23rd Sept 2020

Scalable Engineering Simulation Applications

Outreach Program with NSCC

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Agenda

- **Electronic Application**
  - Simulation Workflow
  - Large scale thermal-fluid simulations
- **COVID Research**
  - Introduction
  - Mitigating Infection Transmission through Simulation Studies
  - Sample Cases & Scalability Study
- **Large Area Simulations**
  - Introduction
  - Sample Cases with Scalability study

Electronic Applications

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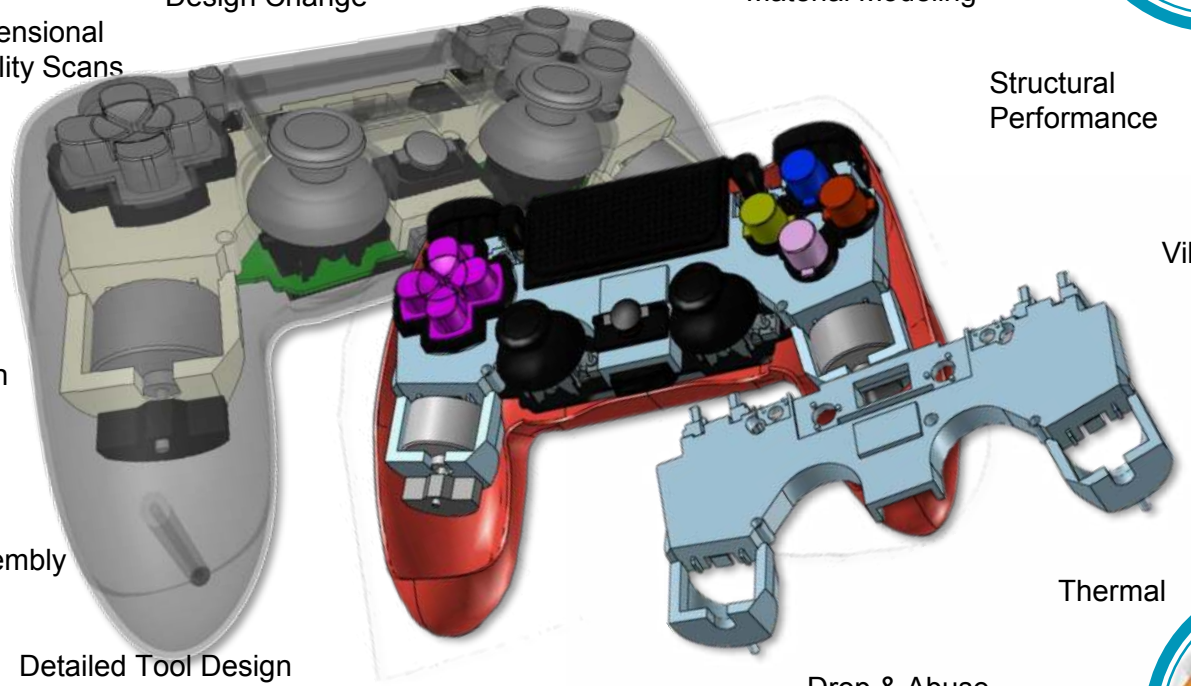

Dimensional Quality Scans

Design Change

Detailed Design

Material Modeling

Structural Performance

Vibration

Fatigue

Thermal

Drop & Abuse

Plastic Forming

Tool Development

Detailed Tool Design

Tooling Assembly

Toolpath Generation

CT Quality Scans

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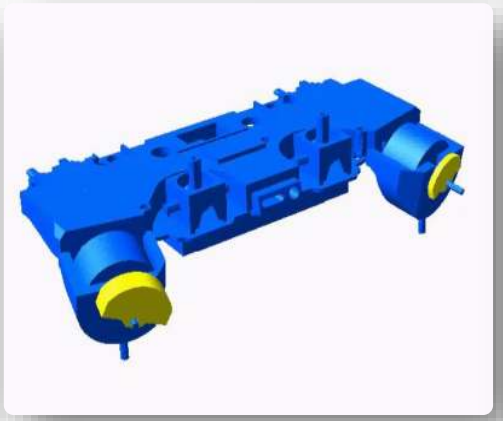
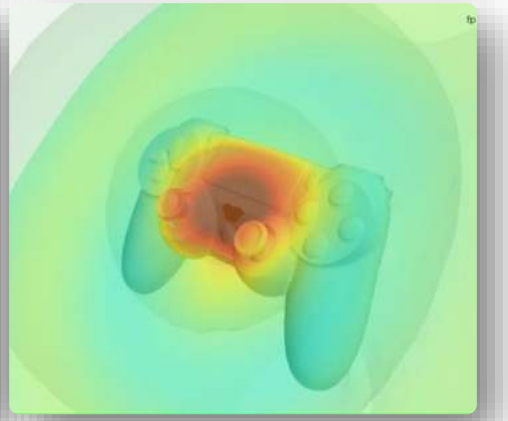
Detailed Simulation Workflow

