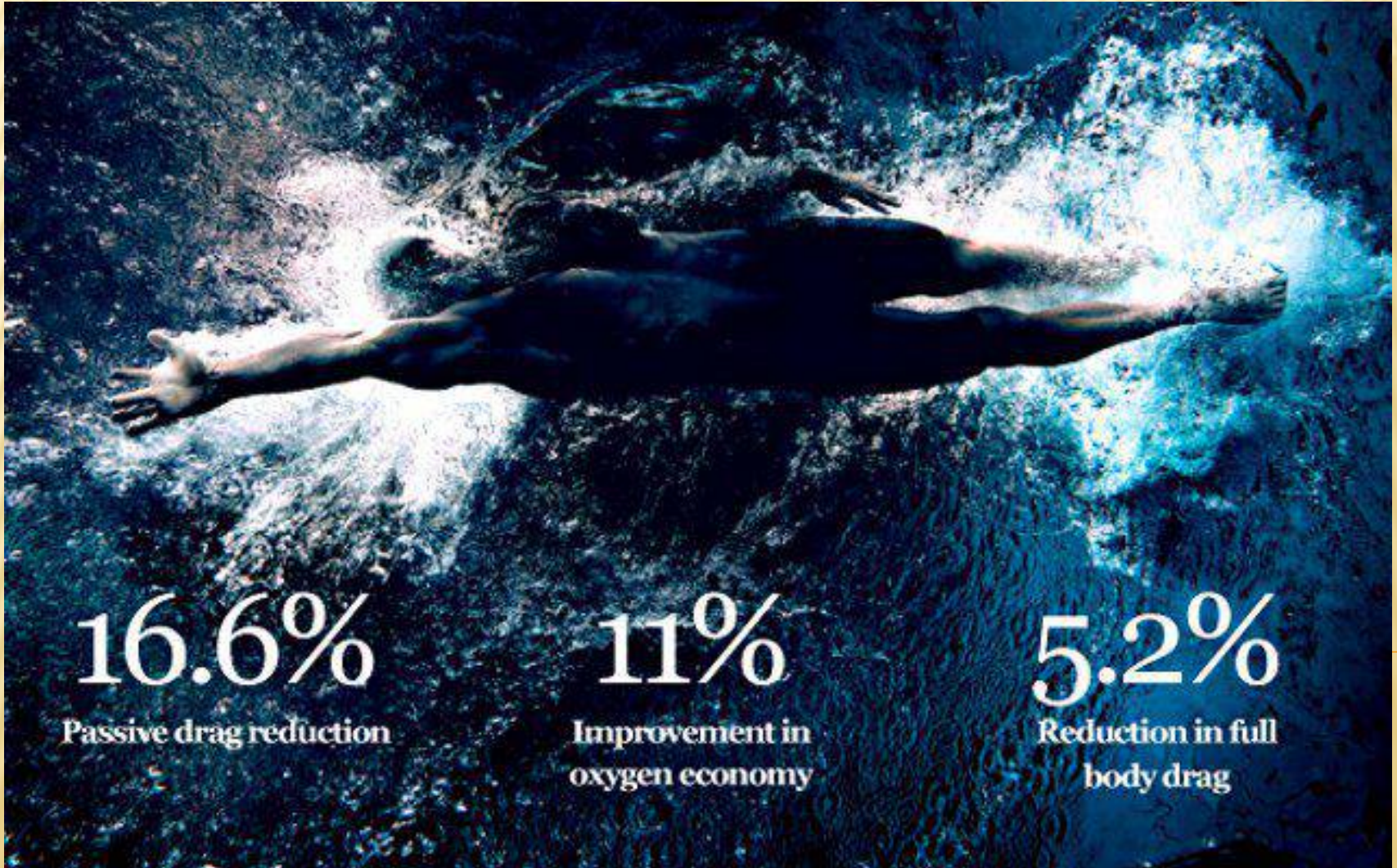


HYDRODYNAMIC ***DRAG REDUCTION***

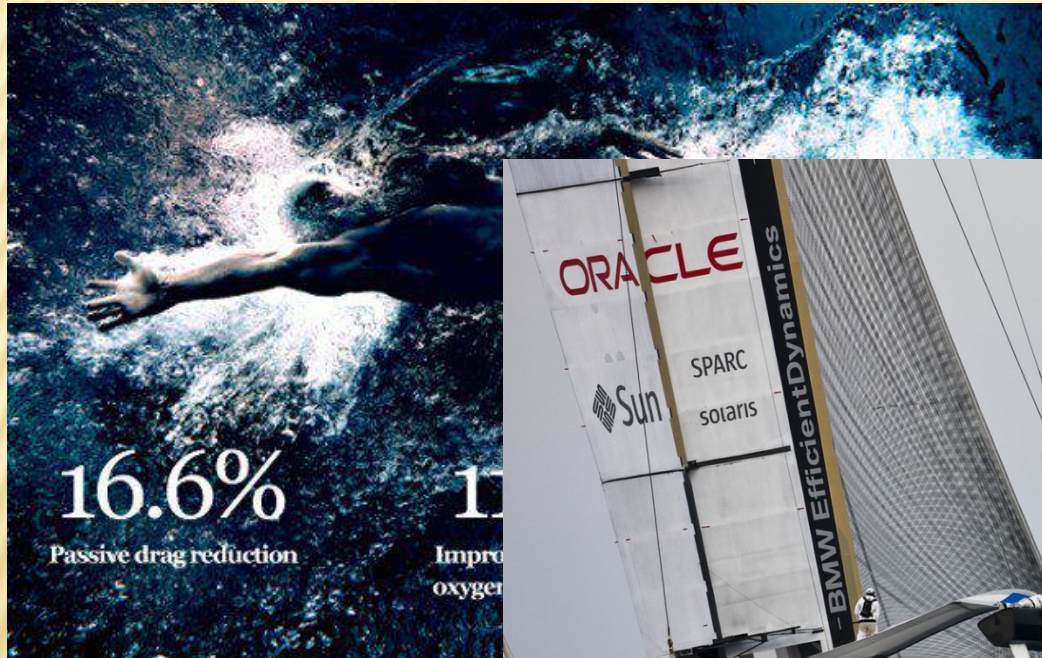
HYDRODYNAMIC DRAG REDUCTION

