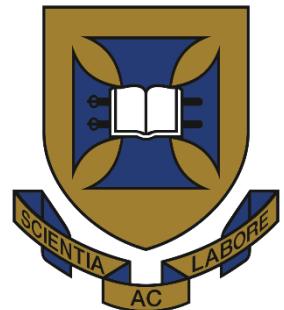


CFD in Industry and F1

The University of Queensland



Lecture

6th September 2017

Dr Stephen Hall

CONTENTS

- Introduction
- Urban Scale CFD
- Toilet Modelling CFD
- Williams Formula 1 CFD
- Questions

INTRODUCTION

- From Port Augusta SA

- Degree (Mech)
Scholarship BHP Steel

Part time study

Apprentice training - fitter, machining,
boilermaker, composites, maintenance,
environmental, drafting

Unique - 5 years of “active learning”

- Wide range of engineering

Design, plant, maintenance, reliability, construction, safety



https://farm2.static.flickr.com/1458/25927871330_ddf32967d6_b.jpg



<http://cdn.newsapi.com.au/image/>

INTRODUCTION

- Sydney Head Office BHP Engineering

International Consulting

Learnt business of engineering

- Masters (Aero) UNSW 1996

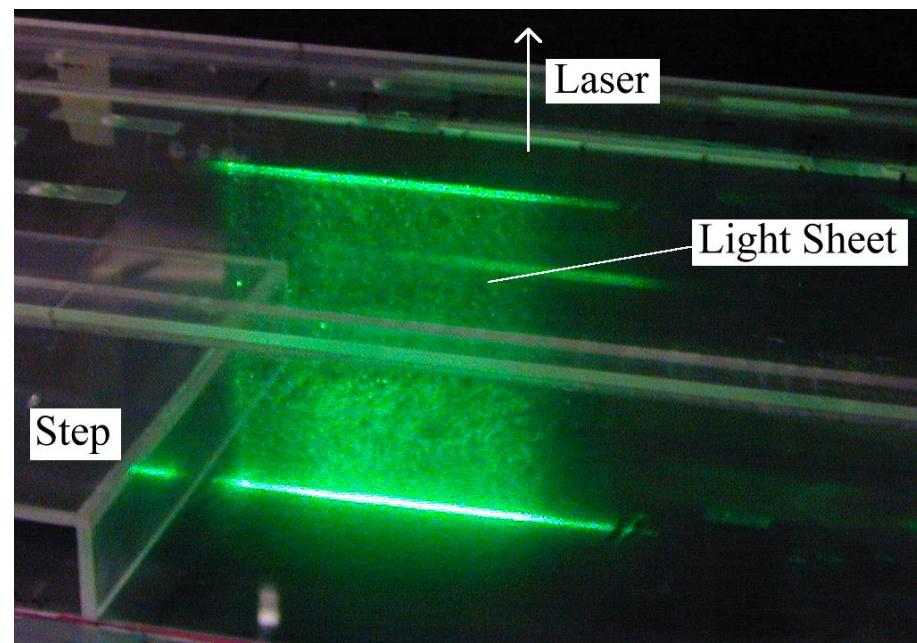
- Ph.D Scholarship APA(I)

UNSW 2000

Turbulent flow

Computational CFD

Experimental PIV, LDV



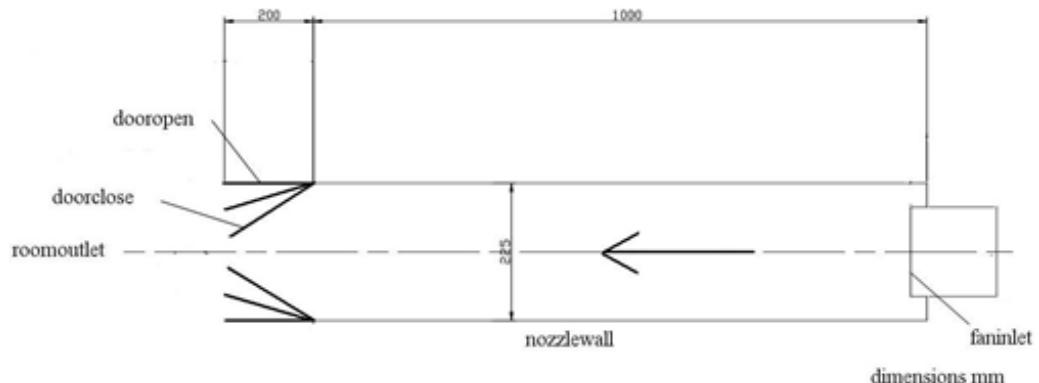
INTRODUCTION

- Lecturer Mechanical and Aerospace UNSW 6 years
Mechanics, statics, dynamics 1st, 2nd yr, machine design 5th yr
materials 2nd yr, automotive postgrad

World Solar Car Challenge 2005 – Mentor

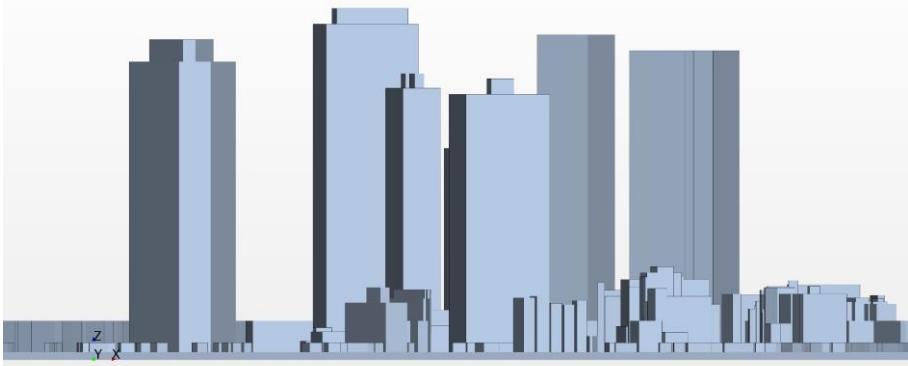
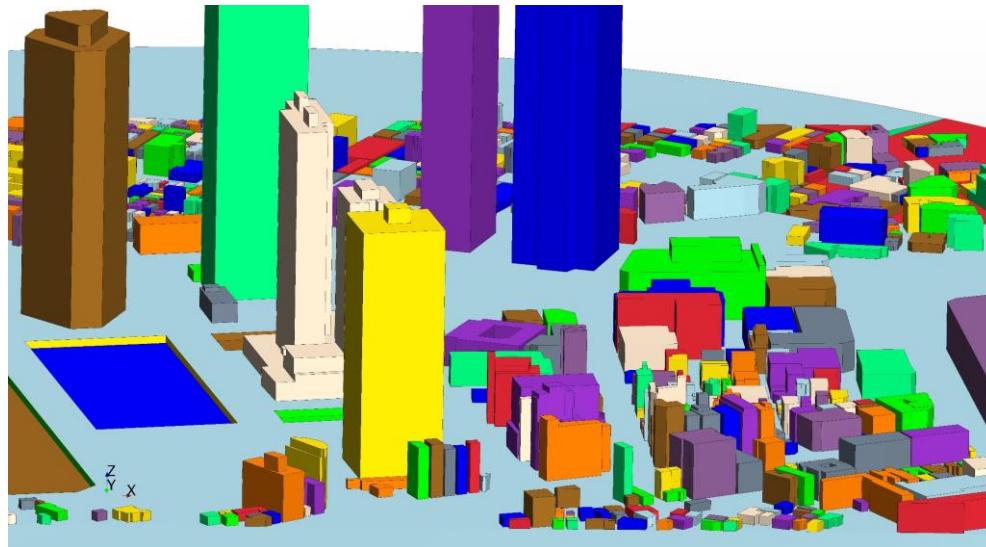
ENG1000 First Year Initiative

- Trail blazing - flipped classroom, active learning
- Intro Fluids Module – simulation CFD, “hands in” experiment
- See and feel flow