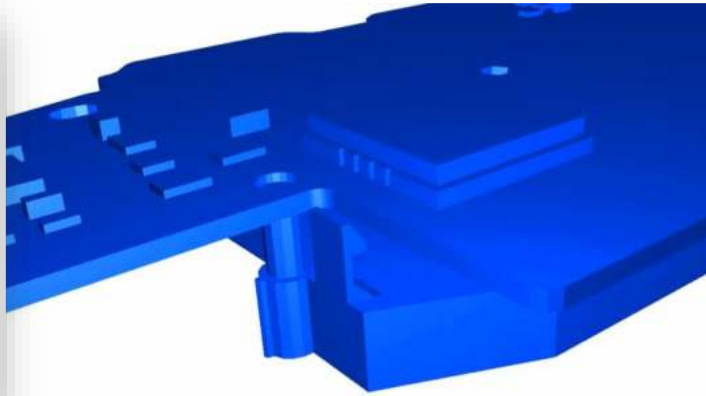
Thermal & Humidity

Motion & Acoustics

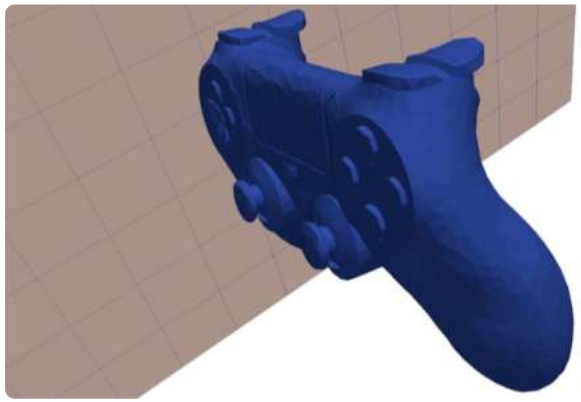




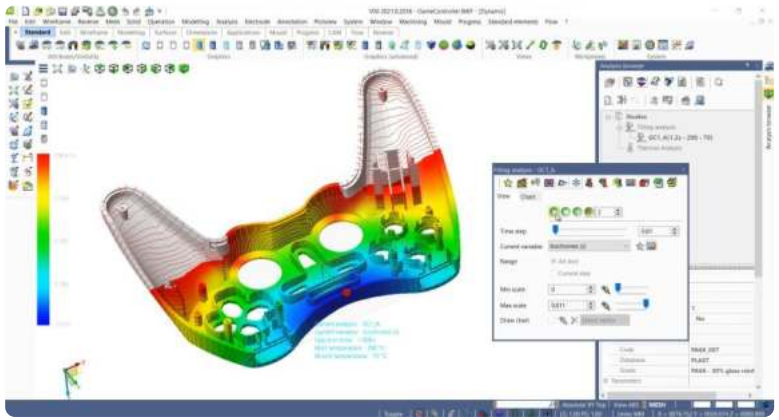
Structural Integrity



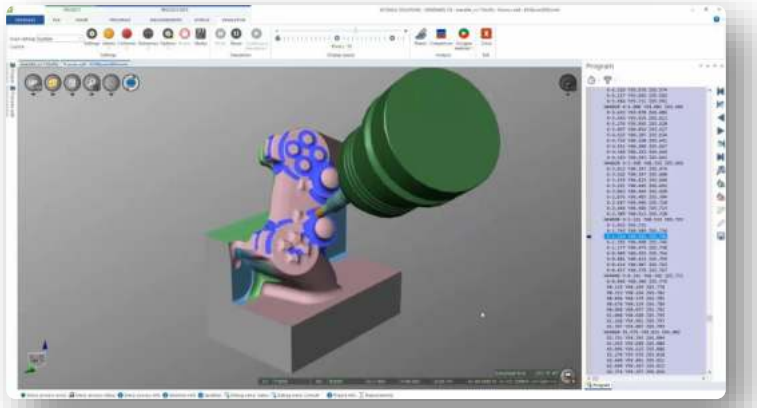
Shock Testing



Injection Molding



Tool Design & Machining



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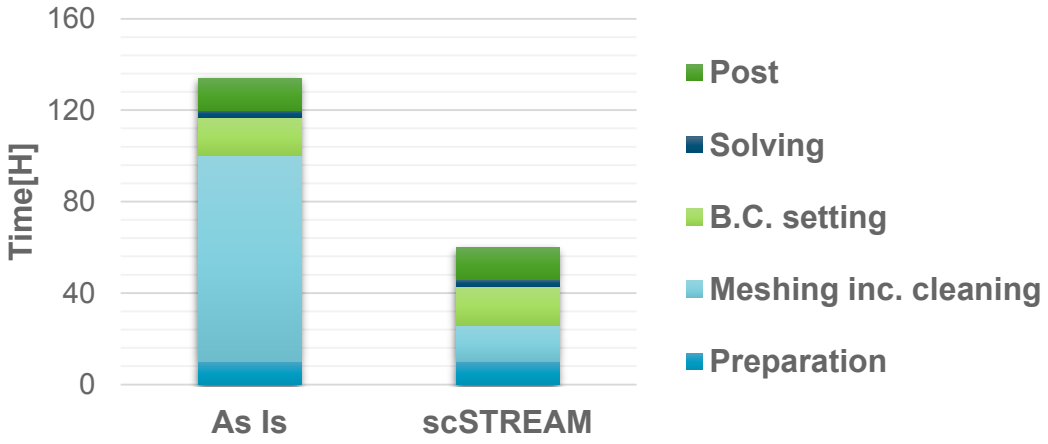
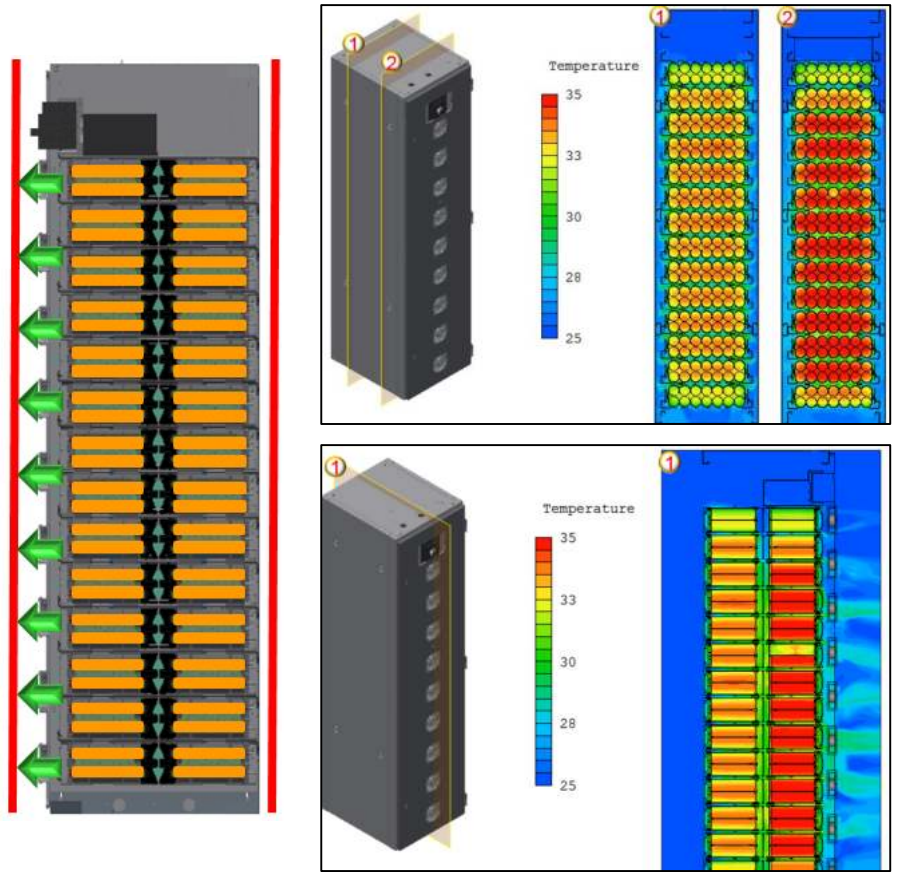
Integrated Results Viewing