Riblet technology well known for hydrodynamic drag reduction



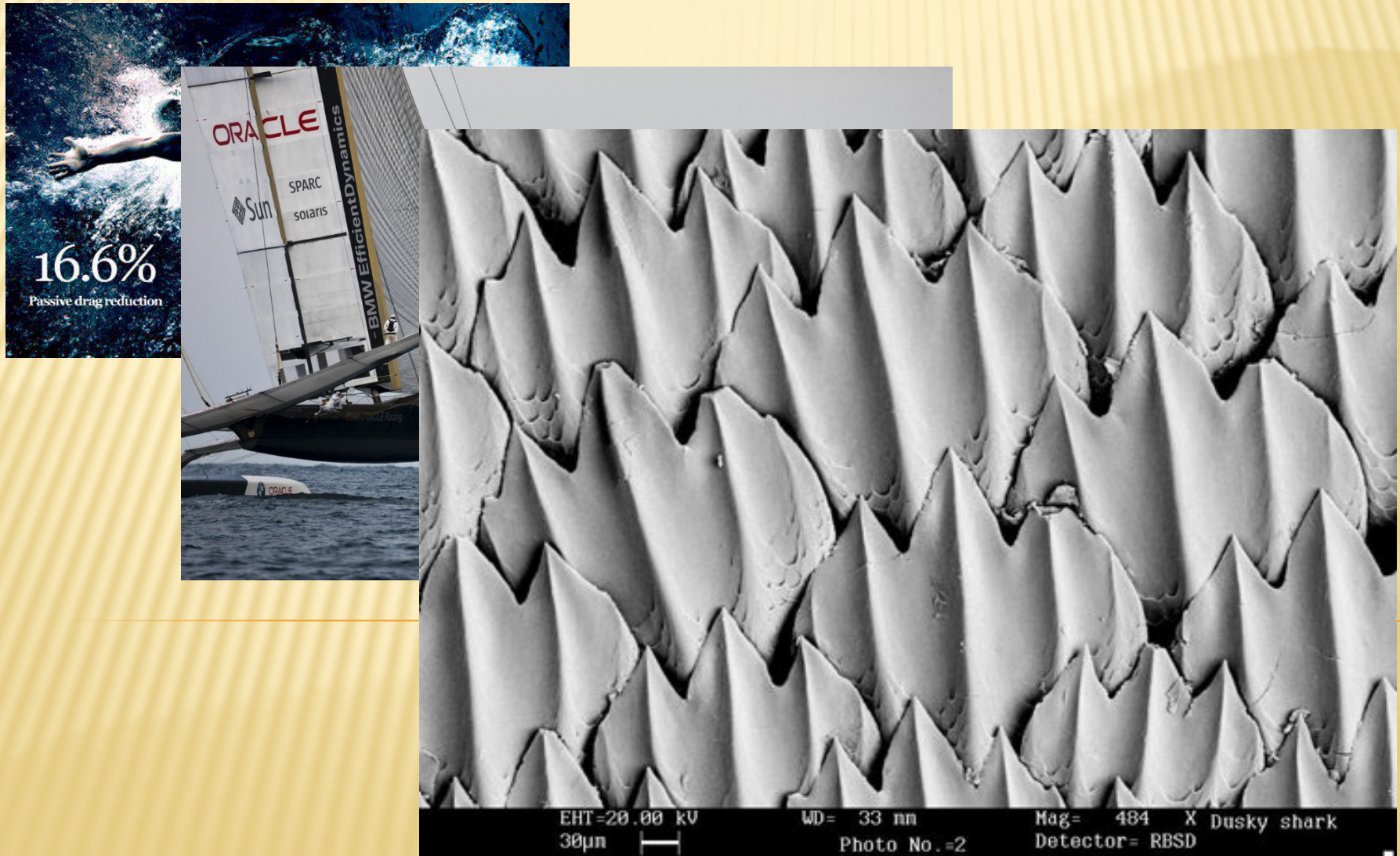
HYDRODYNAMIC DRAG REDUCTION

