Compressor Development Process – Verification of Simulations

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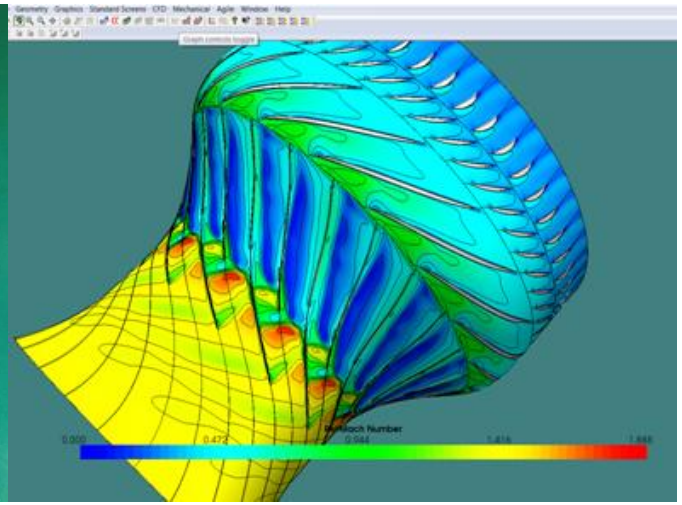
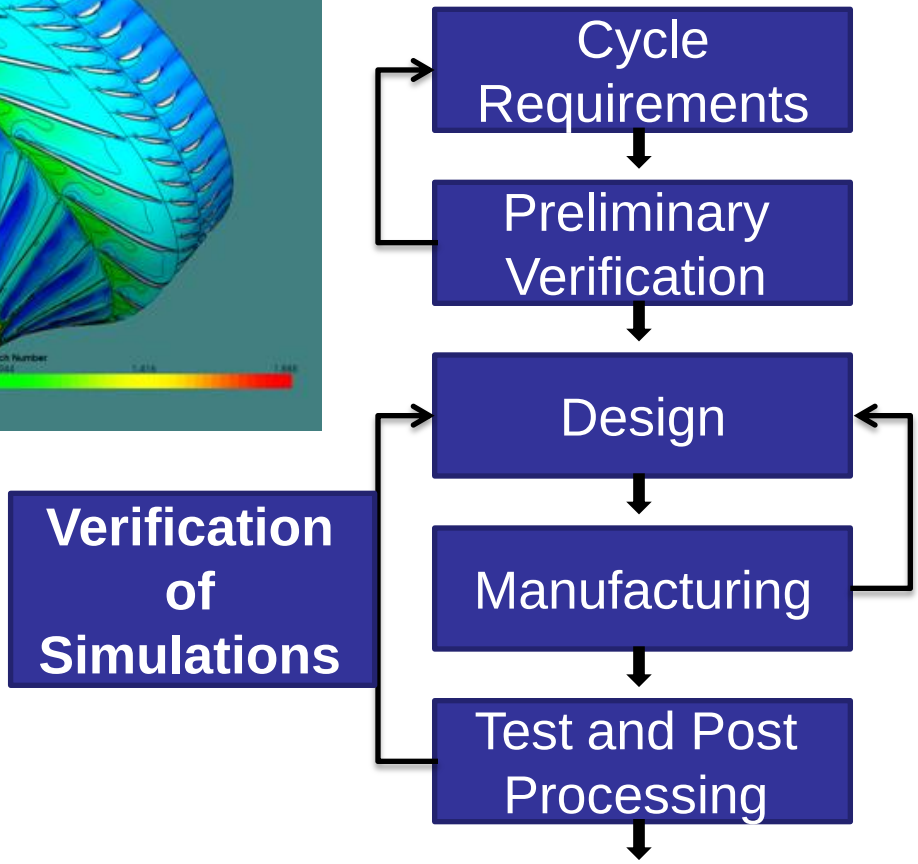
The 15th Israeli Symposium on Jet Engines and Gas Turbines
***Technion, Haifa* , November 17 ,2016**

