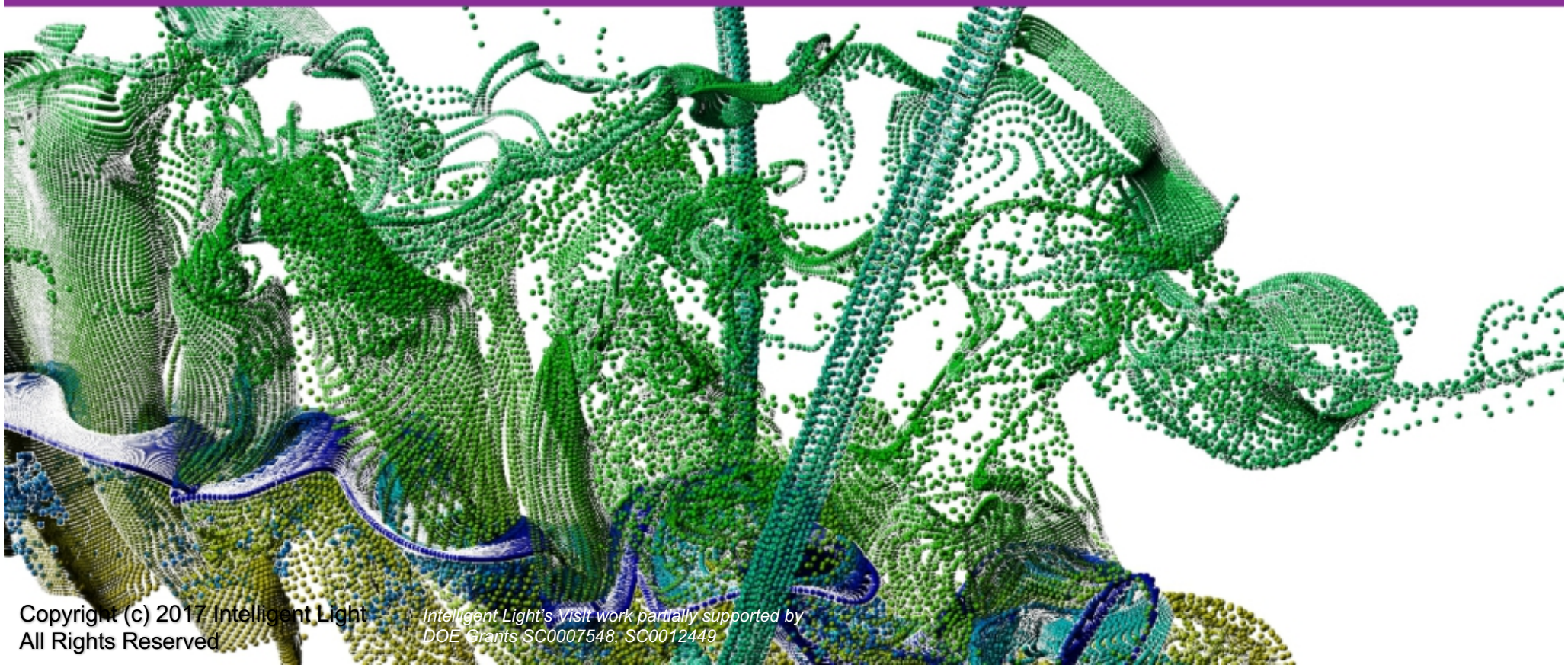
Applied Research Group

Seeking Answers, Deploying Solutions

Intelligent Light



Intelligent Light's VISIT work partially supported by DOE Grants SC0007548, SC0012449

