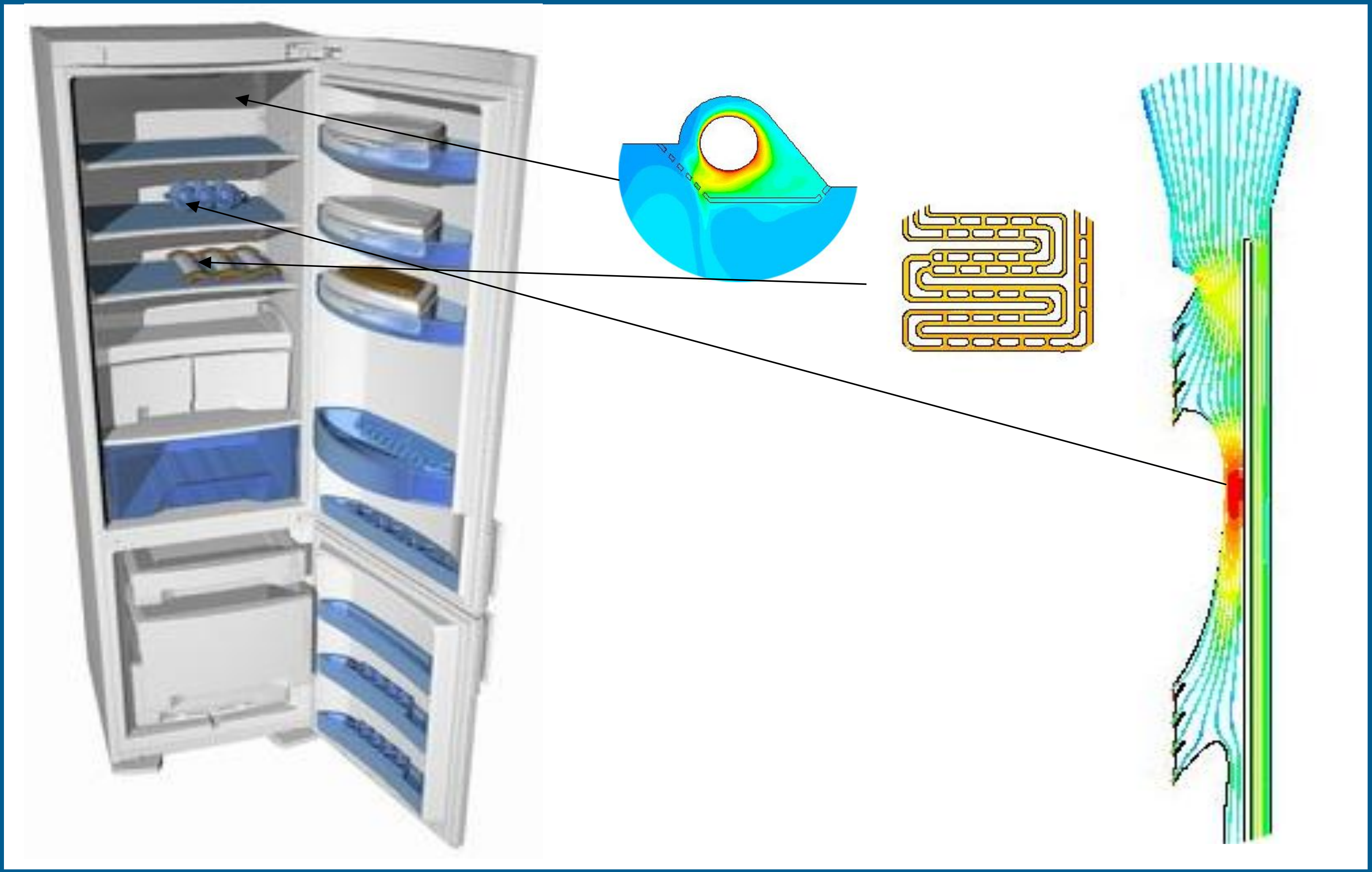
sidex

körting

MORA

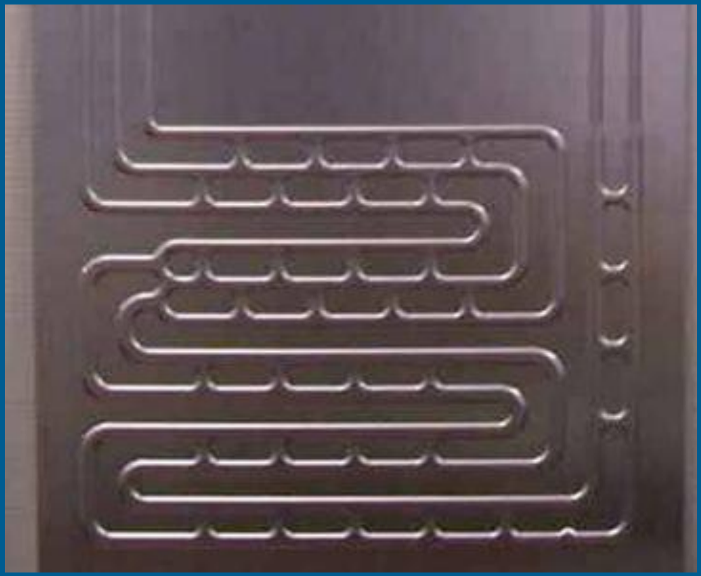
2c. Gorenje d.d.

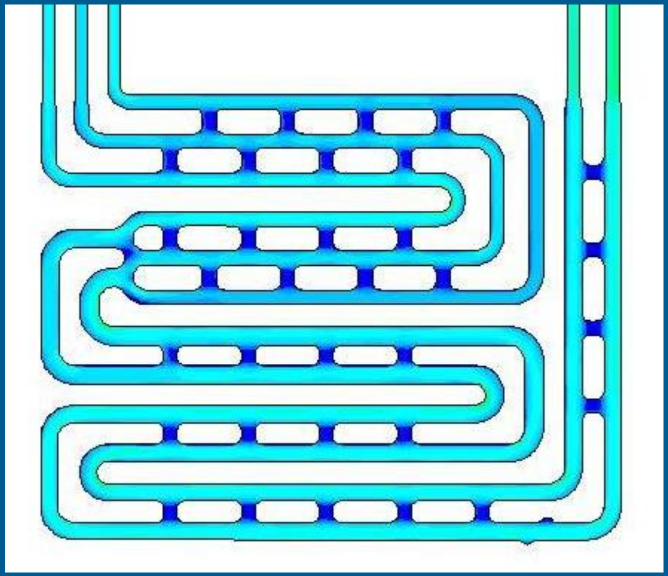
I. Refrigerators – Freezers



2c. Gorenje d.d.

I. Refrigerators – Freezers

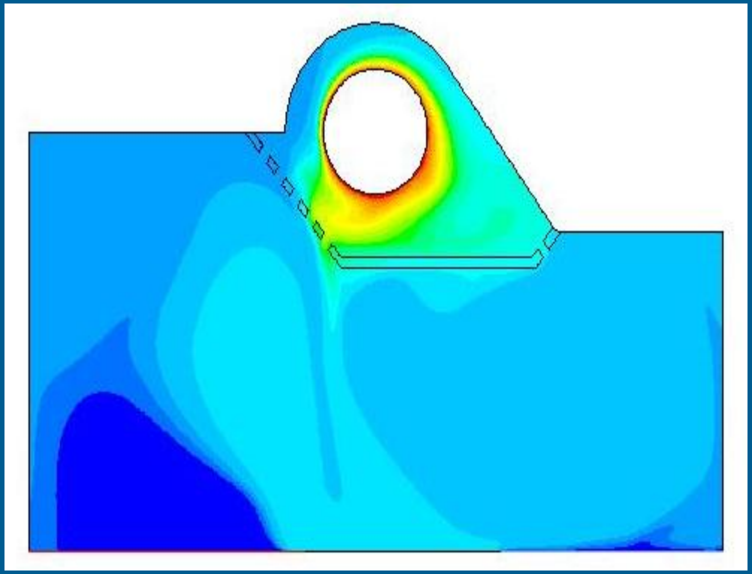




- Target: to reduce the energy consumption for A^{+} class certification.
- 4 different configuration of evaporator channels were simulated.
- A prediction of 5% energy consumption for the best evaporator design was confirmed by measurements in the prototype.

2c. Gorenje d.d.

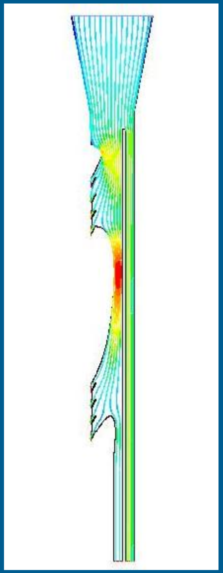
I. Refrigerators – Freezers



- Initial design was exhibiting high temperatures on the surfaces around the lamp.
- After simulating 3 different designs, the problem was solved.

2c. Gorenje d.d.

I. Refrigerators – Freezers

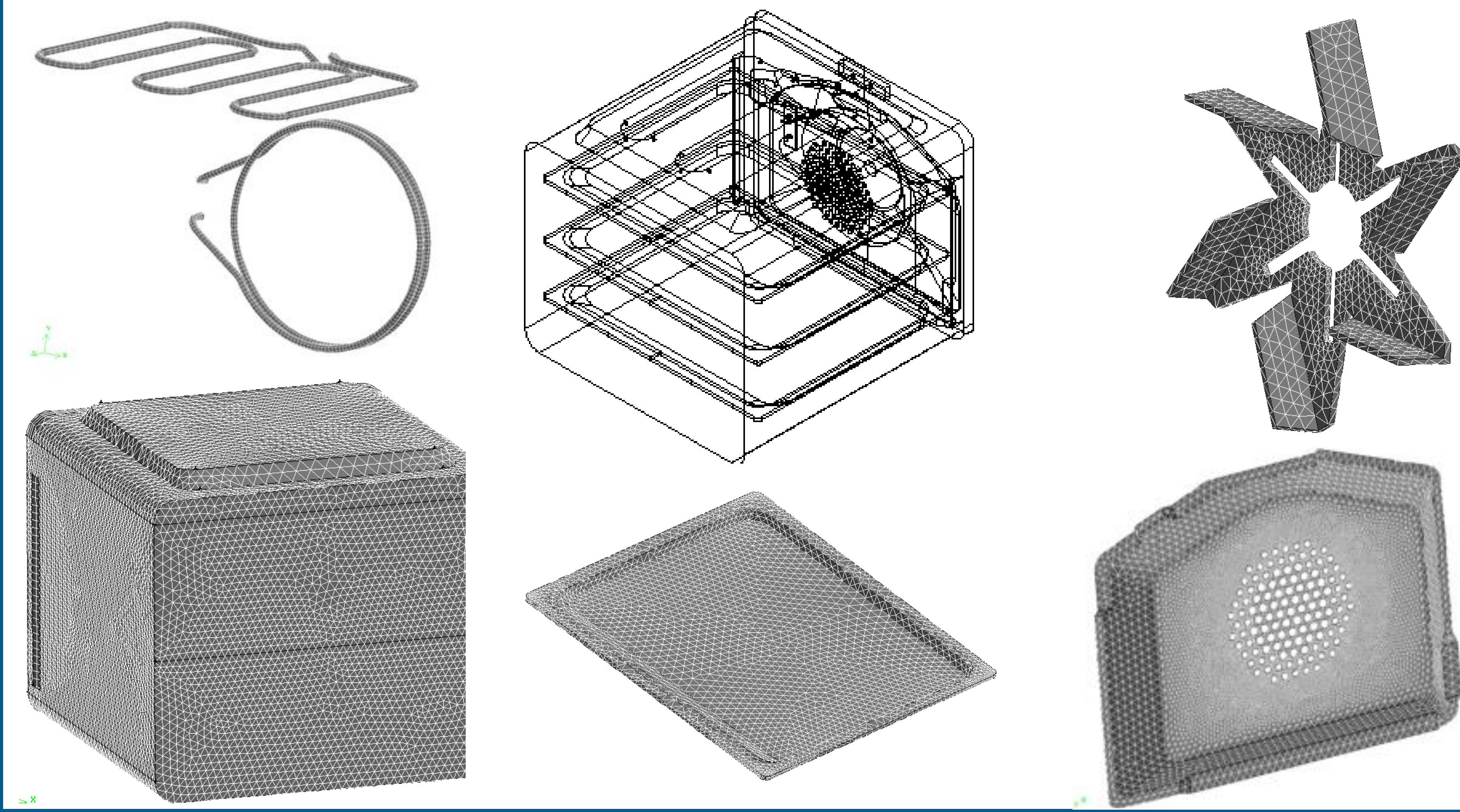


- The analysis target was to optimize the cold air recirculation in the refrigerator.
- A few alternative designs were simulated in FLUENT.
- A prototype was constructed and measured.
- Good temperature control was achieved, as well as temperature stability inside the refrigerator.

2c. Gorenje d.d.

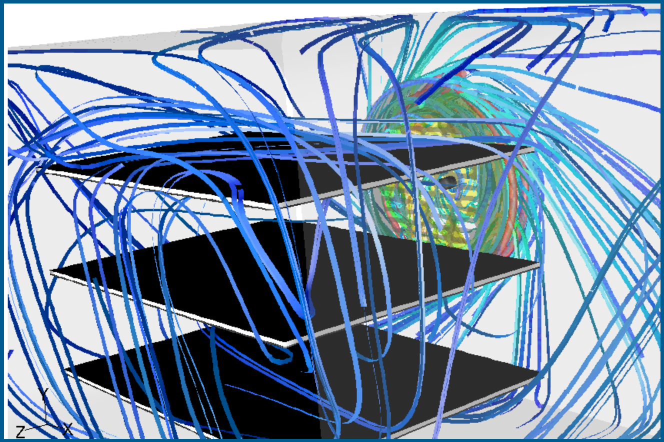
gorenje

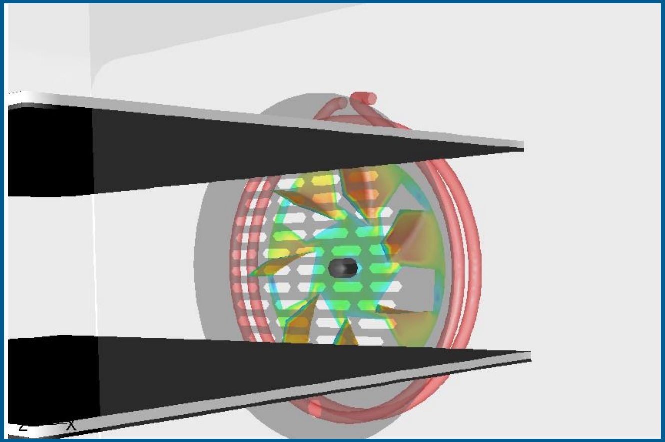
II. Cookers



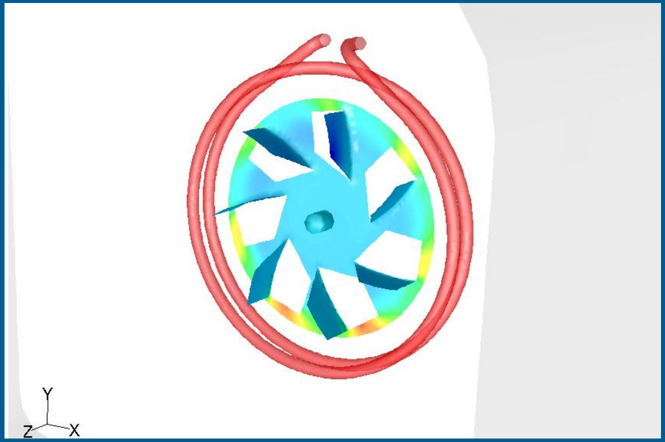
2c. Gorenje d.d.

II. Cookers


Path Lines

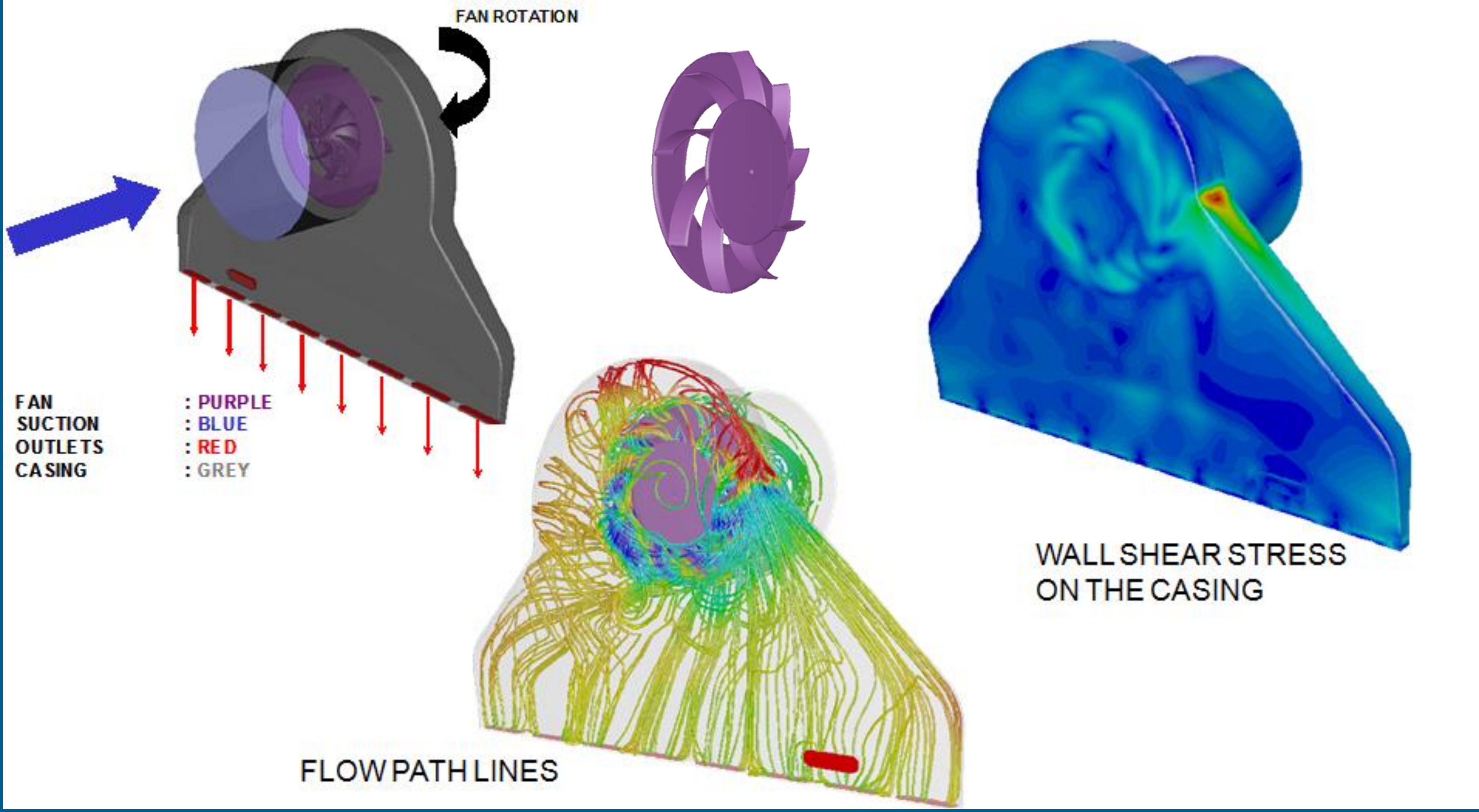

Pressure Contours


Temperature (heater)


Temperature (blades)

2c. Gorenje d.d.