Compressor Development Process

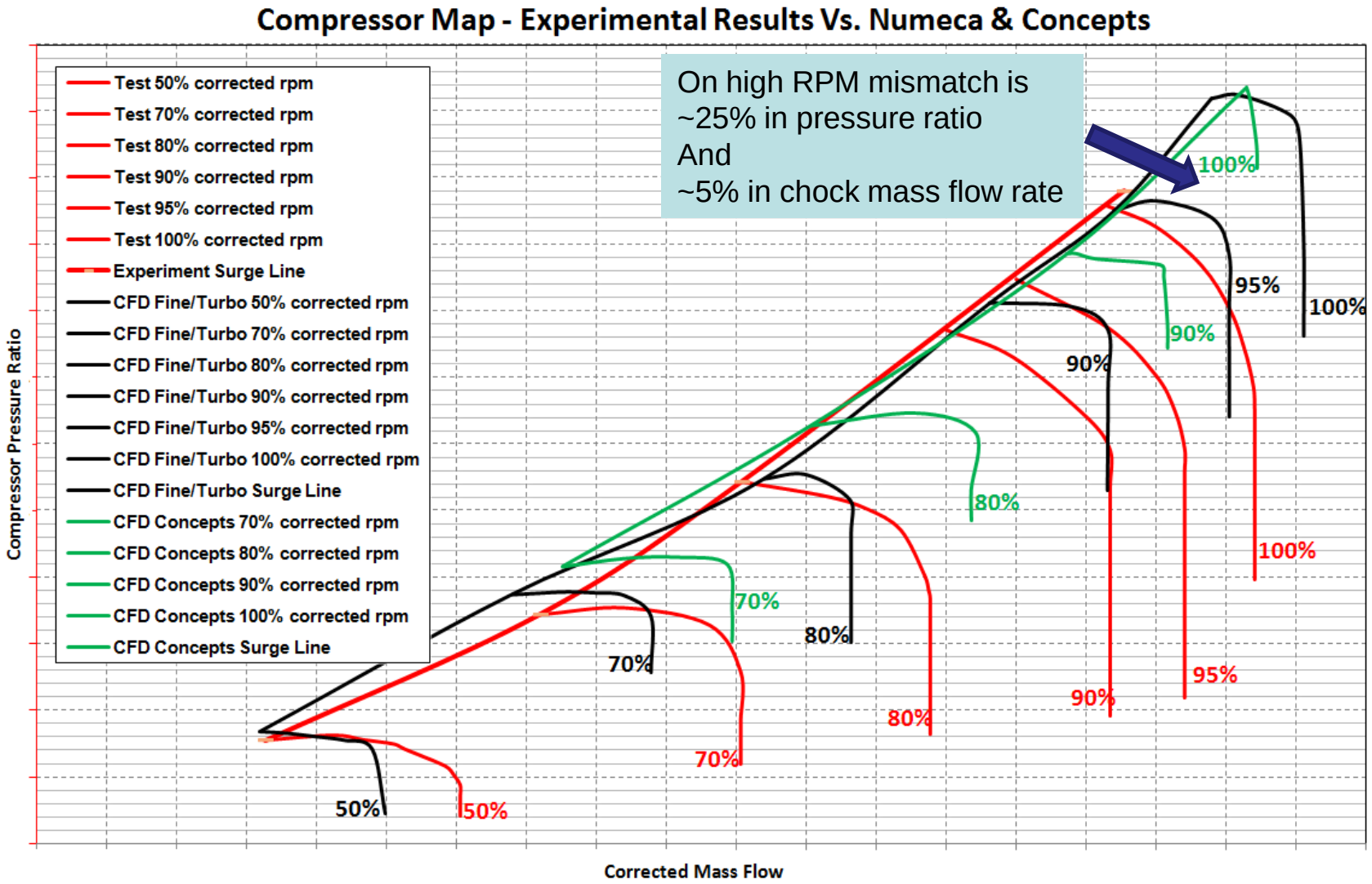




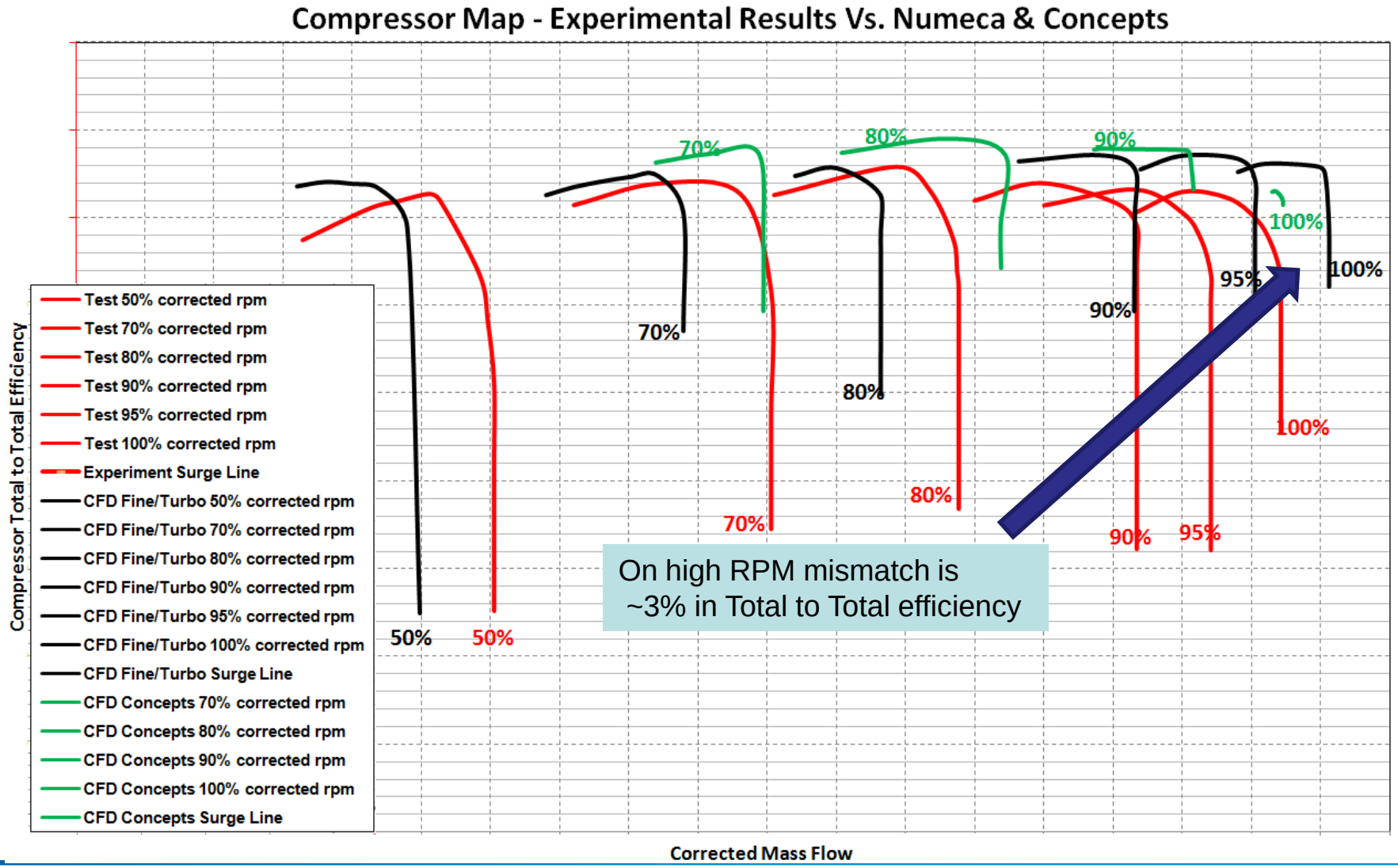
Post processing and Verification of Simulations For Mix Flow Compressor

1) Experimental mapping of compressor prototype.
2) Discovered mismatch between predicted and measured characteristics map of the compressor.
3) The compressor test bench was validated with a proved compressor design
4) Verification of simulation:
   a) Mapping causes for mismatch
   b) Running series of simulations after improving mismatch causes

