# HPC approaches in industry

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- Pipistrel

- Motivation

- Fortissimo project

- Mikelangelo project

www.pipistrel.si
www.panthera-aircraft.com
# Pipistrel, Slovenia
PIPISTREL



VirusSW

2007 & 2008 WINNER

WATTsUP

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

HORIZON 2020



Taurus
Taurus Electro

Taurus G4

Panthera

# Motivation

- Pipistrel cluster:    2 x (8 cores, 66GB RAM)

- Typical simulations:  - fully turbulent RANS
                             simulations
                          - low-Re airfoil simulations
                          - 5M (15M max) cells mesh

# Motivation

- Pipistrel cluster:    2 x (8 cores, 66GB RAM)

- Typical simulations:  - fully turbulent RANS
                         simulations
                       - low-Re airfoil simulations
                       - 5M (15M max) cells mesh

- Pipistrel needs on-demand resources to increase fidelity of the airflow simulations

- Requirements:
    - Resources cheap to use
    - Fast to spin-up
    - Self-service
    - Remote visualization
    - OpenFOAM support
    - Supporting different modes:
                         MPI and EP

# Fortissimo

- Experiment: Cloud-based simulation of aerodynamics of light aircraft

- Partners:   End User:       PIPISTREL

   HPC Expert:     XLAB

   HPC Provider:  ARCTUR

- Application: OpenFOAM 2.2.0

- www.fortissimo-project.eu/

# Fortissimo

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- laminar-turbulent transition modelling
  with RANS simulations: low-Re $k - k_L - omega$ turbulence model

# Fortissimo

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- laminar-turbulent transition modelling
    with RANS simulations: low-Re $k$ - $k_L$ - $omega$ turbulence model

- complete Panthera aircraft at cruise speed (Re=5.7e6)

# Experiment

Course of action:

- Simple test cases with turbulent model $k - k_L - omega$
- A wing at smaller velocities
- A wing at cruise velocity
- Complete Panthera aircraft at smaller velocities
- Complete Panthera aircraft at cruise speed

# Experiment

Course of action:

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|  | In house cluster | Arctur's HPC |
|---|---|---|
| mesh size | 5 -10M cells | 115M cells |
| thinnest layer | ~ 0.1mm | ~ 0.006mm |
| No. cores | 8 | 60 - mesh 180 - simul. |
| simulation time | 1-2 days | 2-3 days |