II. Cookers



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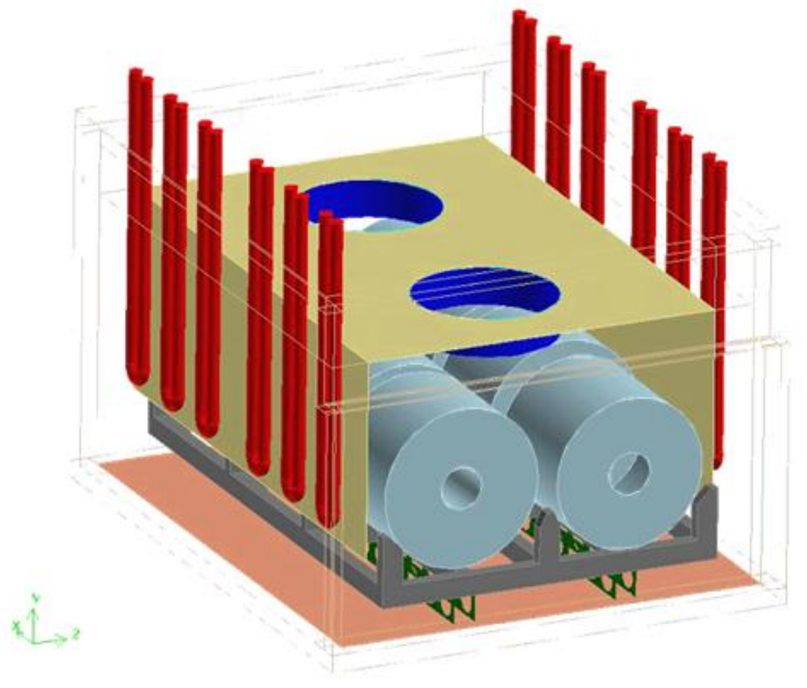
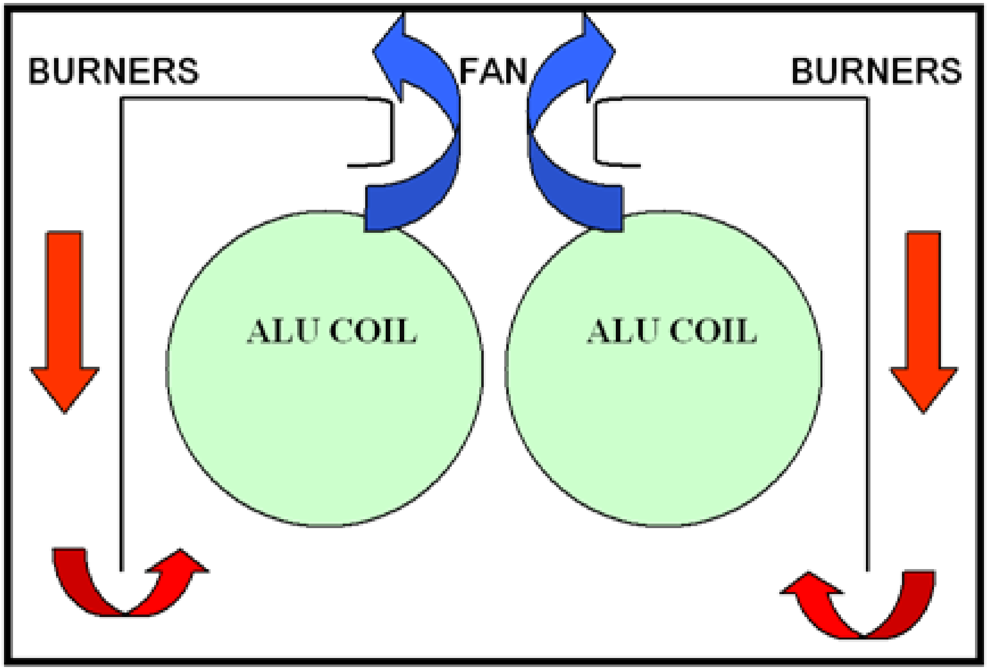
2d. EL.K.E.ME.

ΕΛΛΗΝΙΚΟ ΚΕΝΤΡΟ
ΕΛΚΕΜΕ
ΕΡΕΥΝΗΣ ΜΕΤΑΛΛΩΝ Α.Ε.

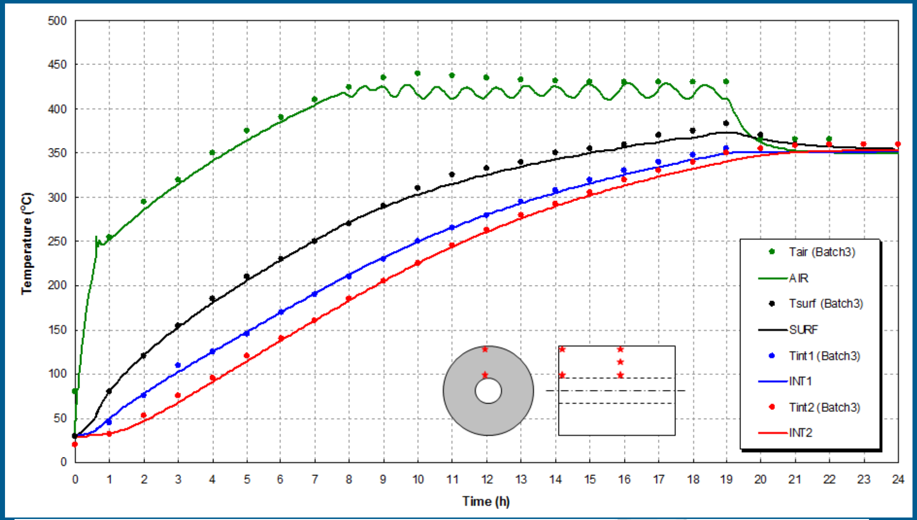
I. Modeling a Furnace for the Annealing of Aluminum Rolls

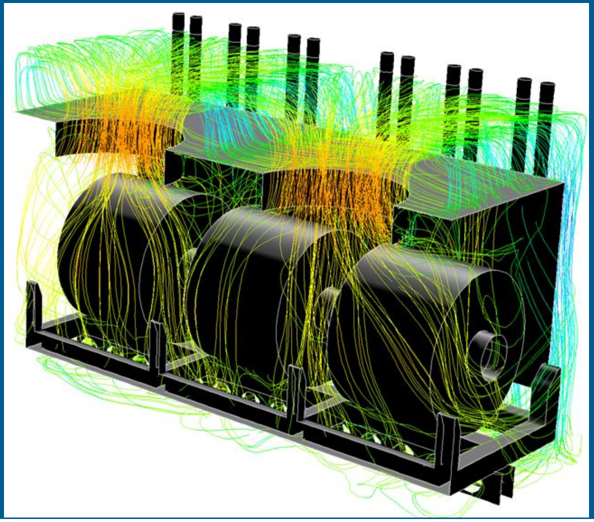


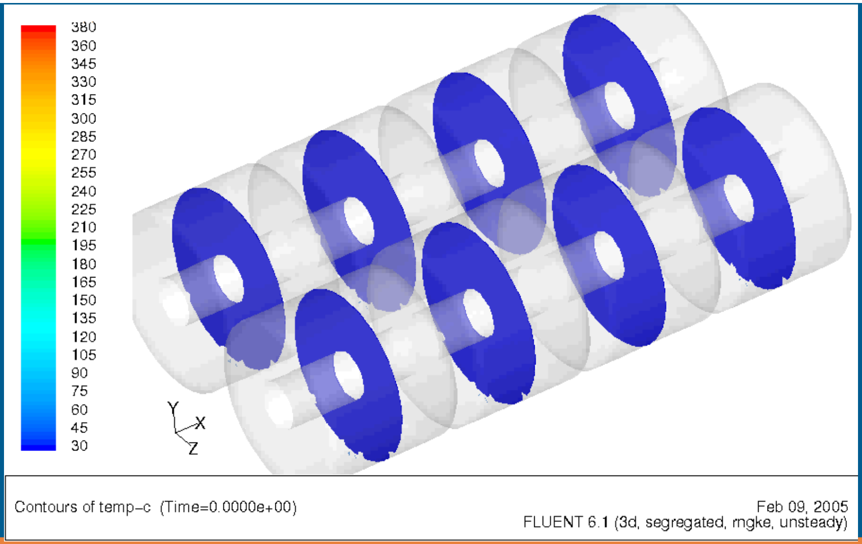


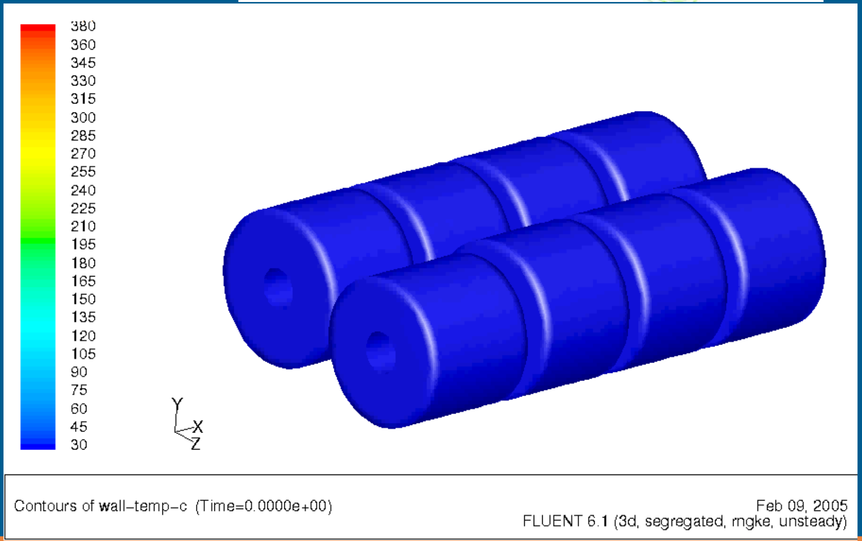
- Thermal power of 1.2 MW (12 direct U–tube burners).
- Convection heat transfer (N_2 flow driven by 2 fans).
- 6 aluminum rolls of different diameter and sheet thickness.
- The burners operate in on/off mode (with pilot) and the fans in two speeds (low/high).
- Anisotropic thermal resistance and thermal conductivity, dependent on the sheet thickness.

I. Modeling a Furnace for the Annealing of Aluminum Rolls



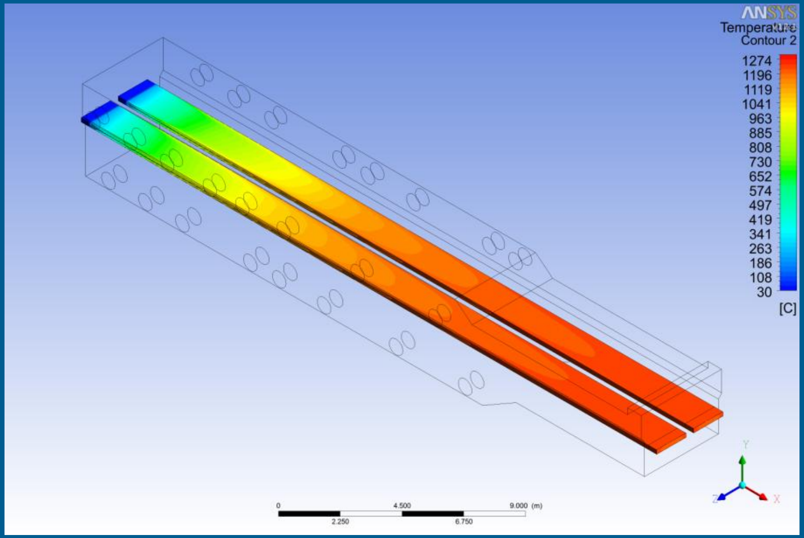




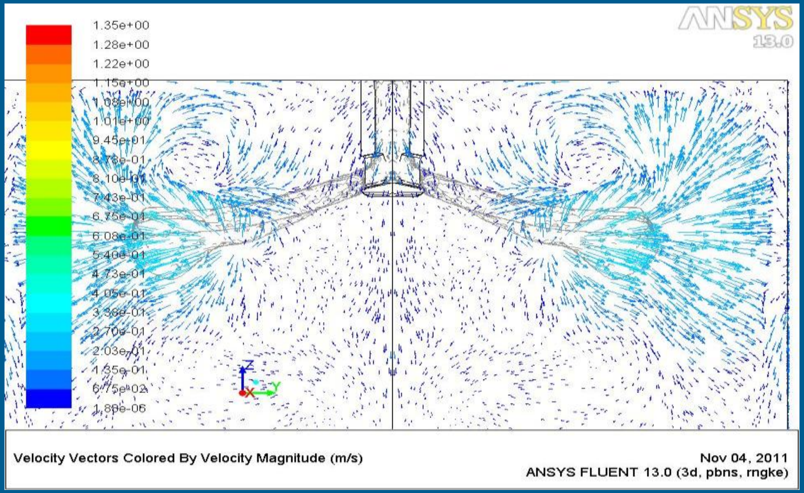


2d. EL.K.E.ME.

II. Modeling the Heating of a Metal Slab in a Furnace of Continuous Flow



III. Modeling of Continuous Casting of Aluminum/Steel (Melting/Solidification)



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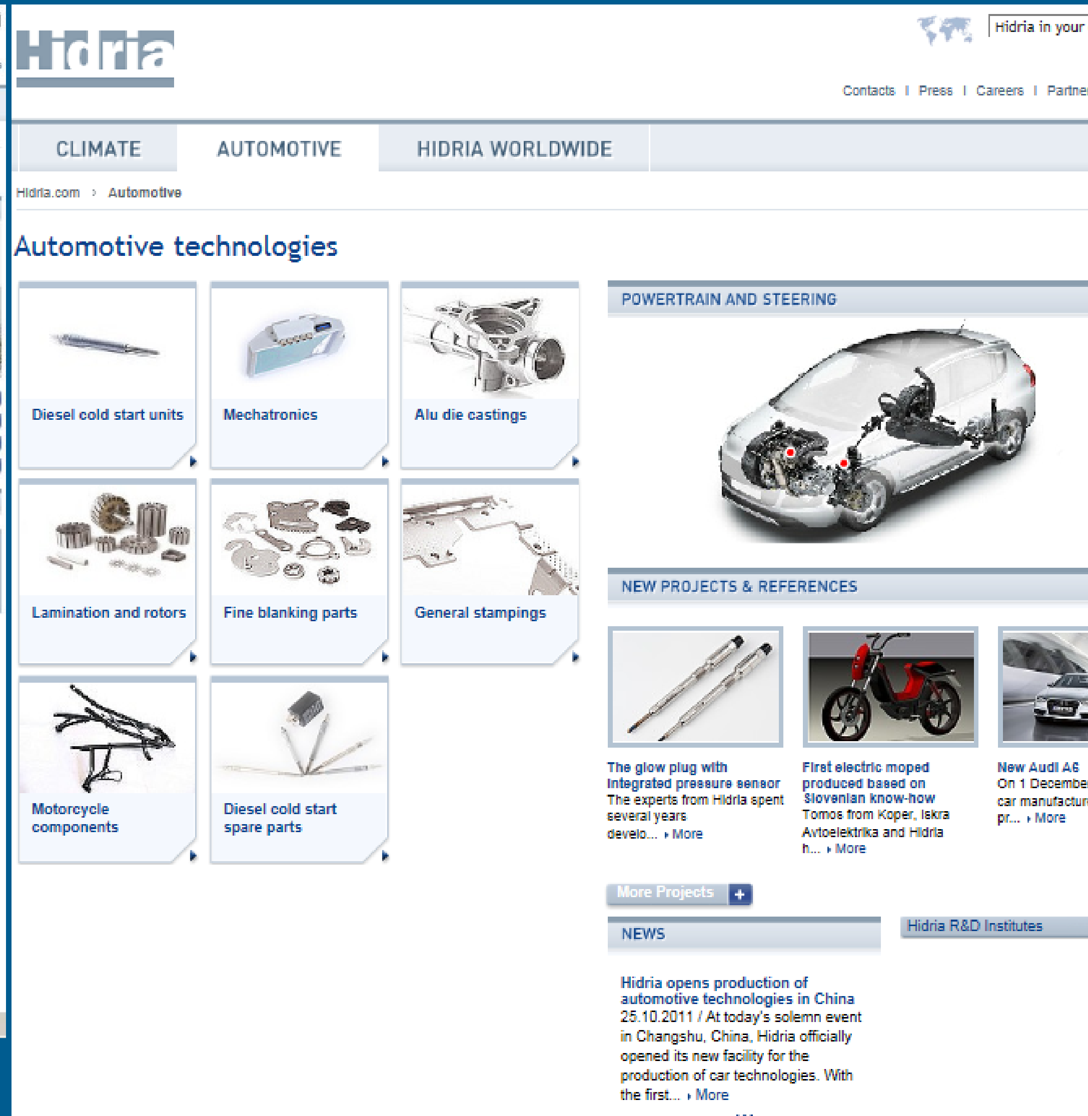
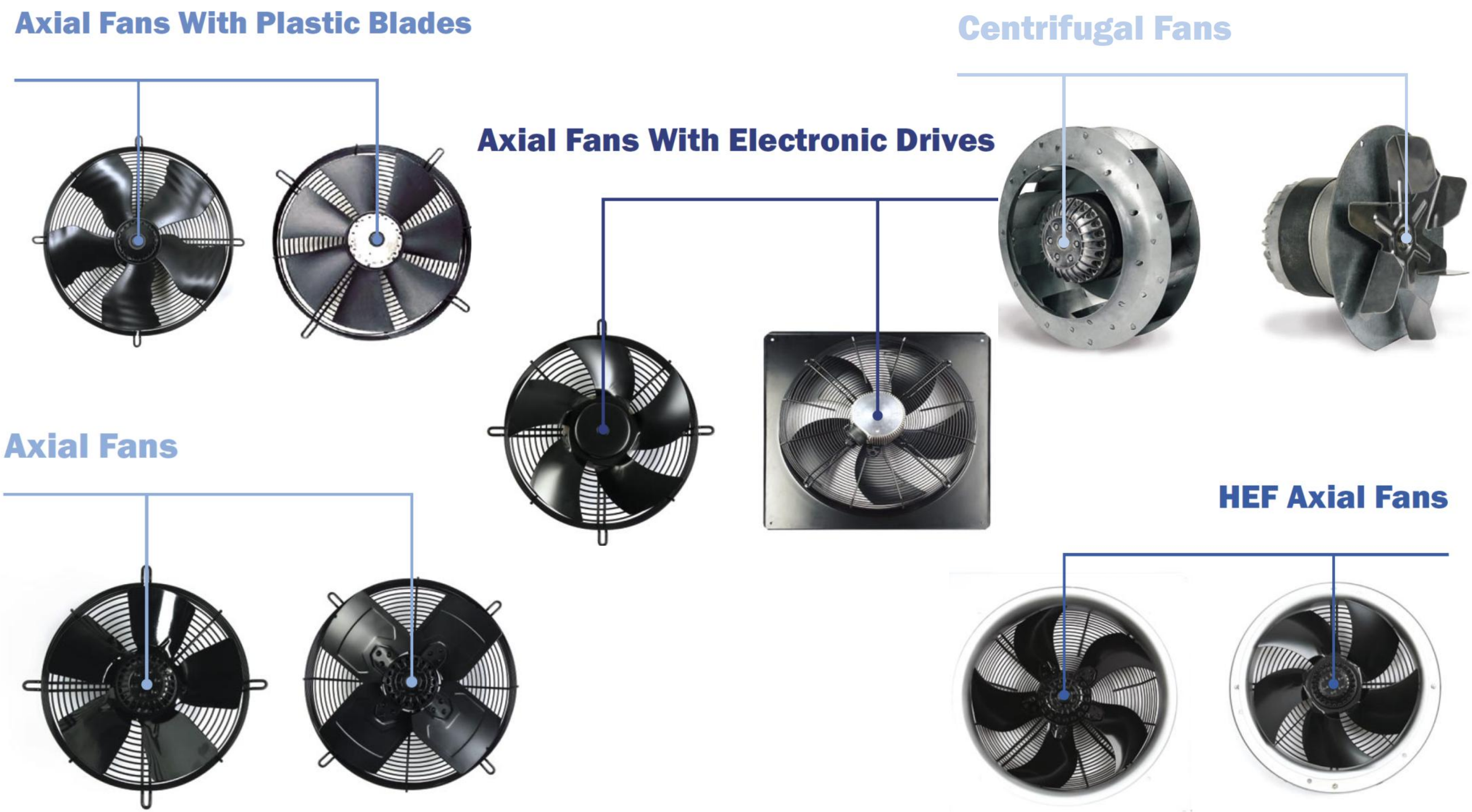
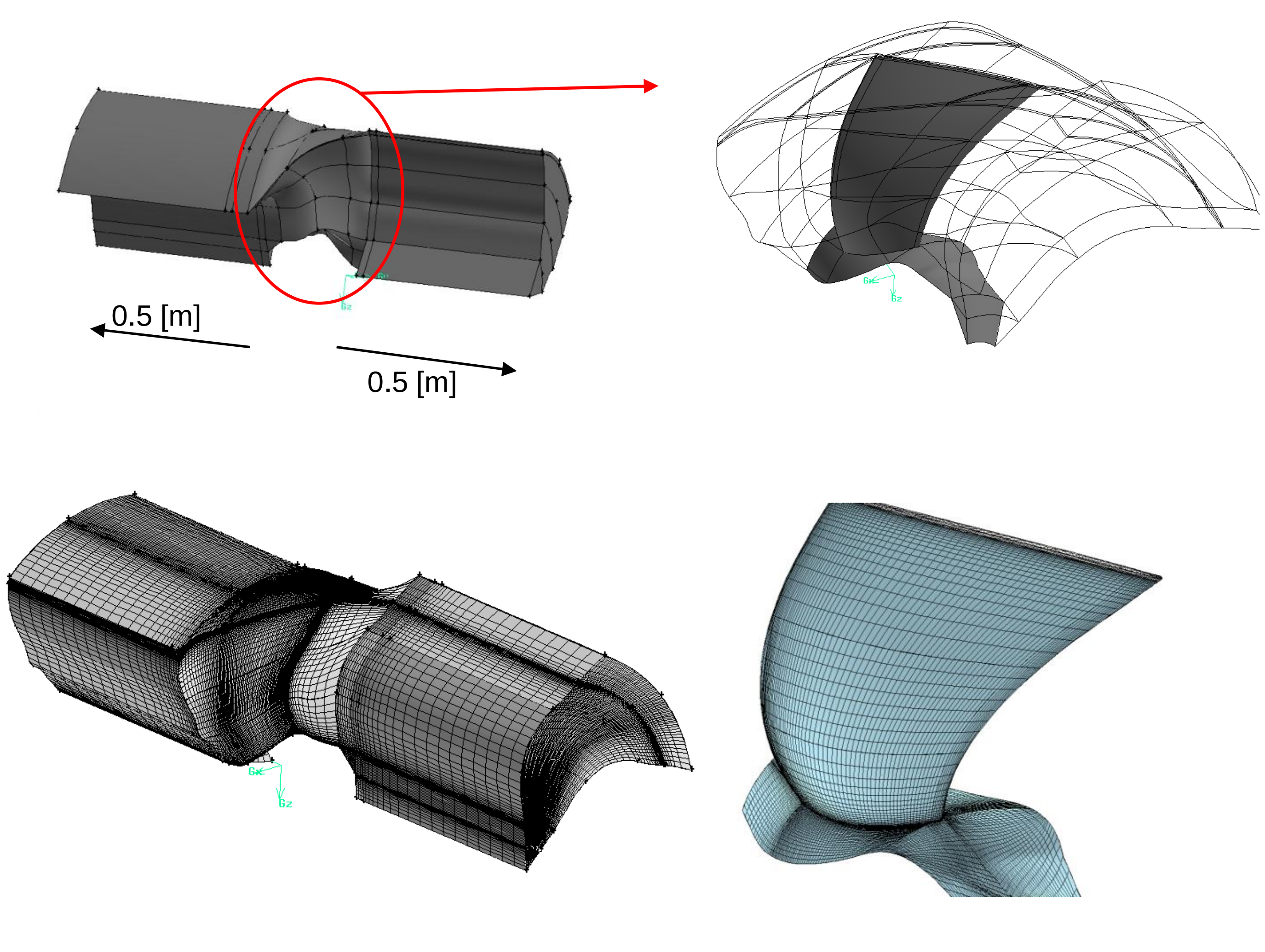
2e. HIDRIA d.d.