Riblet technology well known for hydrodynamic drag reduction



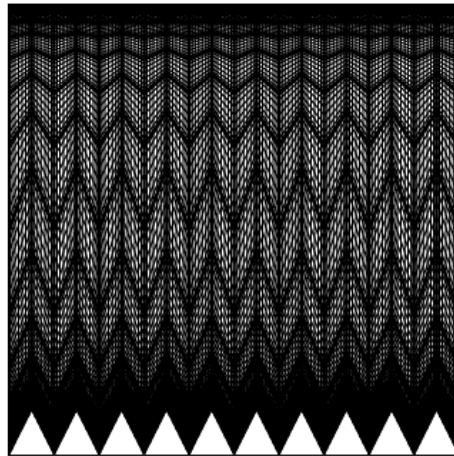
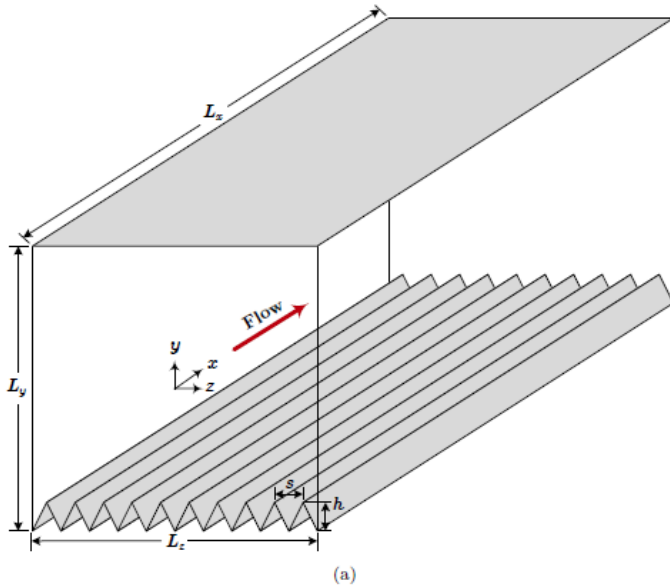
HYDRODYNAMIC DRAG REDUCTION