# Mesh
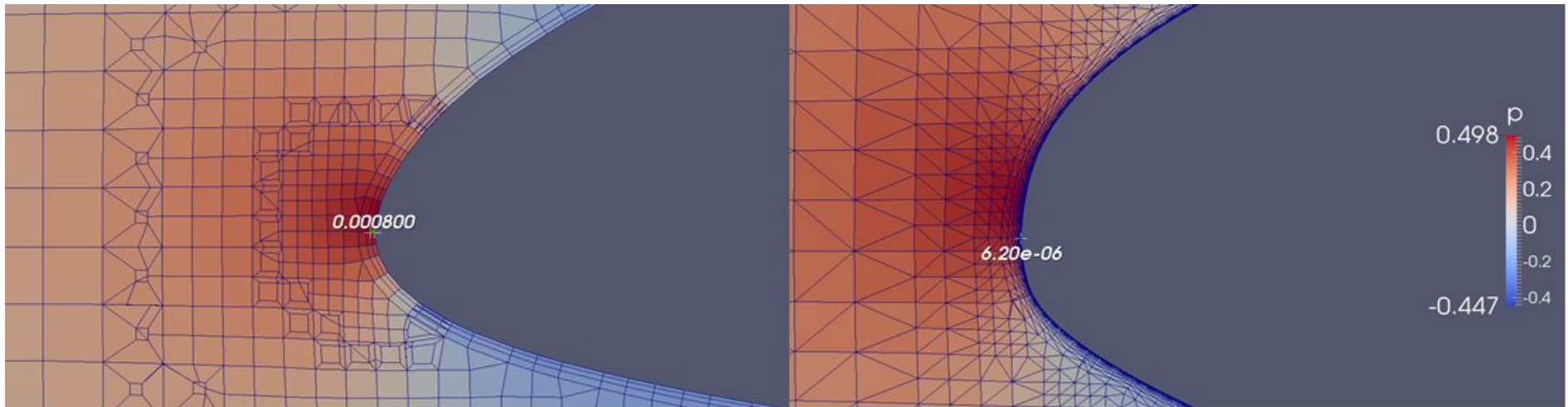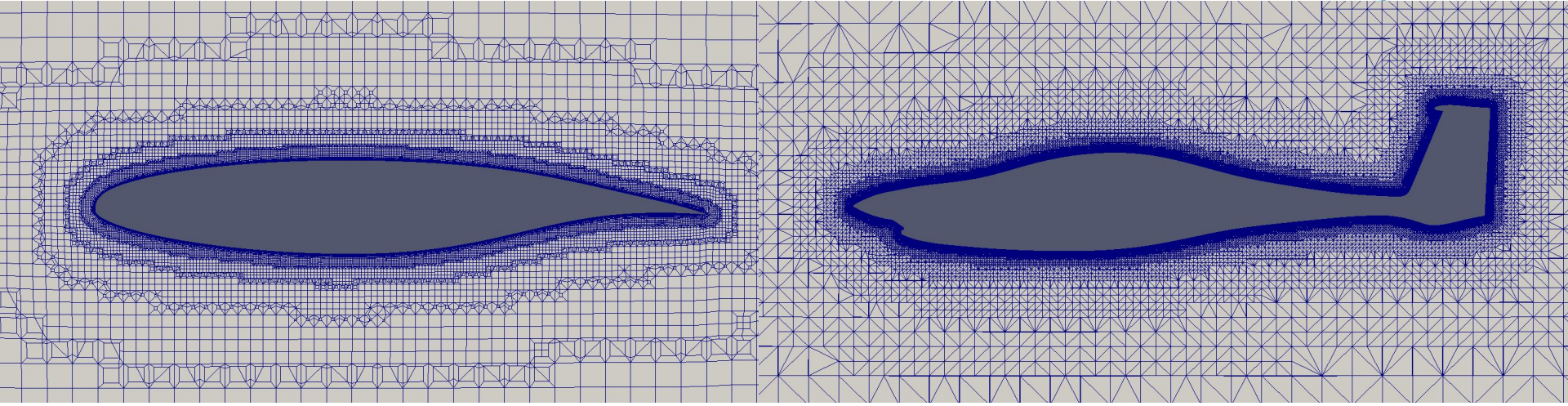
# Mesh

**snappyHexMeshDict:**

```
addLayersControls
{
    relativeSizes false;
    layers
    {    "(body).*"
         {
                 nSurfaceLayers 13;
         }
    }
    expansionRatio 1.5;