I. Modeling of Axial/Centrifugal Fans for A/C Units

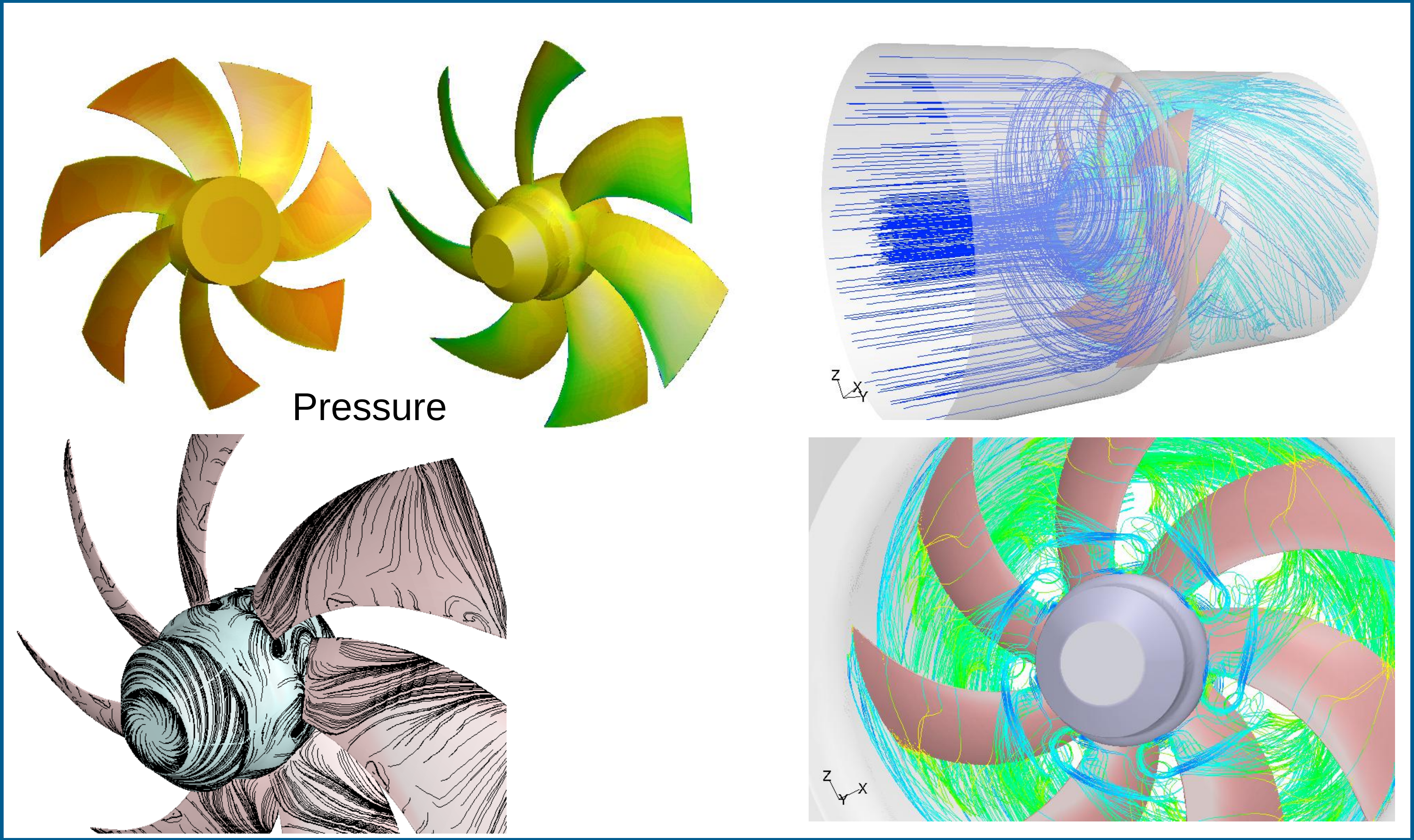


I. Modeling of Axial/Centrifugal Fans for A/C Units

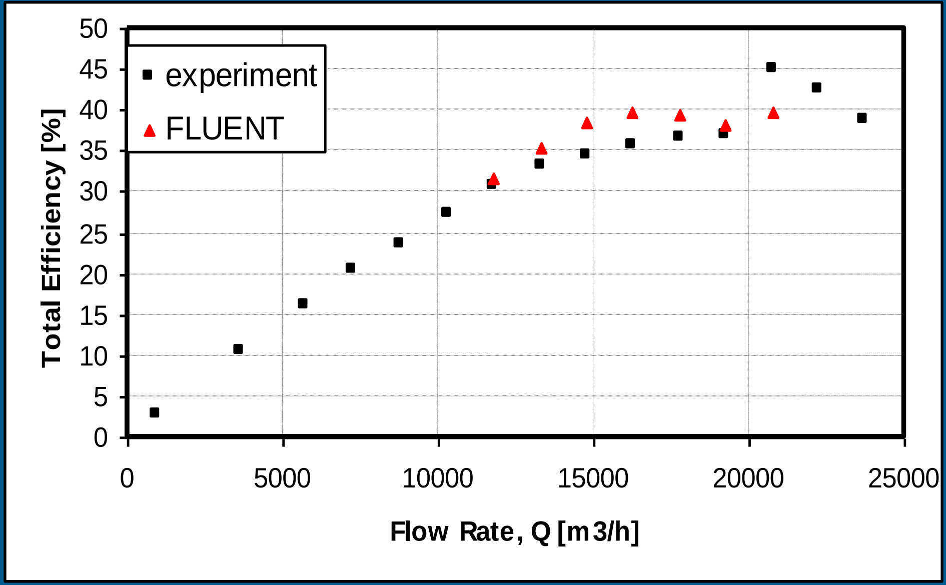


- 1/7th modeled.
- 700k cells.

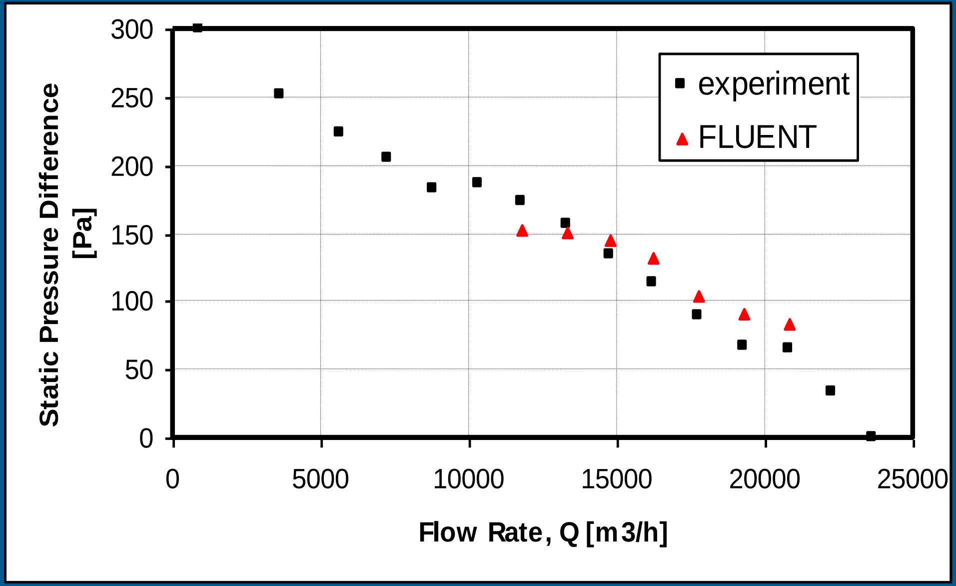
I. Modeling of Axial/Centrifugal Fans for A/C Units



I. Modeling of Axial/Centrifugal Fans for A/C Units



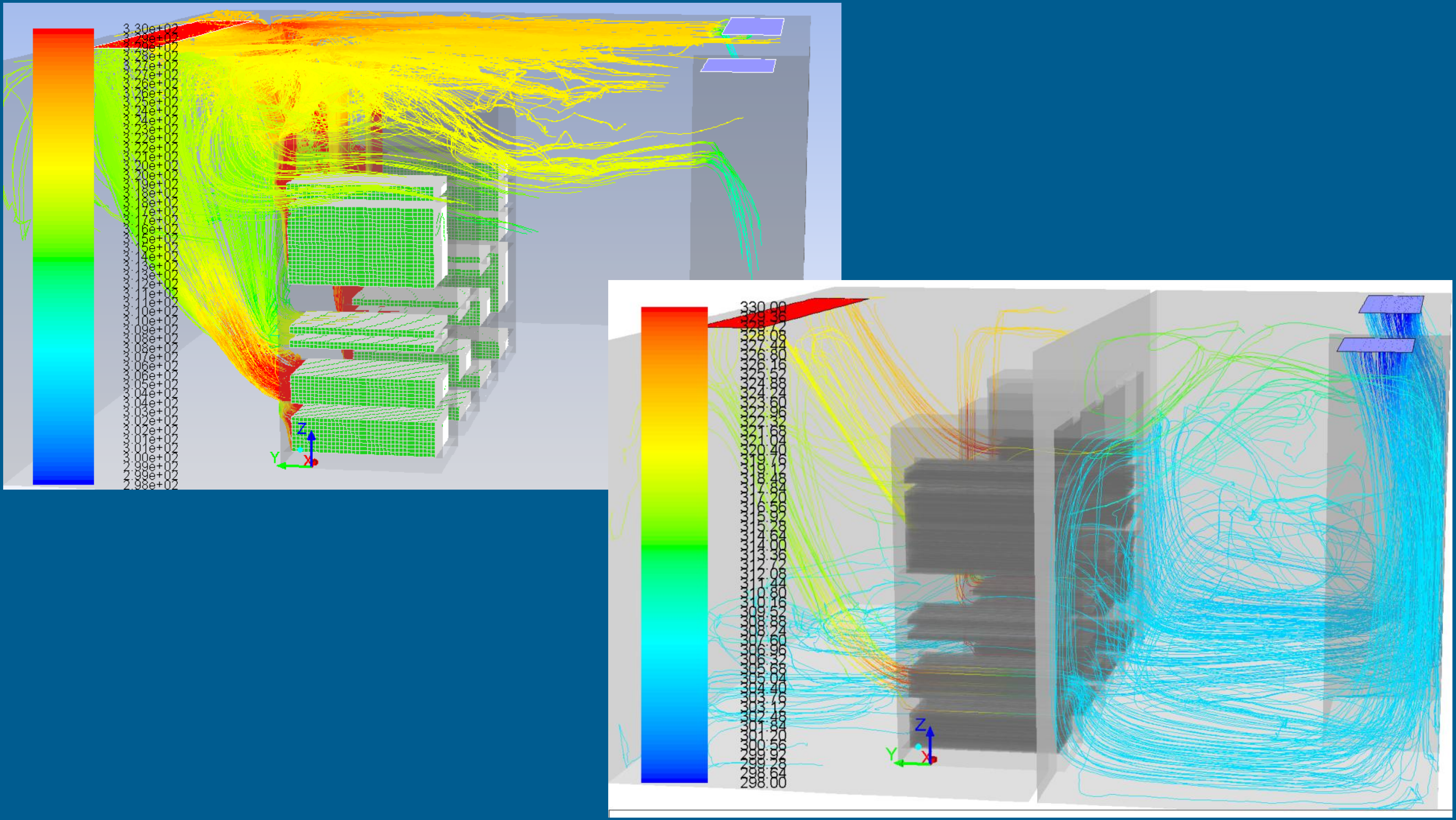
Total Efficiency



Static Pressure Rise

2e. HIDRIA d.d.

II. HVAC Studies



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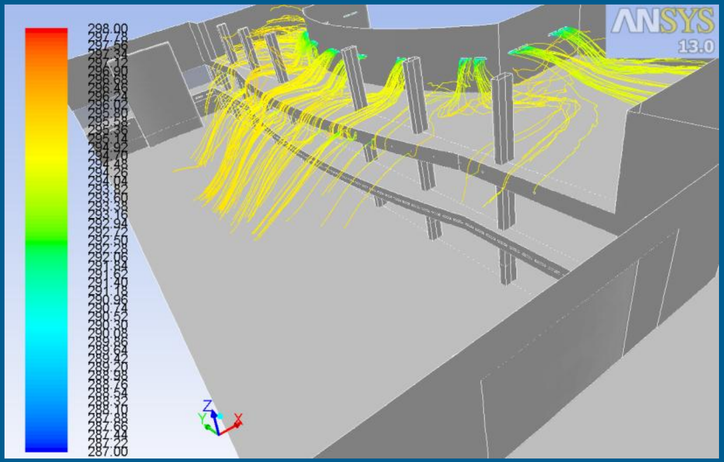
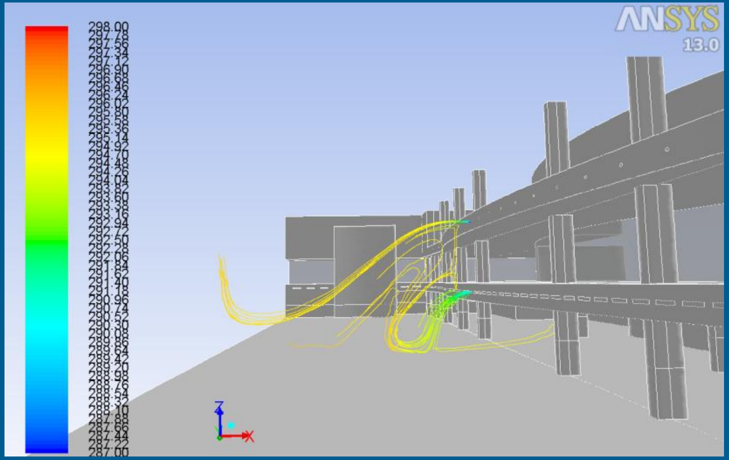
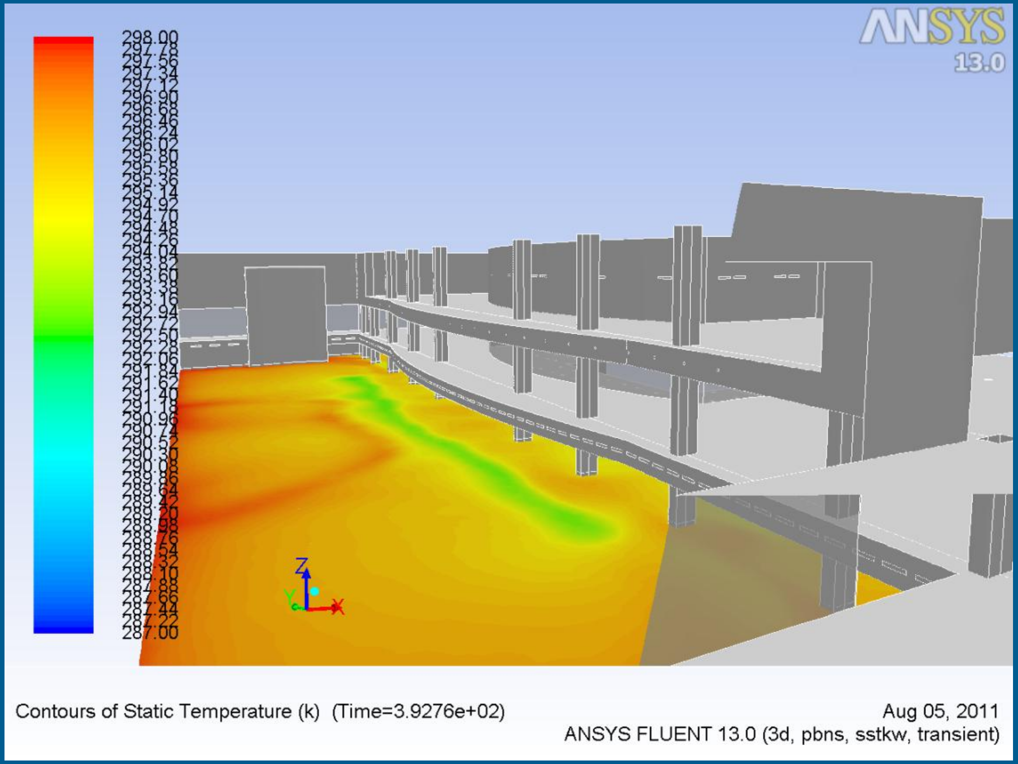
2e. HIDRIA d.d.

Hidria

II. HVAC Studies





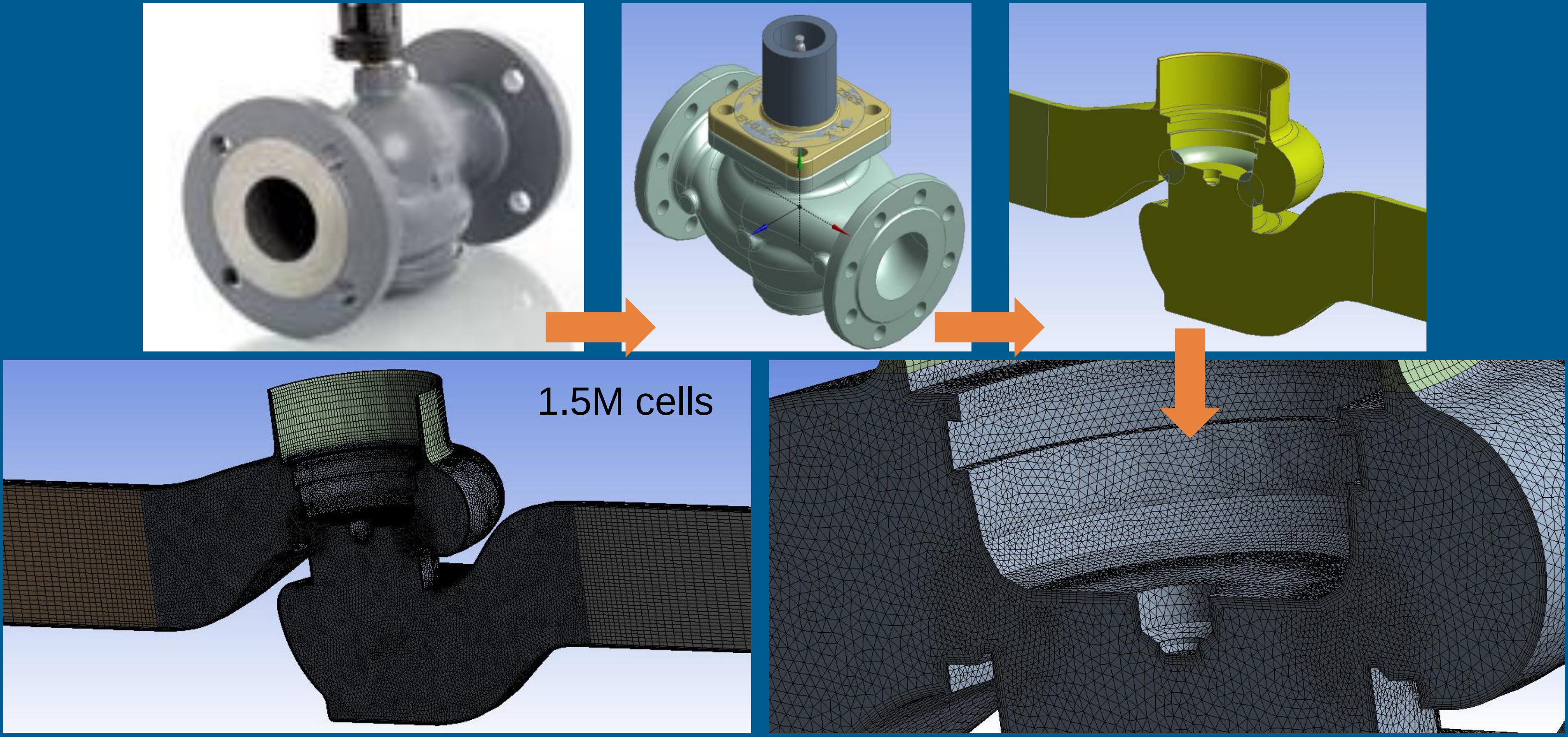


2f. DANFOSS Trata d.o.o.