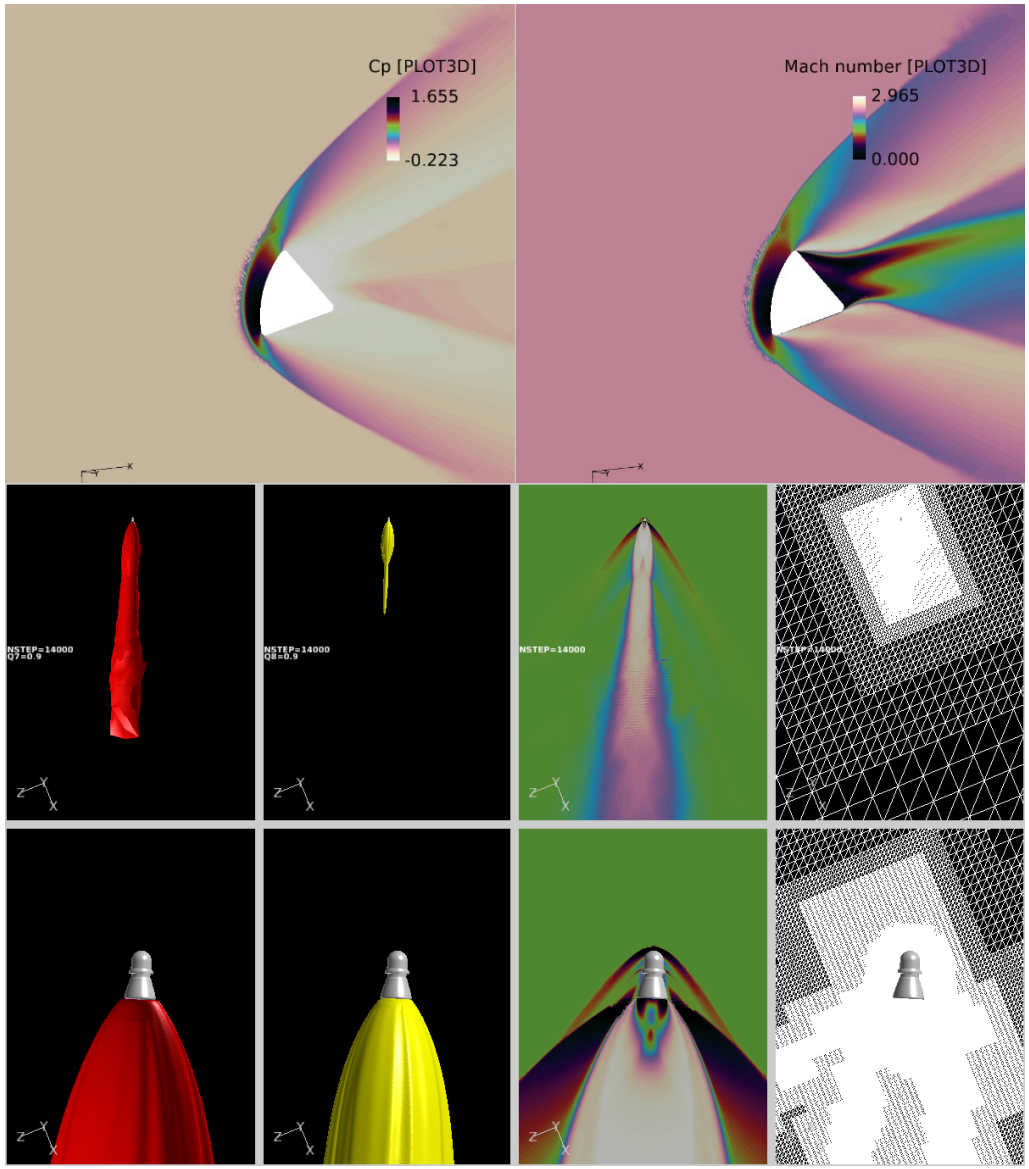
IN SITU SUCCESS STORIES

Brad Whitlock
Intelligent Light

Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

NASA Codes

- Fun3D
  - NASA's Bill Jones instrumented Fun3D with VisIt+Libsim
- OVERFLOW2
  - Widely-used CFD code in the aerospace industry
  - JMSI contracted to have OVERFLOW2 instrumented with Libsim, giving improvements back to the NASA OVERFLOW2 team



Images produced by FieldView from XDB files created in situ by OVERFLOW2

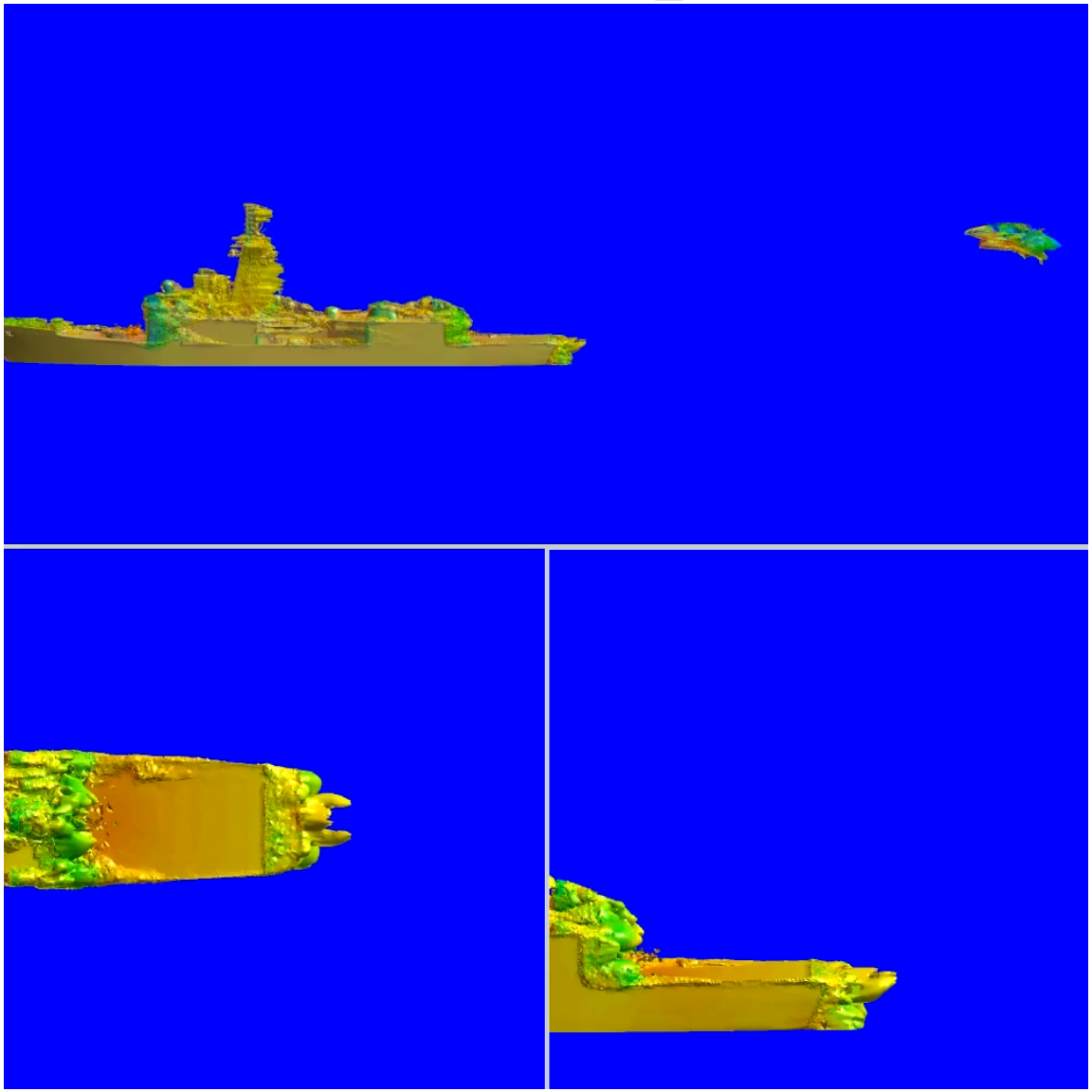
Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