    finalLayerThickness 0.0008;

    featureAngle 30;
    slipFeatureAngle 0;
}
```

```
meshQualityControls
{
    maxNonOrtho 65;

    maxBoundarySkewness -20;
    maxInternalSkewness     -4;

    minDeterminant  1e-6;
}
```
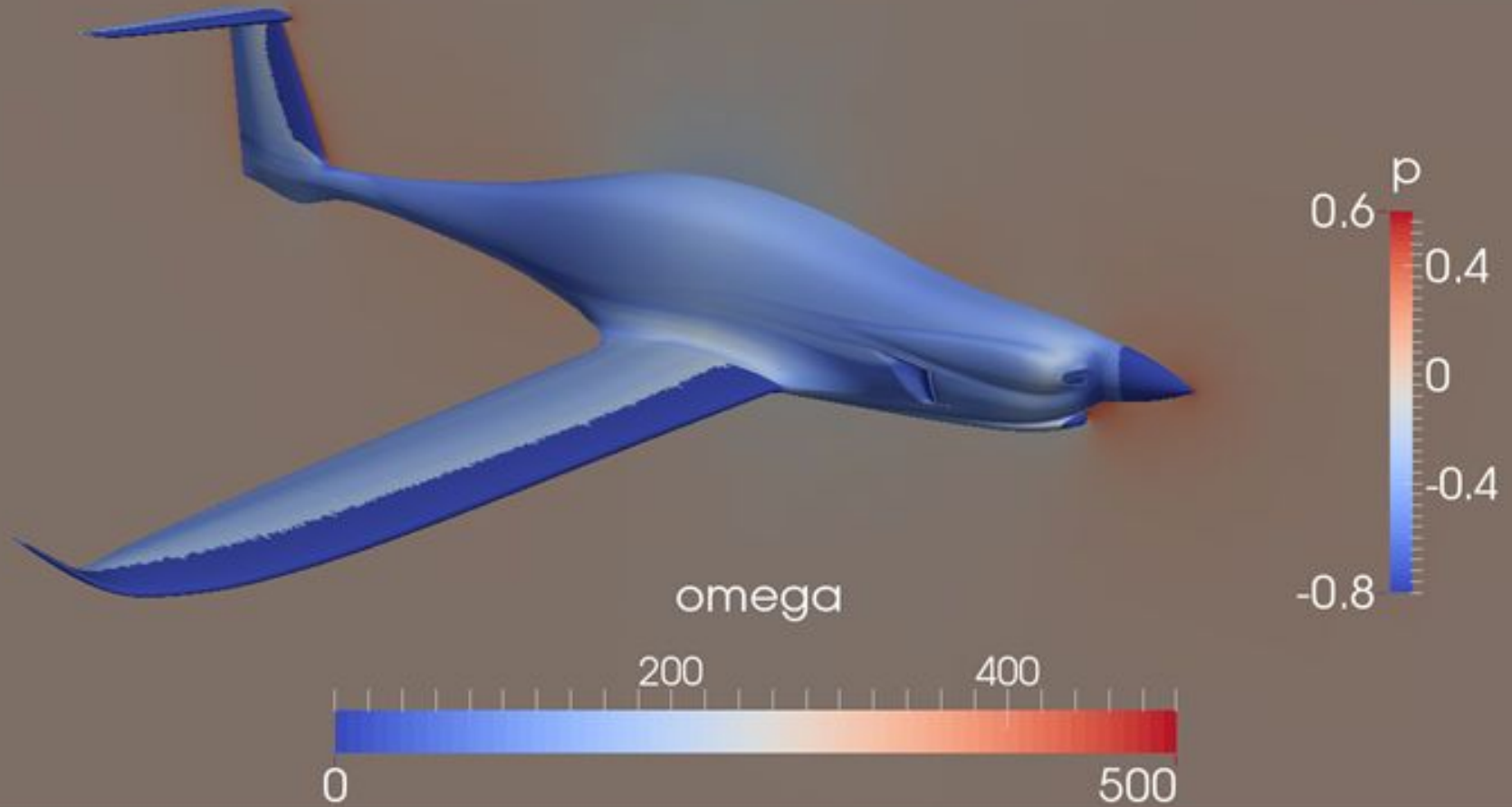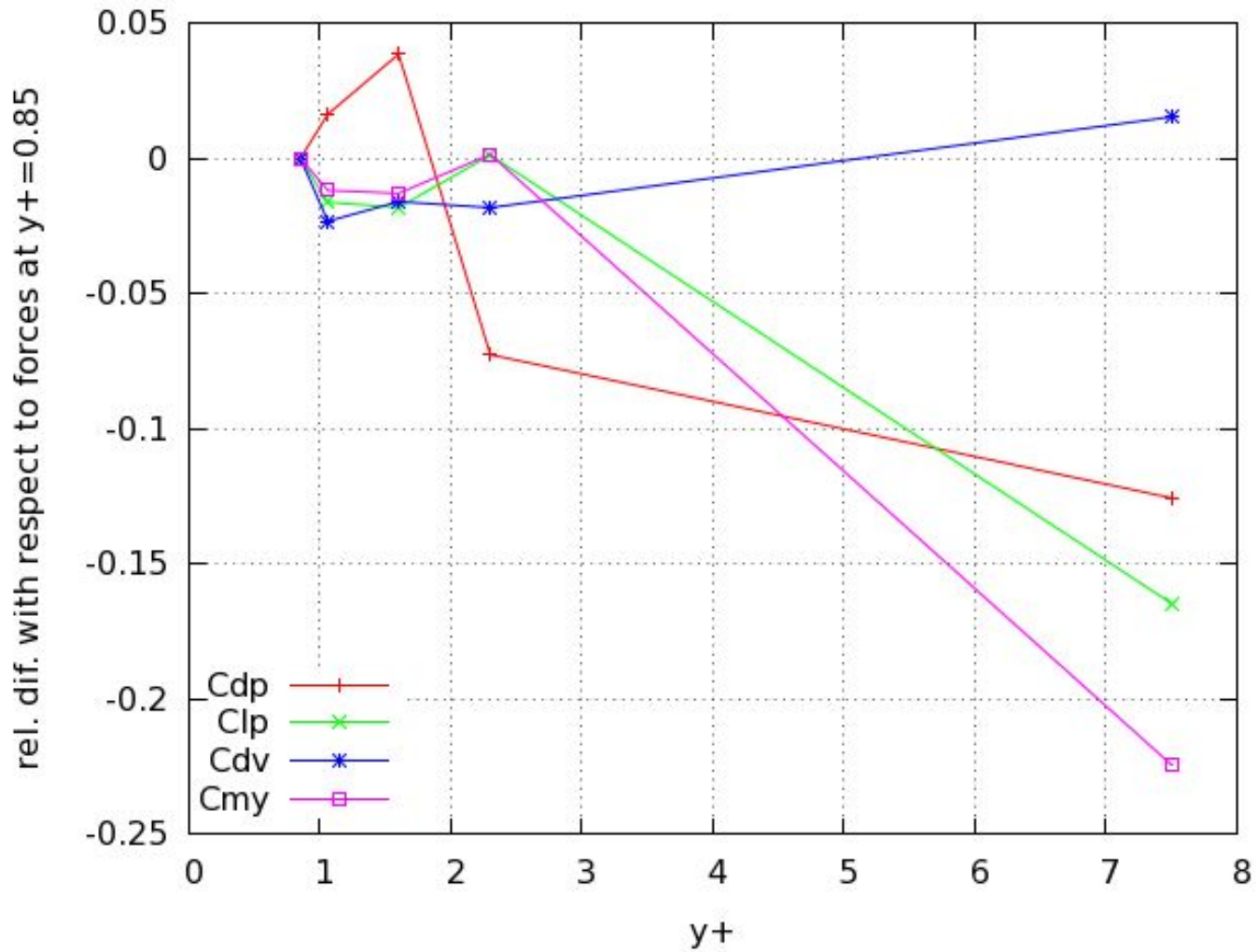
# Results

