



Introduction to SU²

OpenMDAO-SU2 Joint Workshop

Stanford University
Monday, Sept. 30 2013



The Open-Source CFD Code



Prerequisites

- C++ compiler
 - GNU gcc
 - Intel icpc
- GNU Autoconf/Automake tools
 - <http://www.gnu.org/software/autoconf/>
 - <http://www.gnu.org/software/automake/>
- Git
 - <http://github.com>
- Numpy/Scipy



What is SU²?

The Stanford University Unstructured (SU²) is a software package for:

- **Fluid Simulation**
- and **Engineering Design**

SU² is distributed as **Open-source** software

SU² is under active development at Stanford University in the Aerospace Design Lab (ADL) of the Department of Aeronautics and Astronautics.

<http://su2.stanford.edu/>



The Open-Source CFD Code

SU² v3.0 (Eagle) will be released on Jan 11th, 2014



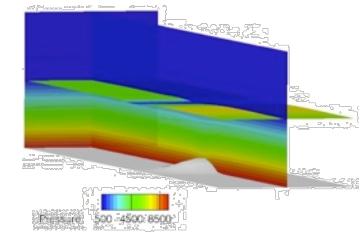
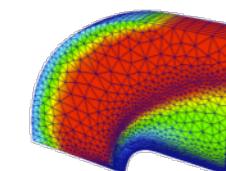
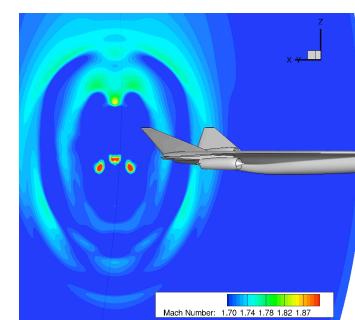
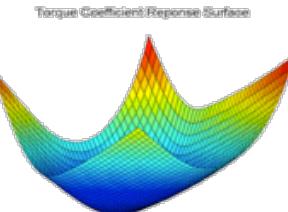
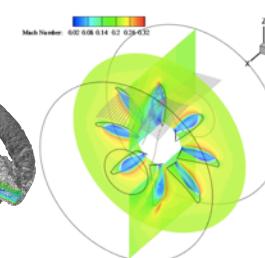
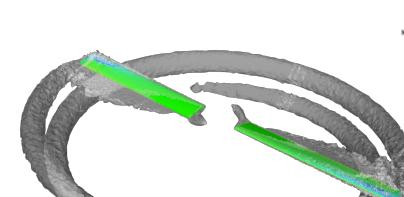
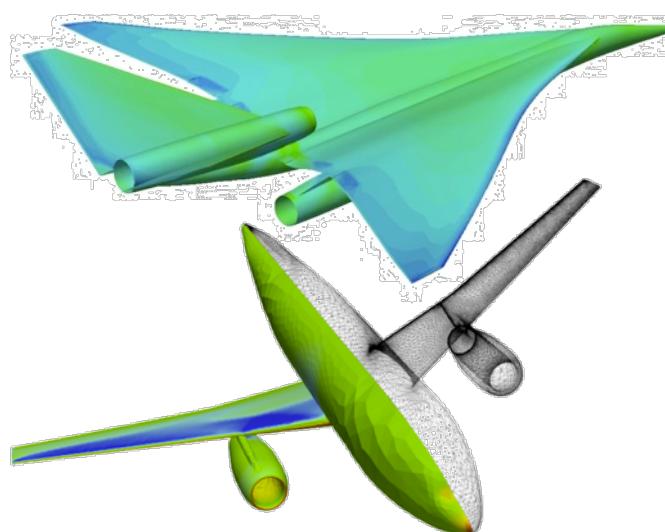
Motivation

Advanced design environment

- Enable analysis and design of complex engineering systems
- Multi-physics simulation

Leading-edge solver technology

- Tool for CFD research
- Global accessibility





Why SU²?