District Heating Equipment

2f. DANFOSS Trata d.o.o.

District Heating Hydraulic Valve Modeling



- Calculation of flow rate, as a function of valve opening and differential pressure.
- Minimization of cavitation, noise and vibrations.

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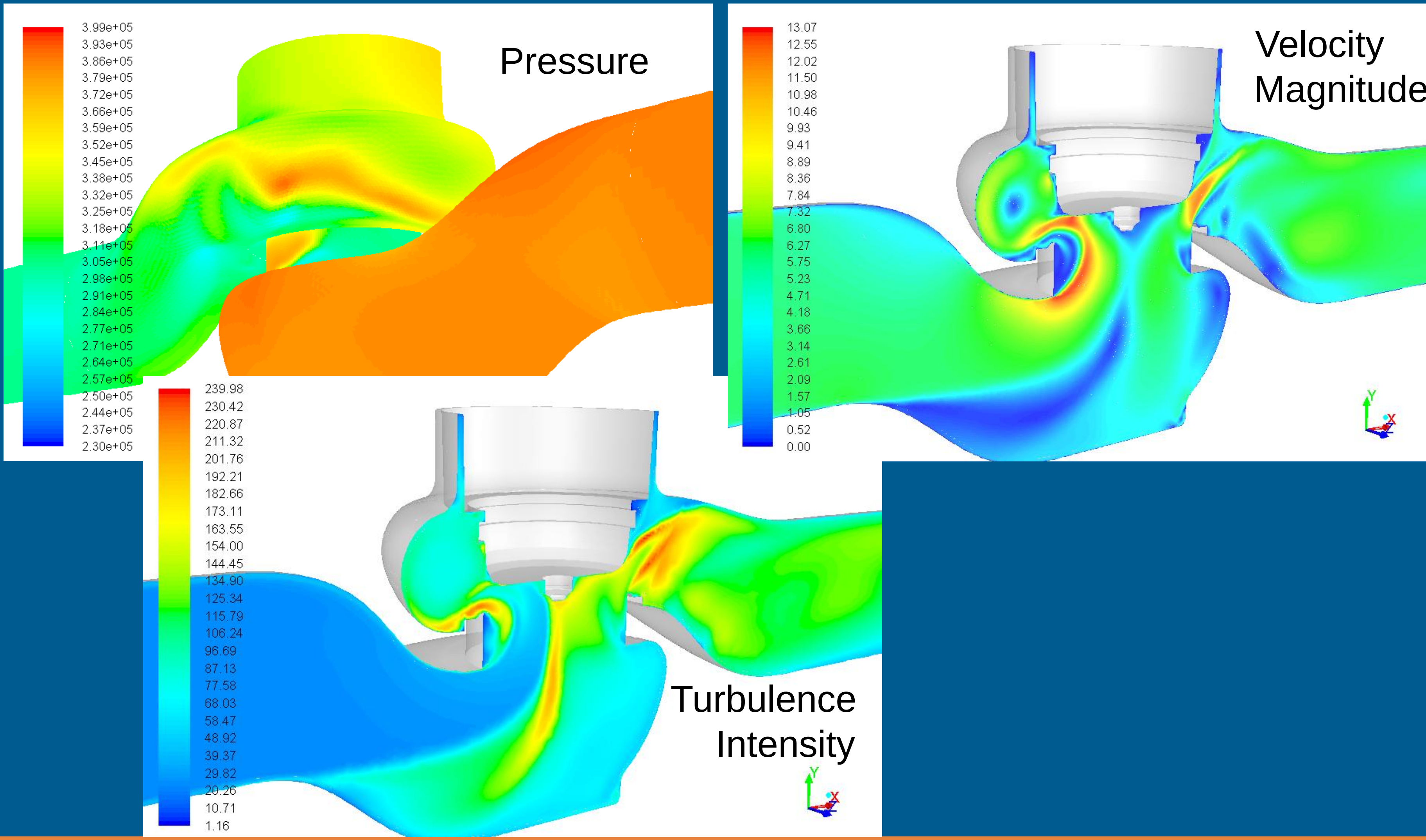
2f. DANFOSS Trata d.o.o.

Danfoss Trata

District Heating Hydraulic Valve Modeling



PARTNERSHIP FOR ADVANCED COMPUTING IN EUROPE

2g. DOMEL d.o.o.

Dry Vacuum Motors

Brushless Pumps & Fans

Commutator Motors

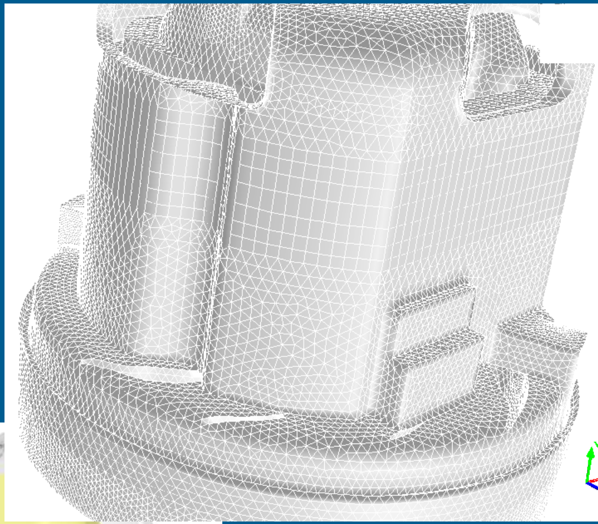
EC Drives & Fans

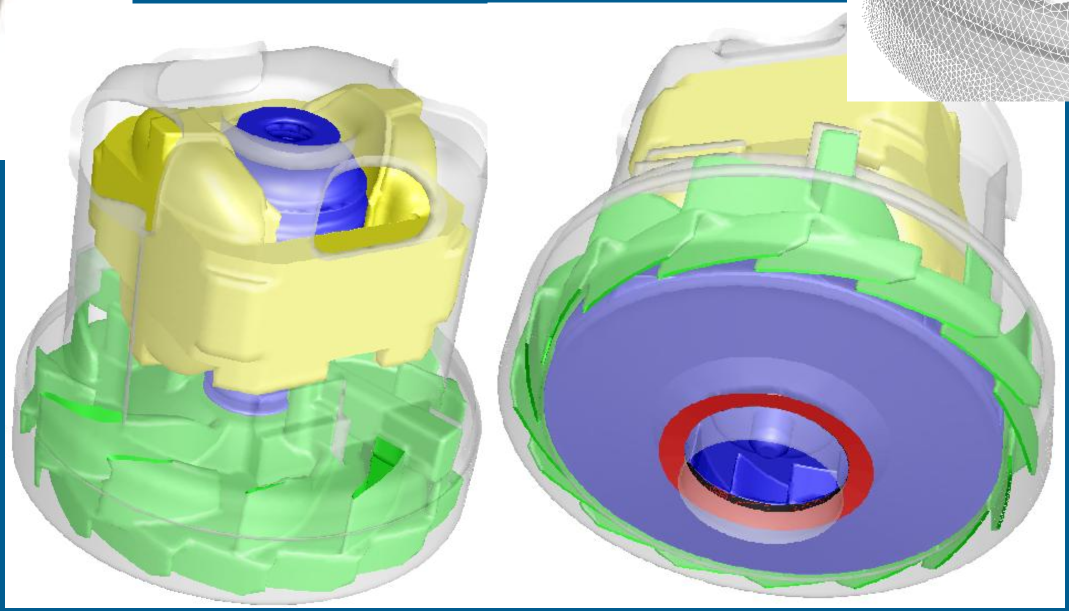
Wet Vacuum Motors

DC Motors

I. Dry Vacuum Motor CFD Model

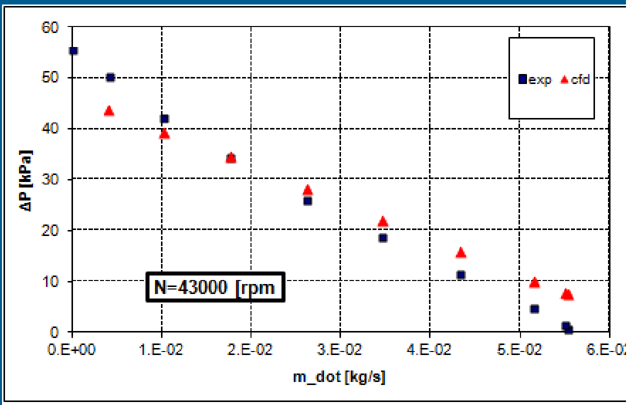
600k cells

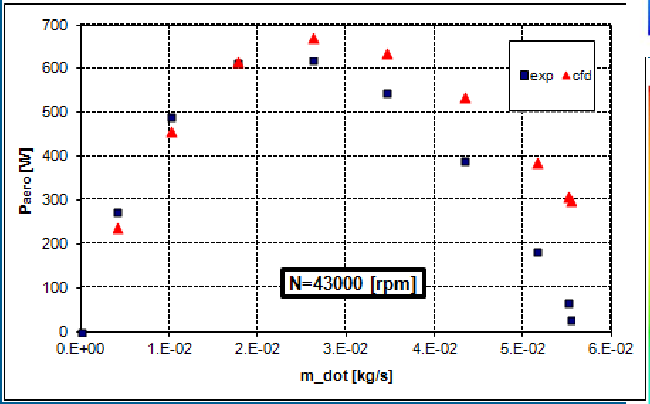


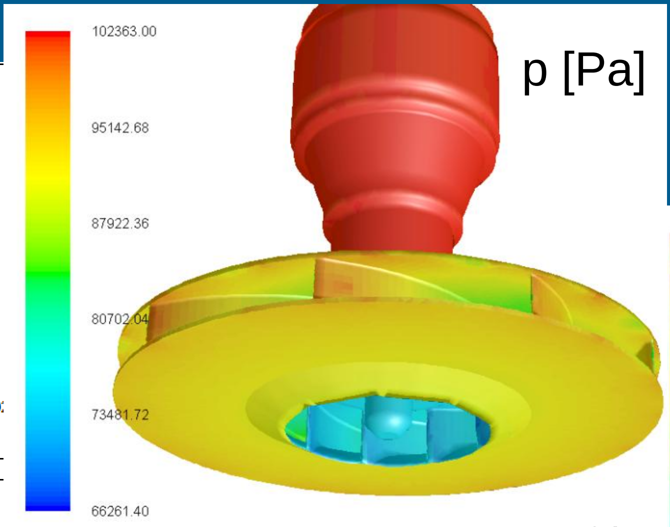


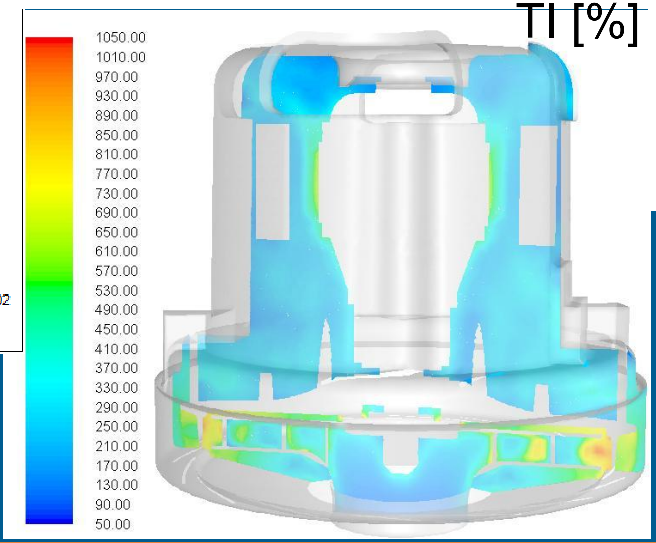
2g. DOMEL d.o.o.

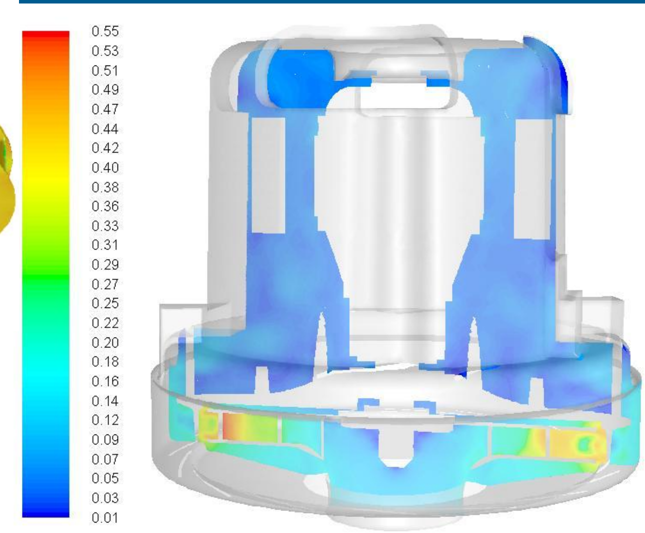
I. Dry Vacuum Motor CFD Model





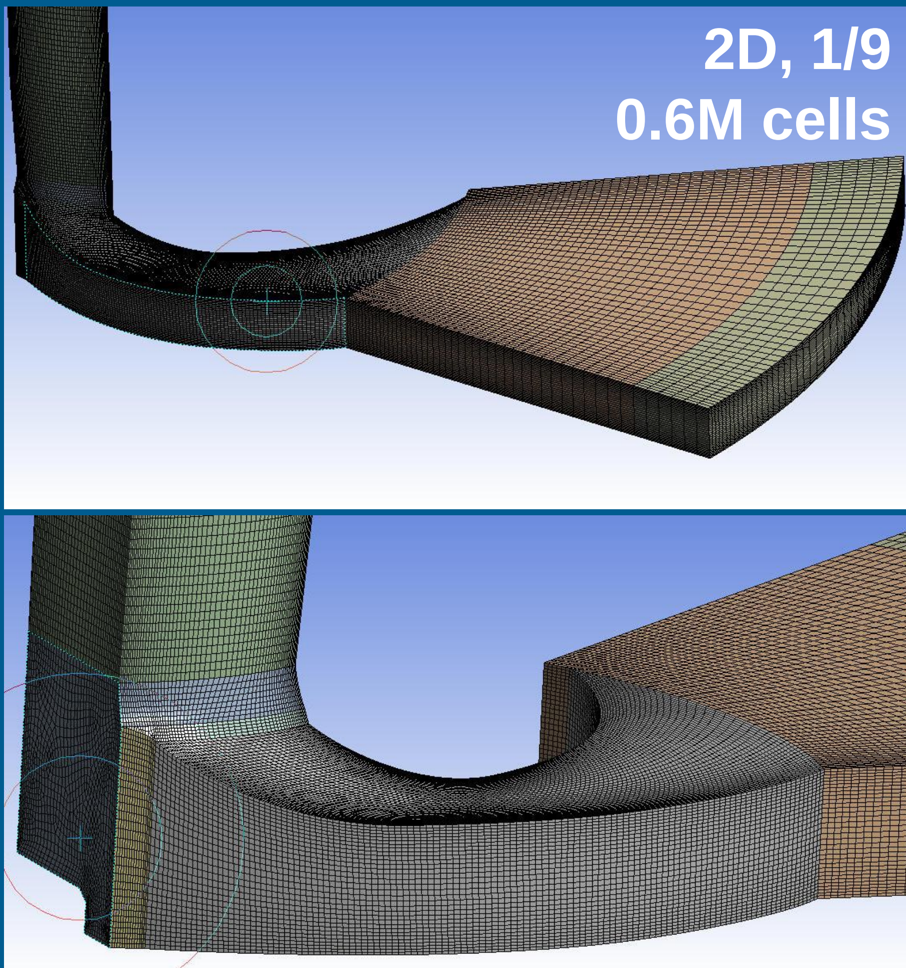


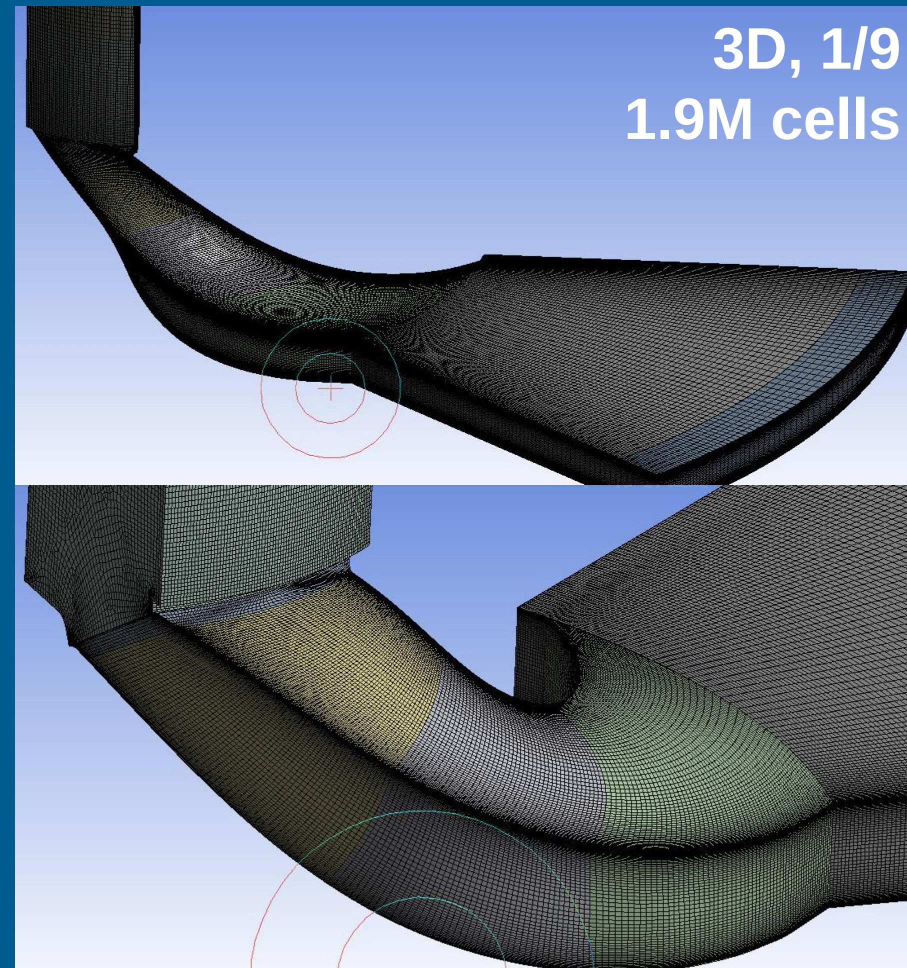




Mach

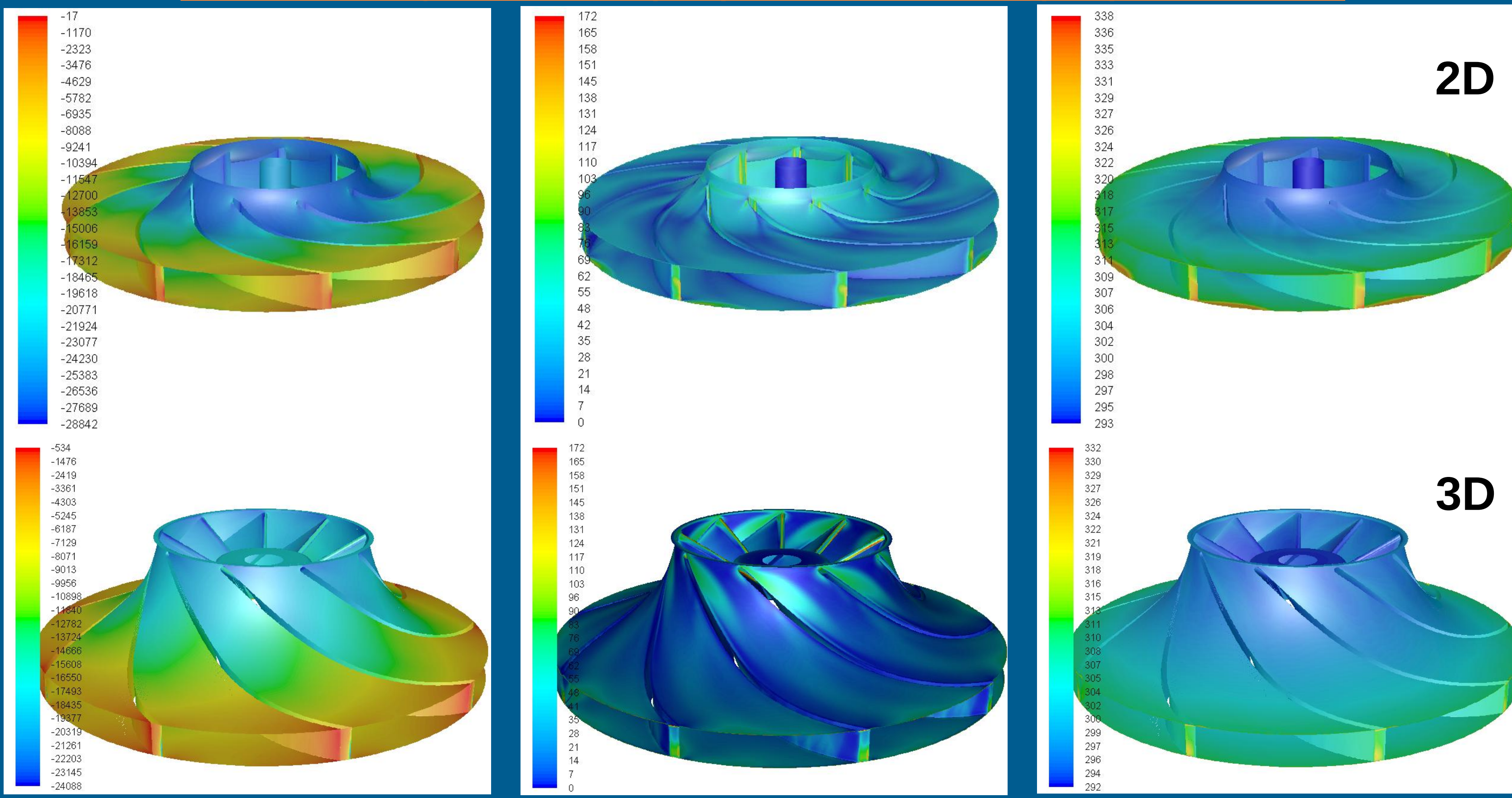
II. Modeling Smooth (2D) and Twisted (3D) Impellers





2g. DOMEL d.o.o.