# Lessons learned

Learn how to:

- make a proper mesh - such a fine mesh at the surface

- use symmery plane

- preview the decomposed case – reconstruction takes a lot of time

- extract only necessary data and preview it with paraView

- automaticaly consecutively run all steps of the simulation process

- how to run, handle and postprocess such big cases

- persuade HPC provider to increase RAM

# Mikelangelo

ONE technology stack
UNIFIED for HPC and Cloud

MISSION: To provide cloud community
with technologies for

- fast, agile and secure Cloud and HPC application deployments in

- diverse hardware environments,

- through packaged applications,

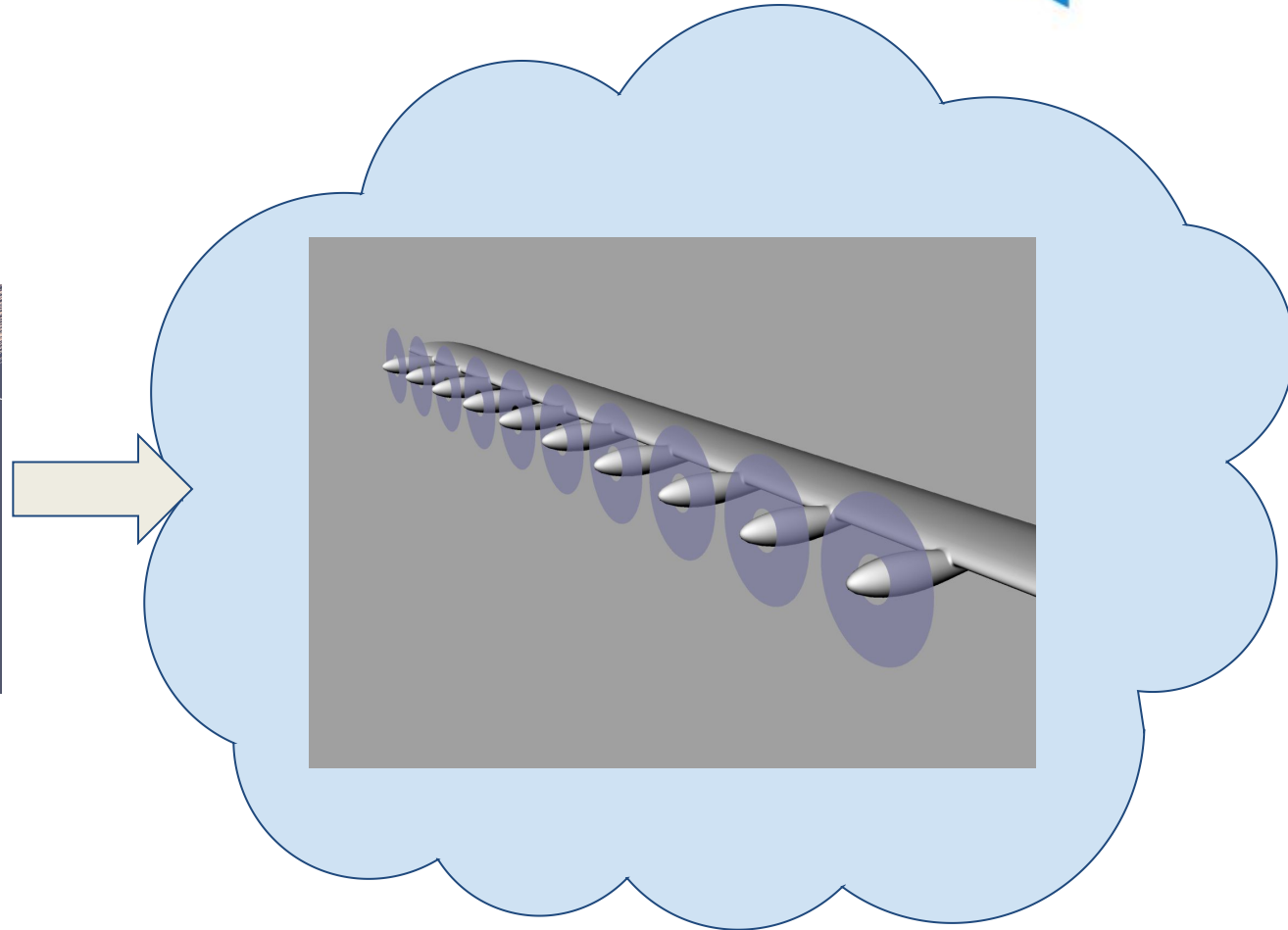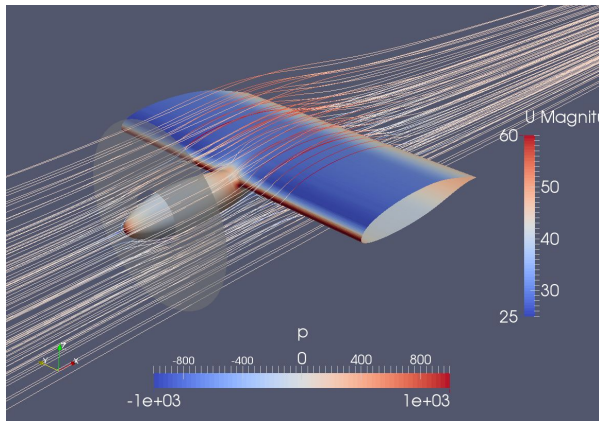- using lean guest operating system OSv