CREATE-AV Kestrel

- Fixed-wing air vehicle simulation suite
- Kestrel user interface enables users to set up problems, modify, submit jobs, and visualize job output
  - Flexible and enables new components to be included using XML and Python
- Includes Navier-Stokes flow simulator with 2 CFD solvers
  - KCFD, 2nd order cell-centered finite volume solver for arbitrary cell topologies
  - SAMCart, a 3rd to 5th order node-centered Cartesian solver with AMR

Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

In Situ Helicopter Landing *(Kestrel movie)*

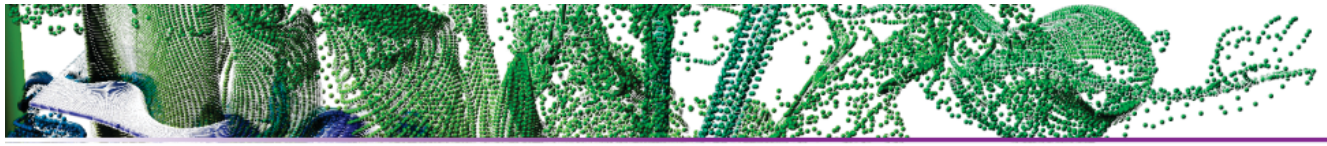


In Situ Extract Benefits

- Costly data extraction done during simulation
- Reduces sizes of files saved for post hoc analysis
- Users can explore extract data in post-processing much more quickly
- Movie-generation and rendering can be decoupled from simulation (use different / smaller resources)

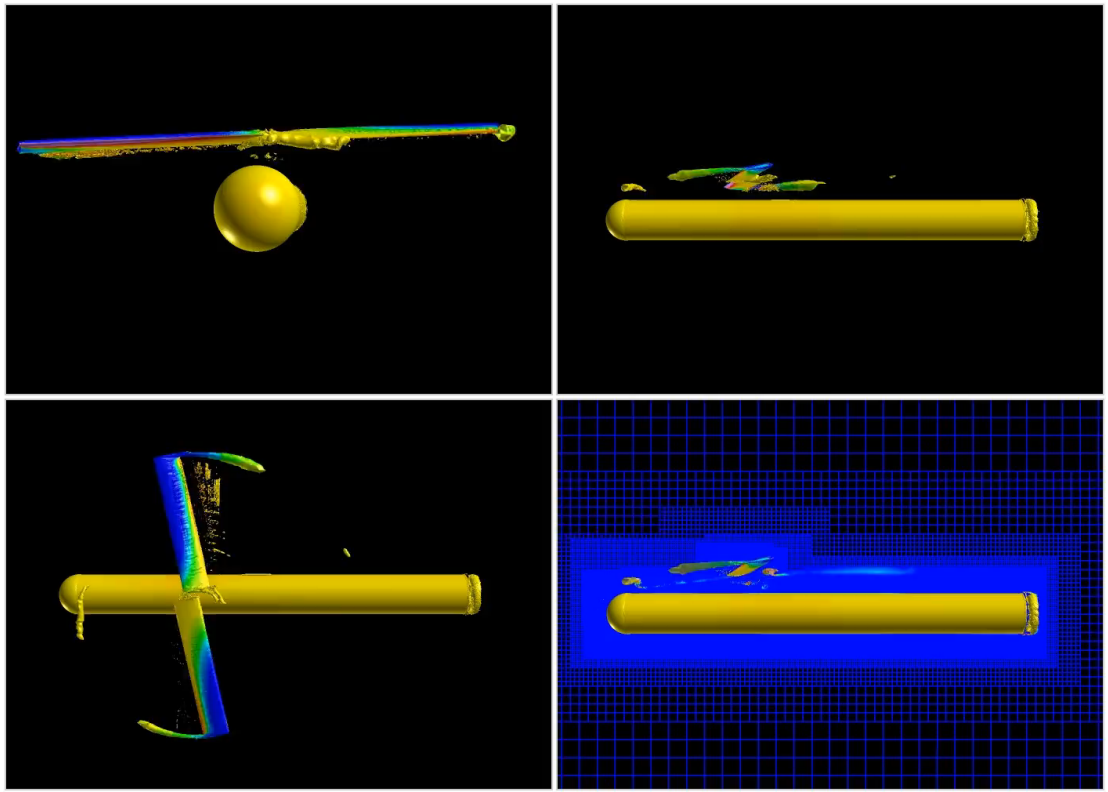
Movie Courtesy of James Forsythe

Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449



CREATE-AV Kestrel

- Fixed-wing air vehicle simulation suite
- Unstructured and AMR geometries
- Extract overhead 2-3% of solver runtime to output isosurface and slice extracts to classic XDB format on 1024 cores
  - Writing volume data at same frequency would take 30% of runtime
- Extracts 21x smaller (427Mb vs 9.1Gb)