Comparison between Test results and CFD predictions

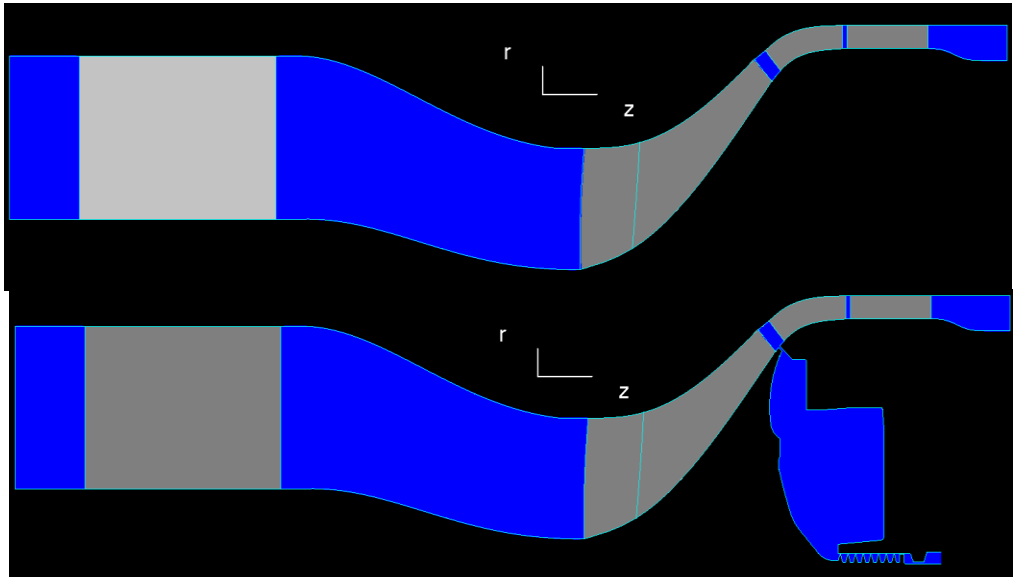


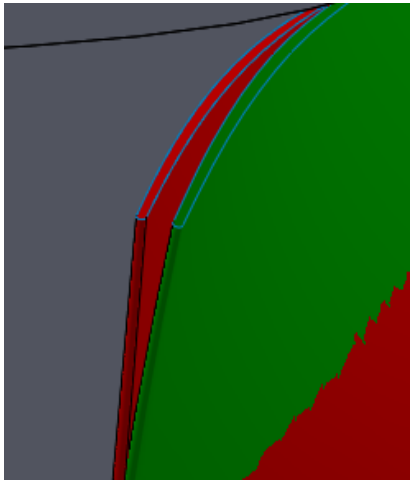
Comparison between Test results and CFD predictions



Reasons for Mismatch Between Test Results and CFD Predictions

1) Blade deformations due to centrifugal forces had not been encountered.
2) Radial clearance in test was 0.5 instead of 0.35.
3) Impeller backward cavity had not been encountered.
4) Steady state Solution is probably not enough accurate in case of narrow distance between impeller and first diffuser.





Verification Approach

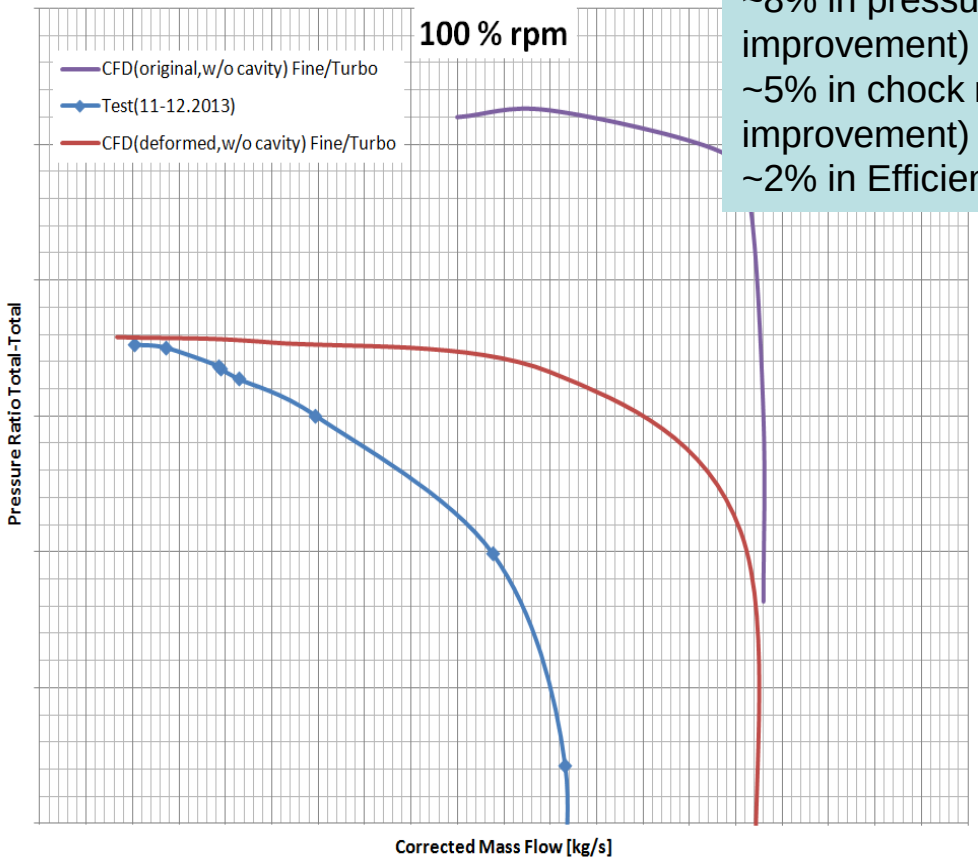
1) Geometry must match the real one as much as possible (cavities, seals, deformations and etc').
2) Clustering of the grid in problematic areas .
3) Testing various approaches of mixing plane. Not all mixing planes good enough for super sonic flow.
4) Testing various turbulence model.
5) Testing various discretization scheme (central differences or upwind).
6) Harmonic calculation