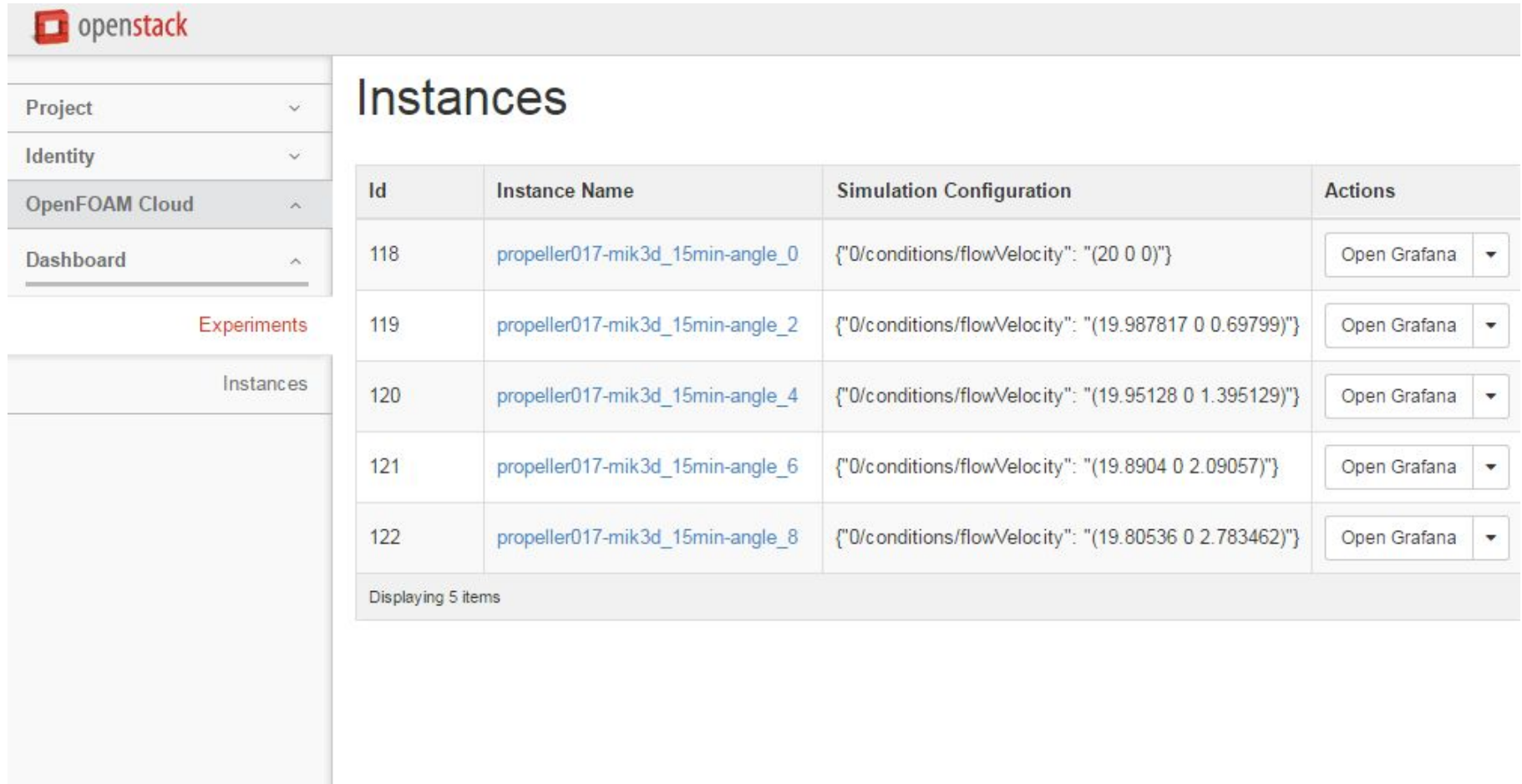- superfast hypervisor – sKVM

www.mikelangelo-project.eu

EP use-case