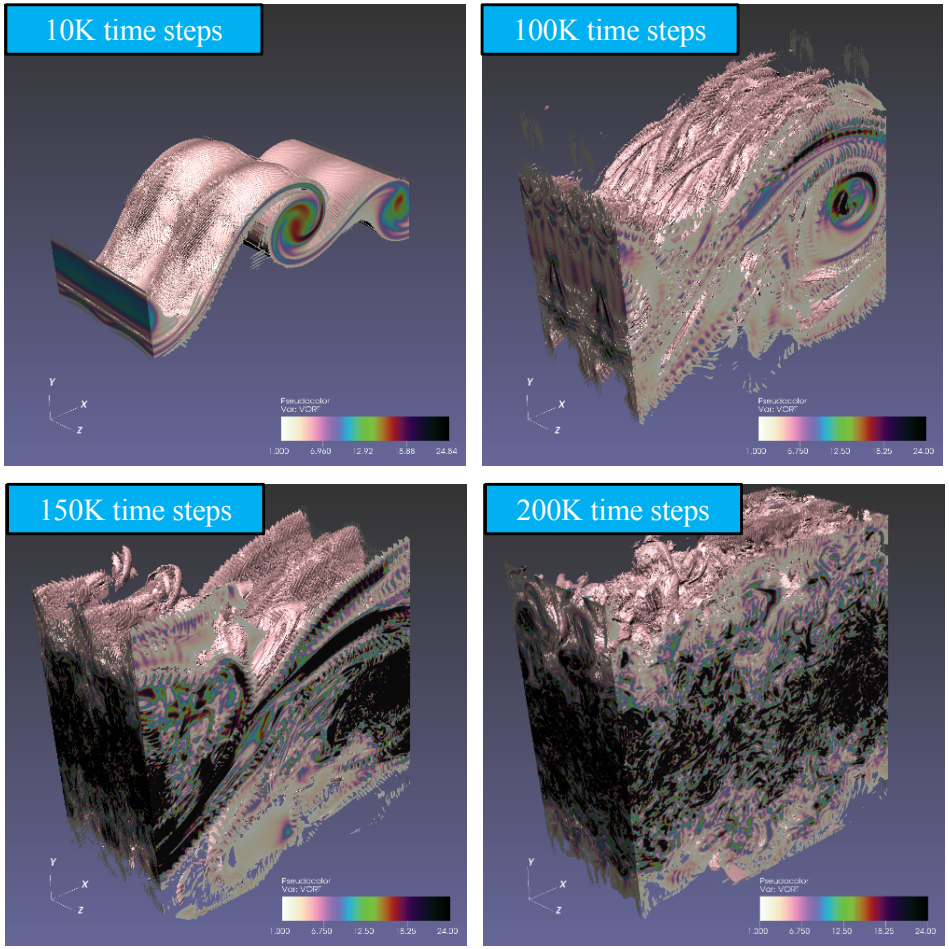


B. Whitlock, J.R. Forsythe, S. M. Legensky *"In Situ Infrastructure Enhancements for Data Extract Generation"*, AIAA SciTech, January 2016, San Diego, CA

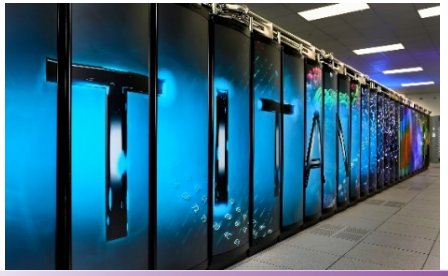
Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

131K Core In Situ!

- AVF-LESLIE + Libsim
  - Reacting flow code for DNS/LES investigation of canonical reactive flows
  - Runs on Titan at ORNL
    - Turbulent mixing layer problem
    - 1025^3 grid points
  - Preparing runs on NERSC's Cori KNL nodes to run flame ignition/extinguish case



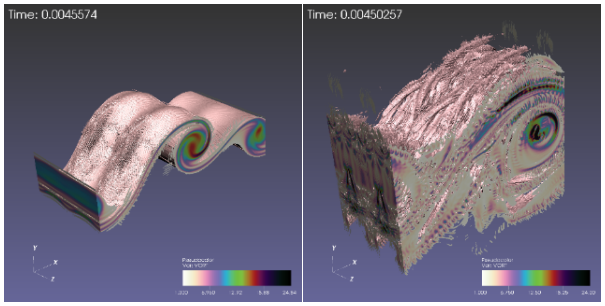
Isosurfaces and slices of vorticity magnitude showing progression of vortex braiding and breakdown