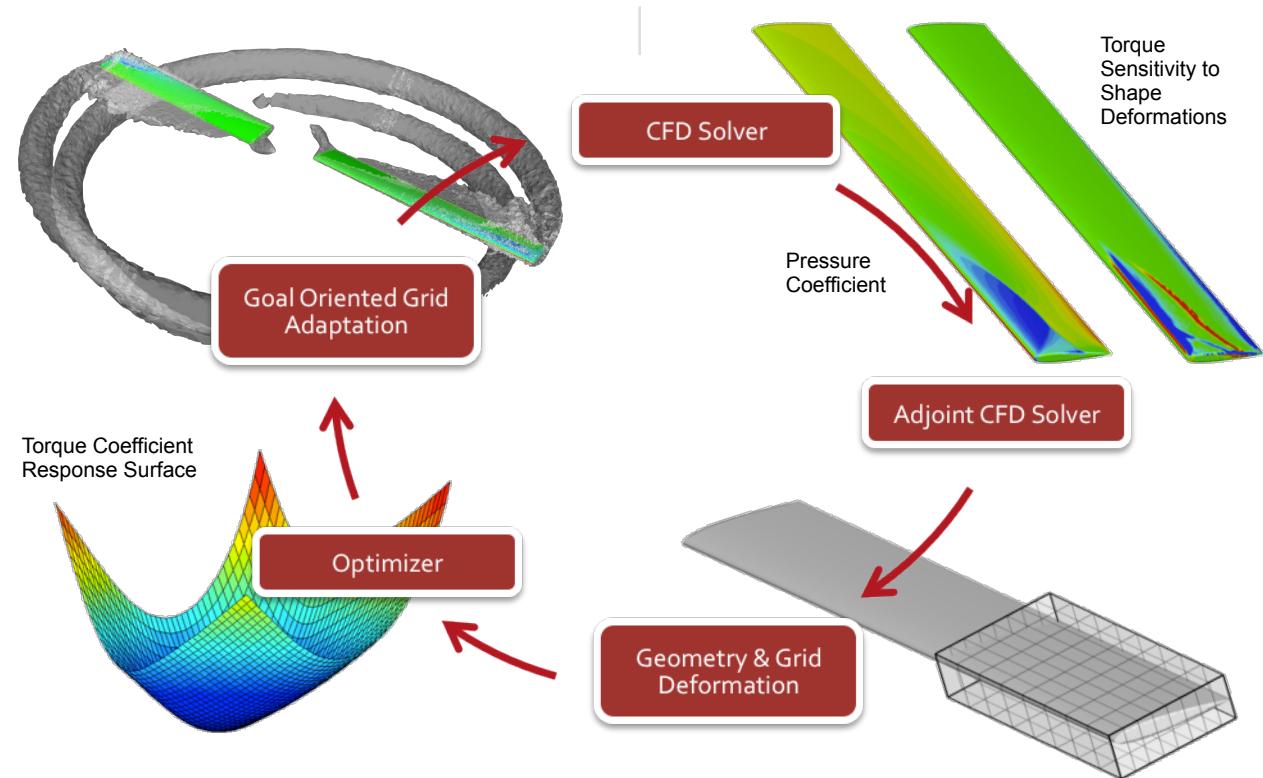
1. **An open-source model:** basic formulation with a reasonable set of initial capabilities, we would like to see contributions from the community!
2. **Portability:** SU² has been developed using ANSI C++ and only relies on widely-available, well-supported, open-source software.
3. **Reusability and encapsulation:** SU² is built so that the main concepts (geometry, sol. algorithms, num. algorithms, etc) are abstracted to a very high-level. This abstraction promotes reusability of the code and enables modifications without incorrectly affecting other portions of the suite.
4. **Flexibility** required to re-purpose existing software for new and different uses. Enabling a common interface for all the necessary components.
5. **Performance:** we have attempted to develop numerical solution algorithms that result in high-performance convergence of the solver in SU².
6. **Gradient availability:** for many applications it is important to obtain grad. of the responses computed by SU² to variations of design parameters.