(parameter exploration)

# Mikelangelo

MIKELANGELO
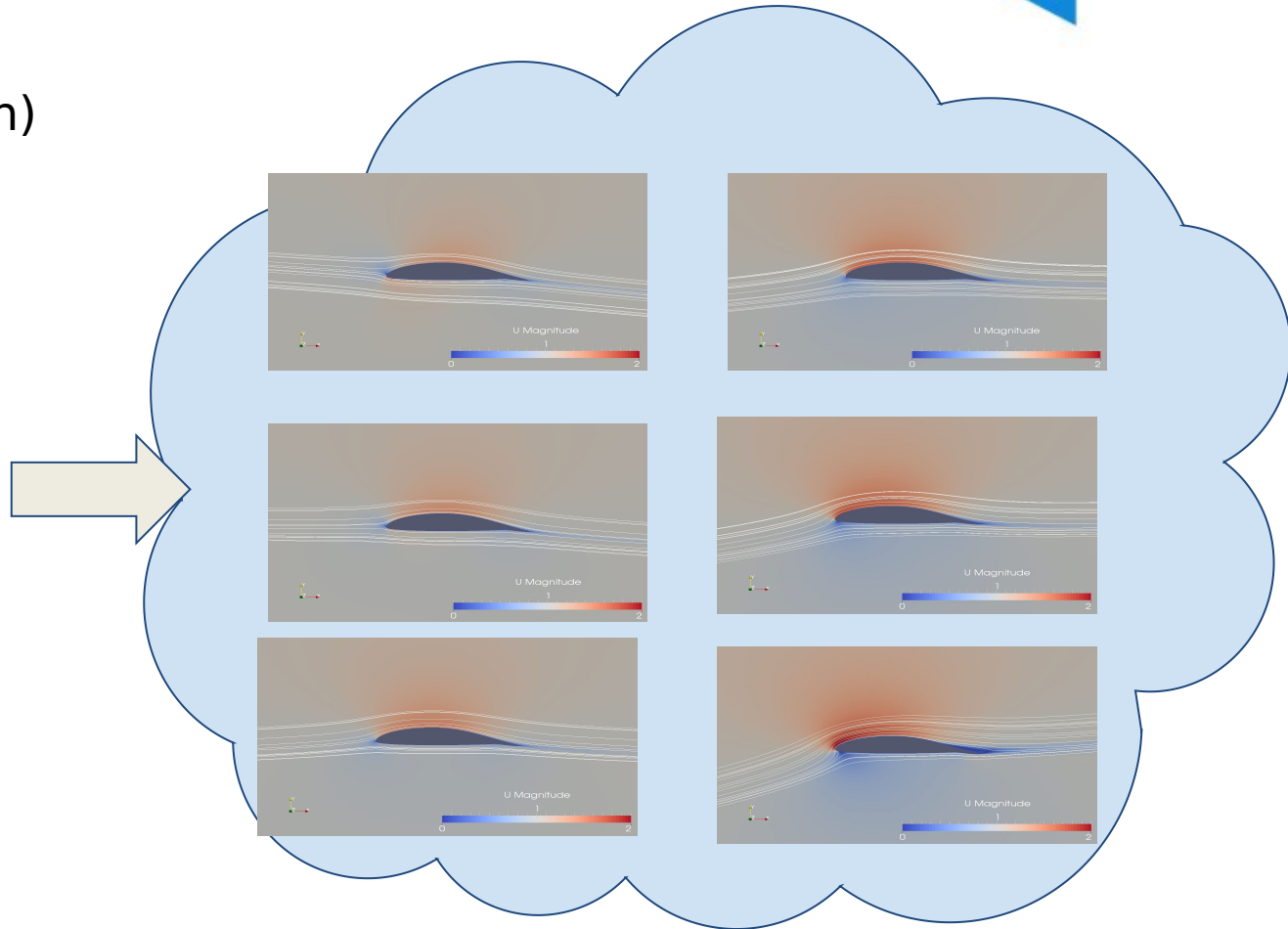
MPI use-case
(typical HPC use case)