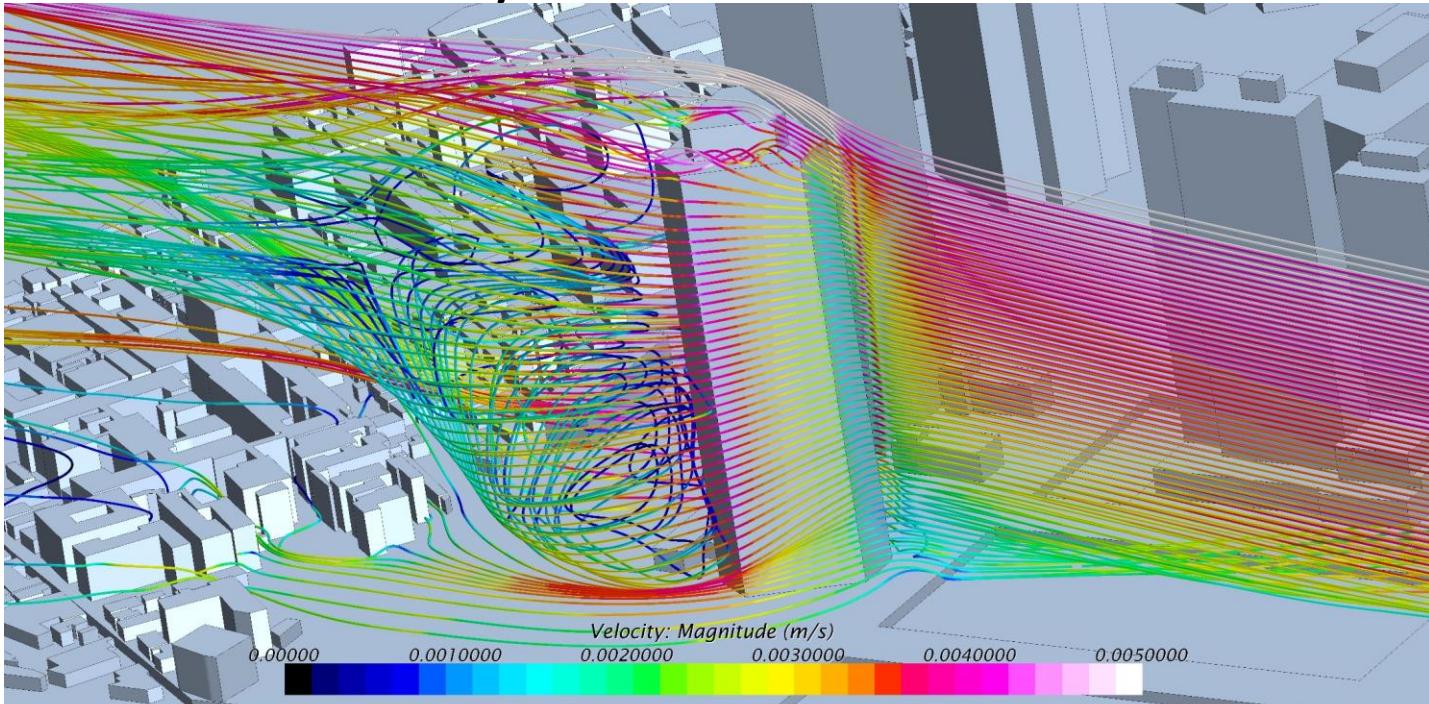
URBAN SCALE CFD

- Modelling the urban built environment
- Usually city high-rise
- Quality of air, speeds and pollution
- Hong Kong and China – massive development



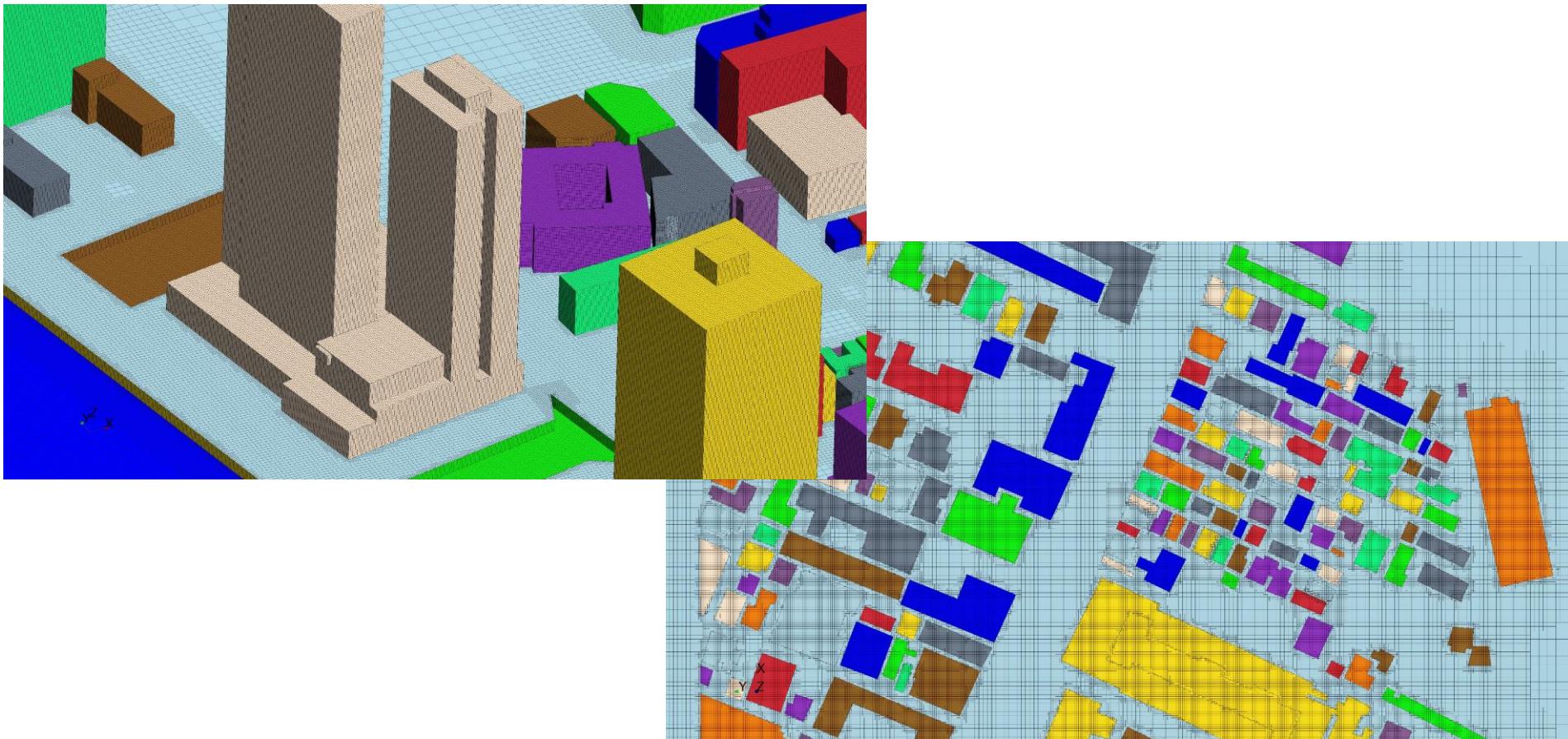
URBAN SCALE CFD

- No other way – can't flow vis or instrument a city
- Tried army smoke
- Wind tunnel Reynolds no. $V_m = V_f \cdot H_f / H_m$
- Little V&V – Industry rules and customs



URBAN SCALE CFD

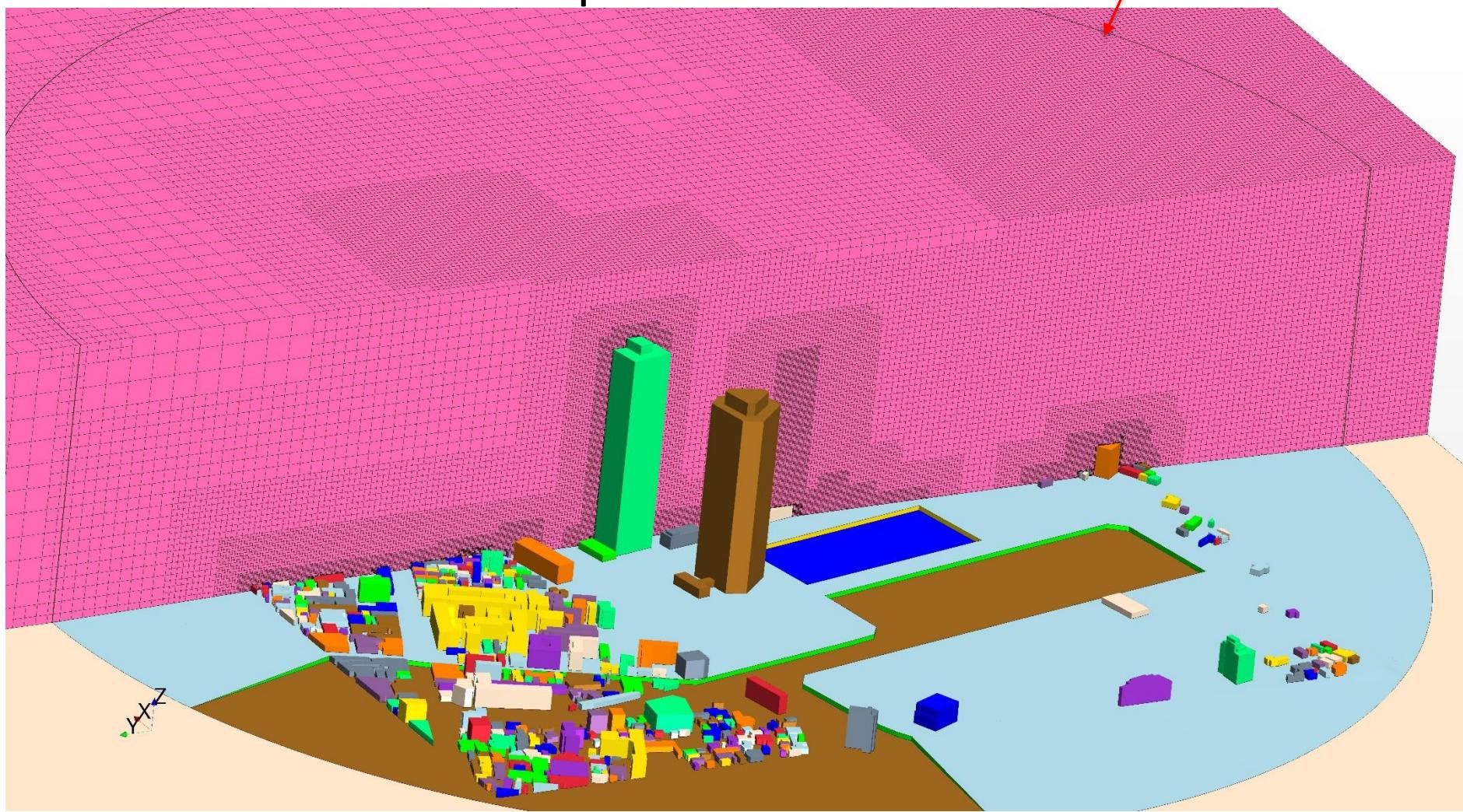
- Trimmer mesh with prisms – StarCCM+
- Hex dominant – orthogonal – well suited