Large-scale Thermal Fluid Simulations

Billion Cell Models

- **Simulation time reduced by 1/2**
- **Minimal geometry data clean up. 80% less manual process**
  - meshing speed.
  - calculation speed.
  - memory efficient.





Server tower power & cooling requirements

- 5000 parts.
- No CAD clean-up, or preparation

Powering the highest resolution video display in the history of Times Square

Engagement Details

- 32 PCB; 157 components; 128 thermal via (bloc); 23 Fan ; 2,2kW heat dissipation,

Turn-around

- No model preparation
- Solved across 20 cores, in one night

Scope

- 3 x Simulation, with results and report, 1 week, from the receipt of data

COVID Research

Particle Dynamics & HVAC

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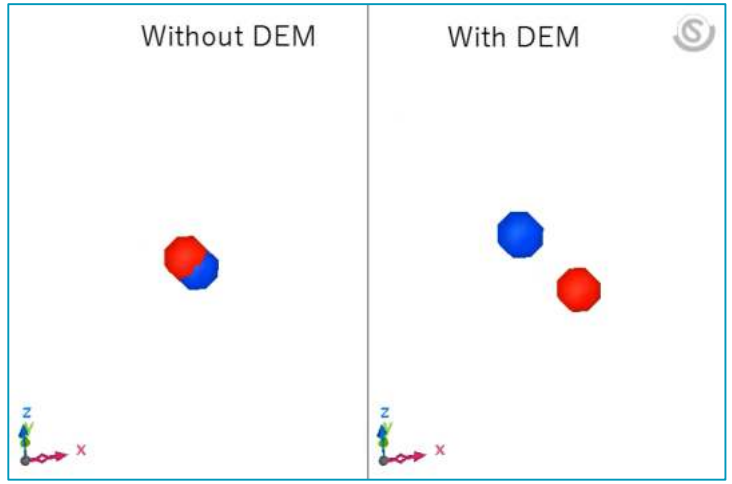
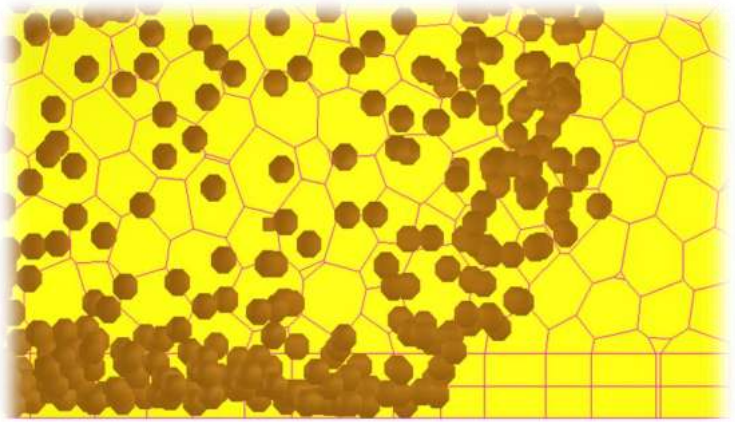
Introduction to Particle Dynamics

Complex Particle Dynamics



- Interaction between fluid and particles
- Contact forces between particles
- Volume of each particle also to be considered

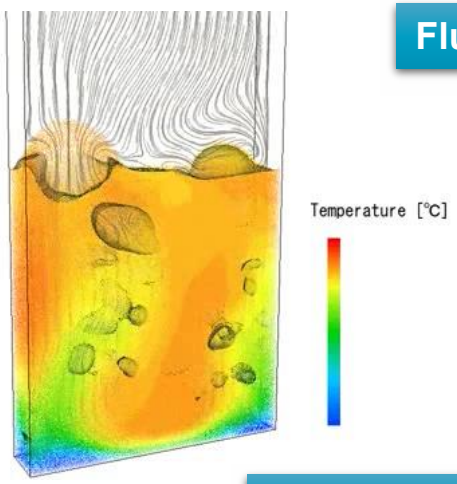
Large Mesh Size



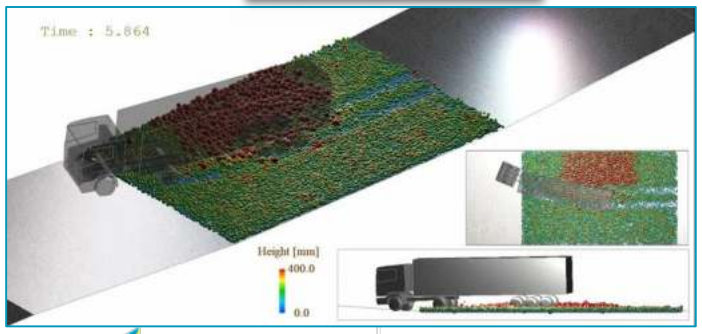
- Particle size is assumed to be relatively small compared to CFD mesh size