II. Modeling Smooth (2D) and Twisted (3D) Impellers



Pressure | Wall Shear Stress | Temperature

2h. NV–FLUID d.o.o.

Fuel Tankers

Bitumen/Heavy Oil Tankers

Chemicals Tankers

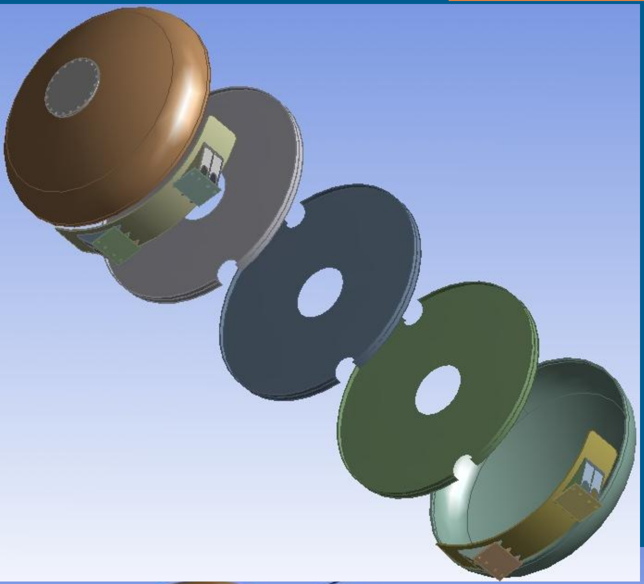
Liquified Gases Tankers

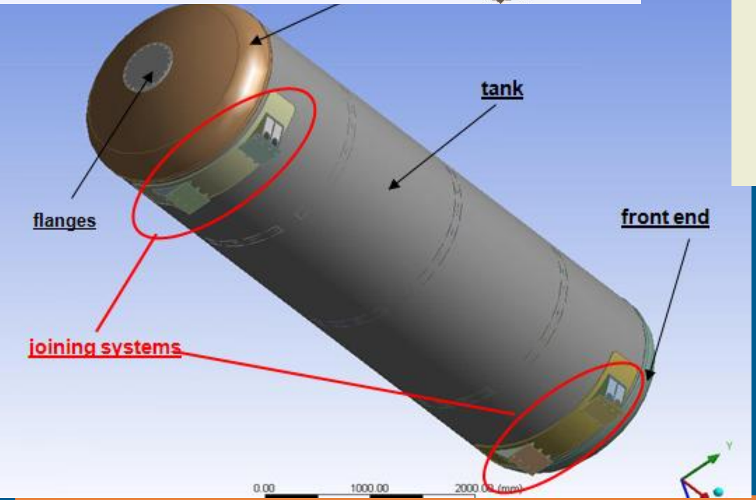
Aircraft Refuelers

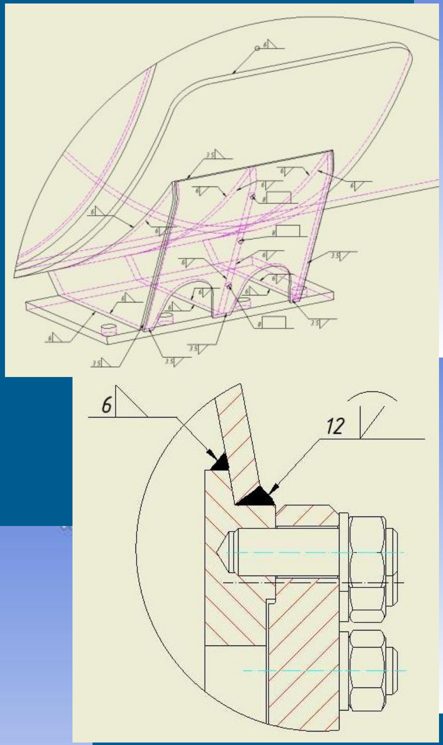
Special Tankers

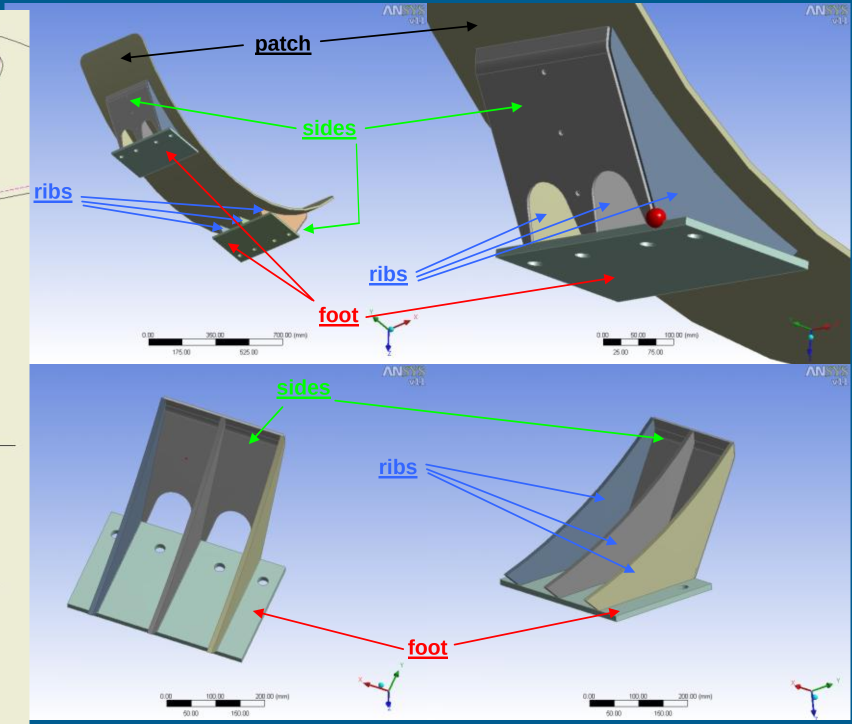
2h. NV–FLUID d.o.o.

Structural Analysis of a Road Tanker









- Check for ADR2007 certification.
- Combination of loading conditions.

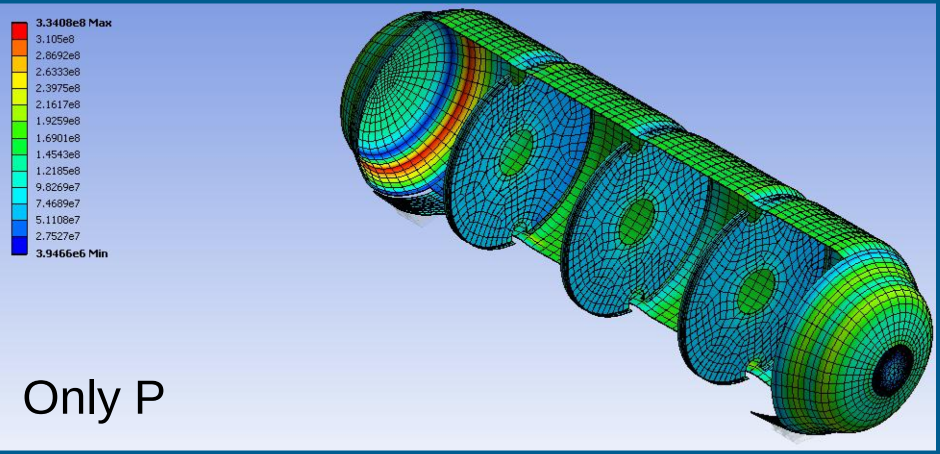
Structural Analysis of a Road Tanker

The following loading scenarios were solved:

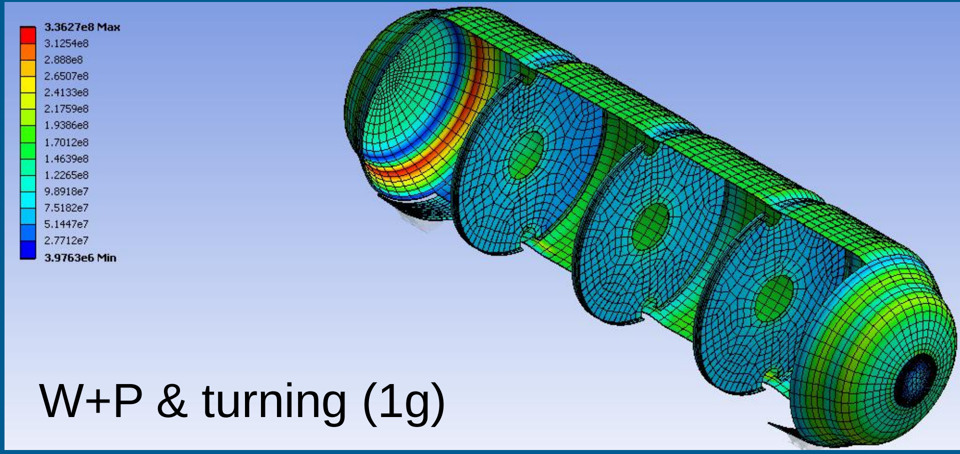
I. Only the weight of the structure (19 [kN]) & fluid (110 [kN]).
II. Only the gas pressure (18 [bar]).
III. Weight of structure/fluid & gas pressure, i.e. W+P load.
IV. W+P load & accelerating with 2g.
V. W+P load & breaking with 2g.
VI. W+P load & turning with 1g.
VII. W+P load & dropping with 2g.
VIII. W+P load & rising with 1g.
IX. W+P load & accelerating by 2g & temperature 40^{o}C.
X. W+P load & accelerating by 2g & temperature 60^{o}C.
XI. W+P load & breaking by 2g & temperature 40^{o}C.
XII. W+P load & breaking by 2g & temperature 60^{o}C.

2h. NV–FLUID d.o.o.

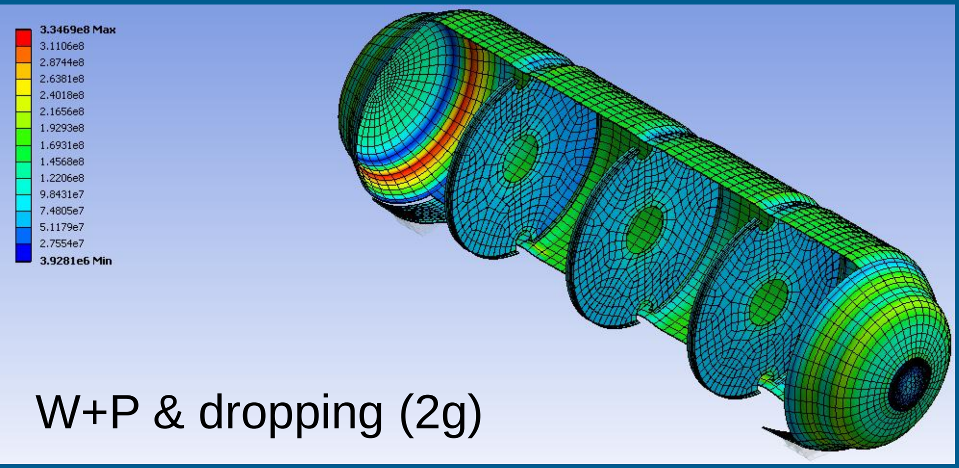
Structural Analysis of a Road Tanker



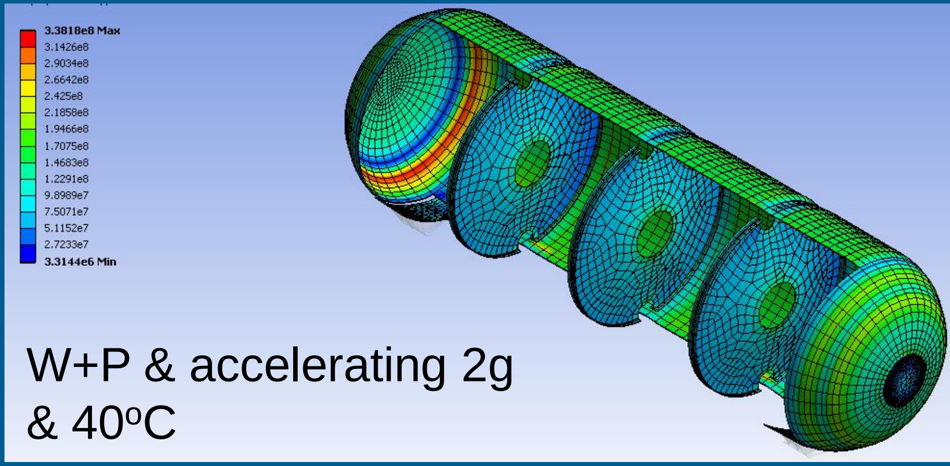
Only P



W+P & turning (1g)



W+P & dropping (2g)

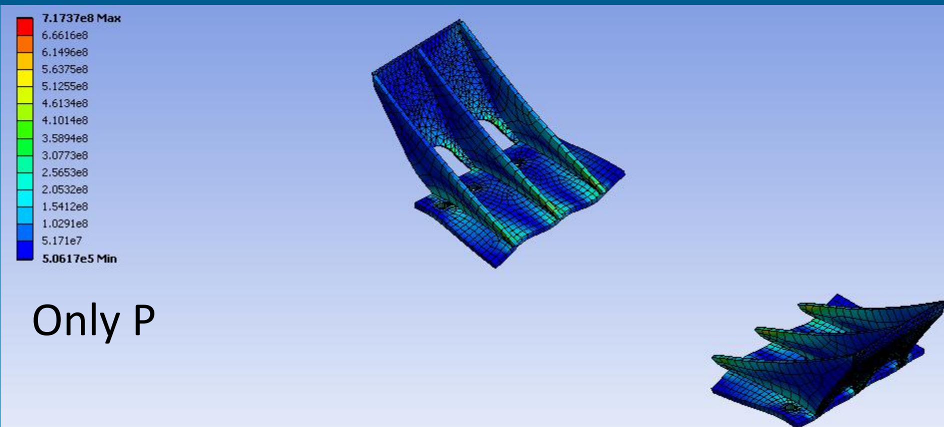


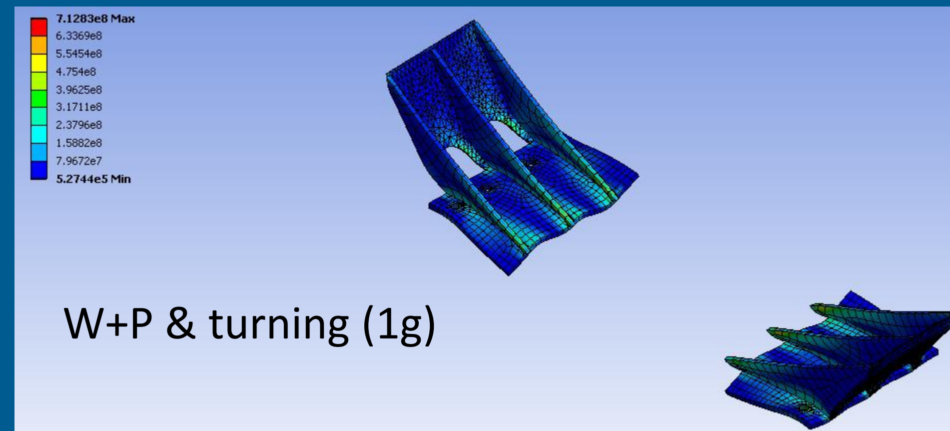
W+P & accelerating 2g & 40^{o}C

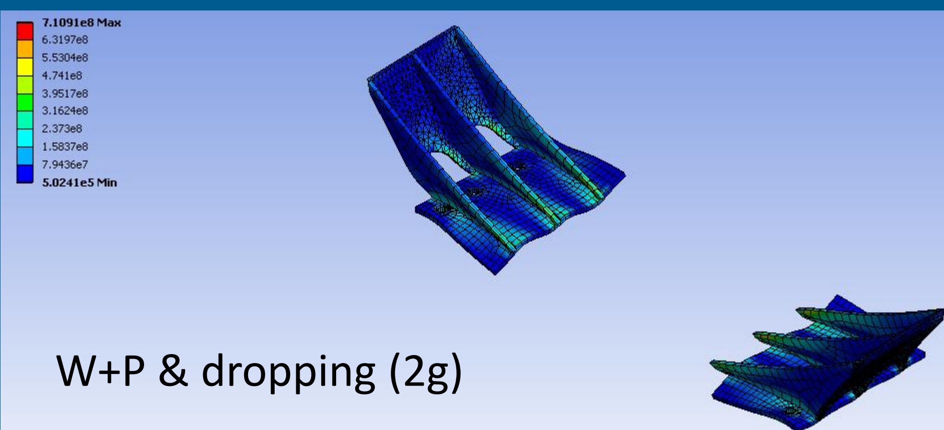
Equivalent Stress

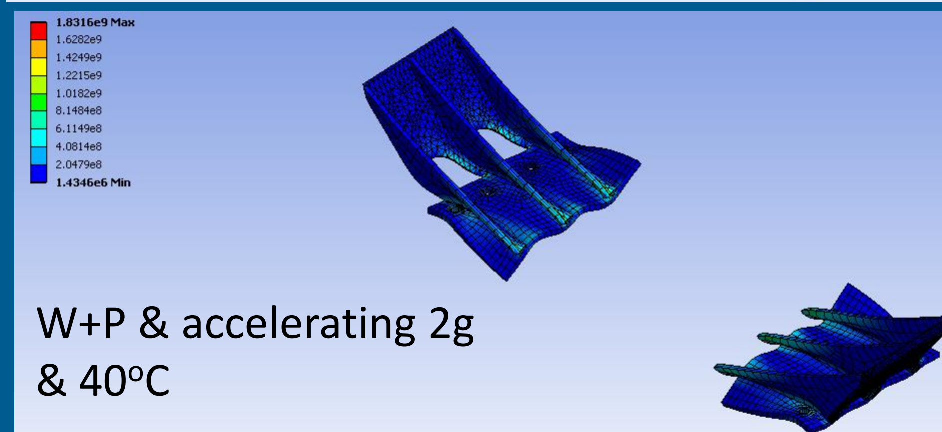
2h. NV–FLUID d.o.o.