URBAN SCALE CFD

- Trimmer mesh with prisms

Cylinder Domain
Rotate

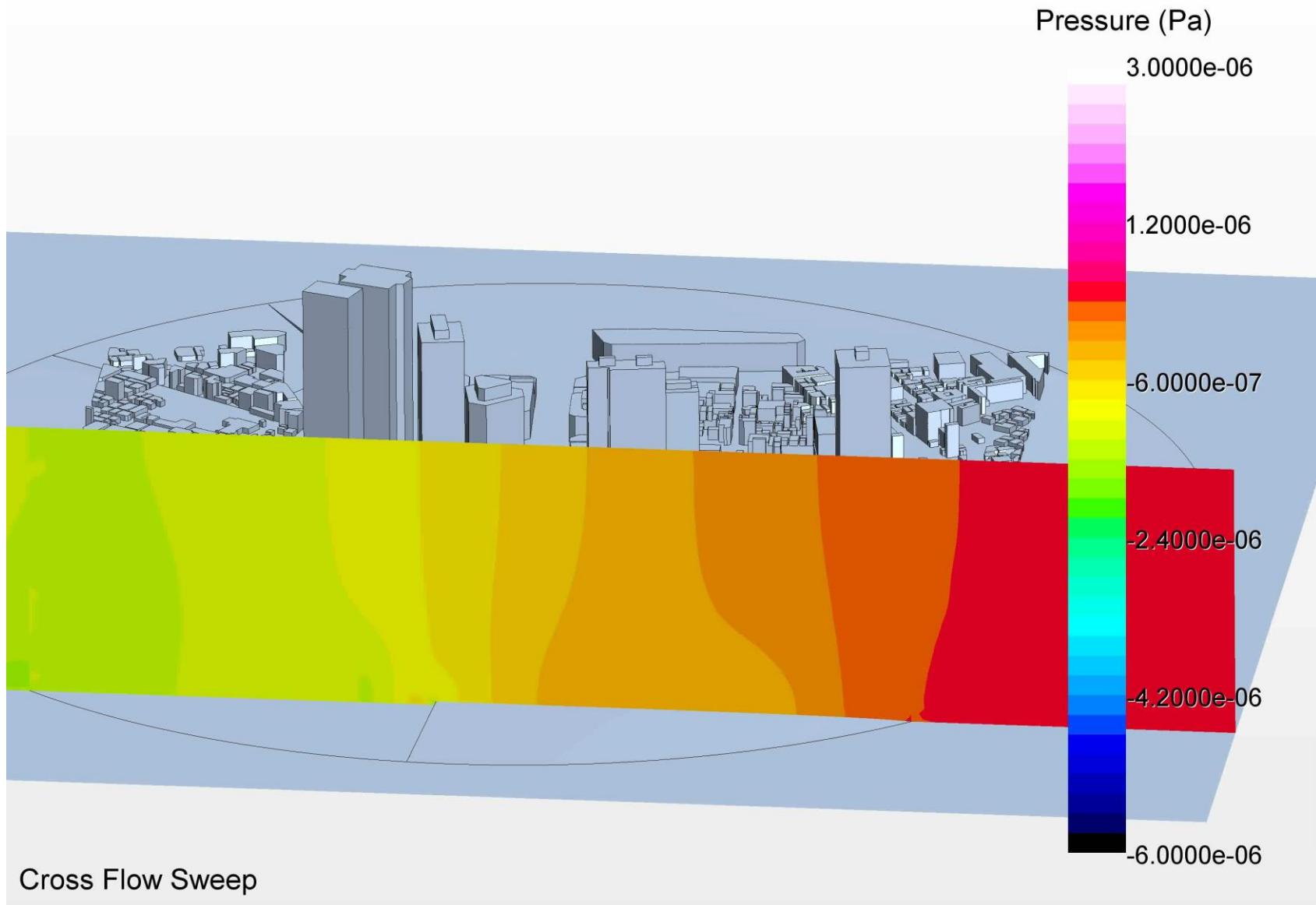


URBAN SCALE CFD

- 40 Million cells
 - RANS K Epsilon Realizable, 2 layer, all Y+ wall function
 - Large Atmospheric Boundary Layer 120 m
 - Dominant wind directions – weighted results
 - 16 Processors, 40 Gbytes ram, 5 hrs/wind
-
- 3 schemes designed
 - Avoid urban canyon