Riblet technology well known for hydrodynamic drag reduction



HYDRODYNAMIC DRAG REDUCTION

DNS study of drag reduction using triangular riblets

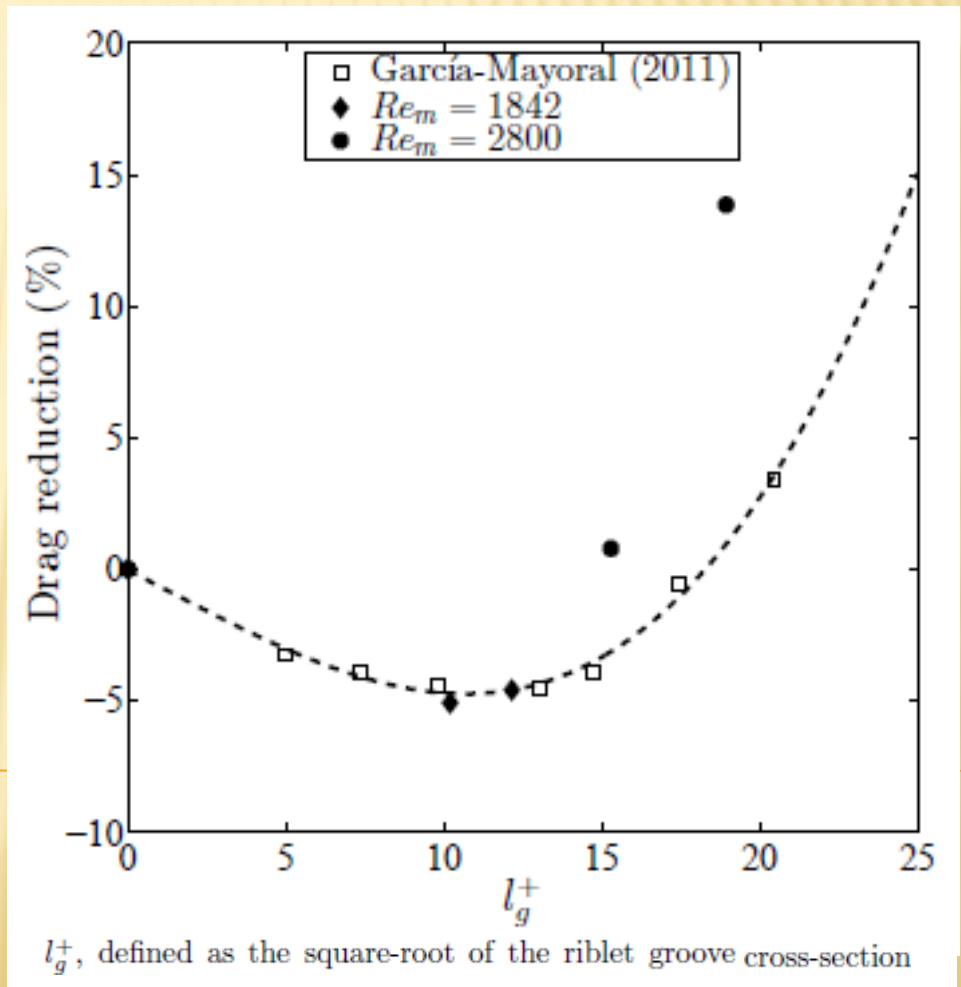
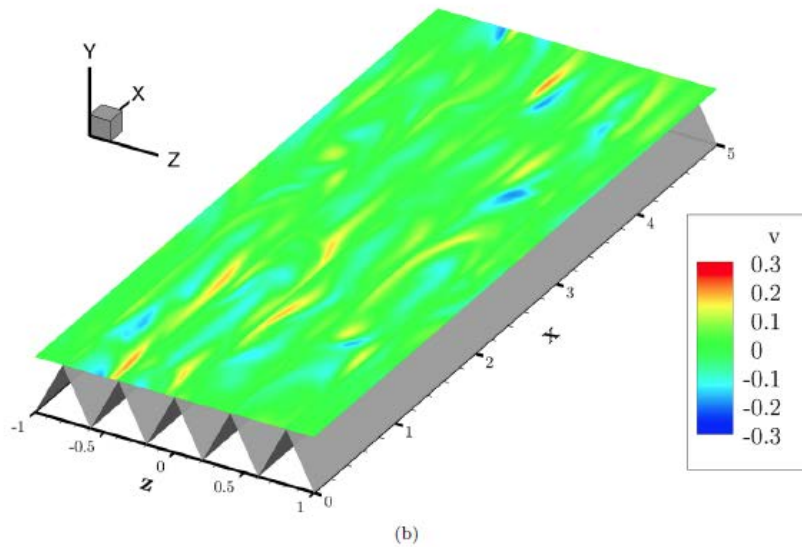
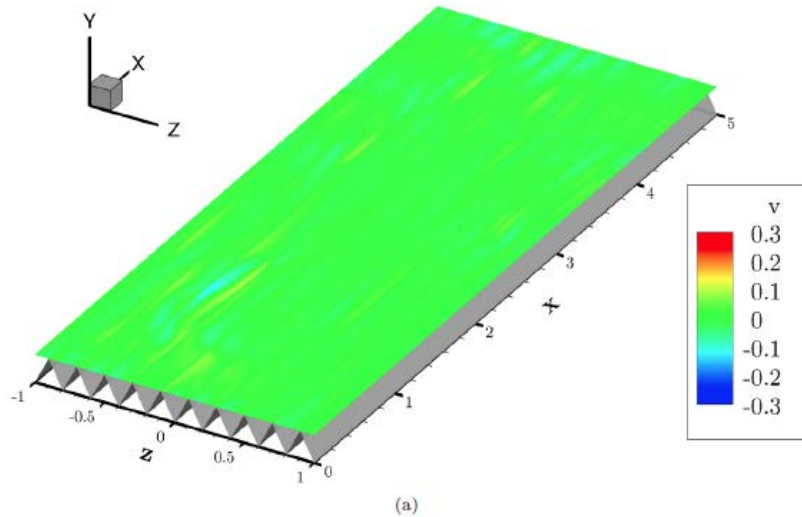


Re_m	s	h	s^+	h^+	l_g^+	Re_τ	$\Delta\text{Drag (\%)}$
1842	0.2δ	0.1δ	20.4	10.2	10.21	125	-5.08%
	0.2δ	0.2δ	17.2	17.2	12.15	130	-4.59%
	0.4δ	0.4δ	43.0	43.0	30.41	137	+35.81%
2800	0.2δ	0.1δ	30.6	15.3	15.28	181	+0.79%
	0.2δ	0.2δ	26.9	26.9	19.10	186	+13.86%
	0.4δ	0.4δ	65.2	65.2	46.15	196	+54.20%

- **Triangular riblets in turbulent channel flow**
- **Simulated for drag increasing and drag reducing riblet geometry for comparison of flow features**