Complexity with Coupling

Fluid Coupling

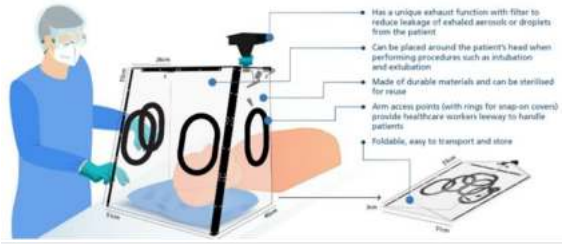


MBD Coupling



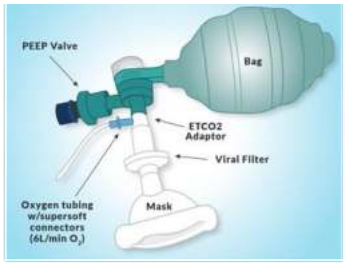
Mitigating Infection Transmission

Reduced Droplet Spread during Airway Manipulation



Credits: National University of Singapore

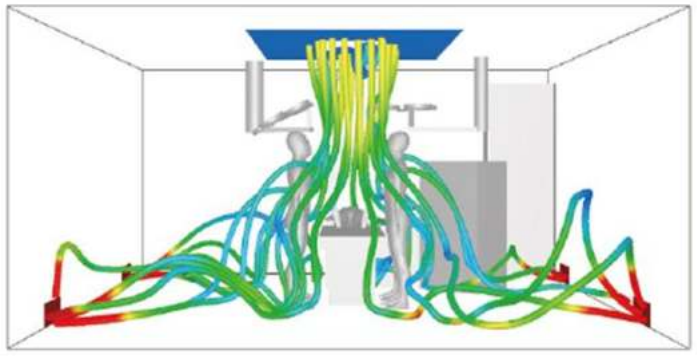
Spread Reducing Tent:
- Air flow pattern with breathing cycles
- Particulate dynamics & leakage study
- Study of exhaust function
- Intubation and Extubation processes
- Material study and 3D Printing



Credits: EMCrit

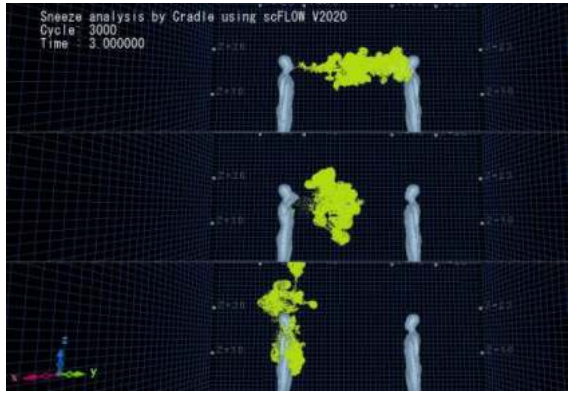
Modified Hudson Masks:
- Modified filter and valve attachments
- Specialised Airway Management
- Ingress and Egress slots for Extubation
- Materials study and 3D Printing

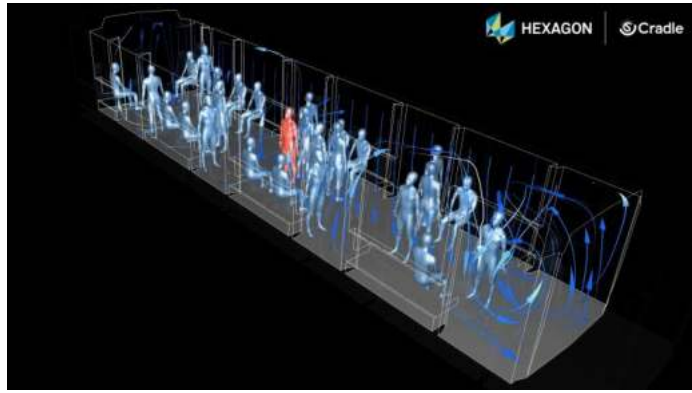
Containment Wards / ICU / OT



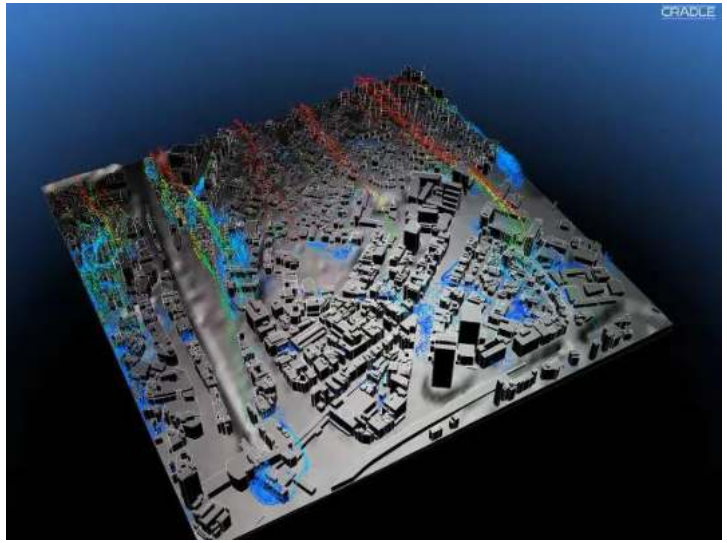
Key Areas:
- Effective Ventilation Configuration
- Reduce flow circulations
- Identify exhaust vent positions for effective evacuation