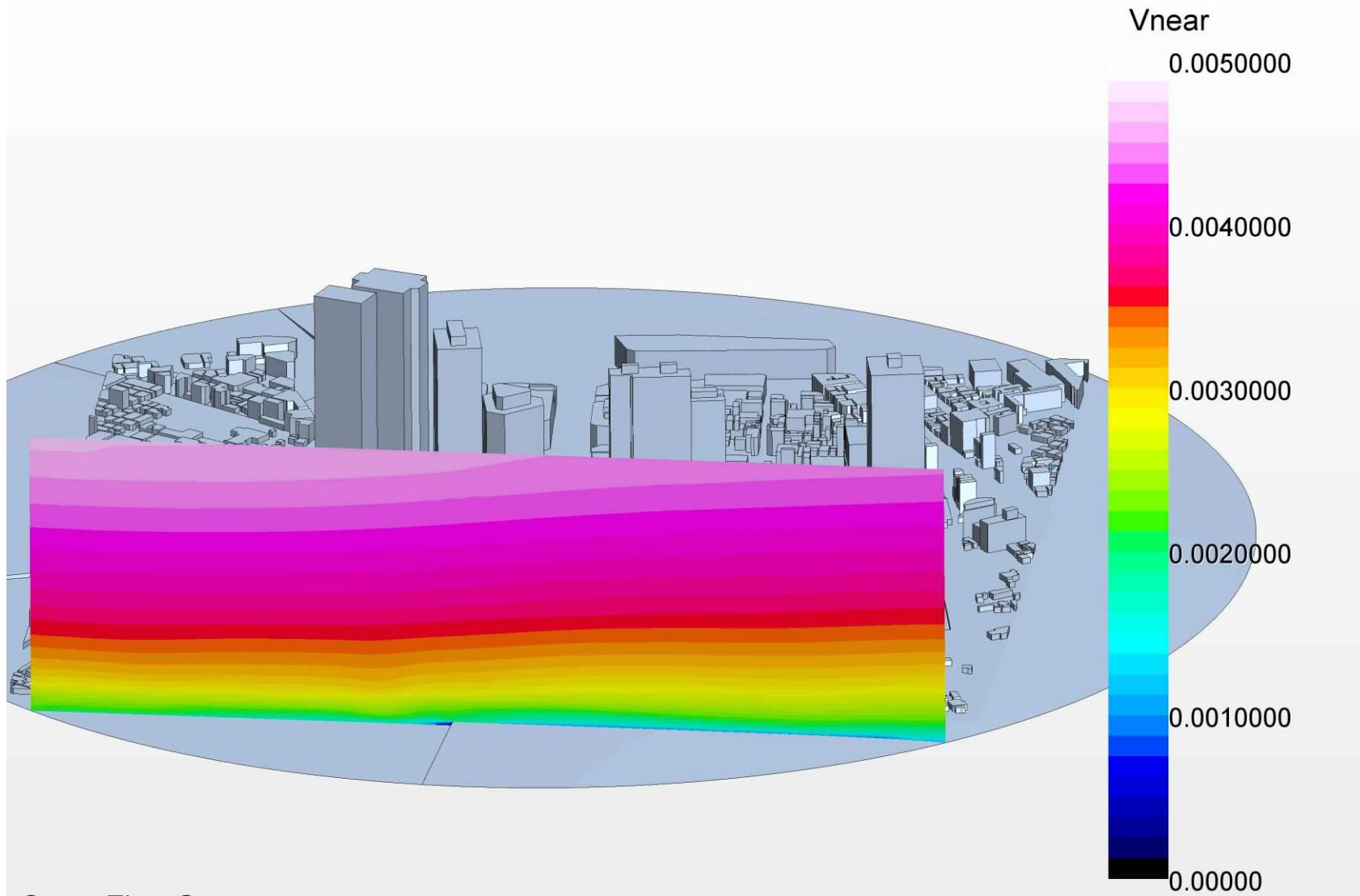
URBAN SCALE CFD

Ignore scale – normalised badly

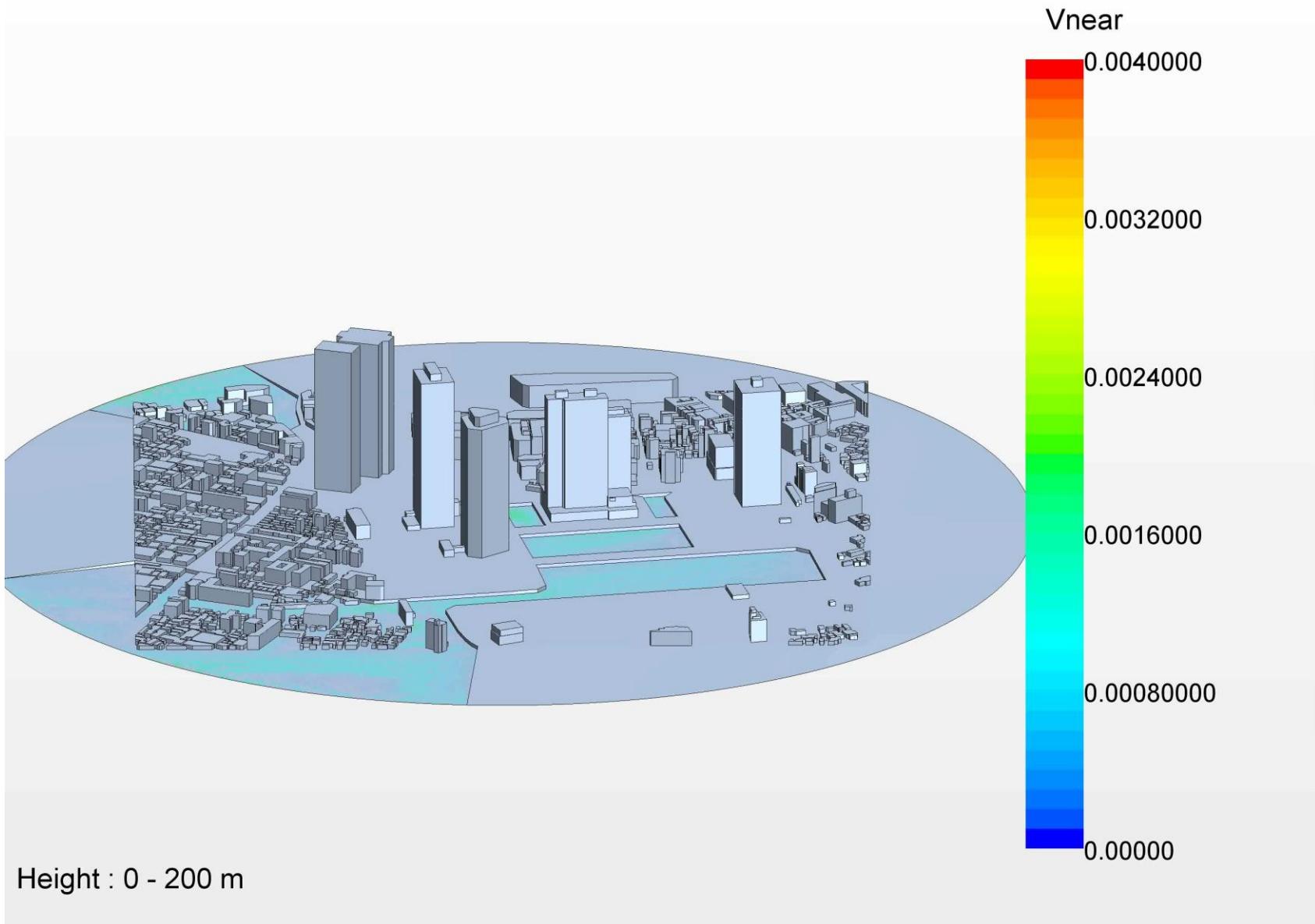


URBAN SCALE CFD

Ignore scale – normalised badly

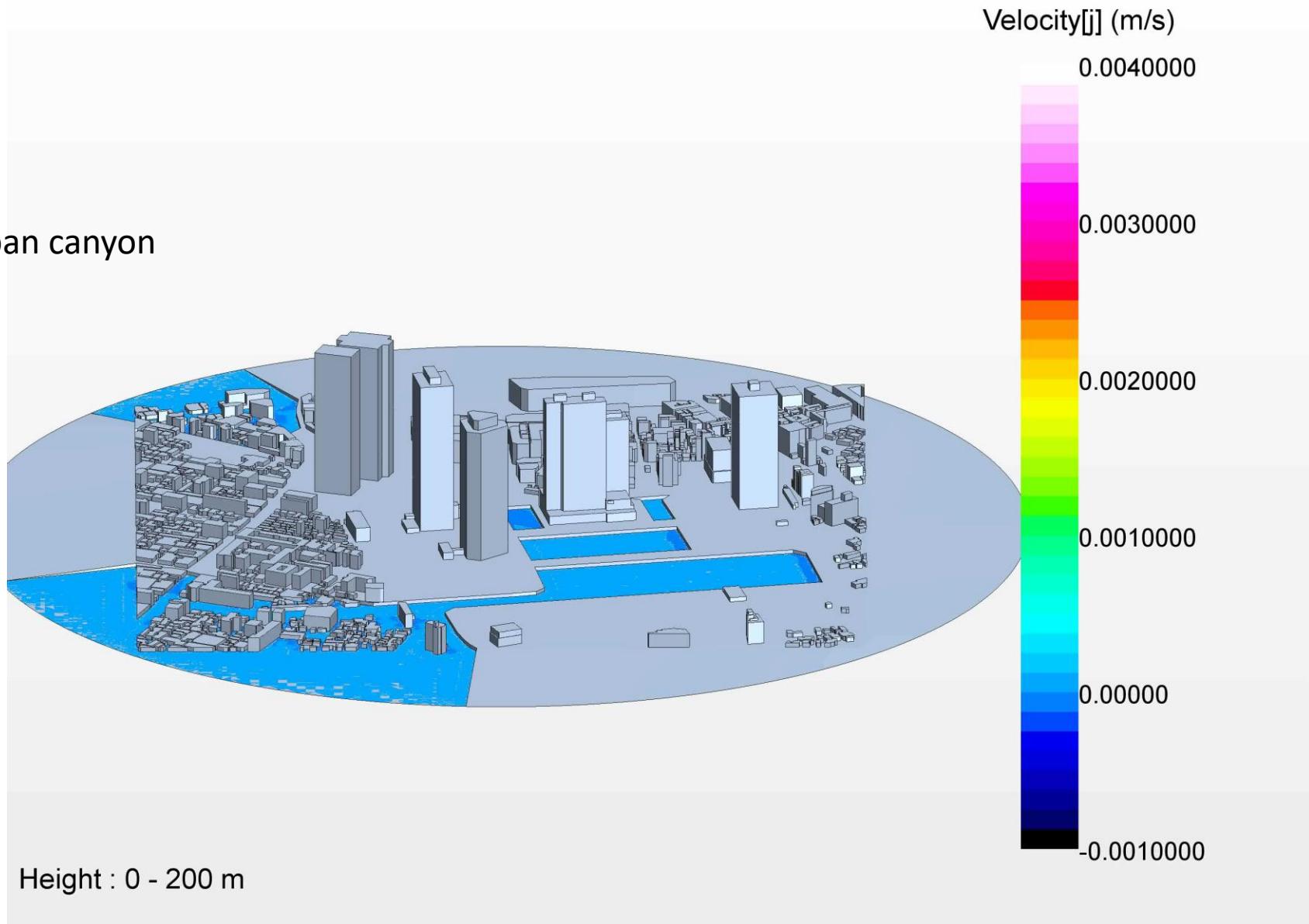


URBAN SCALE CFD



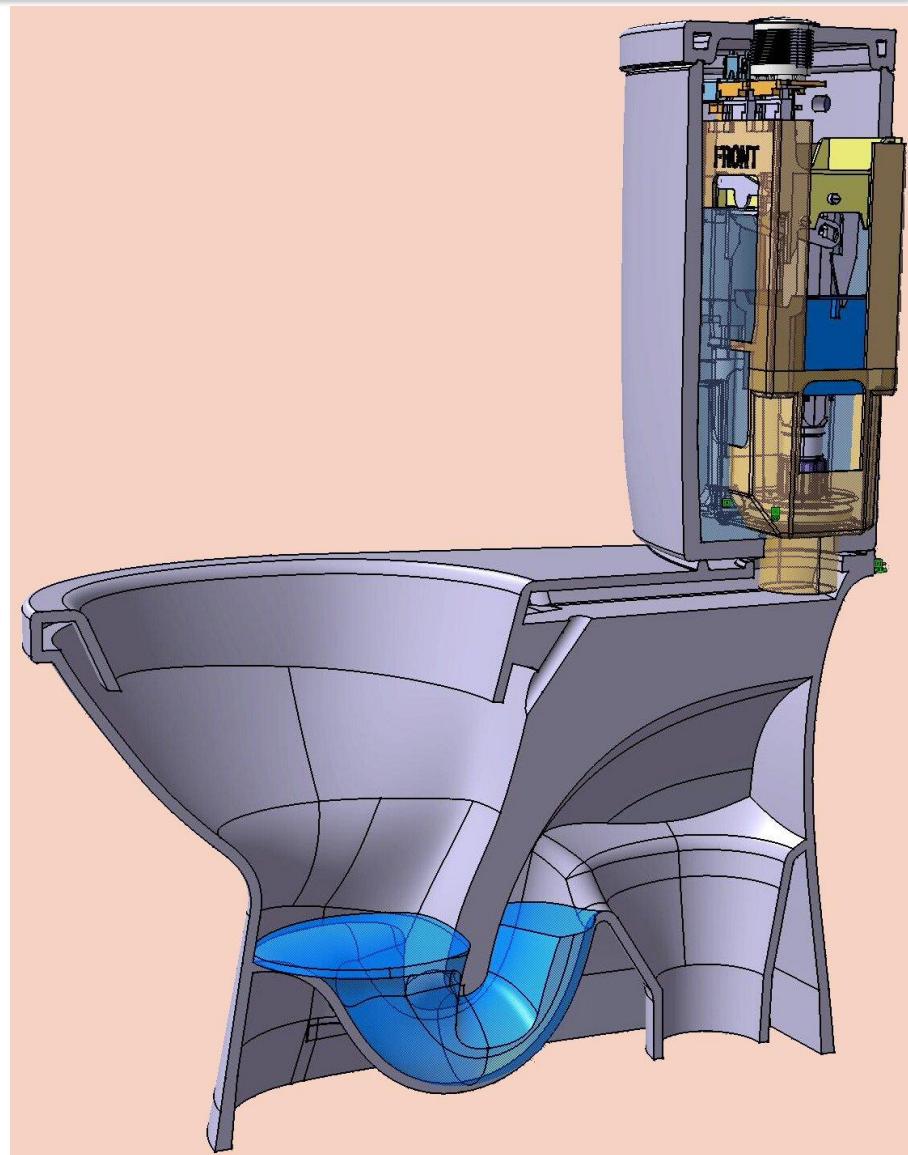
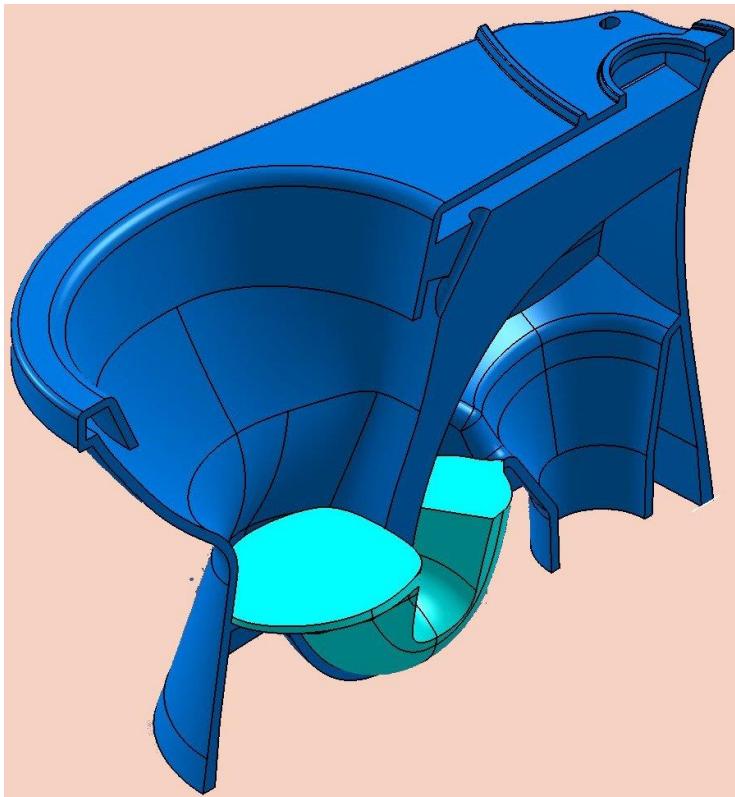
URBAN SCALE CFD

Urban canyon



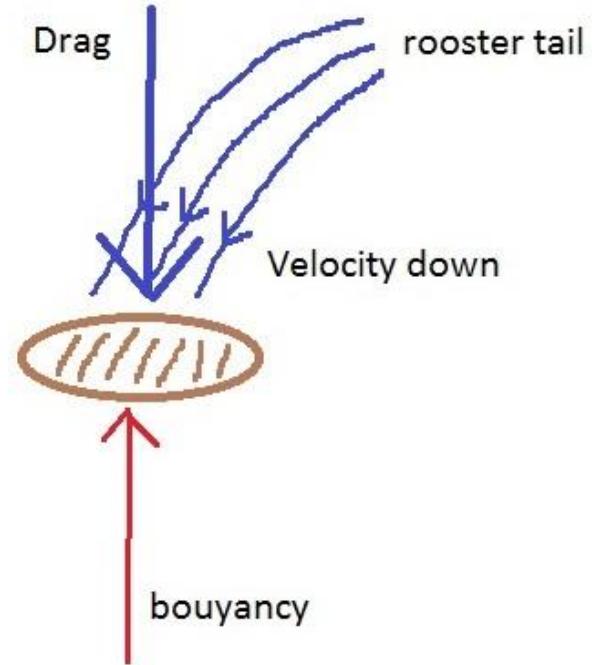
TOILET MODELLING

- Caroma Sydney Factory
- New designs – save water