# Mikelangelo

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## OpenFOAM Cloud application

openstack

| | |
|---|---|
| Project | ⌄ |
| Identity | ⌄ |
| OpenFOAM Cloud | ⌃ |
| Dashboard | ⌃ |

Experiments

Instances

## Instances

| Id | Instance Name | Simulation Configuration | Actions |
|---|---|---|---|
| 118 | propeller017-mik3d_15min-angle_0 | {"0/conditions/flowVelocity": "(20 0 0)"} | Open Grafana ▾ |
| 119 | propeller017-mik3d_15min-angle_2 | {"0/conditions/flowVelocity": "(19.987817 0 0.69799)"} | Open Grafana ▾ |
| 120 | propeller017-mik3d_15min-angle_4 | {"0/conditions/flowVelocity": "(19.95128 0 1.395129)"} | Open Grafana ▾ |
| 121 | propeller017-mik3d_15min-angle_6 | {"0/conditions/flowVelocity": "(19.8904 0 2.09057)"} | Open Grafana ▾ |
| 122 | propeller017-mik3d_15min-angle_8 | {"0/conditions/flowVelocity": "(19.80536 0 2.783462)"} | Open Grafana ▾ |

Displaying 5 items

# Mikelangelo

MIKELANGELO

## OpenFOAM Cloud application

openstack

Project

Identity

OpenFOAM Cloud

Dashboard

Experiments

Instances

### Instance Details: propeller017-mik3d_15min-angle_8

Open Grafana

Overview    Configurations    **Log**

Log Length 35    Go

#### Instance Console Log

```
Time = 498

smoothSolver:  Solving for Ux, Initial residual = 8.59654183e-09, Final residual = 8.59654183e-09, No Iterations 0
smoothSolver:  Solving for Uy, Initial residual = 3.40398342e-07, Final residual = 2.91711568e-08, No Iterations 4
smoothSolver:  Solving for Uz, Initial residual = 4.01008674e-08, Final residual = 6.02654984e-09, No Iterations 3
GAMG:  Solving for p, Initial residual = 1.02734664e-07, Final residual = 1.17029414e-08, No Iterations 1
time step continuity errors : sum local = 1.13807502e-08, global = 7.52746917e-11, cumulative = 0.000231720351
smoothSolver:  Solving for nuTilda, Initial residual = 1.98934906e-07, Final residual = 1.12326154e-08, No Iterations 3
ExecutionTime = 1011.20418 s  ClockTime = 1011 s

Time = 499