Distancing Effectiveness & Droplet Dynamics





Large Area Disinfection



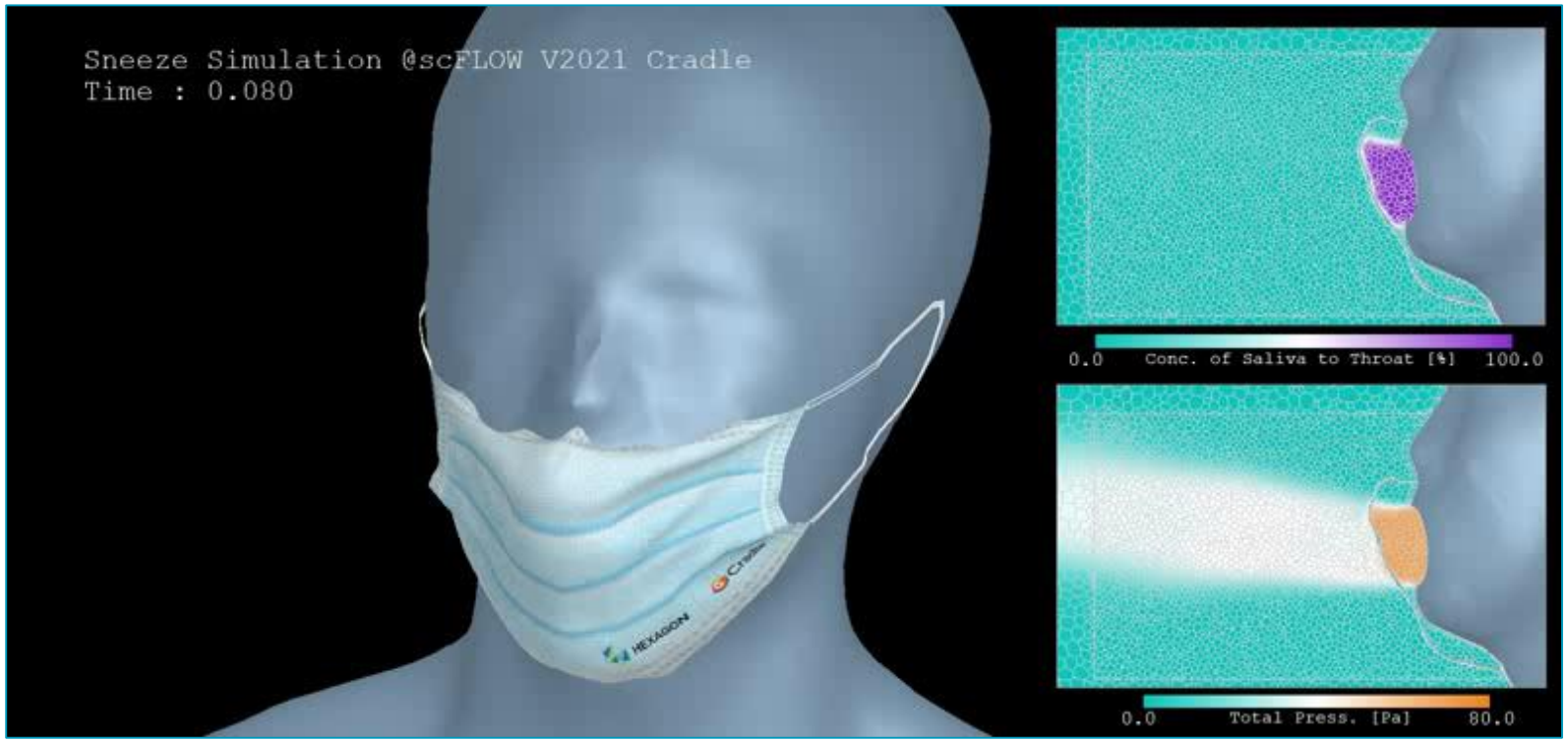
Key Impact:
- Infection Mitigation & Control
- Spray Effectiveness & Dispersion
- Flow Pattern and Disinfectant Spread
- Concentration through VOF

Phui S. Au Yong* and Xuanxuan Chen. (2020). Reducing droplet spread during airway manipulation: lessons from the COVID-19 pandemic in Singapore. *British Journal of Anaesthesia*. 125

Particle Dynamics – With CFD Coupling

Cloth model emulating a Mask

Mask Trapping Sneezing Droplets



Conditions

- Sneezing Max speed : 10 m/s
- DEM particle count : 4,753
- Particle Diameter : 2 mm (Uniform)
- Particle Density : 200 kg/m^3 (4 g at the whole Mask)
- Contact model : Walton-Braun
- Young's modulus : 1 kPa
- Static friction : 0.3
- Rolling friction : 0.3
- Restitution coeff. : 0.01
- CFD coupling : Used
- Mesh Count : 728,289

Calc.Spec.