- Some science and tech



TOILET MODELLING

- Two main flows regimes
 - Flush rooster tail forces flocks down with drag against their buoyancy
(depends on fat eaten)
 - Mixing of clean water with dirty
Multiphase but same phase



TOILET MODELLING

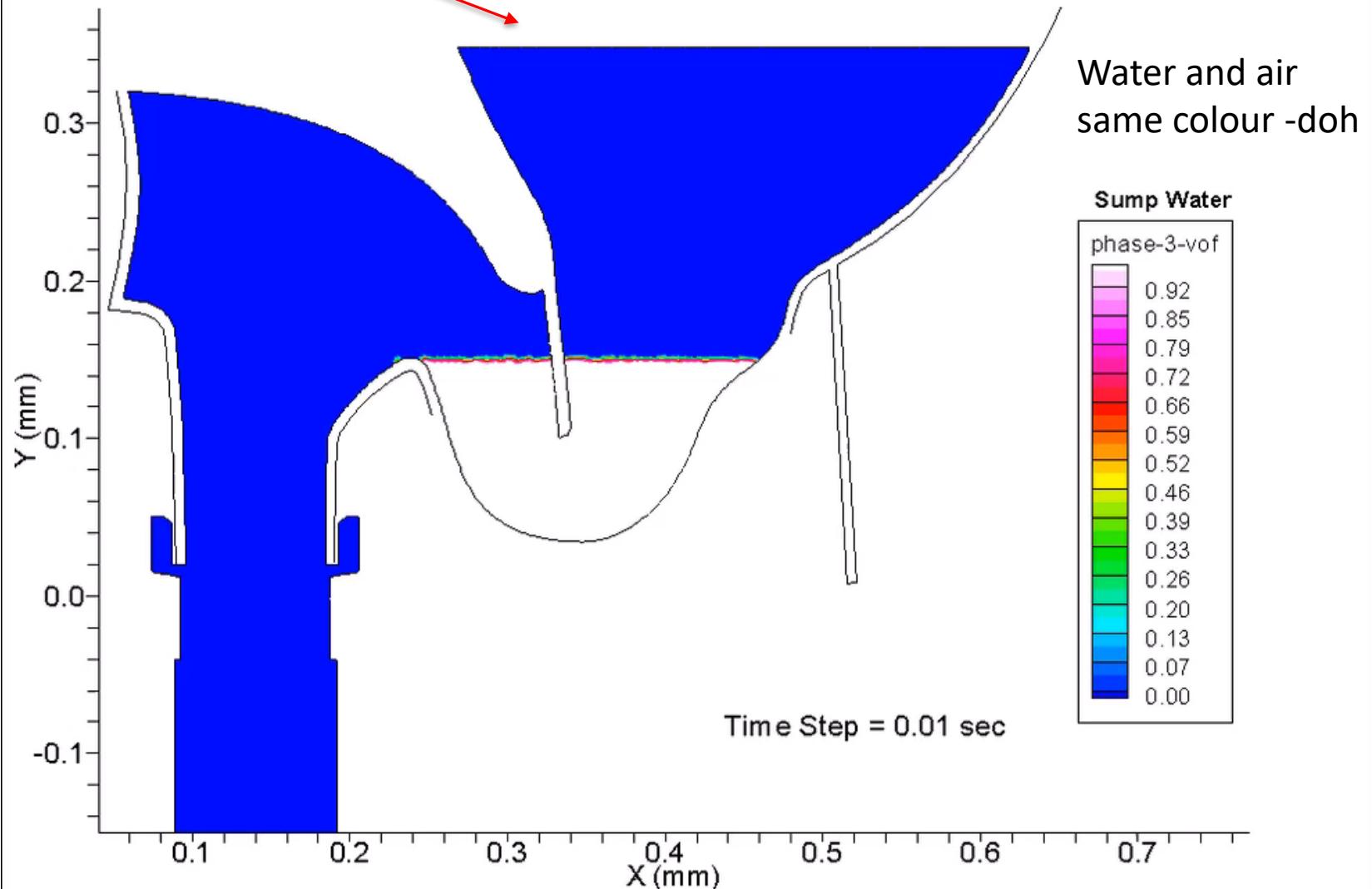
- 2D first go at mixing
 - Multiphase with rooster
 - K Epsilon standard, Fluent
 - VOF immiscible, 2nd order geo
 - URANS – transient
 - Time to clean
- 200 k cells, 2 processors
- 16 Gbytes ram, 10 hrs