HYDRODYNAMIC DRAG REDUCTION

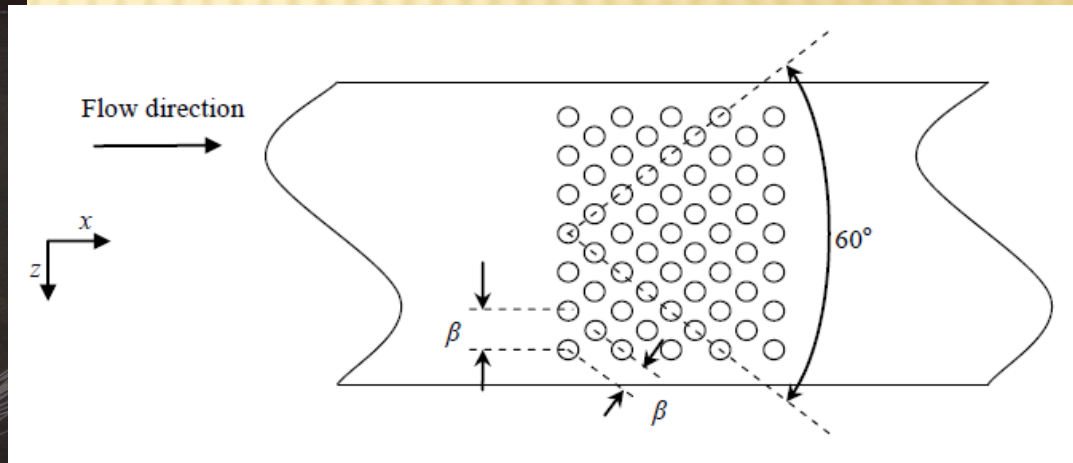
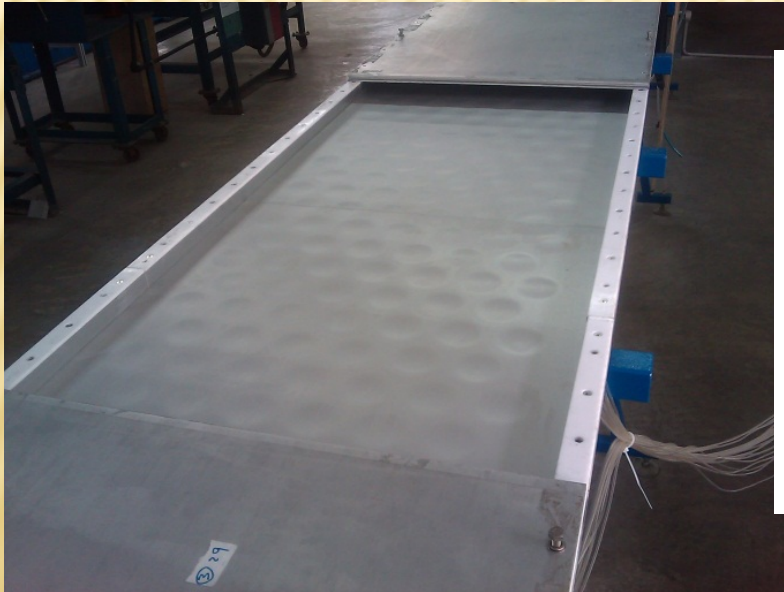
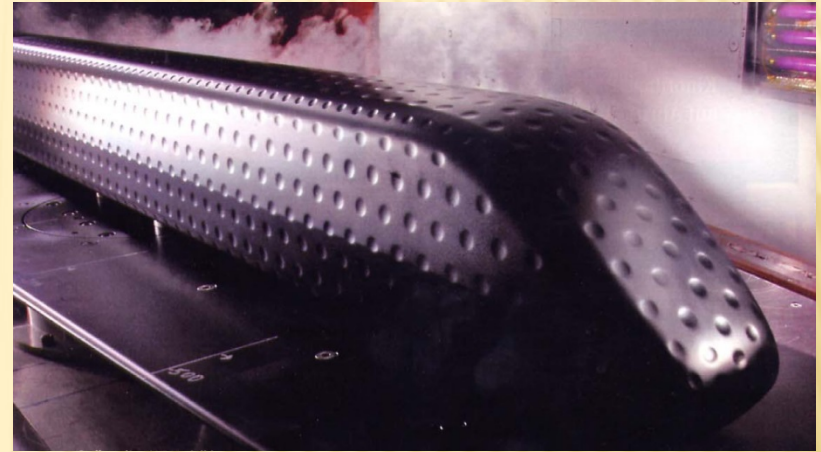
DNS study of drag reduction using triangular riblets