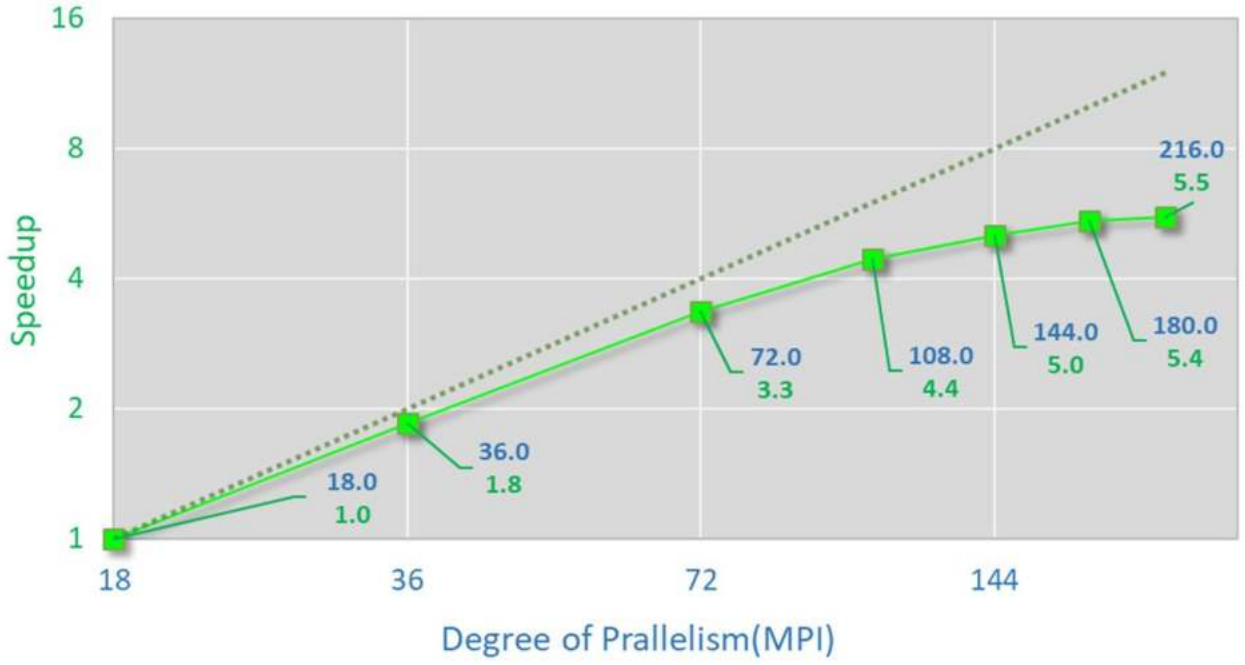
- Calc. Time : 6h : 36m : 29s @ rx2530
- MAX Memory(ALL) : approx. 38 GB
- Degree of parallelism : 144 MPI procs.
- Physical Time : 2 s
- CFD time step : 0.5 ms
- DEM time step :

the lesser of either 10 % of the critical Rayleigh time step, and 10 % of diameter divided by the velocity of particle (Avg. : approx. 0.1 ms)

Particle Dynamics - Scalability Study

*** Conditions**

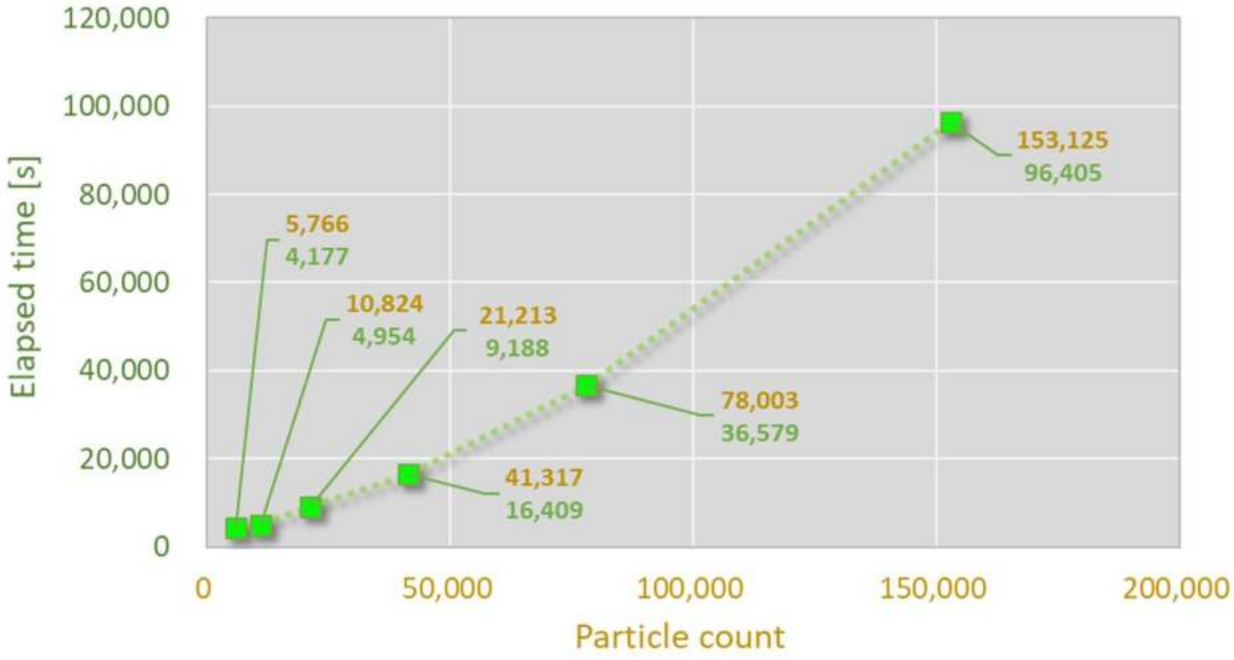
- DEM Particle count : 153,124
- Mesh Count : 28,513
- Contact Model : Walton-Braun
- Young's modulus : 1,000 Pa
- Diameter : 0.14 mm (uniform)
- Density : 2,650 kg/m^3



➡ With CFD skip mode, good efficiency achieved.

*** Conditions**

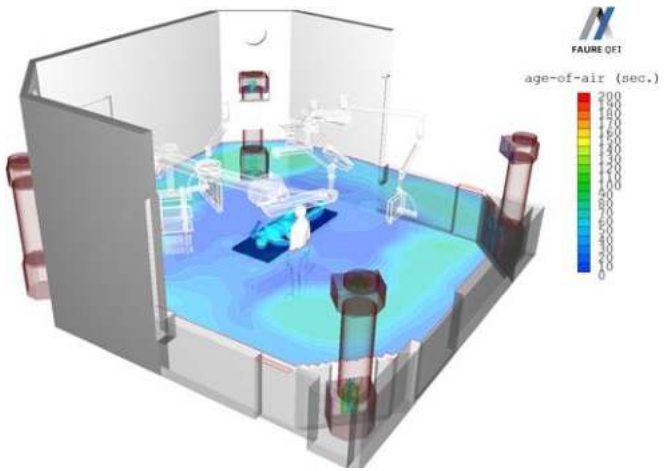
- Mesh Count : 28,513
- Contact Model : Walton-Braun
- Young's modulus : 1,000 Pa
- Diameter : 0.14 [mm] (uniform)
- Density : 2,650 [kg/m^3]



➡ The elapsed time is almost linear to the particle count.