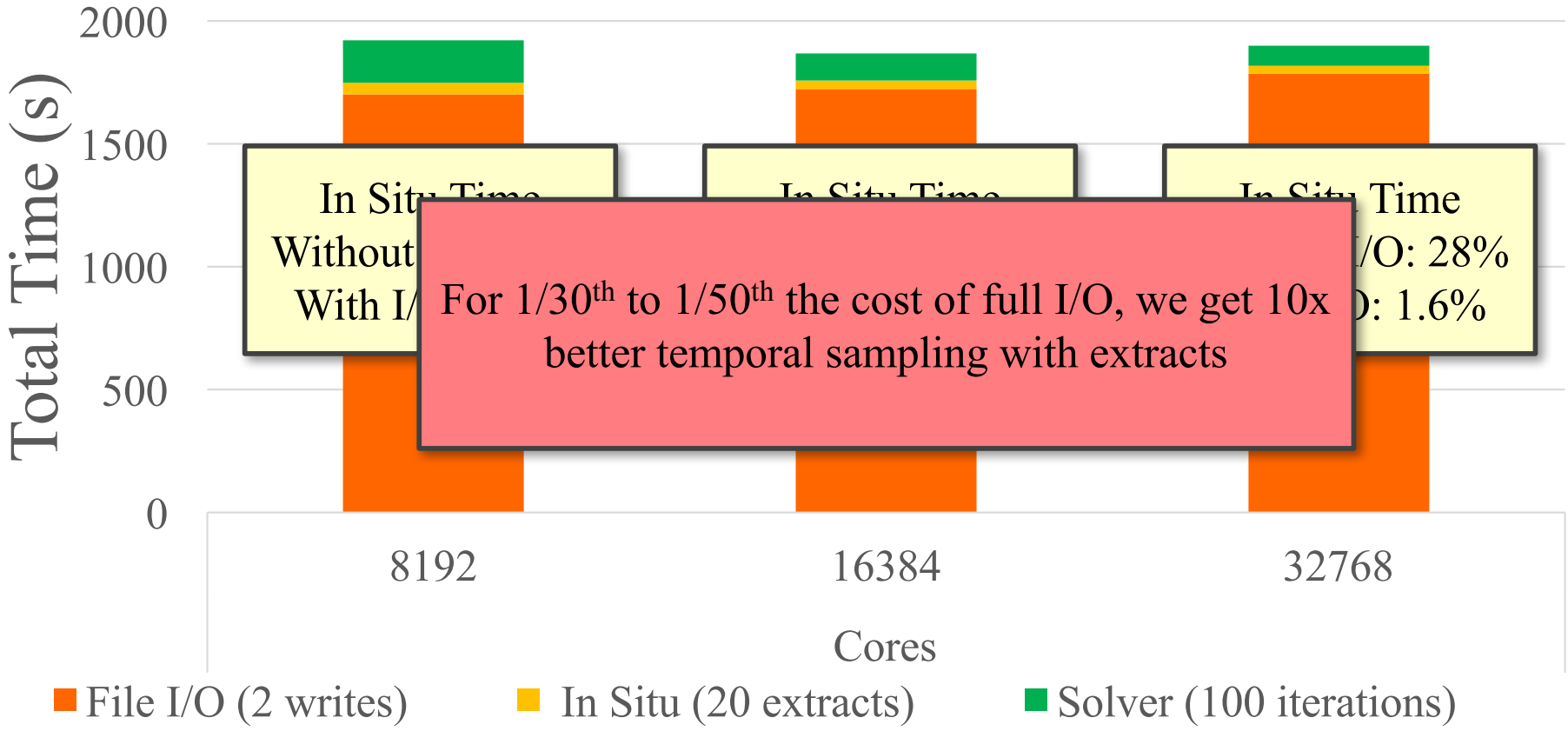


Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

AVF-LESLIE In Situ Extract Generation

- Combustion code / Turbulent mixing use case
- Save vorticity isosurface every 5th iteration to FieldView XDB format
- Write groups to partially aggregate extract I/O



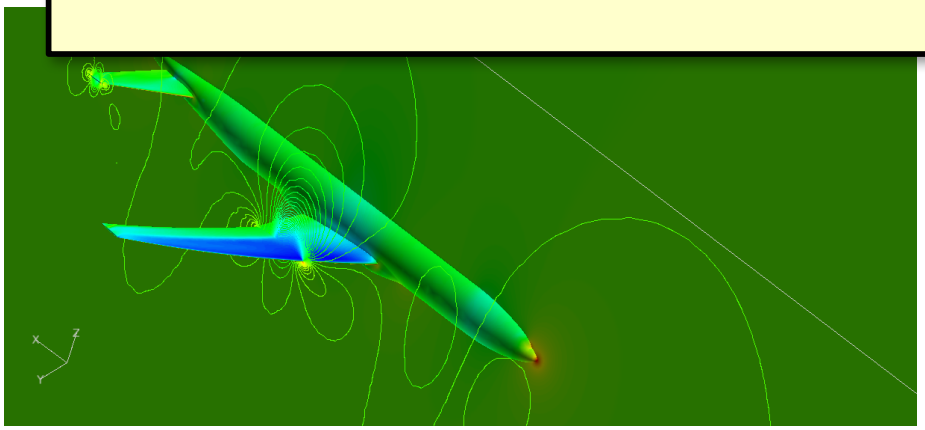


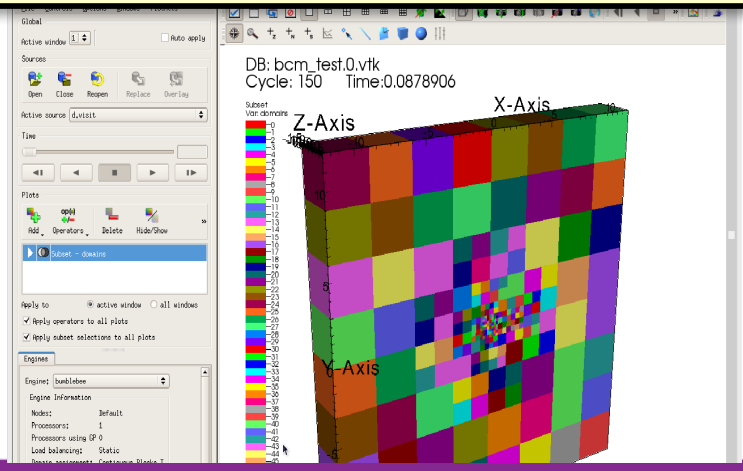
Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