Why SU²?

Shape Optimization

- Self-contained optimization env.
- Gradient availability (adjoint method)
- Built-in:
 - Design var. definitions
 - Surface deformation
 - Mesh deformation



Multi-Physics Simulations

- Simultaneous analysis of different equation sets w/ tight coupling
- Aero-structural, aero-acoustic, free-surface, reacting gas mixtures, etc.

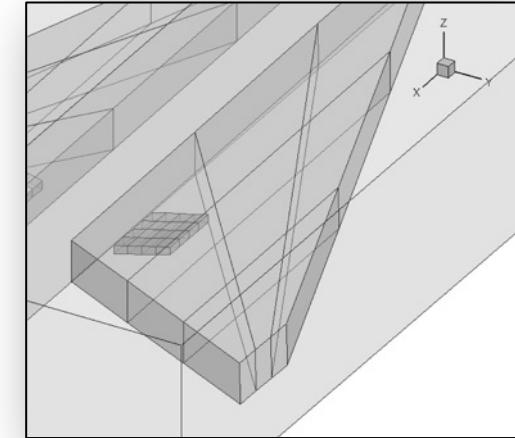
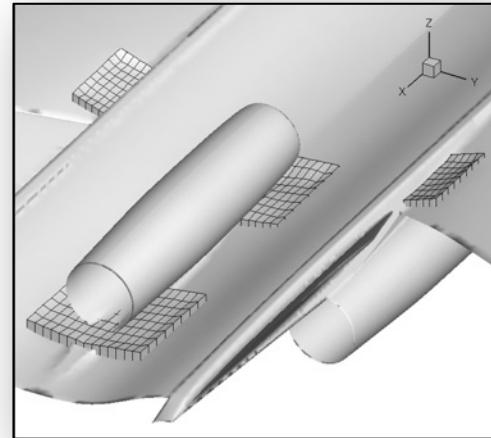
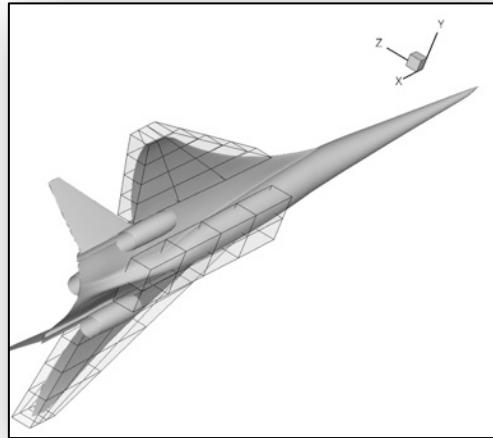


SU² Modules

- SU2_CFD: Computational Fluid Dynamics
- SU2_DDC: Domain Decomposition Code
- SU2_MAC: Mesh Adaptation Code
- SU2_MDC: Mesh Deformation Code
- SU2_PY: Python drivers
- SU2_SOL: Solution file processing
- + More



Capabilities: Geometry Deformation

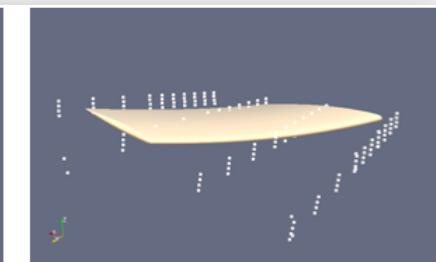
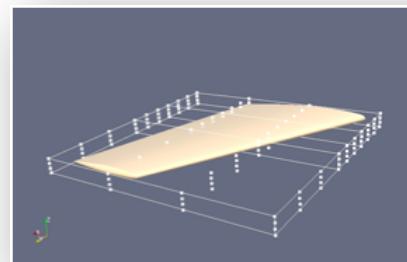


Engineering-like design variables

Fine control of the design surfaces

Nested FFD strategy (local and global control)

The main idea is to **embed the physical object into a 3D grid, and then modify it as a whole**. The object inherits the deformation of the auxiliary grid.