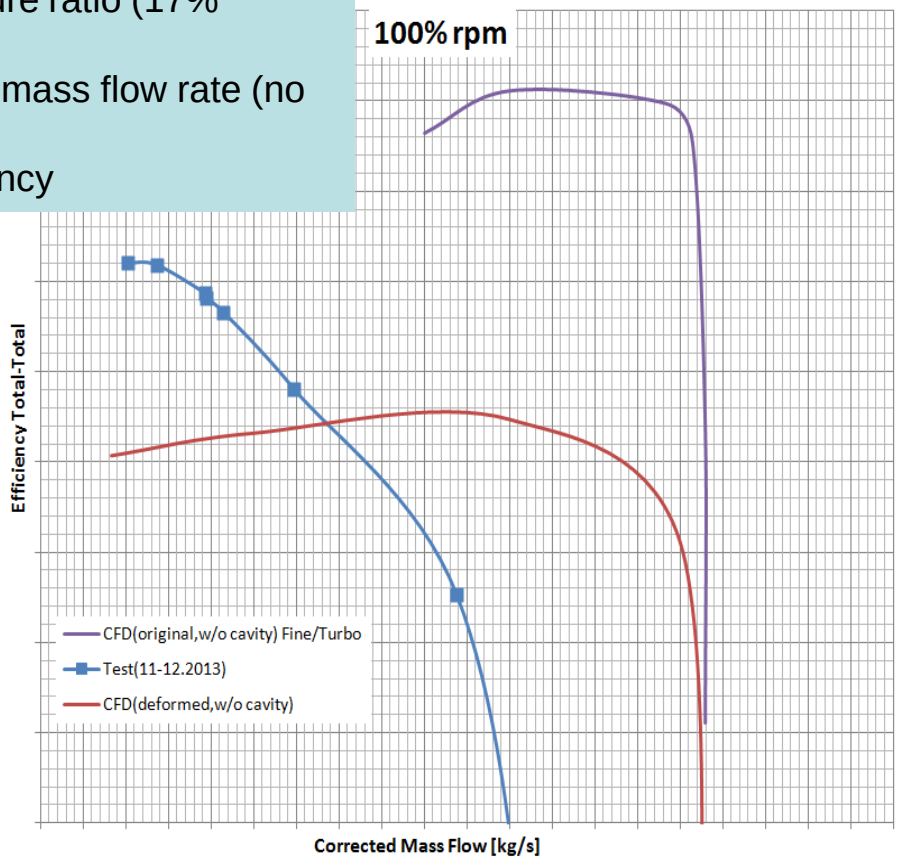
Numerical Approaches Used In Project

1) Full non-matching interface instead of rotor-stator interface between 1st and 2nd diffusers.
2) Non reflective 1D rotor-stator interface between impeller and 1st diffuser.
3) Spalart-Almaras turbulence model.
4) Central differences were used for discretization scheme.
5) 3 level multigrid.
6) Full non-matching interface between impeller hub and impeller rear cavity.