Japanese Solvers

- Intelligent Light instrumented 2 solvers for a large manufacturing company and demonstrated feasibility

The lead engineer remarked:
"*The research target to reduce visualization work load was achieved and it ended successfully."*



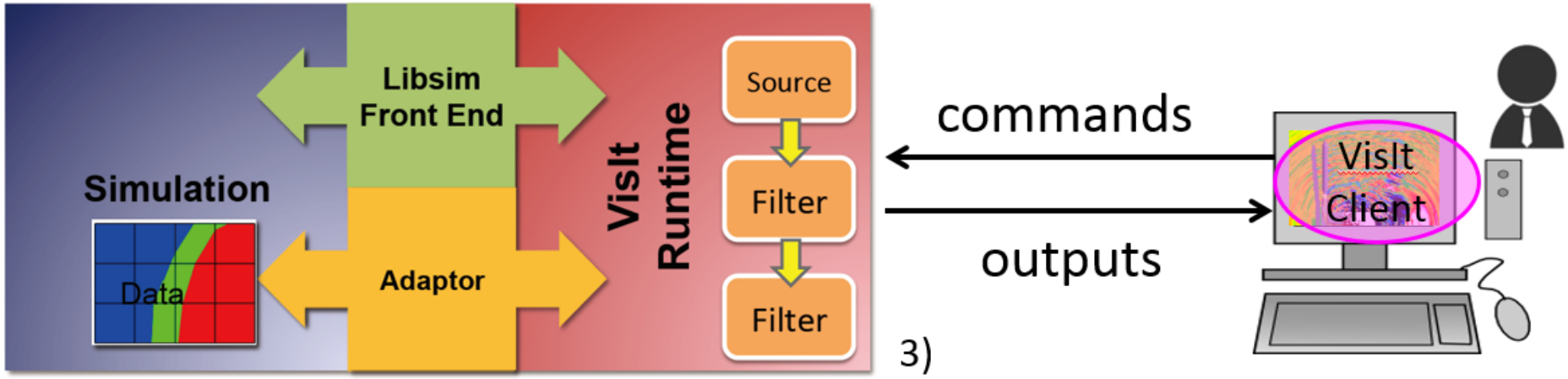


Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

Implementation into CFD Program

- The libSim is incorporated into the JAXA's in-house CFD program, UPACS-LES[1,2], developed mainly in Fortran90.
- The UPACS-LES is a cell-centered finite-volume solver using multi-block structured grid. High-fidelity compressible Large-Eddy Simulation for thermally perfect gas with multi-species is available.

- CFD program links with the VisIt runtime through the libSim.
- Array of data in the memory shares with the VisIt runtime.



1. Tsutsumi, S., and Terashima, K., Trans. JSASS Aerospace Tech. Japan, Vol.15, pp.7-12, 2017.
2. Imamura, T., and et al., AIAA Journal, Vol.46, No.5, May, 2008, pp.1045-1053.
3. Whitlock, B., Applied Modeling & Simulation Seminar Series, NASA ARC, 2015.

WwAaKE3D (wake3d)