Dirty water
Up flow

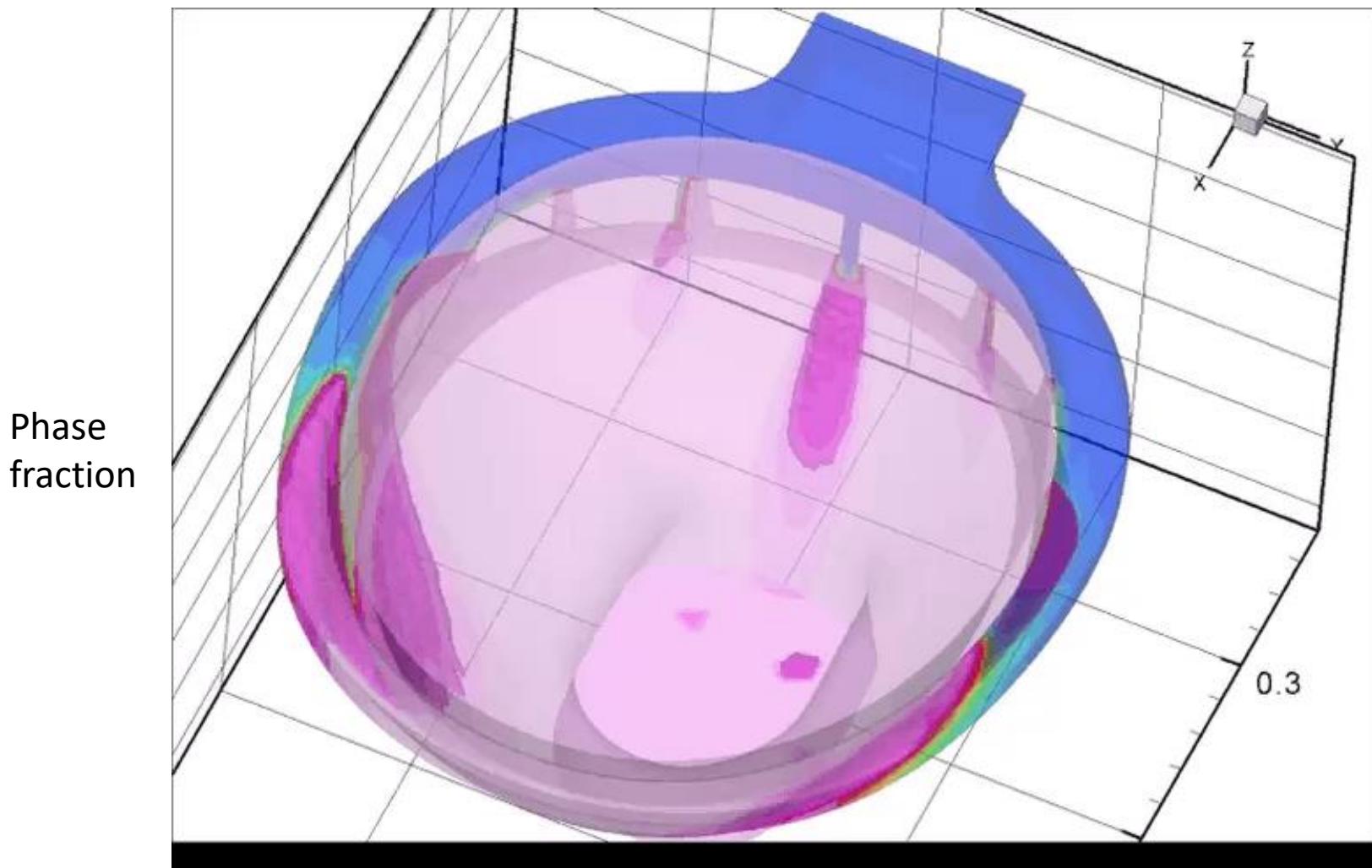
TOILET MODELLING

REECE VAND S TRAP SIMULATION : CASE01



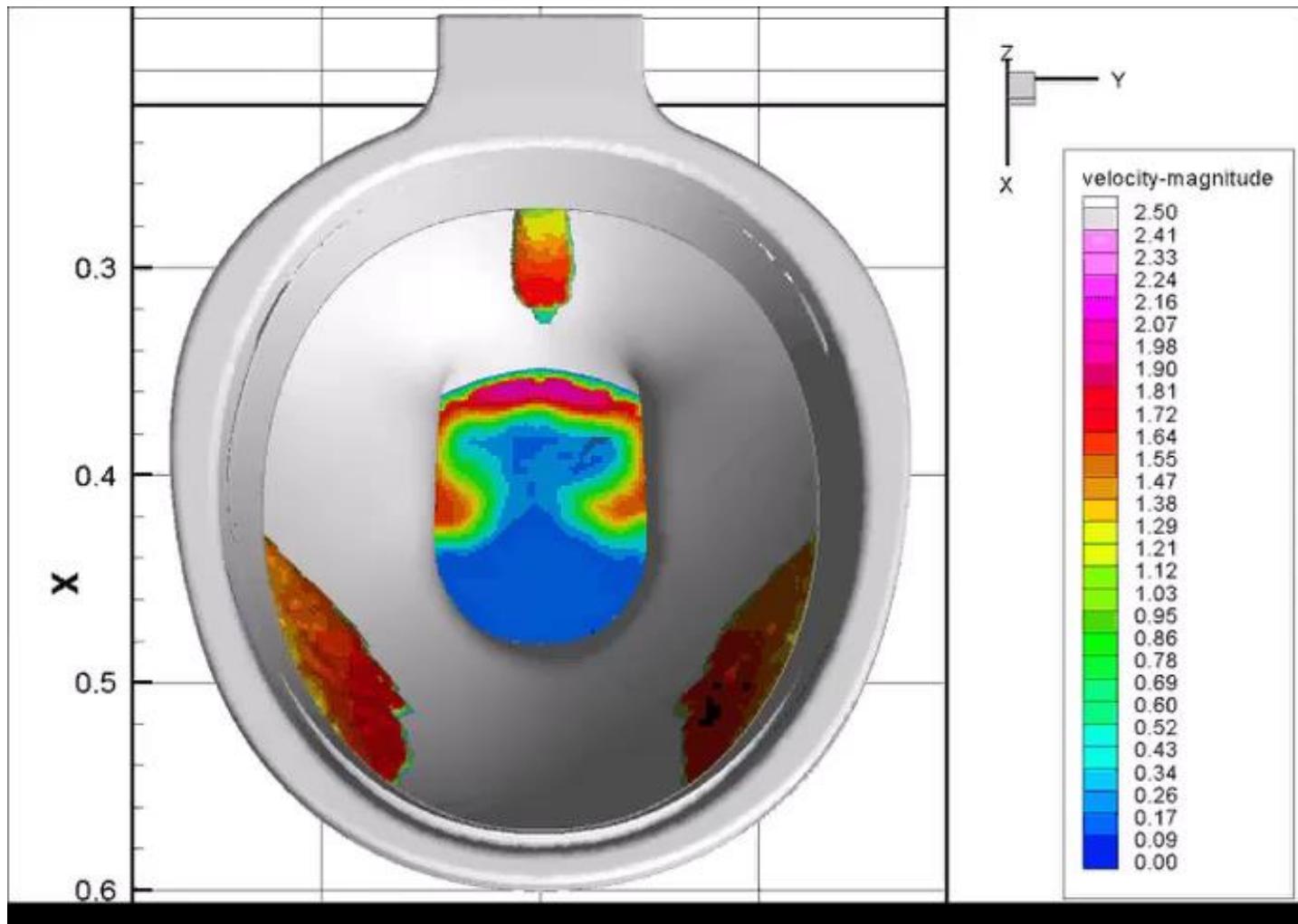
TOILET MODELLING

- 3D 4 processors, 32 Gbytes ram, 2 days



TOILET MODELLING

- 3D rooster velocity no flocks (beyond CFD at time)



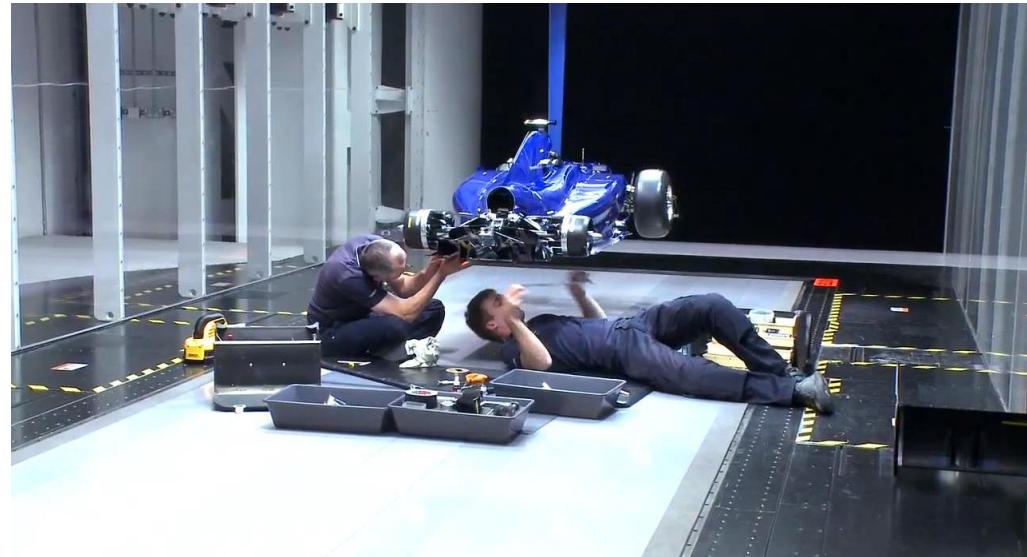
TOILET MODELLING

- Qualitative Validation - good!