FAURE QEI *scales up with the cloud*

Cleanroom



More information on Faure's use of MSC CFD's scStream can be had from their website

Industrial Plant

e.g. Pharma, Electronics, energy

"We're working at the extremes of our industry for nuclear, medical & micro-electronic applications at the micro and nano level. We need to provide our customers with confidence that they're going to be protected"

Pierre Bombardier, Faure QEI

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Large-Scale Simulations

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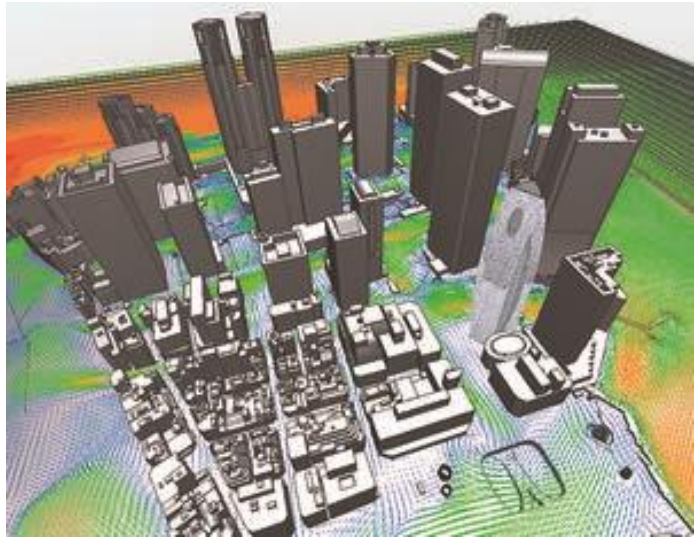
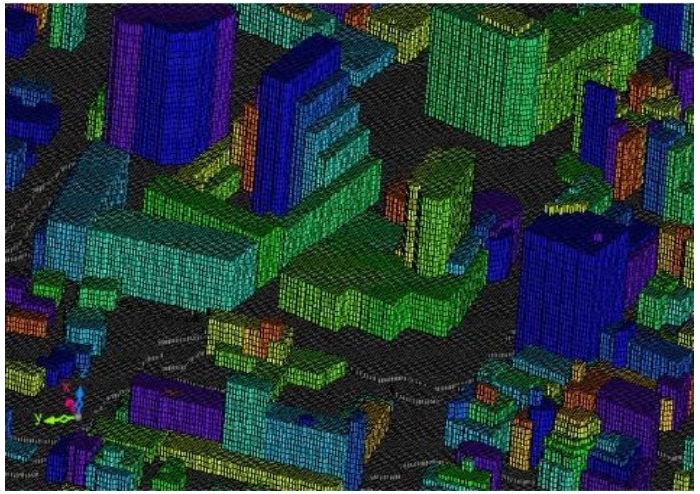
Introduction to Large Scale Simulations

Problem Size



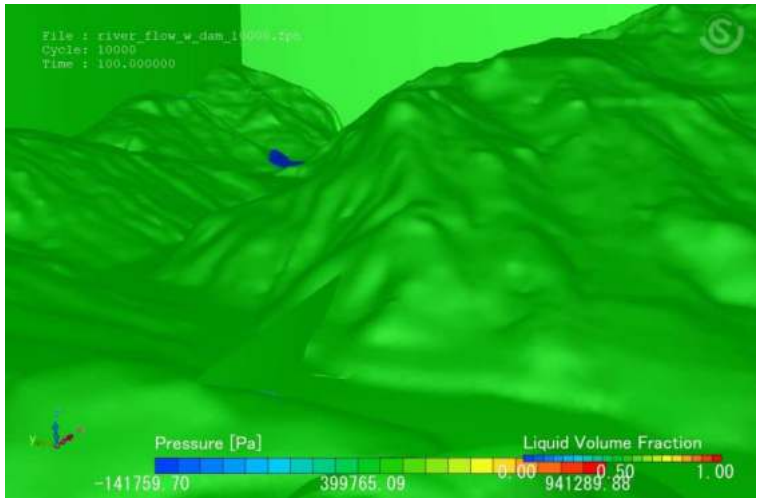
- Ranging from few sq. meter to sq. kms

Large Mesh Size



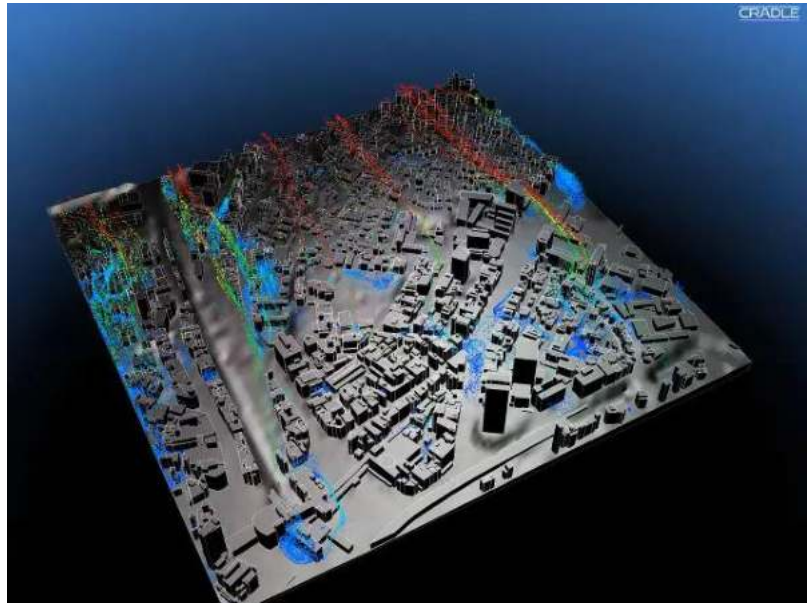
- Ranging between 50 – 500 million and above