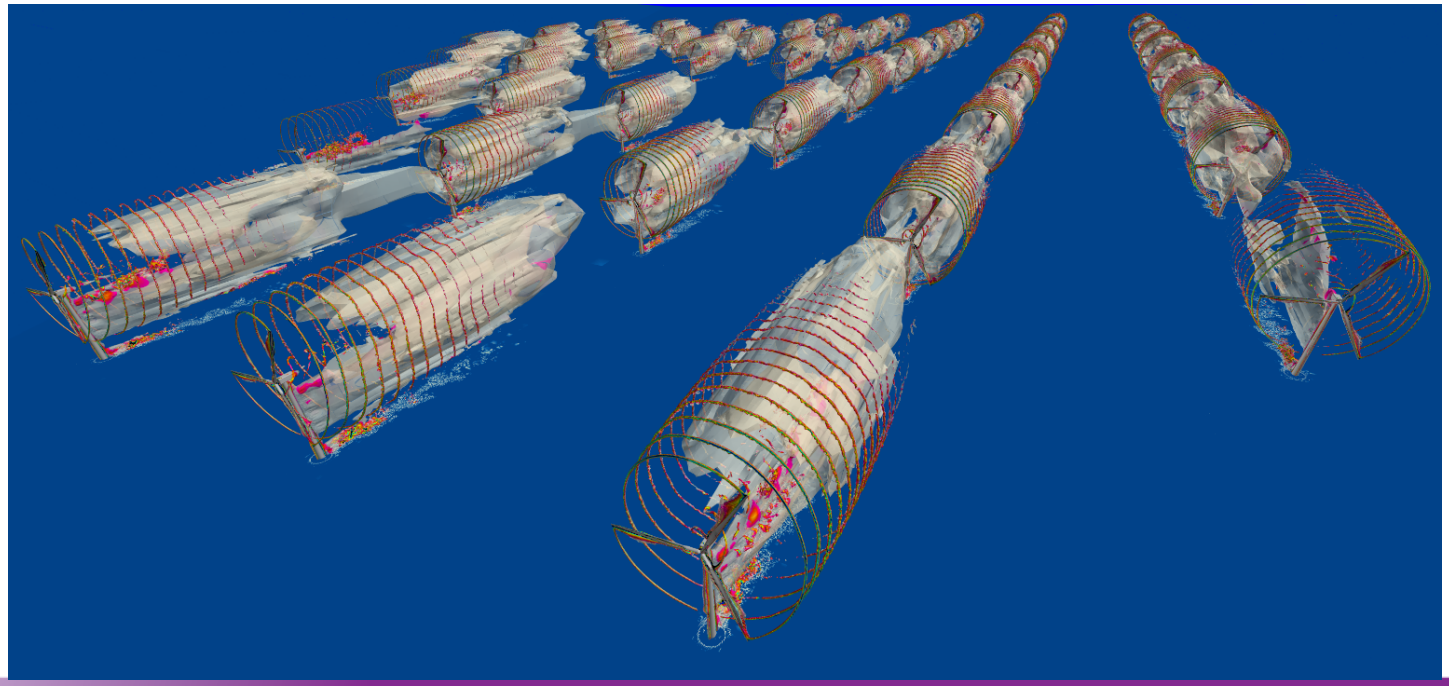
- Prof. Mavriplis and Dr. Michael Brazell at Univ. Wyoming
- Intelligent Light provided guidance to their team while they instrumented using VisIt+Libsim
- Higher order unstructured solver
  - Galerkin mixed p-enrichment of second/third order accurate with 12 levels of h-refinement
- Liligrund Wind Plant with uniform inflow
  - Domain size: 10kmx10km, 1.1 billion degrees of freedom (DOFS) off-body and 340 million DOFS for the near body (7.1 million per turbine)
- Computed on Cheyenne, a 5.34 petaflop SGI ICE XA Cluster with 145,152 Intel Xeon processor cores

Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

WwAaKE3D (wake3d)

- Used to extract slices and isosurfaces and save to XDB files, Silo files, and VTK files
- According to Dr. Brazell:

"In Situ has helped reduce the amount of 3d data that we need to store; just the restart files take 10 TB on a 12 hour run. So, we can't store volume vtk files. Automation has gone way up, we have scripts to go straight from simulation to animation. Also, in situ has helped with debugging, I can detect a problem area, move the slices and get quick viz and diagnose issues. This way I don't need to pull down 3d data and I can just use slices on my local machine."



Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

Uintah

- Uintah is a set of libraries and applications for simulating and analyzing complex chemical and physical reactions
- Uintah + VisIt/Libsim integration done by Dr. Allen Sanderson from SCI Institute
  - We provided some guidance on extensions Dr. Sanderson made to VisIt's custom simulation user interfaces
  - He built a simulation dash board user interface for Uintah