WILLIAMS FORMULA 1

- Senior Aerodynamicist \approx 10 years
- Responsible for aero simulation and models
 - Correct and accurate – Verification and Validation
 - Devise Wind Tunnel and Track Car experiments
 - Manage fidelity and resolution



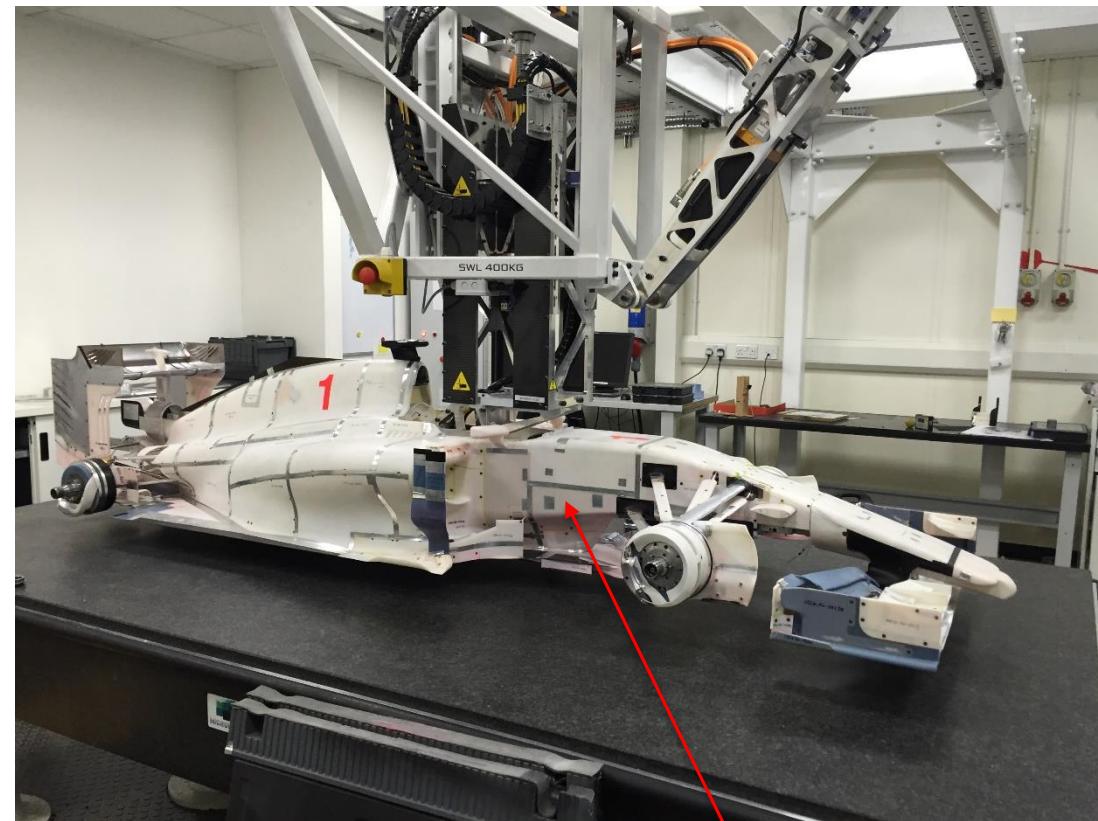
<http://i.imgur.com/JLpdH.jpg>



<http://i.imgur.com/m3sk9.jpg>

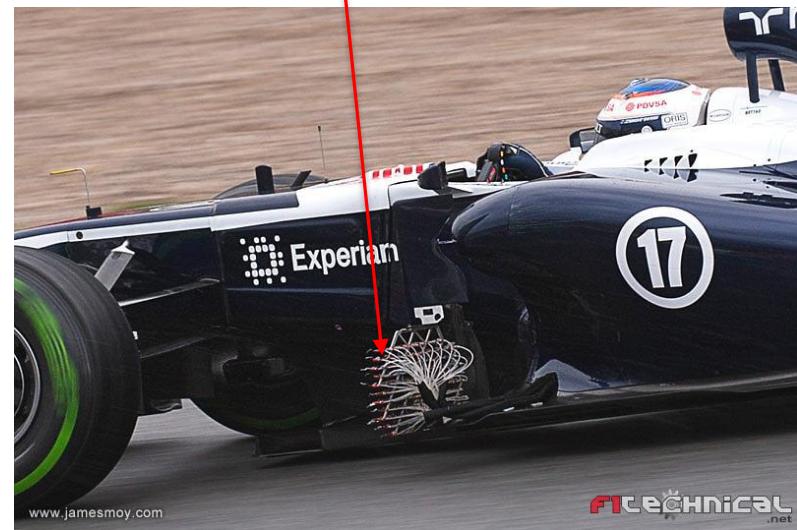
WILLIAMS FORMULA 1

- Develop Wind Tunnel and Track Experiments



<https://farm9.staticflickr.com>

For Sale



<http://f1cdn.net/gallery/var/resizes/2013/barcelona-test-28/williams-pitot-array.jpg>

Kiel probe rig
- vortex position
- velocity mag

WILLIAMS FORMULA 1

- CFD Simulation Fidelity

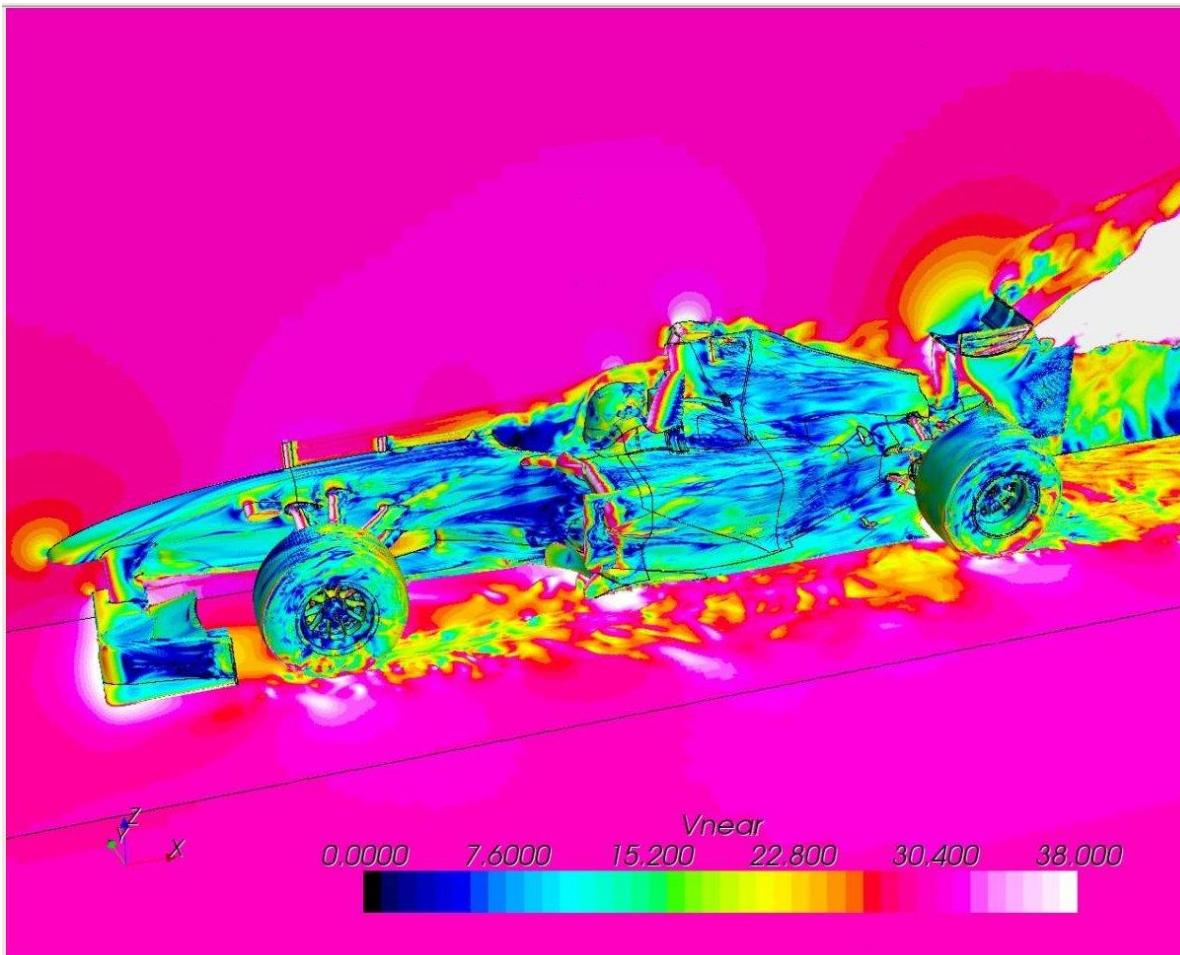
Competition push - always getting better?