HYDRODYNAMIC DRAG REDUCTION

Dimples for drag reduction

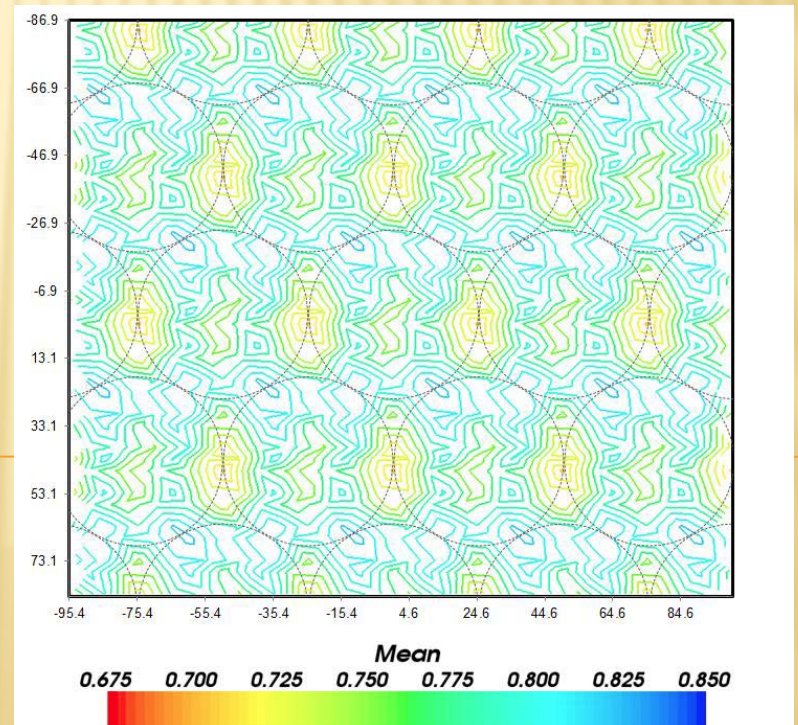
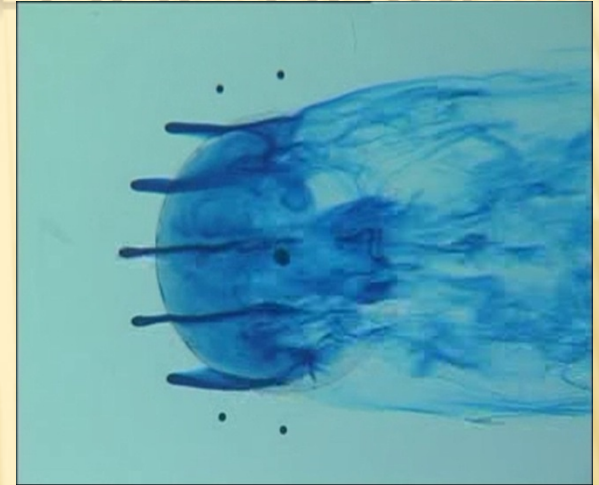
- Dimples are physically larger.
- Experiments to study effect of dimple on drag.



HYDRODYNAMIC DRAG REDUCTION

Dimples for drag reduction

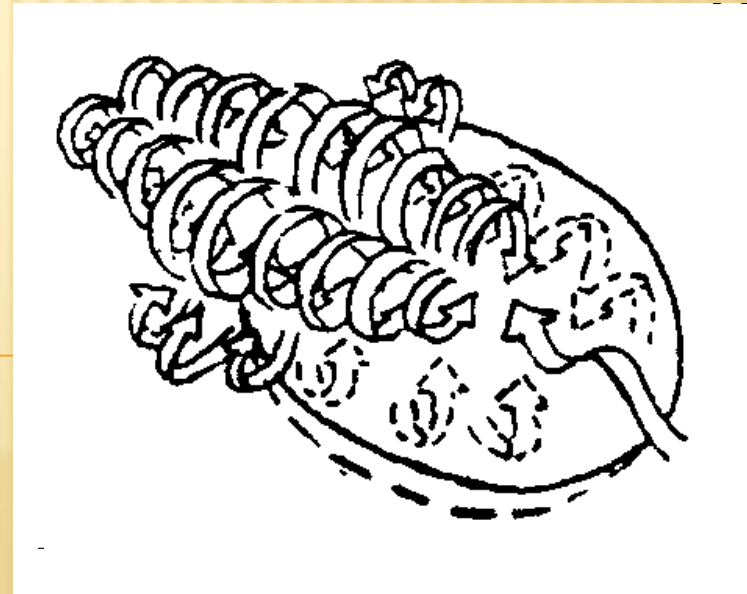
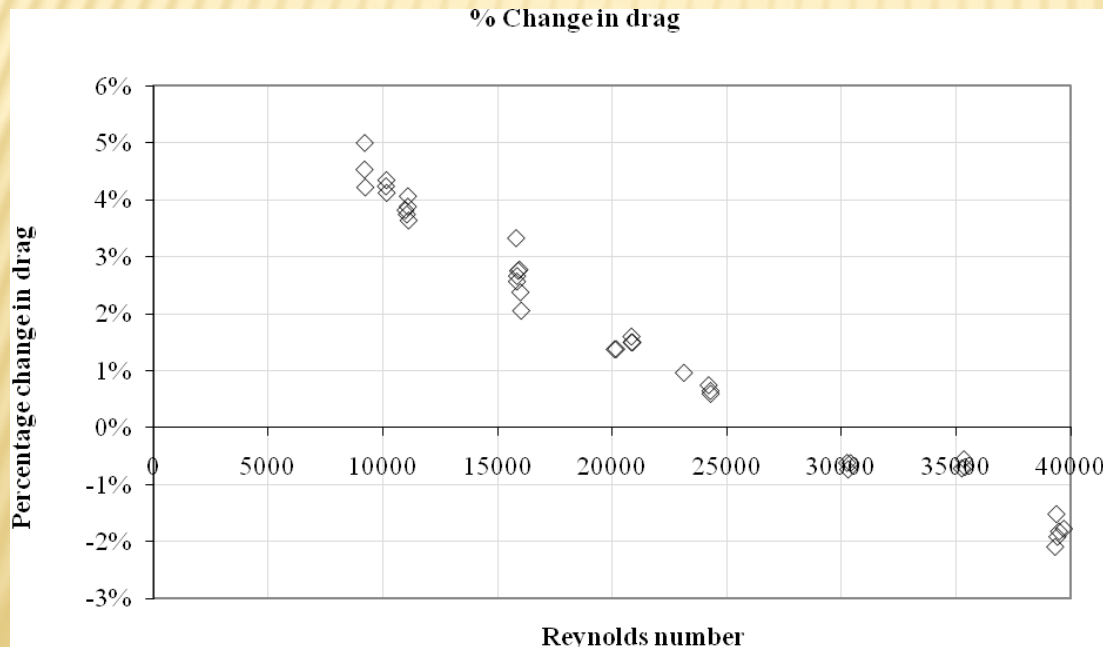
- Dye flow visualization in water tunnel.
- Numerical simulation of flow and comparison with experiments.