Structural Analysis of a Road Tanker









Equivalent Stress

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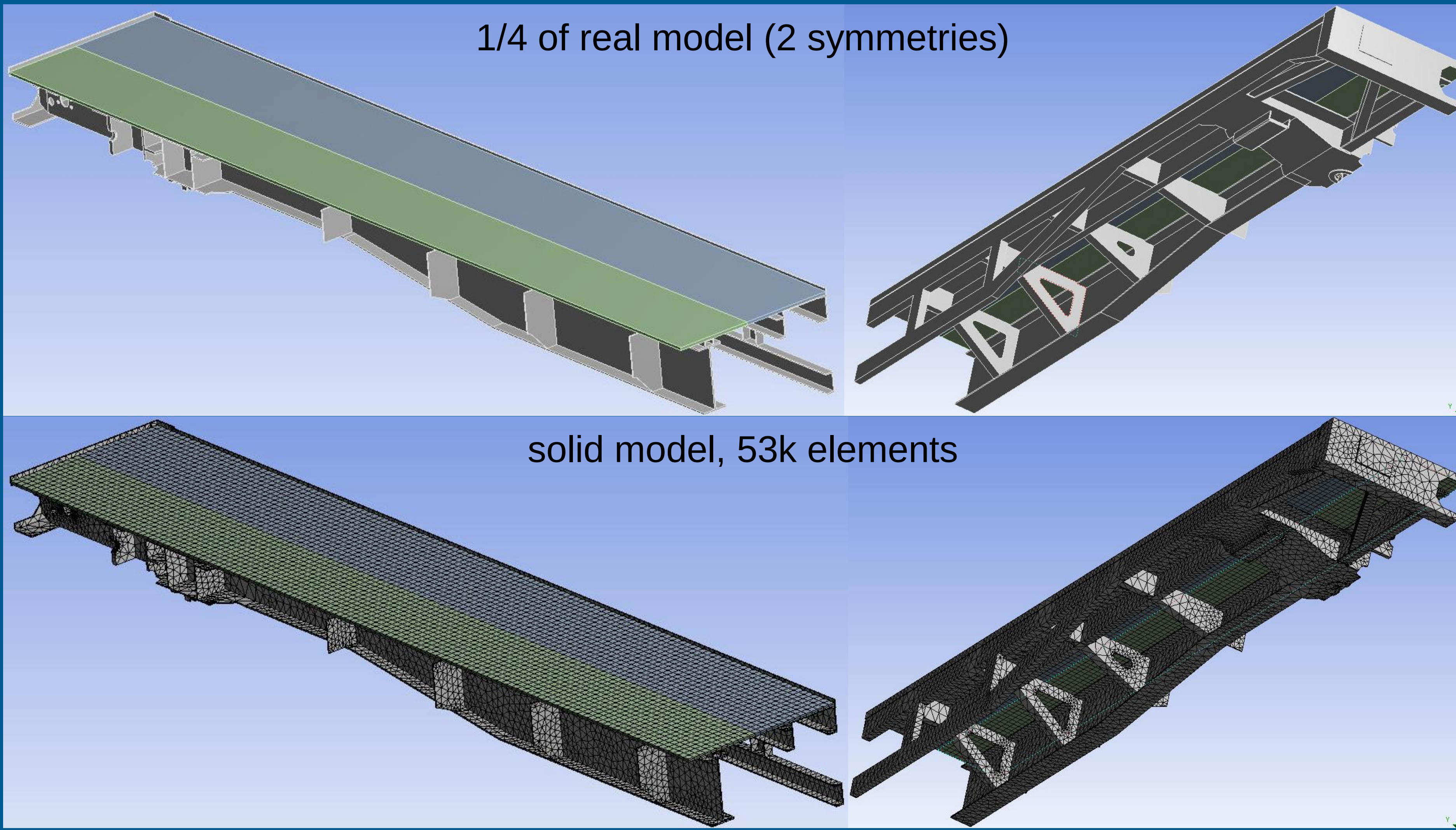
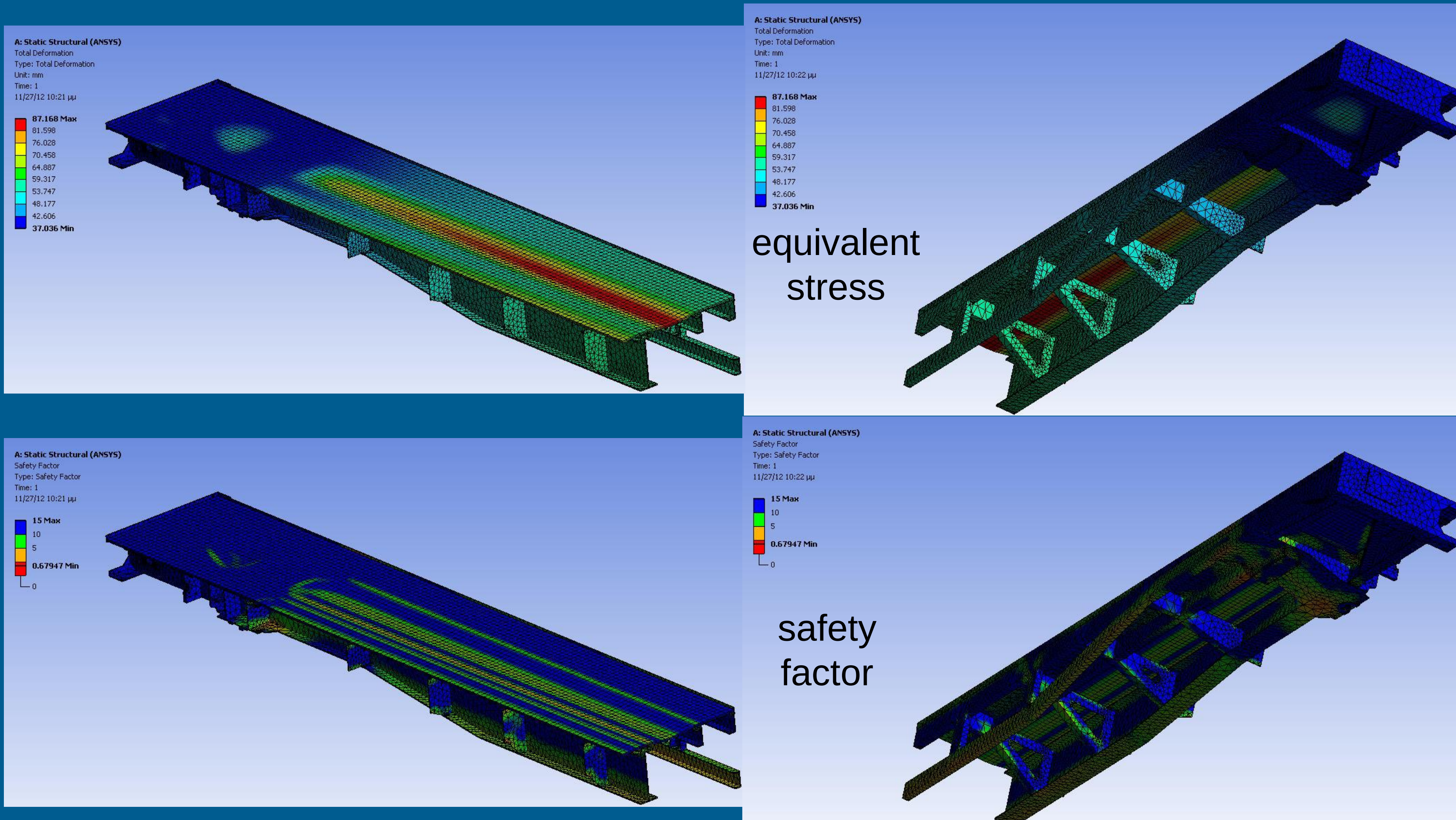
2i. TŽV–GREDELJ d.o.o.

GREDELJ

Structural Analysis of a Wagon Base

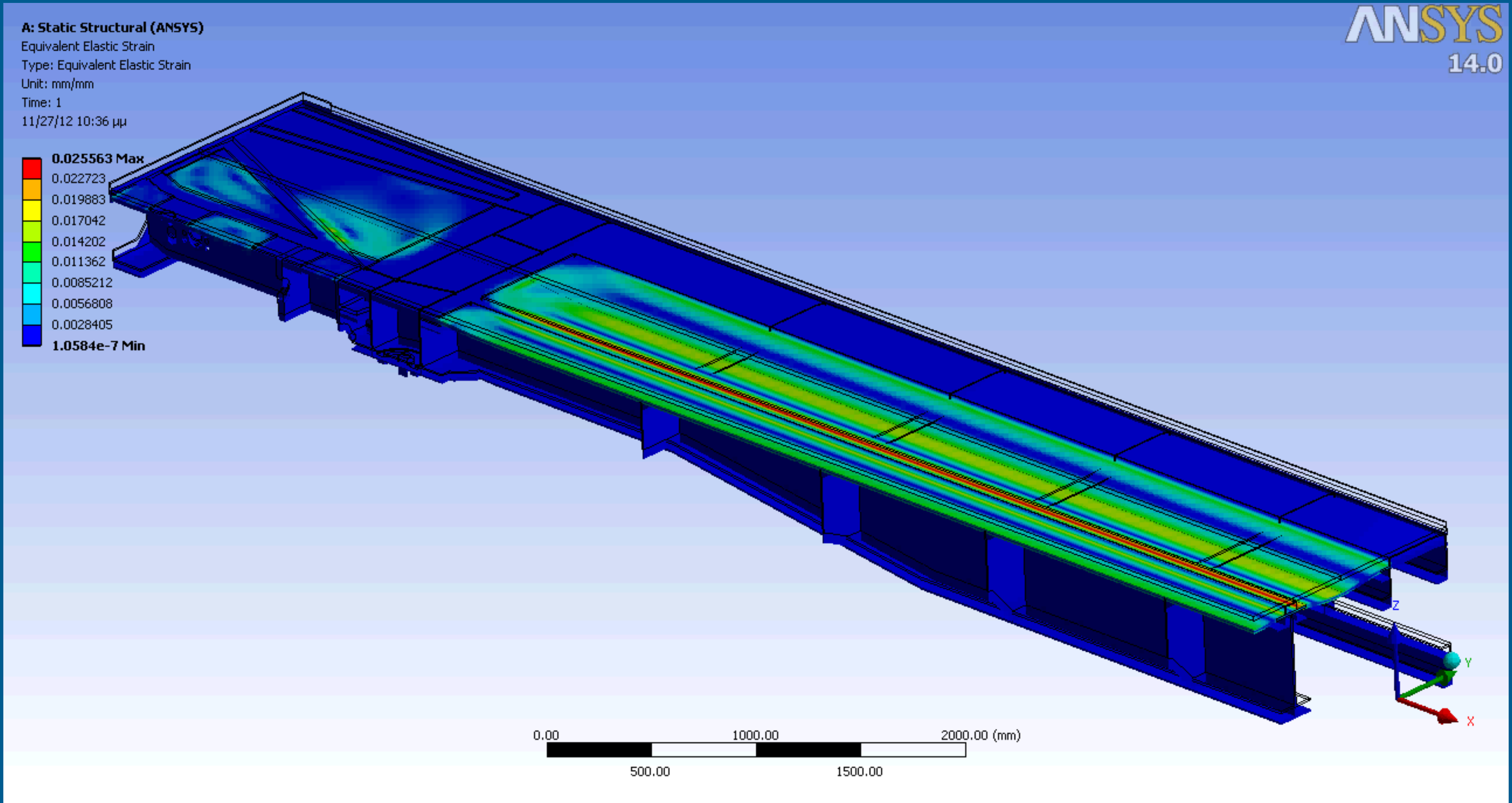


Structural Analysis of a Wagon Base



2i. TŽV–GREDELJ d.o.o.

Structural Analysis of a Wagon Base



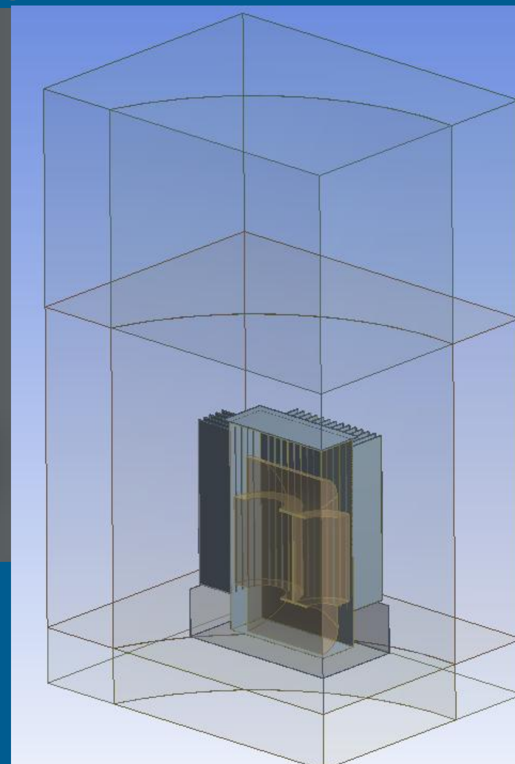
Equivalent Elastic Strain

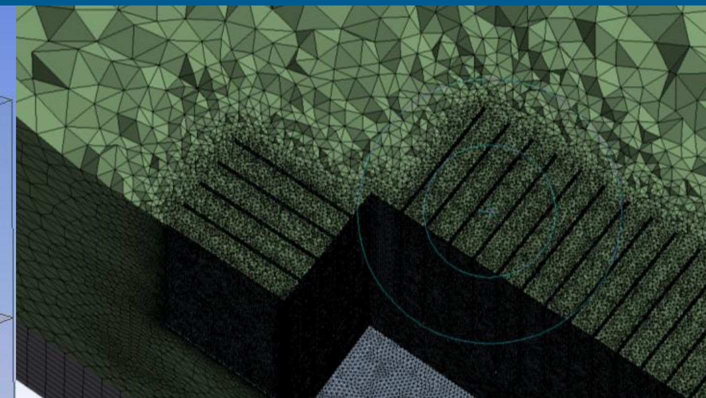
2j. KOLEKTOR ETRA d.o.o.

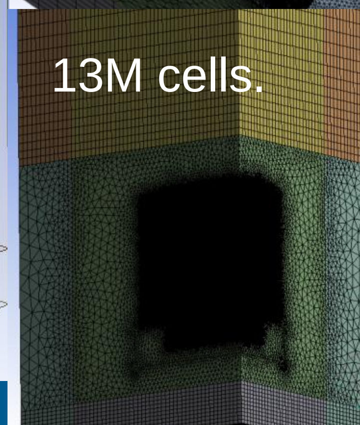
Power Transformers

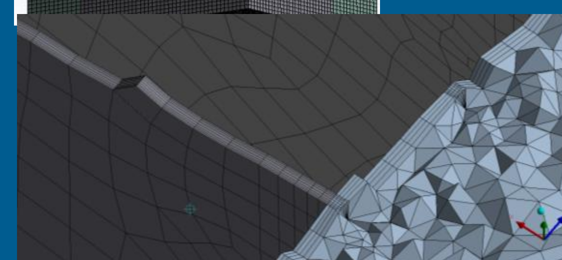
2j. KOLEKTOR ETRA d.o.o.

I. Modellling of an Oil-Cooled Transformer



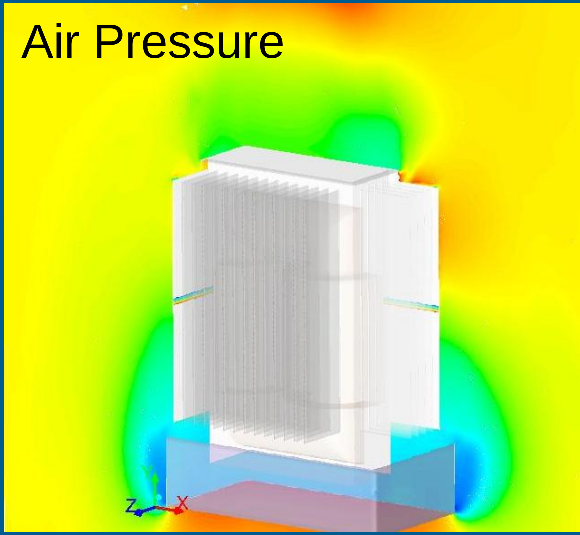


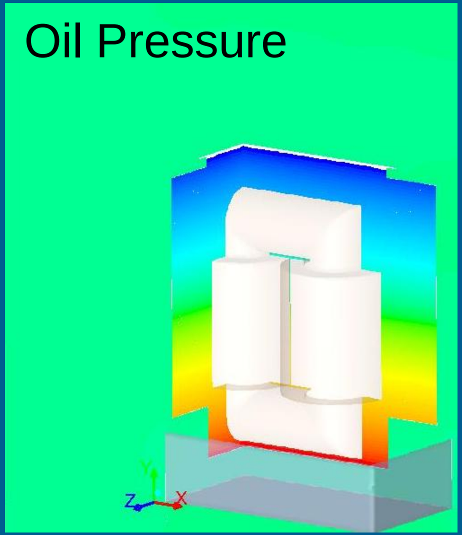


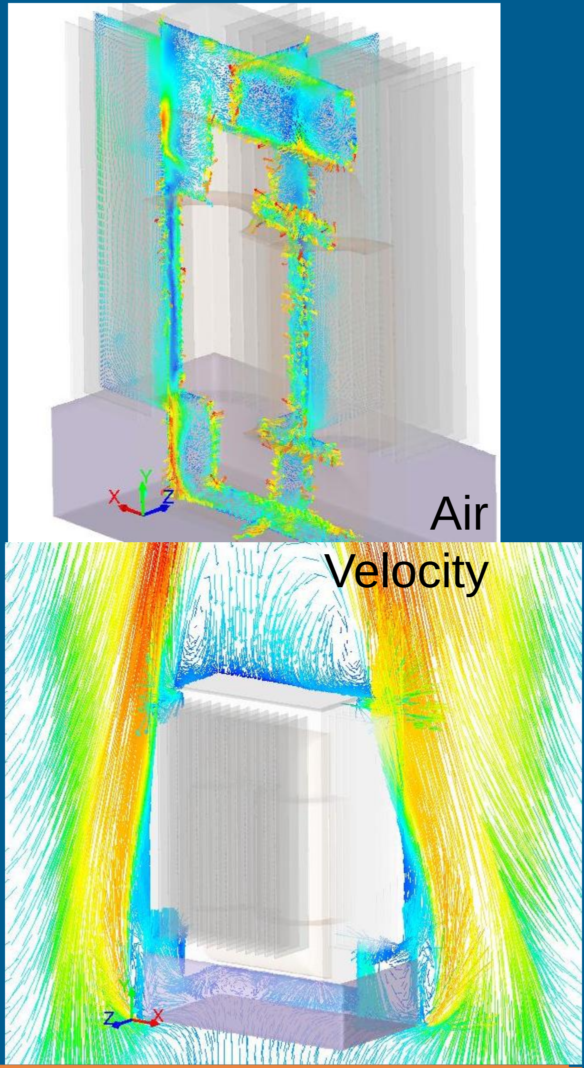


- 1/4 of the model simulated, due to symmetry.
- Oil, air & steel materials, with temperature–dependent properties.
- Heat (3.1 [kW]) is dissipated from the transformer.
- Calculate heat drawn by the oil (buoyant flow).