Simulation Fidelity	Implementation (%)	My Role
Car pitch yaw roll	Fully	Advisor
Moving suspension	90	Major in a team
Flexing wings and body -1 way	50	Major in a team
Deforming tyres (FEA)	90	Principal
Thermal deforming tyres (FEA)	80	Principal
Road shape and roughness	90	Advisor
Wind Tunnel or track	Fully	Advisor
Pressure drop radiators	Fully	Advisor
Thermal radiators	80	Major in a team
Engine block cooling - coupled	80	Advisor
Thermal brake disks	Fully	Principal
Thermal pulsing exhaust	90	Principal
Pseudo steady flow	Fully	Major in a team
Time resolved flow LES	70	Principal
Full lap simulation	50	Major in a team

WILLIAMS FORMULA 1

- Time Resolved LES

2000 processors, 4000 Gbytes RAM, 3000 Gbytes files, 1.5 months



WILLIAMS FORMULA 1

- Resources
 - 5000 cores, 4 Gbytes per core ram, 20 Tbytes
 - Intel Sandybridge, Westmere
 - 2010 was Lenovo – named “Great Wall China”
 - 1 MW water chiller (out back, freezes up in winter?)
 - Star CCM+
 - 50 aerodynamicists/engineers
 - 5 CFD specialists

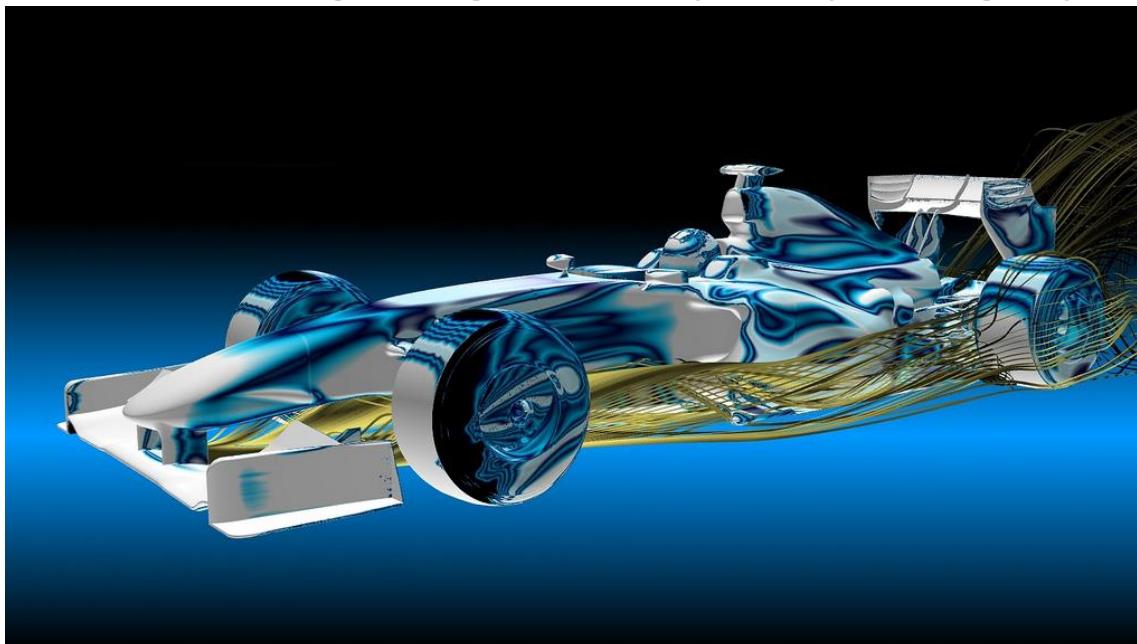
WILLIAMS FORMULA 1

- Wind Tunnel
 - Jacob full size, 5W x 2H m section, 85 m/s, cooled
 - Wall and roof adaption for blockage
 - Steel belt rolling road (2 MW, belt cost £55 k)



WILLIAMS FORMULA 1

- CFD Model
 - Full car in cross wind, yaw, track or tunnel
 - Varying ride height and roll
 - Moving wing flap, DRS, suspension, deformed tyres FEA
 - Deforming wings - 1 way coupled (grey rules)



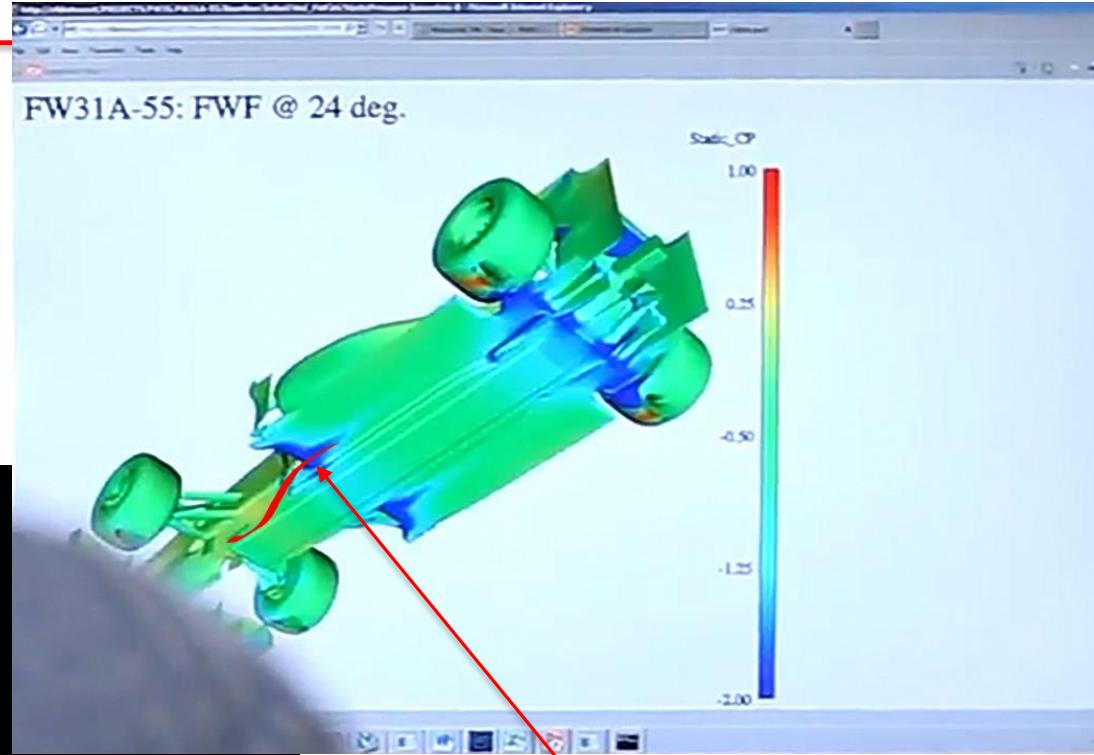
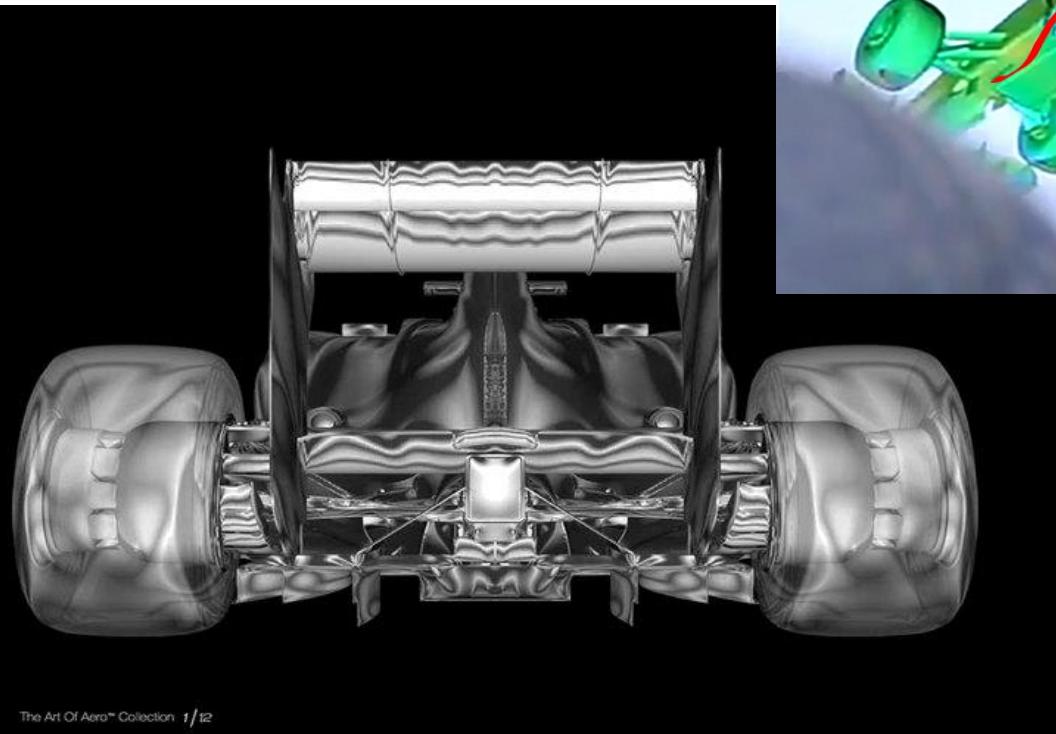
WILLIAMS FORMULA 1

- CFD Model
 - 350 M cells, 300 cores, 1.2 Tbytes ram, 5-10 hrs
 - Run 200 – 300 cases/week
 - K Epsilon Standard, EB lag wall function
 - Some RSM and LES – solver cascade



WILLIAMS FORMULA 1

- CFD Model
- Real pics



Vortex reuse Y250
Front floor Dforce
Like gold!

THANK YOU

- Questions
- No CFD cowboys!



http://static.tvtropes.org/pmwiki/pub/images/LuckyLuke_8441.gif