Multiphysics



- Volume of Fluids
- Particle tracking / DEM
- Solar Tracking / Rays
- Topology Mapping

Wind flow & Pollution Dispersion



Simulation Details & benefits

- 50 Million+ mesh count
- Inclusion of Multiphase – Air and Particles
- Complex terrain conditions through topology mapping
- Effect of wind direction and ground elevation
- Pollution diffusion analysis
- Study on pollution concentrations
- Flow And structure interactions
- Inclusion of vehicular emissions, fog and moisture

Tsunami Run-up Simulation

Analysis details and benefits

- Mesh Count – 100 million
- Simulation involves wave generation and VOF
- Catastrophe Assessment
- Effective Disaster response
- Water Ingress and flow path analysis
- Infrastructure damage

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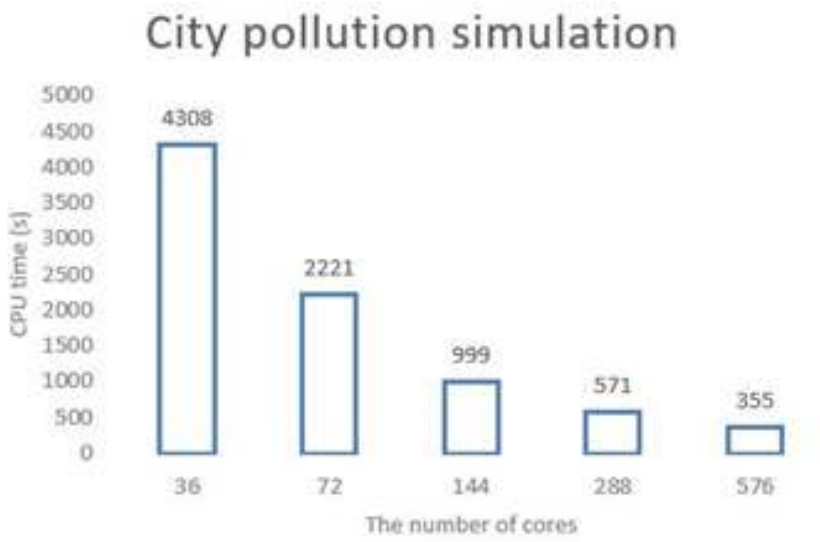
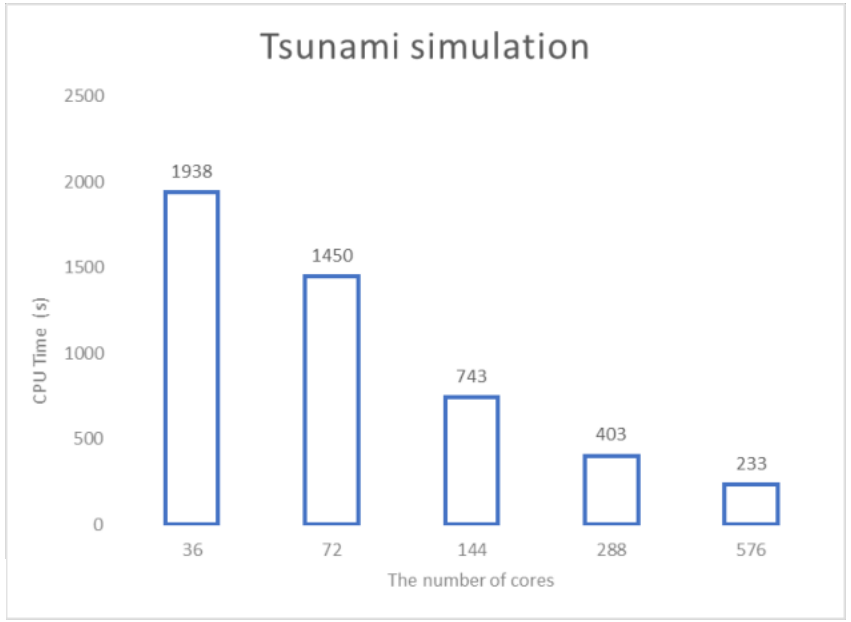
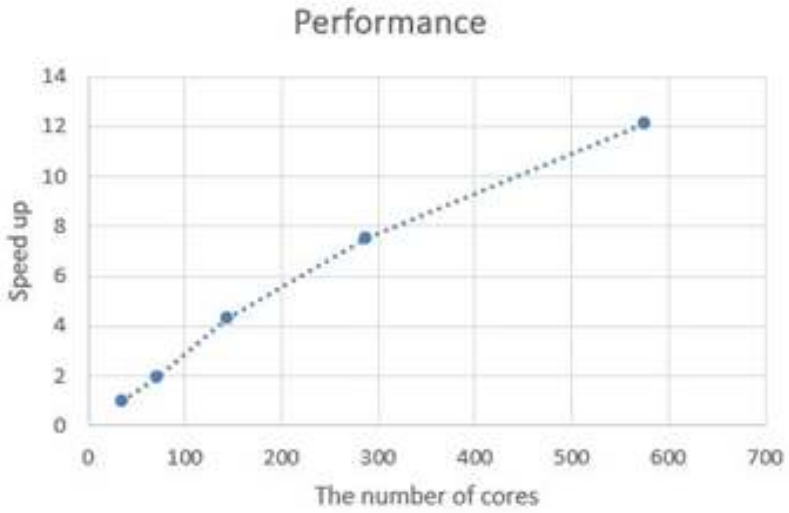
Large Scale Simulations - Scalability Study







THANK YOU

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