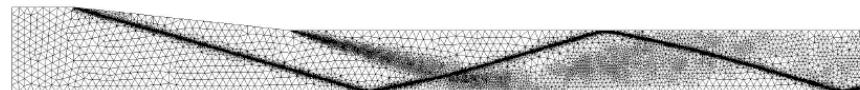




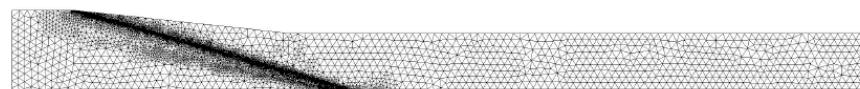
Capabilities: Mesh Adaptation

The Mesh Adaptation Code in the SU² suite facilitates **strategic mesh adaptation based on several common schemes**, including gradient and goal-oriented methods.

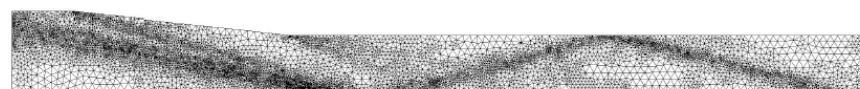
1. Goal-oriented mesh adaptation.
2. Engine propulsion effect adaptation.



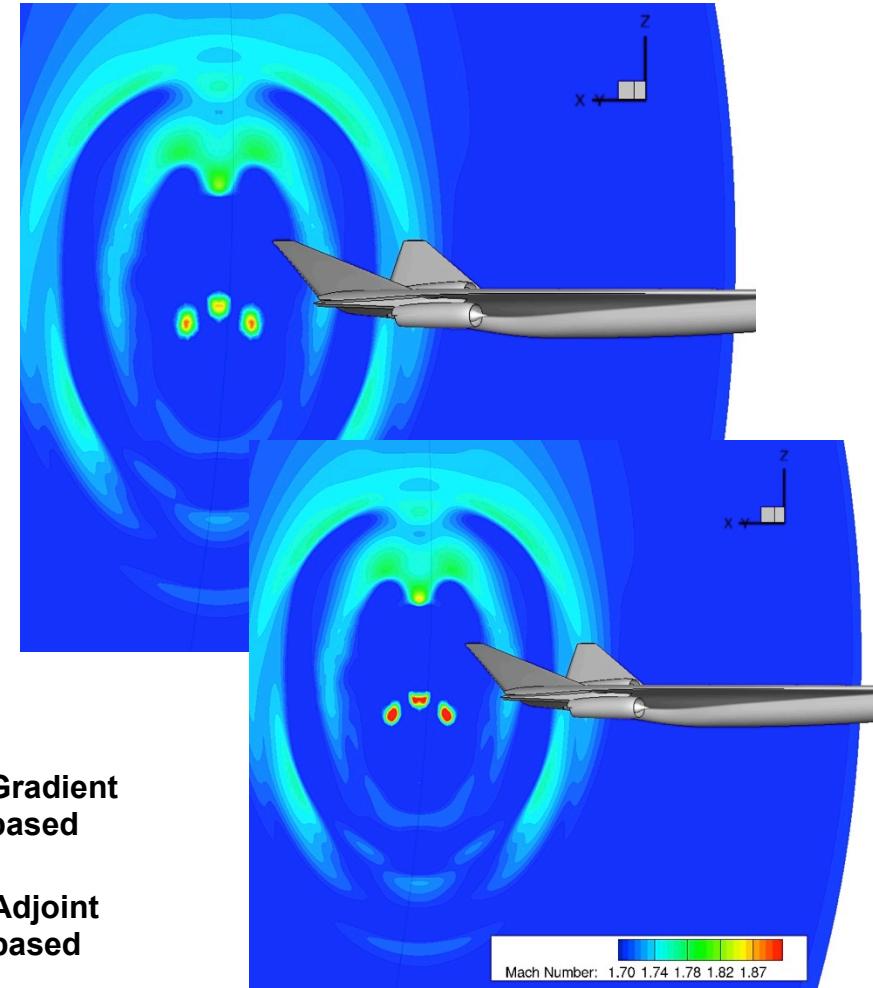
Gradient based



Adjoint based



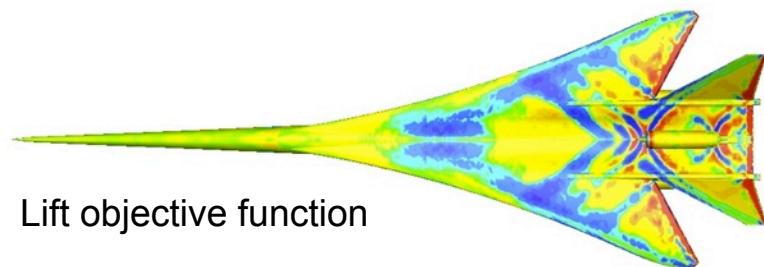
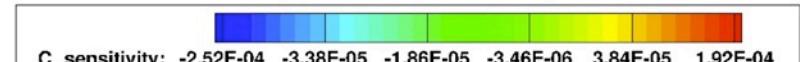
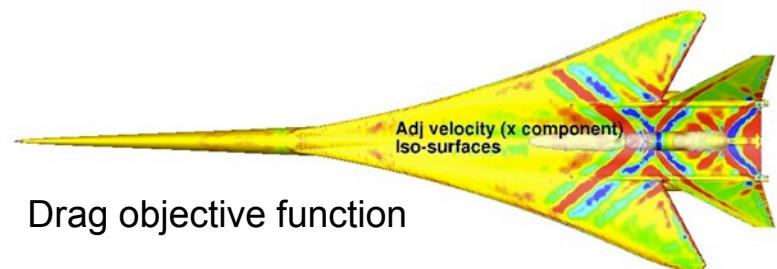
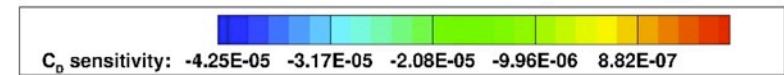
Robust adaptation





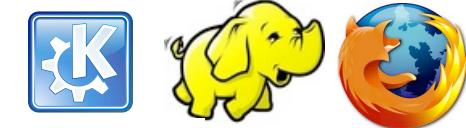
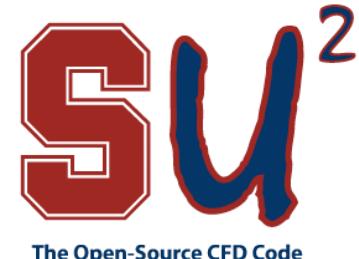
Capabilities: Optimal Shape Design

- Magnitude of surface sensitivity is related to changes in cost function caused by changes in geometry.
- Designers can use this sensitivity information to determine appropriate parameterizations of the configuration prior to optimization.



SU² as an open-source project

- Computational analysis tools have revolutionized the way we design aerospace systems, but most established codes are proprietary, unavailable, or prohibitively expensive for many users.
- The SU² team is changing this, making computational analysis and design freely available as open-source software and involving everyone in its creation and development.
- Why?
 - Worldwide accessibility.
 - Encourage contributions from everyone.
 - Enables CFD research everywhere... the complexity of today's problems requires tools to start from in order to make a technological impact.