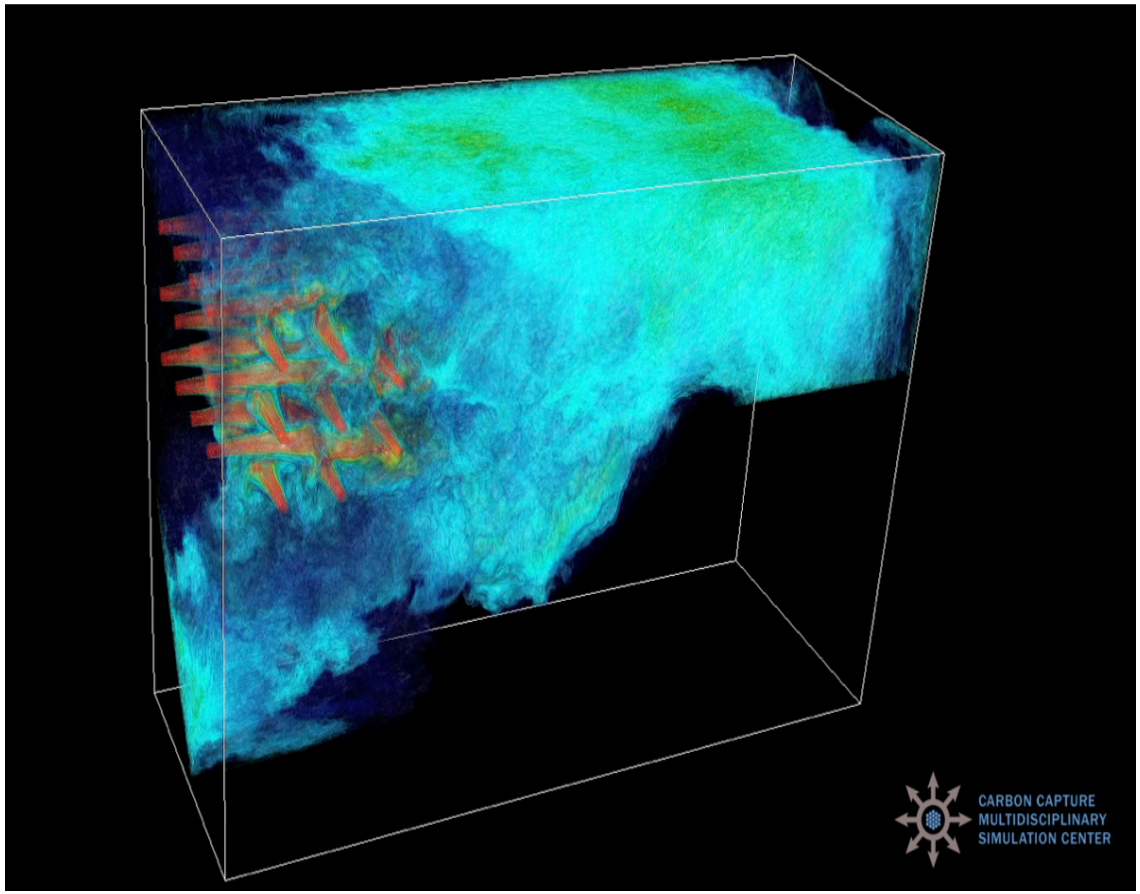
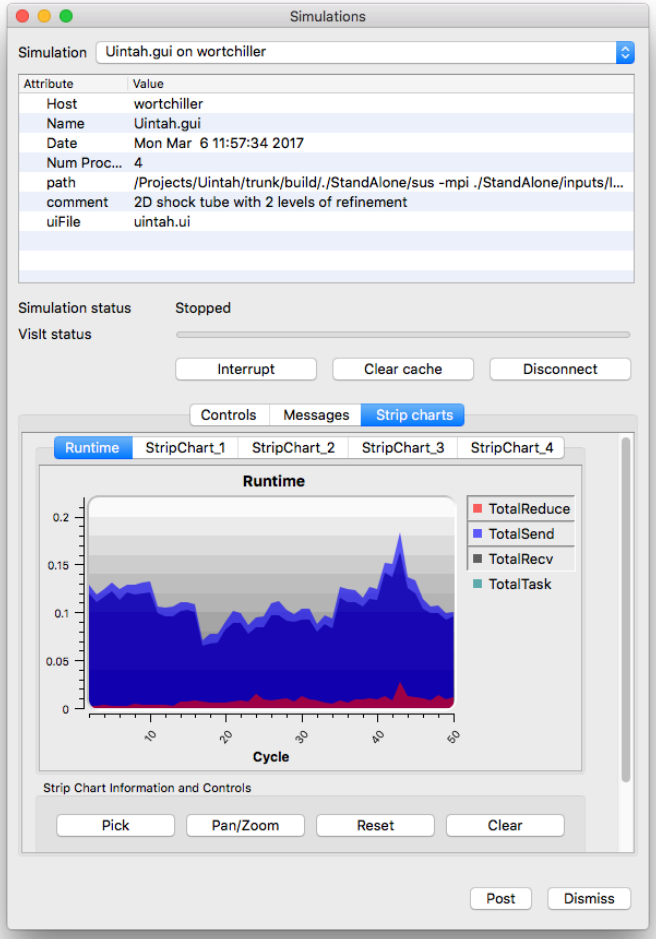


Image Source:
http://www.sandia.gov/psaap/ReferenceMaterials/PI%20Presentations/Utah%20PI%20Presentation.pdf

Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

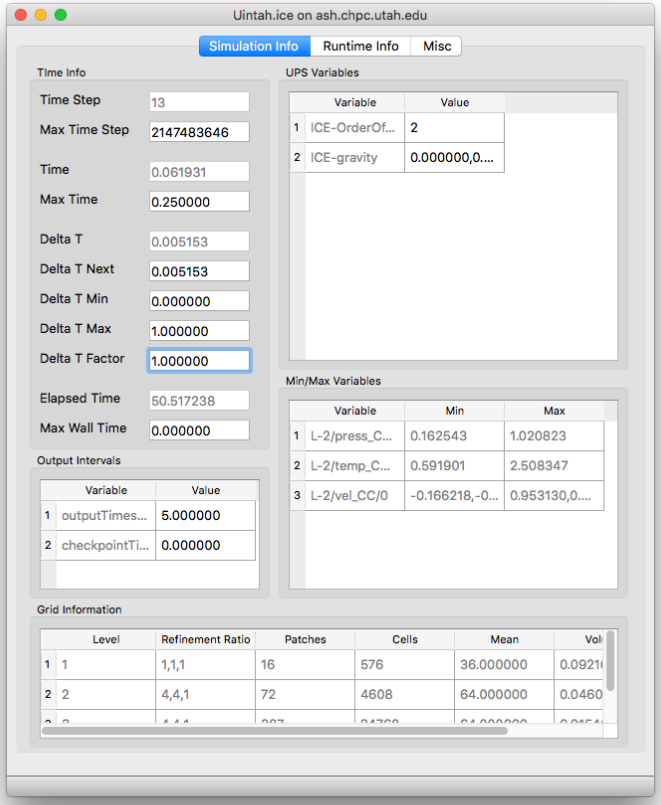
Uintah Simulation Dashboard

- Plot runtime quantities in VisIt's Simulation Window



Images courtesy of Allen Sanderson

- Design custom window or simulation dashboard to contain values and statistics gathered by simulation
- Use to steer calculation



Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449

Libsim Update

- We have developed a new parallel XDB library for writing / reading XDB's
  - Write from Libsim in parallel via ADIOS
  - Read in parallel with FieldView
- We are looking at
  - ways to simplify in situ instrumentation and extract creation
  - Better zero-copy for array slices

Intelligent Light's VisIt work partially supported by DOE Grants SC0007548, SC0012449