I. Modeling of an Oil–Cooled Transformer

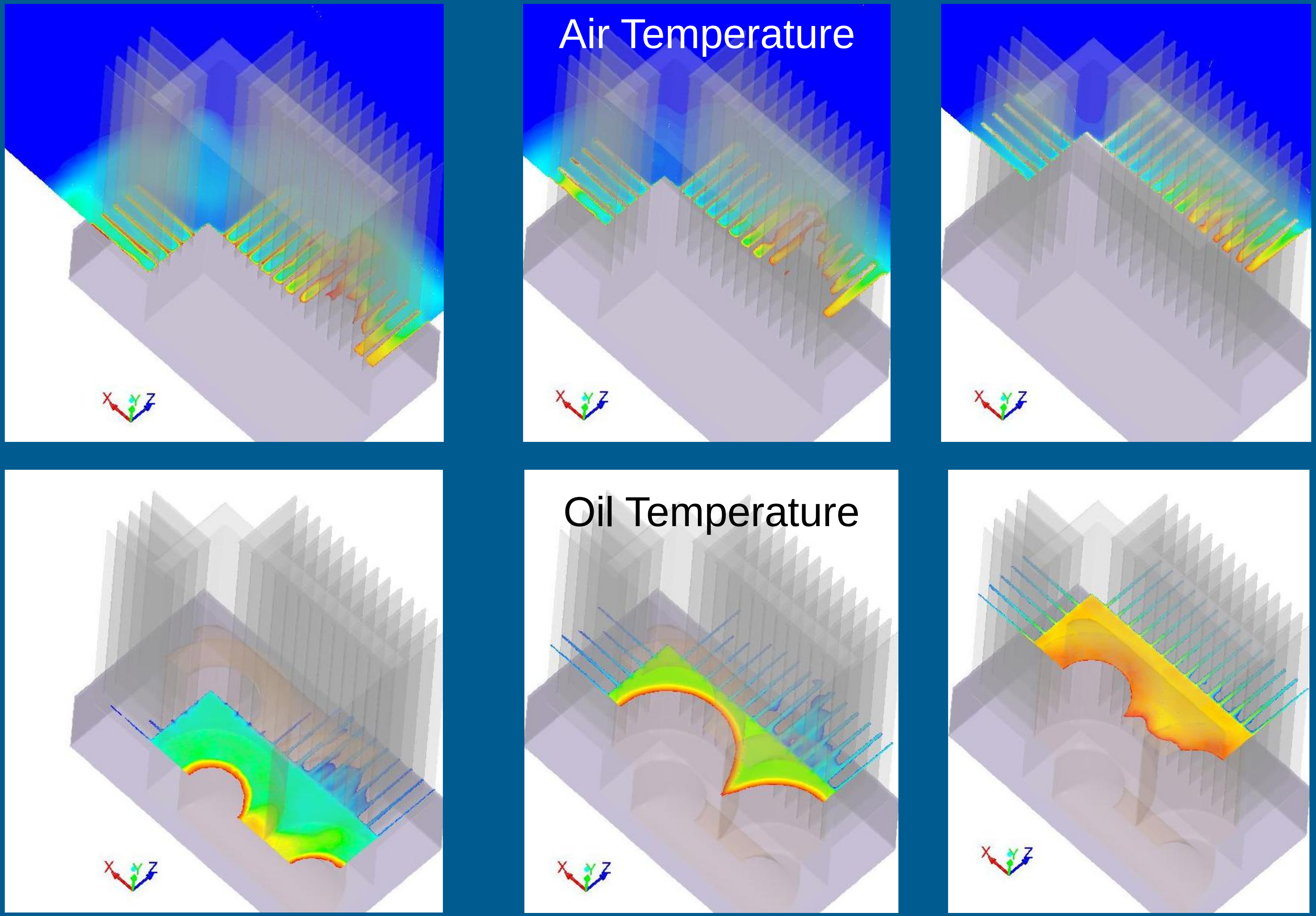




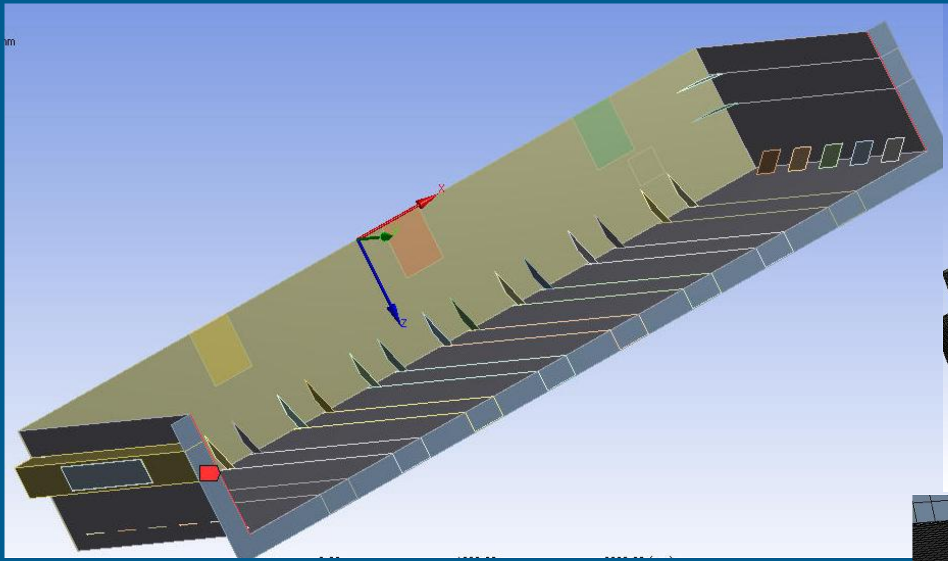


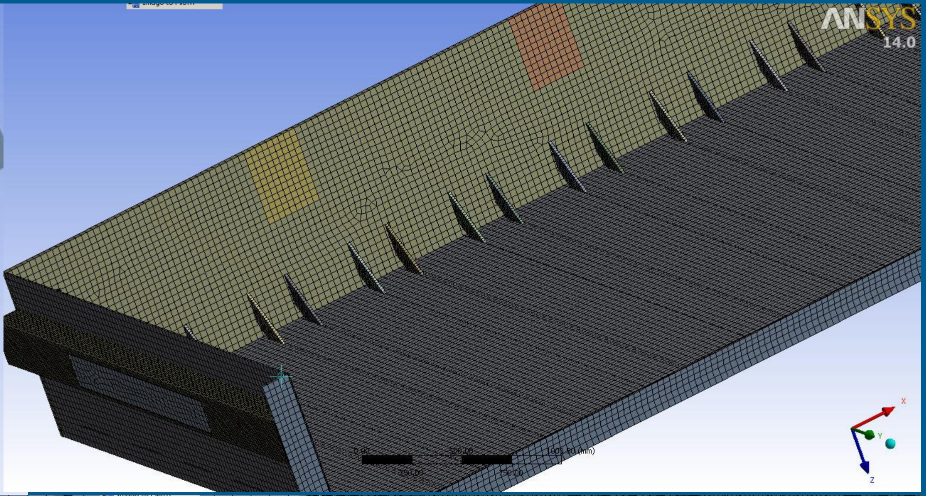
2j. KOLEKTOR ETRA d.o.o.

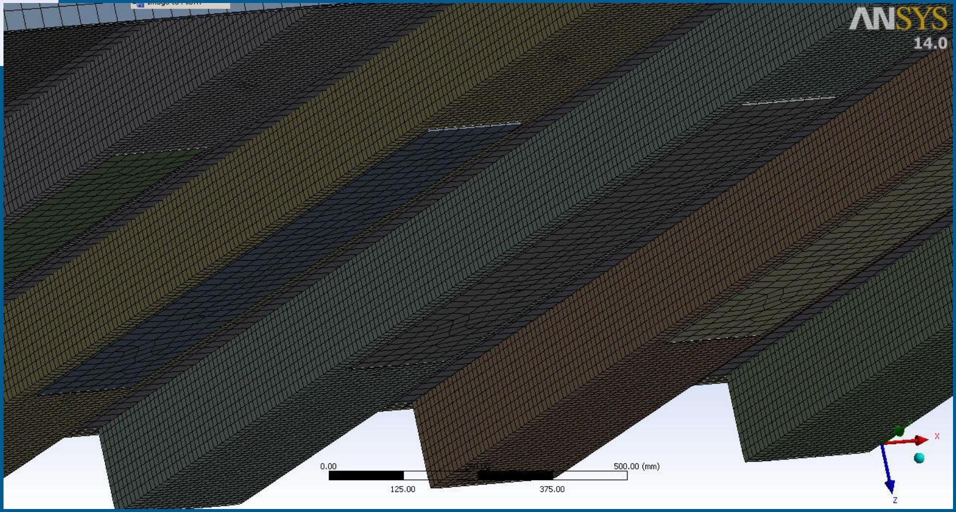
I. Modeling of an Oil–Cooled Transformer



II. Structural Modeling of the Frame of a Transformer



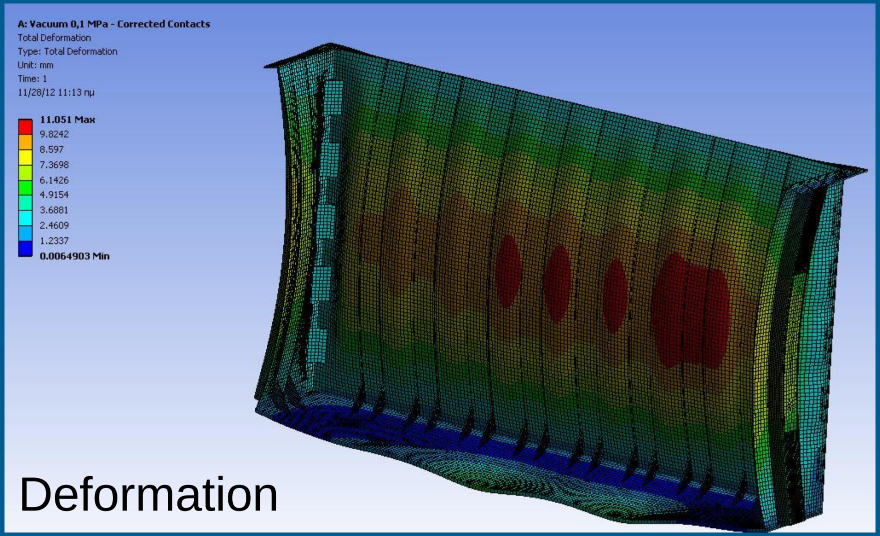


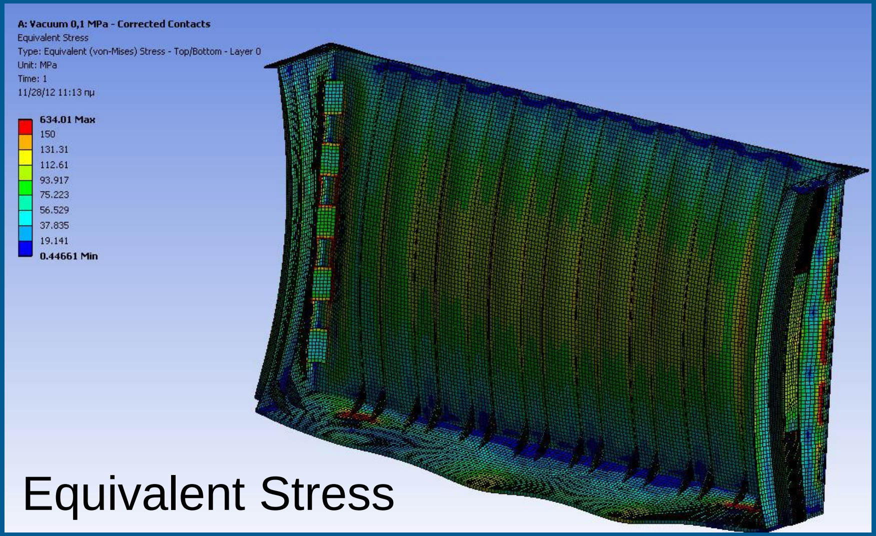


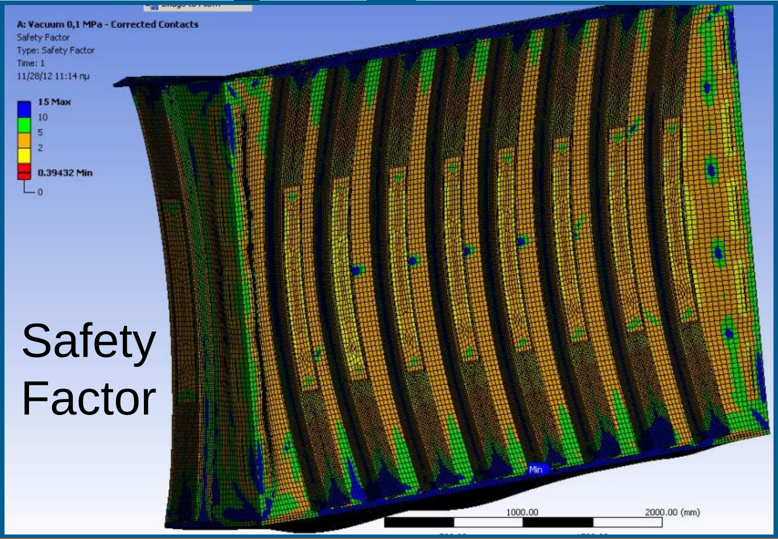
- 1/4 of the model simulated, due to symmetry.
- Shell model.
- Material: Structural steel.
- Load: Vacuum.

- 95k elements.

II. Structural Modeling of the Frame of a Transformer



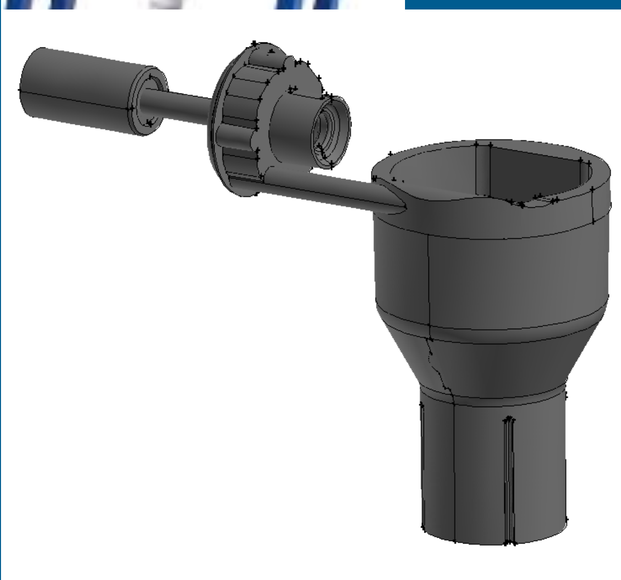


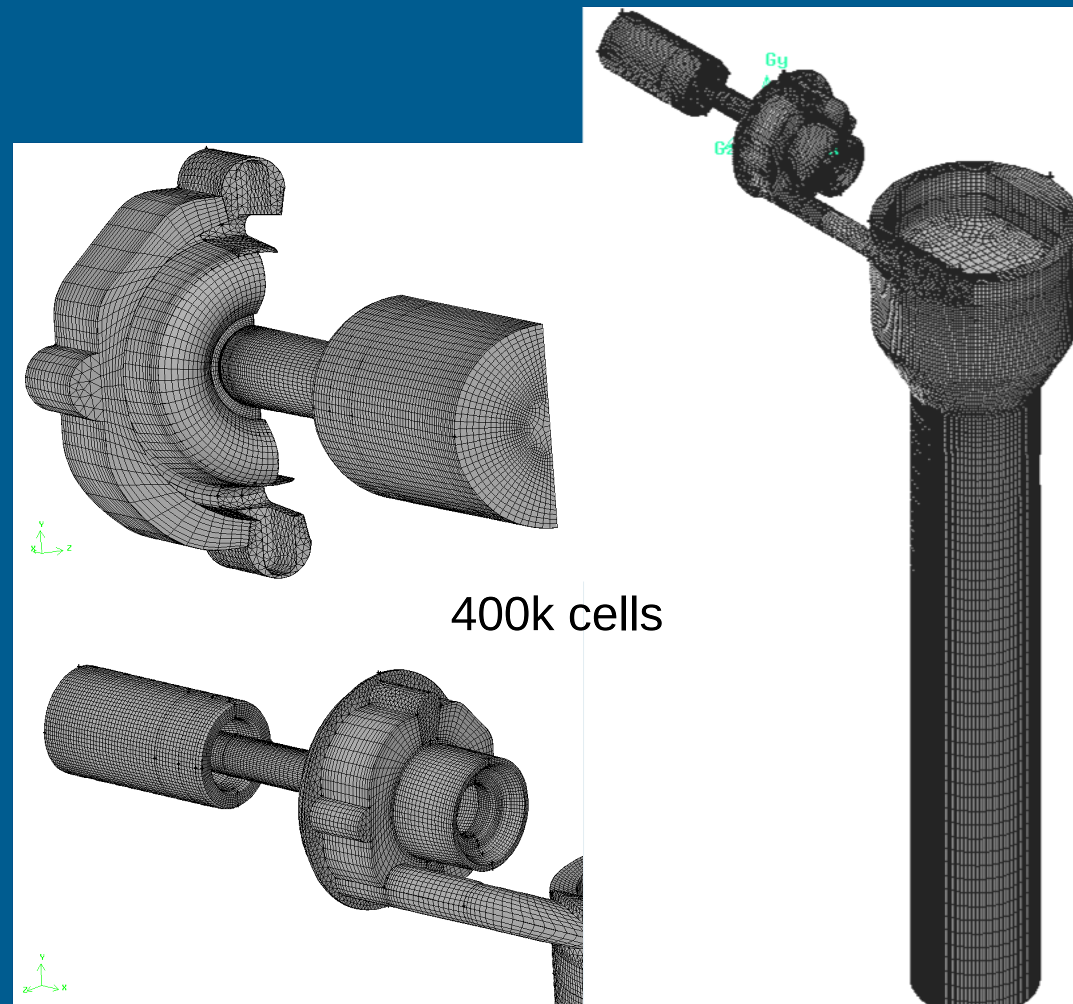


2k. KOLEKTOR LIV d.o.o.

2k. KOLEKTOR LIV d.o.o.

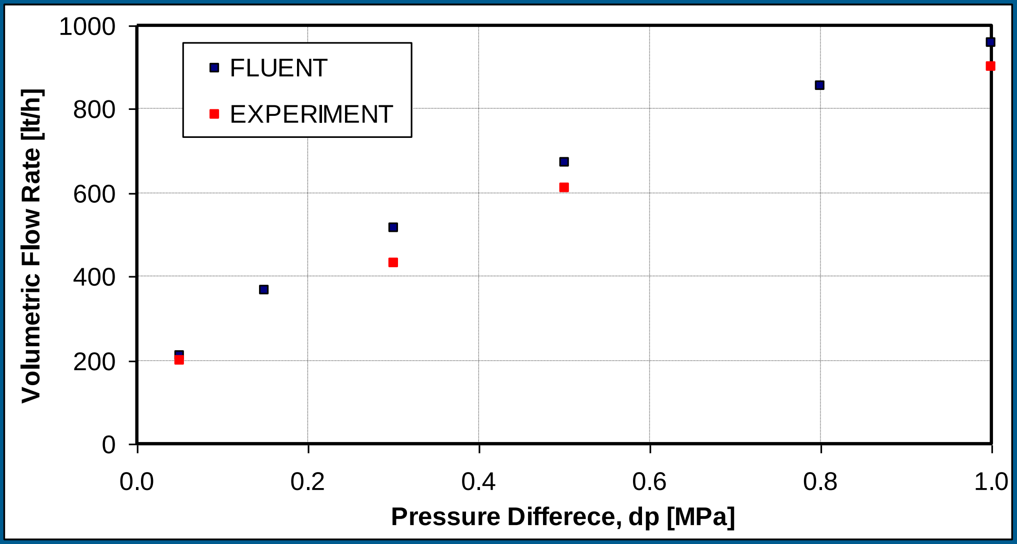
CFD Model of a Cavitating Valve

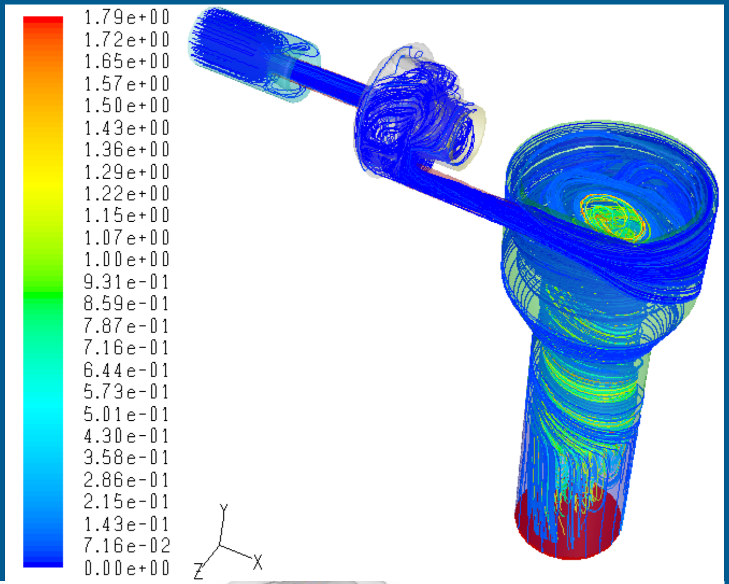


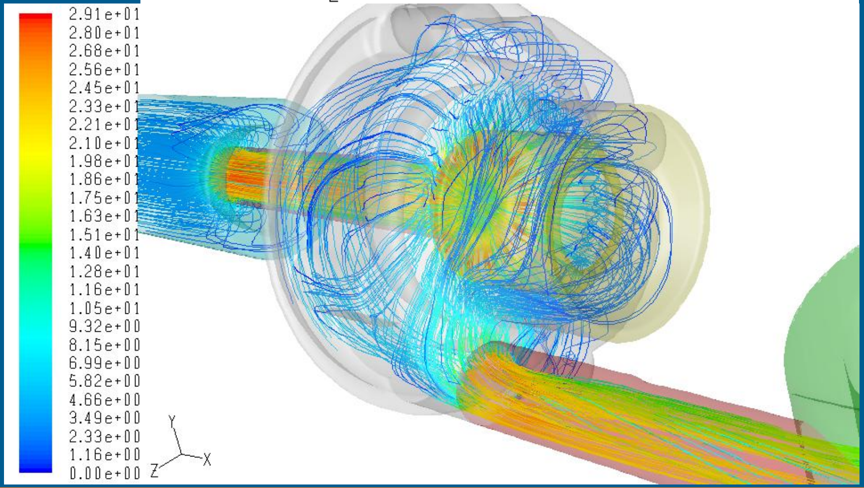


2k. KOLEKTOR LIV d.o.o.