Open-source Community

SU2 -- CFD Online Discussion Forums

Run CFD with HPC in the cloud ANSYS, STAR-CCM+, OpenFoam [Free Trial](#)

[rescale](#)

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SU2

Sub-Forums : SU2

Forum

SU2 News & Announcements by mecl July 11, 2013 05:40 3 30

SU2 Installation by incamachol July 13, 2013 20:21 34 193

SU2 Shape Design by Akash C July 8, 2013 07:47 28 153

New Thread

Threads in Forum : SU2

Thread / Thread Starter Rating Last Post Replies Views

- Which Meshing software can I use? shreekanth Today 06:03 0 17
- Unsteady Adjoint Shape Design EMolina July 11, 2013 18:46 0 37
- SU2_DDC error with version 2.0.5 diwakaranant July 11, 2013 07:34 0 26
- Viscous flow over naca0012 airfoil shreekanth July 11, 2013 05:33 0 42
- su2_manual.pdf? rmurone July 9, 2013 12:16 3 111
- Multigrid parameters aero_amit July 9, 2013 06:33 0 32
- Shape Optimization mesh file name error Gramanzini July 8, 2013 14:45 0 32
- How does SU2 calculate of_gradient.plt? robyTKD July 8, 2013 09:27 0 27
- Running SU2_DDC in parallel diwakaranant July 5, 2013 07:21 1 55
- Creating a custom objective function vil3 July 3, 2013 07:22 2 142
- Sumo, the mesh generator by Larosterna Engineering Dynamics now supports SU2 mesh format larosterna.com July 29, 2013 04:11 0 11

Main Page

The SU² Suite

The Stanford University constrained optimization extensible to include under active development under an open-source license.

The following technical documentation, including

Generated on Mon Jan 7 2013 10:28:04 for Stanford University Unstructured (SU2) by doxygen 1.7.5.1

Stanford University Unstructured (SU2). Analyze, Optimize, Design!

Utilities

About Download Installation Quick Start Tutorial User's Guide User's Tutorials Developer's Guide FAQs References & Citations Contact

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Stanford University Unstructured (SU2) - ADL Software Documentation

GitHub, Inc. [github.com/su2code/SU2](#)

su2code/SU2

Stanford University Unstructured Suite [http://su2.stanford.edu](#)

54 commits 9 branches 8 releases 3 contributors

optimizer updates

- aerialhedgehog authored a day ago latest commit 49c3d256
- Common Fixed hex cutting. 4 days ago
- Doxxygen commit v2.0.2 17 days ago
- MeshTools commit v2.0.5 17 days ago
- SU2_CFD New files for tre2 3 days ago
- SU2_DDC Commented out new grid output in SU2_MDC 3 days ago
- SU2_GDC makefile fixes 14 days ago
- SU2_GPC makefile fixes 14 days ago
- SU2_MAC makefile fixes 14 days ago
- SU2_MDC Commented out new grid output in SU2_MDC 3 days ago
- SU2_PBC makefile fixes 14 days ago
- SU2_PY optimizer updates a day ago
- SU2_SMC makefile fixes 14 days ago
- SU2_SOL makefile fixes 14 days ago
- bin Added a bin/ directory for holding compiled executables. 4 days ago
- .gitignore commit v1.0 17 days ago
- AUTHORS commit v2.0.2 17 days ago
- COPYING commit v2.0 17 days ago
- ChangeLog commit v2.0 17 days ago
- INSTALL commit v2.0 17 days ago

Worldwide Trends - Change

- #Euro2013
- Like a Champion
- #buslproblems
- Justin and Believers
- #CfdOnTheBrain
- #FluidMechanics
- #ComputationalFluidDynamics
- #ComputationalAerodynamics
- True Blood
- Max Scherer
- HojeLancamentoDoClipeFifaR

pic.twitter.com/HLKTPqrtc6 View photo

SU2 @su2code 8 Questions with Stanford's Juan Alonso wp.me/p1mx0-FN via GitHub 4 Jun Expand

SU2 @su2code 3 Jun Currently working on a RANS rotating frame validation/redesign case using the NREL Phase VI wind turbine geometry... pic.twitter.com/qgjVfISmT View photo