HYDRODYNAMIC DRAG REDUCTION

Dimples for drag reduction

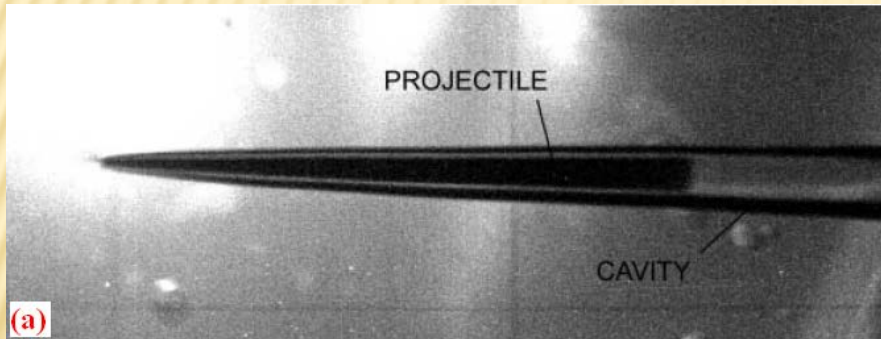
- Quantitative measurement of drag reduction with dimples of various geometry.
- Drag reduction due to generation of strong streamwise vortices.



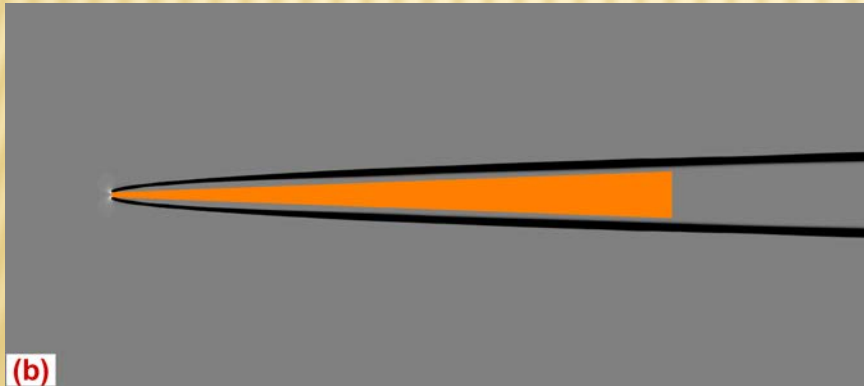
HYDRODYNAMIC DRAG REDUCTION

Drag reduction with supercavitation

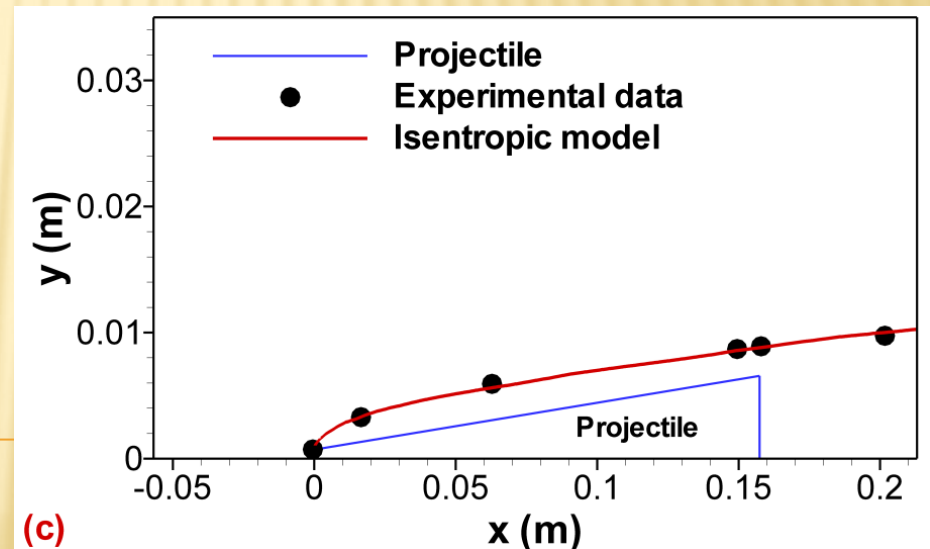
- Cavitation is the evaporation phenomenon that occurs when the local flow pressure drops below the saturated vapor pressure.