CFD Model of a Cavitating Valve





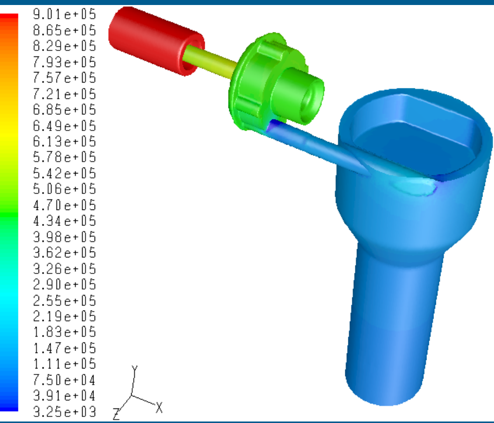


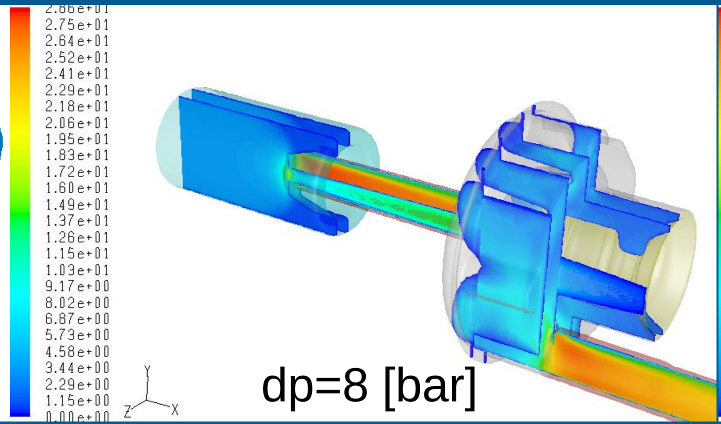
- Multiphase flow (liquid–vapor).
- Predict flow rate vs dp.
- Evaluate cavitation rate, as a function of dp.

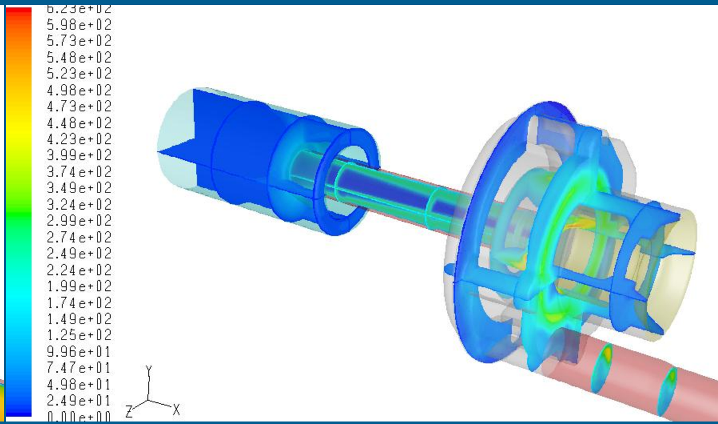
Path lines (colored with time) for dp=8 [bar].

2k. KOLEKTOR LIV d.o.o.

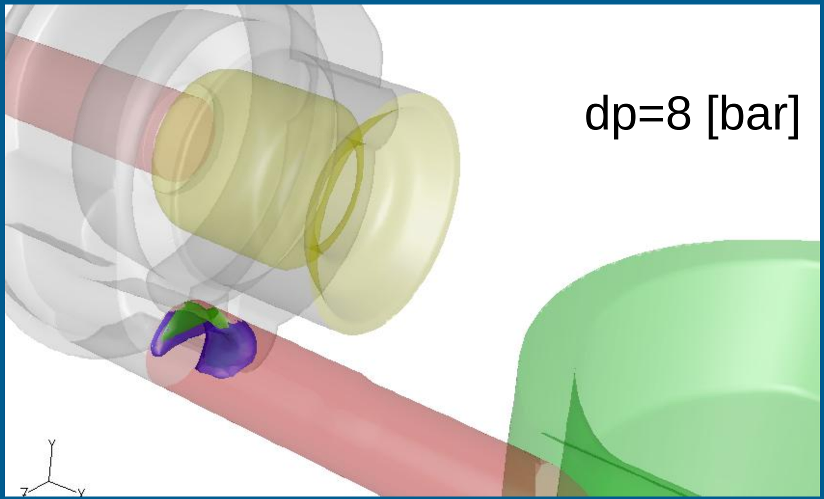
CFD Model of a Cavitating Valve

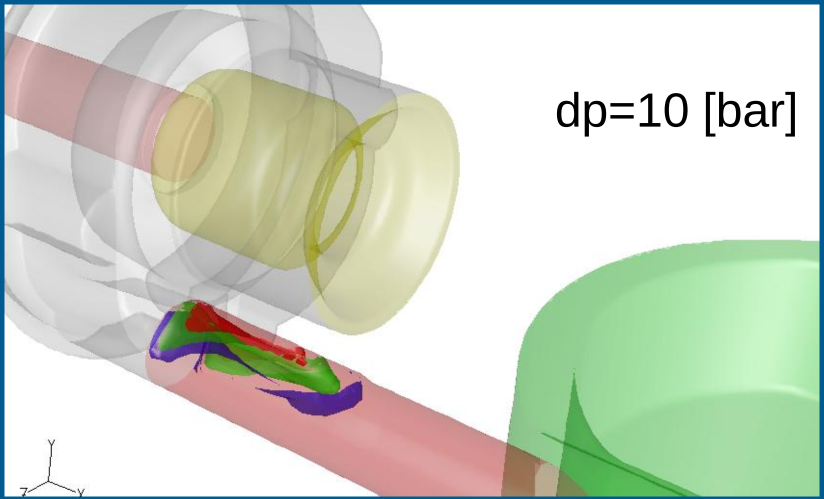




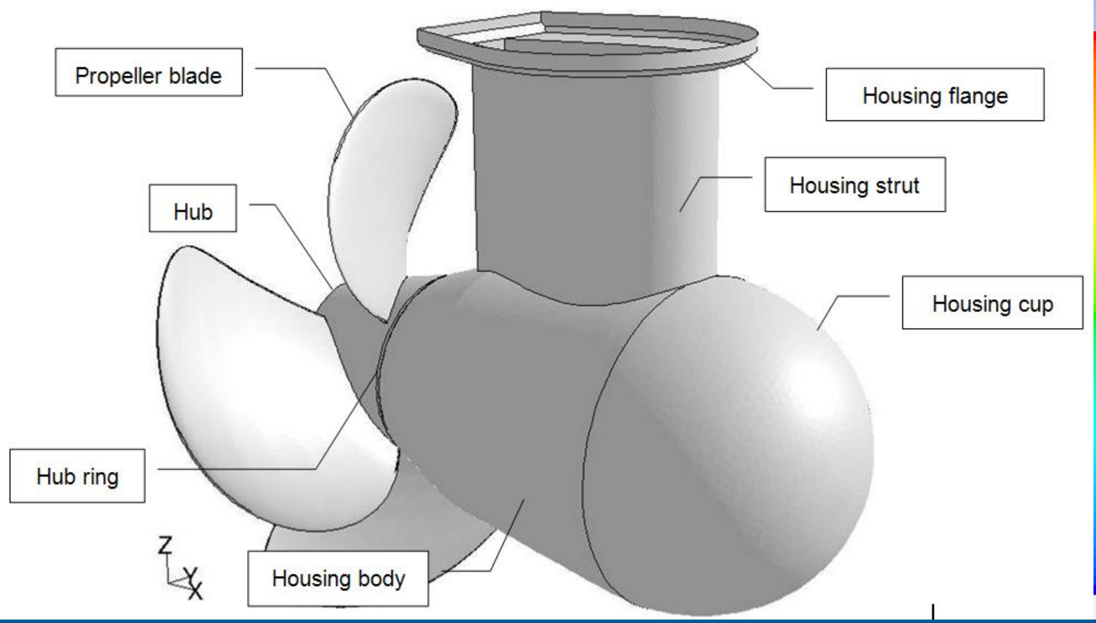


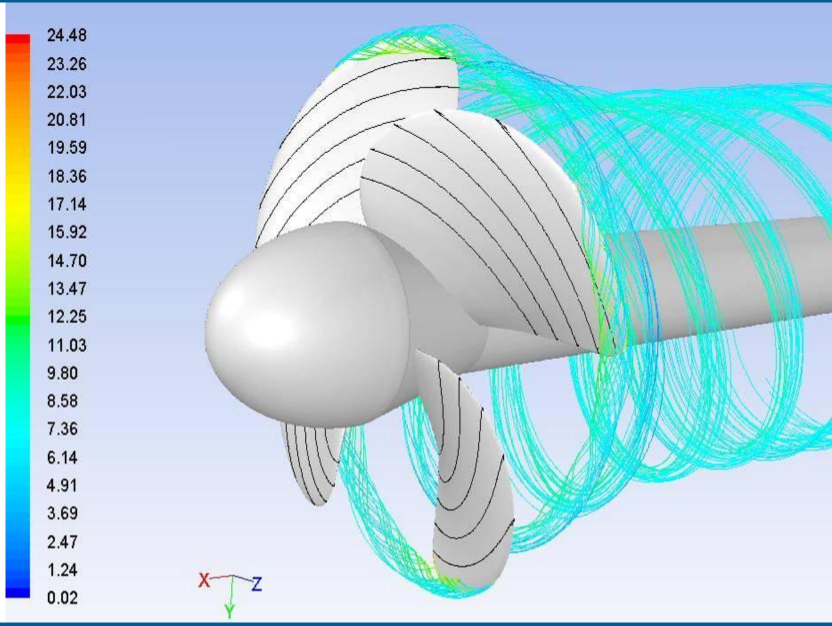
Pressure | Velocity Magnitude | Turbulence Intensity



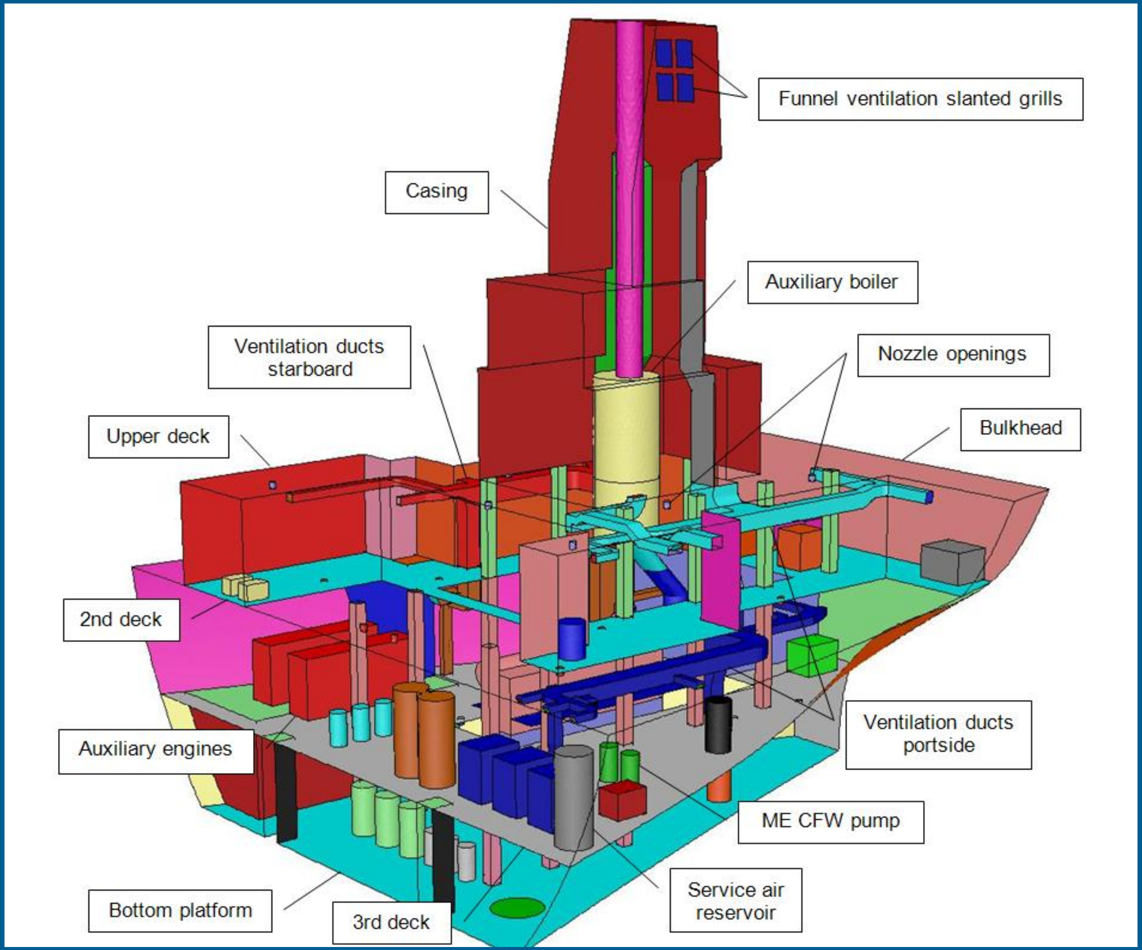


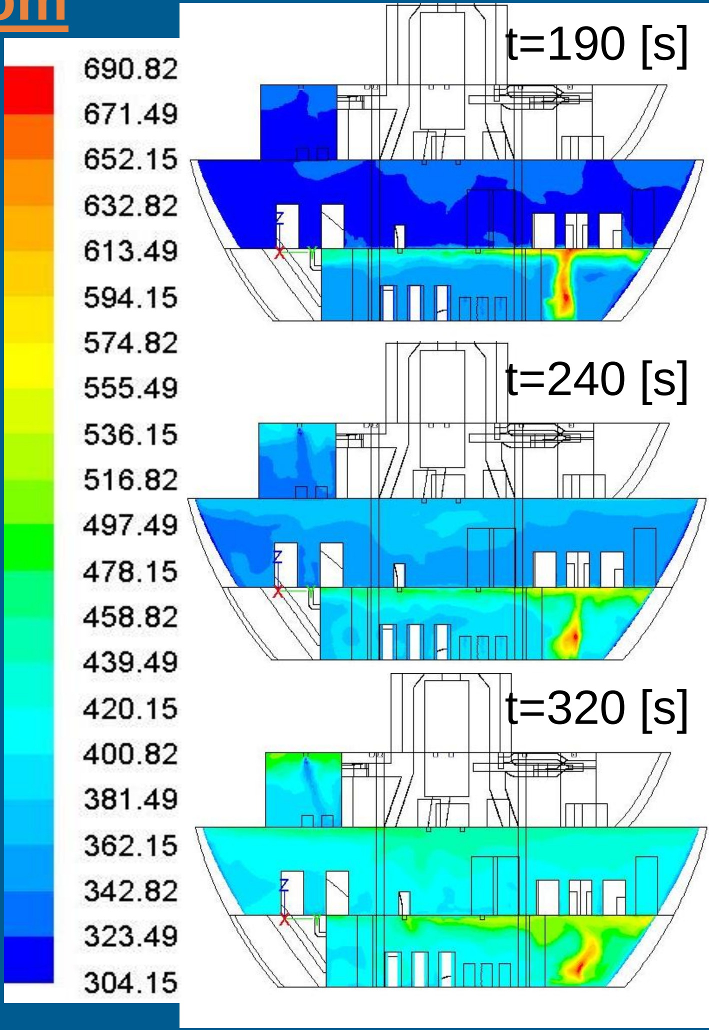
I. CFD Analysis of an Azimuth Pushing Type Thruster



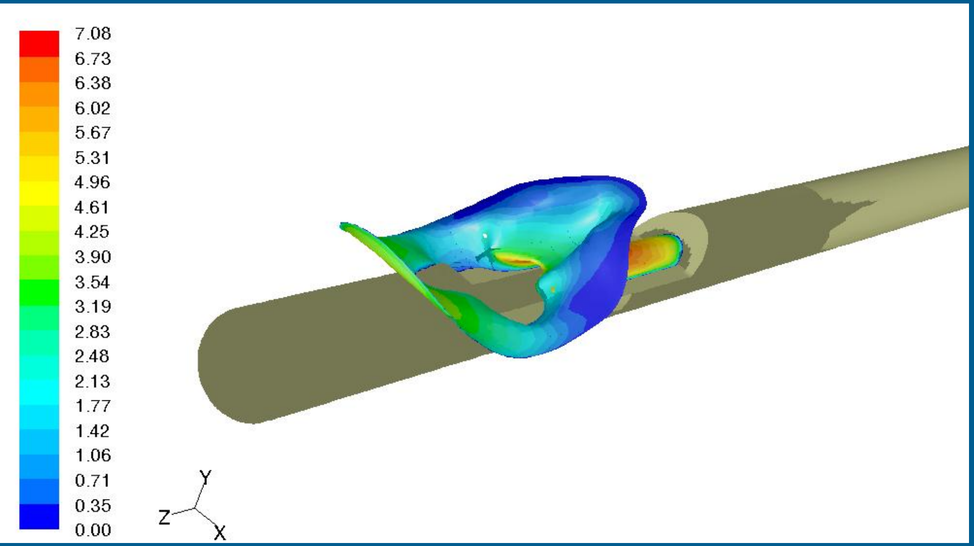


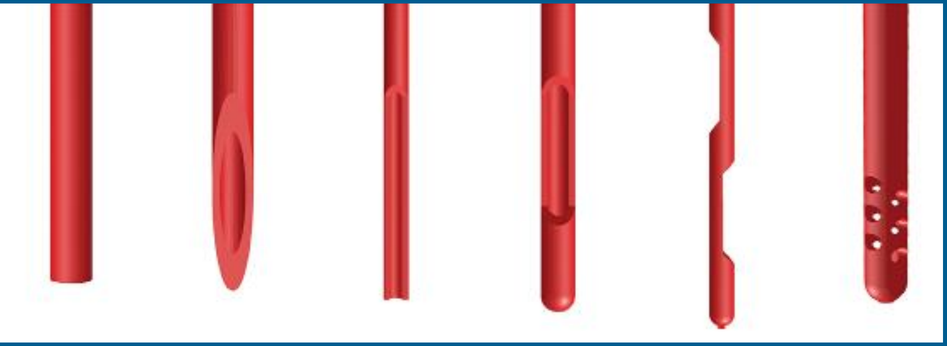
II. Modeling the Operation of CO_2 Fire Extinguish System in a Ship Engine Room

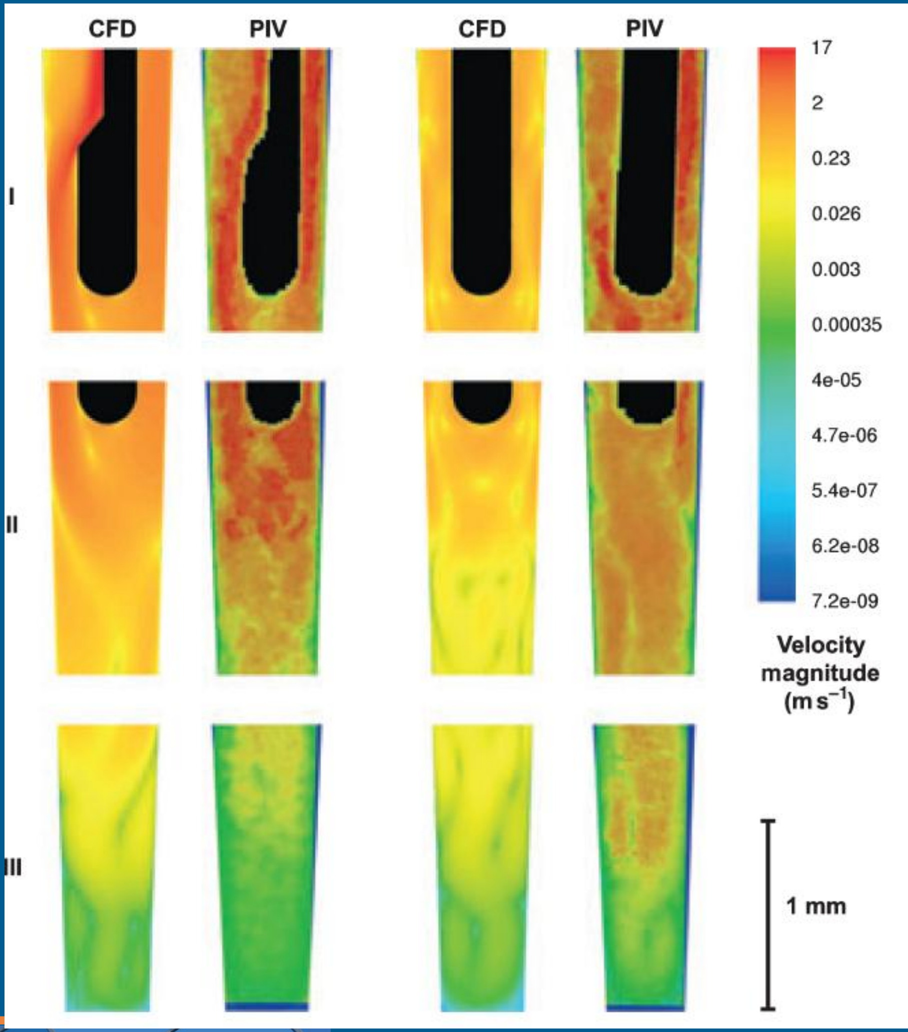




Unconventional simulations







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