SU2 @su2code 31 May SU2 2.0.5 (developer version) is now

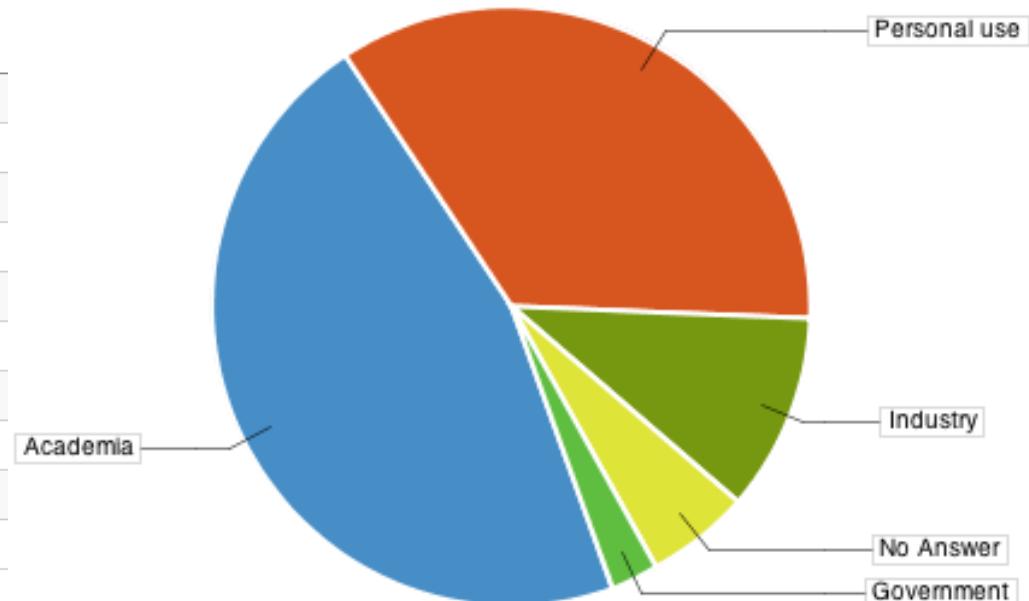
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The first 20 months...