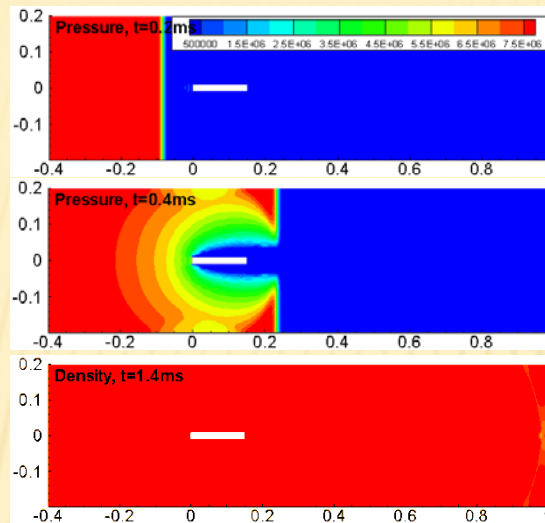
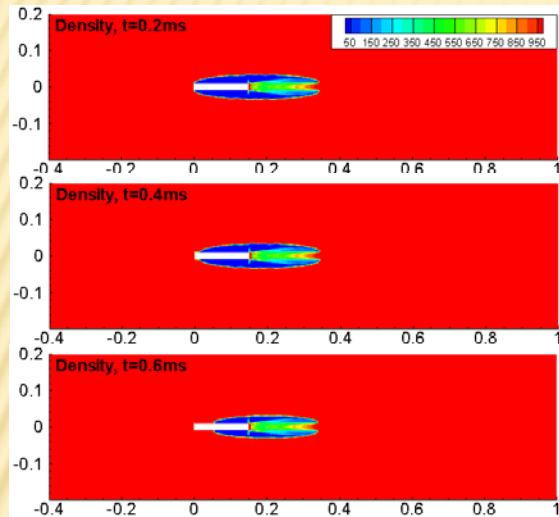
J.D. Hrubes. *Exp. Fluids*. (2001) Vol. 30, pp. 57–64.



Present numerical result employing compressible one-fluid model.

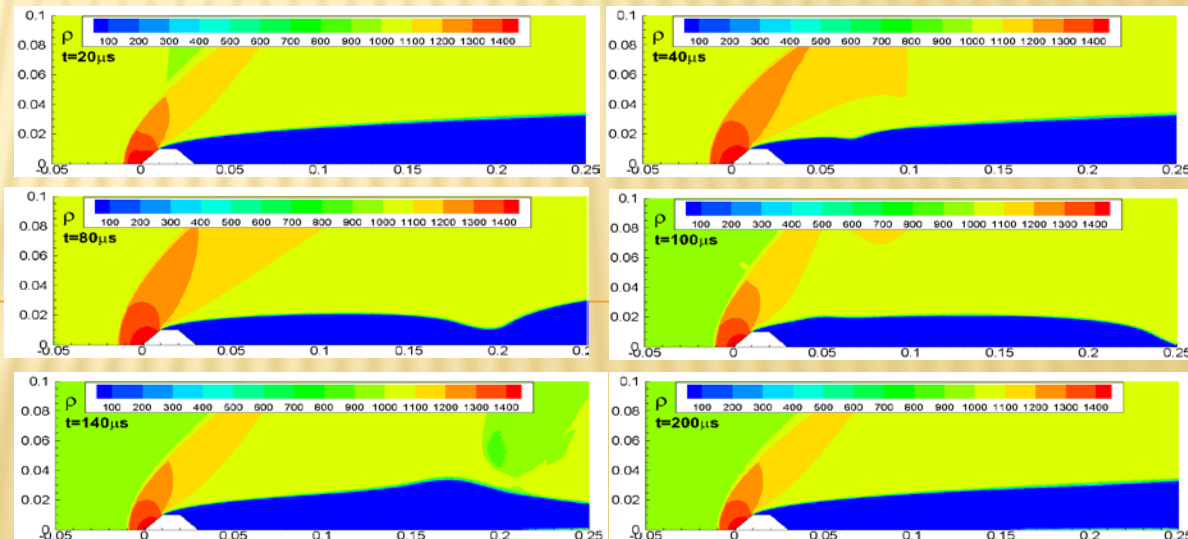


HYDRODYNAMIC DRAG REDUCTION



Interaction between
pressure wave and
supercavitation of
cylinder

Supersonic
supercavitation impacted
by Mach 3.1 shock wave



The time evolution of supercavitation impacted by a Mach 3.1 shock wave.

HYDRODYNAMIC DRAG REDUCTION

Upcoming work on drag reduction

- **Dimple geometry optimization: use of asymmetric dimples**
- **Drag reduction coatings**
- **High speed drag reduction experiments**