Improving CFD Prediction by Taking into Account Blade Deformations Due to Centrifugal Forces

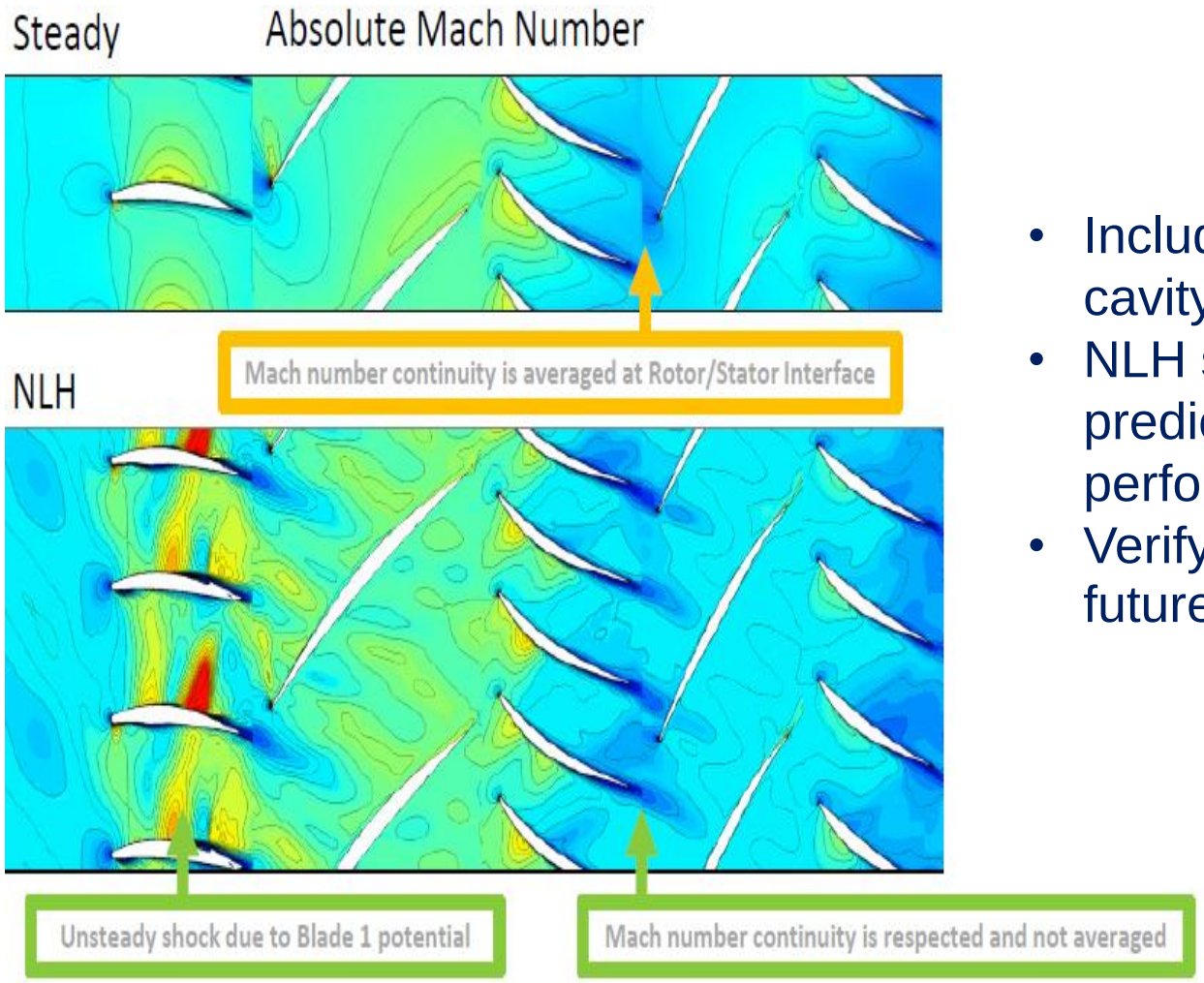
Mismatch after fixed:
~8% in pressure ratio (17% improvement)
~5% in chock mass flow rate (no improvement)
~2% in Efficiency





Future Steps to Improve CFD Prediction

Numeca Unsteady Treatment NLH Introduction



- Including impeller rear cavity in simulation.
- NLH simulation for better prediction of the first stator performance.
- Verify simulation tools for future design improvements.

Summary

1) Geometry must match the real one as much as possible (cavities, seals, deformations and etc').

2) Testing various numerical approaches.

3) Harmonic calculations to understand unsteady physics.

Thank you !