smoothSolver:  Solving for Ux, Initial residual = 6.59538424e-09, Final residual = 6.59538424e-09, No Iterations 0
smoothSolver:  Solving for Uy, Initial residual = 4.06215896e-07, Final residual = 3.54231039e-08, No Iterations 4
smoothSolver:  Solving for Uz, Initial residual = 4.82948477e-08, Final residual = 7.20537599e-09, No Iterations 3
GAMG:  Solving for p, Initial residual = 8.92147218e-08, Final residual = 8.92147218e-08, No Iterations 0
time step continuity errors : sum local = 8.6758571e-08, global = 7.05776354e-11, cumulative = 0.000231720421
smoothSolver:  Solving for nuTilda, Initial residual = 2.15646728e-07, Final residual = 2.14679309e-08, No Iterations 2
ExecutionTime = 1012.5037 s  ClockTime = 1012 s

Time = 500

smoothSolver:  Solving for Ux, Initial residual = 8.47967314e-09, Final residual = 8.47967314e-09, No Iterations 0
smoothSolver:  Solving for Uy, Initial residual = 3.36074288e-07, Final residual = 2.94551483e-08, No Iterations 4
smoothSolver:  Solving for Uz, Initial residual = 3.89361536e-08, Final residual = 5.86469592e-09, No Iterations 3
GAMG:  Solving for p, Initial residual = 9.95062099e-08, Final residual = 9.95062099e-08, No Iterations 0
time step continuity errors : sum local = 9.6766726e-08, global = 8.60675765e-11, cumulative = 0.000231720507
smoothSolver:  Solving for nuTilda, Initial residual = 1.99244634e-07, Final residual = 1.13033085e-08, No Iterations 3
ExecutionTime = 1021.2018 s  ClockTime = 1021 s

forces forceCoeffs1 output:
    sum of forces:
        pressure : (3.25168492 0.000271958824 47.0743495)
        viscous  : (0.812352192 1.52393965e-05 0.0175473364)
        porous   : (0 0 0)
    sum of moments:
        pressure : (-0.0032130266 23.650434 -0.00123414582)
        viscous  : (-6.74220369e-06 0.0259565388 -7.47318381e-06)
        porous   : (0 0 0)

End
```
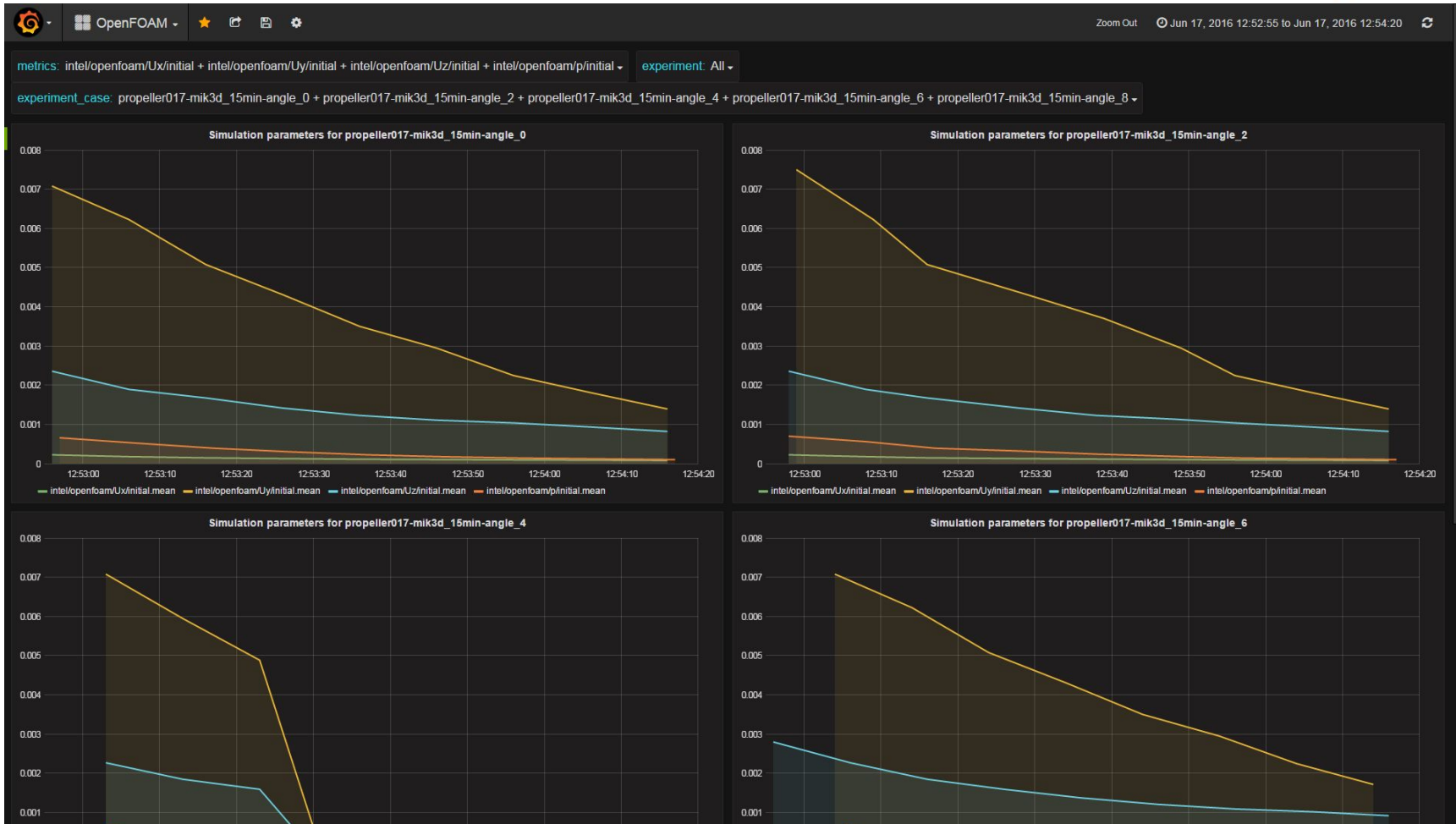
# Mikelangelo

## OpenFOAM Cloud application

# Thank you for your attention!

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