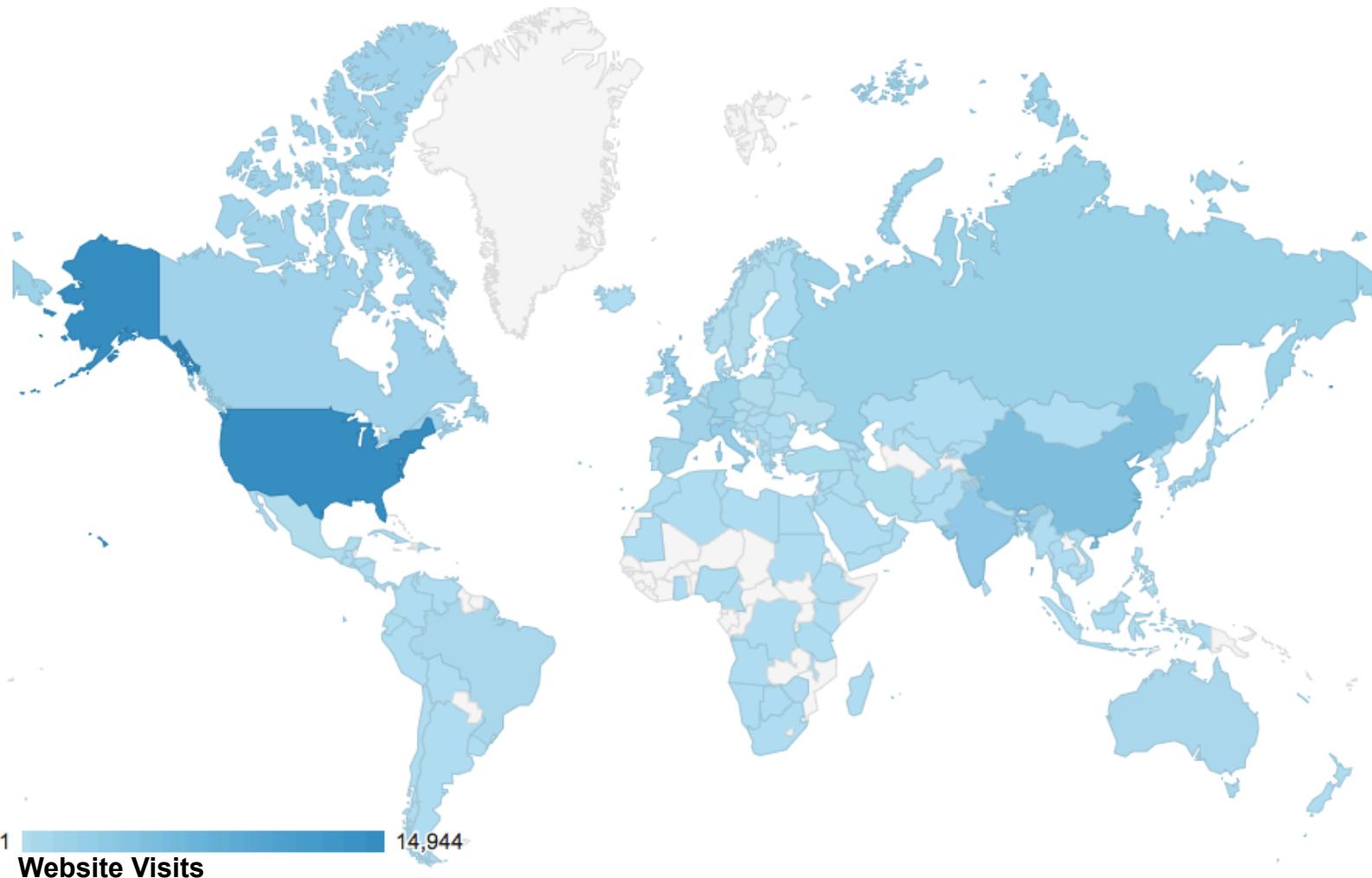
- 49,000 website visits from 136 countries
- 6,000 code downloads
- Many top universities and aerospace companies

Country / Territory	Visits	% Visits
1. United States	14,944	30.71%
2. China	5,315	10.92%
3. India	3,193	6.56%
4. United Kingdom	2,677	5.50%
5. Italy	2,577	5.30%
6. Germany	2,150	4.42%
7. Russia	1,792	3.68%
8. France	1,636	3.36%
9. Spain	1,631	3.35%
10. Canada	1,411	2.90%





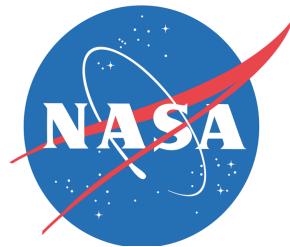
Global Reach





A Student-led Initiative

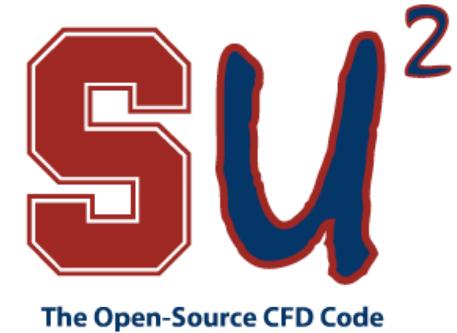
- “Learning through building”
- Two-way information exchange
 - Students equipped with expertise
 - Research & Industry interest





The SU² Team

- Aniket C. Aranake, Alejandro Campos, Sean R. Copeland, Thomas D. Economou, Kedar R. Naik, Amrita K. Lonkar, Trent W. Lukaczyk, Santiago Padrón, Brendan D. Tracey
 - Ph.D. Candidates in the Aero/Astro department.
- Francisco Palacios
 - Engineering Research Associate in the Aero/Astro department.
 - Lead Developer.
- Michael R. Colonna
 - Engineering Research Associate in the Aero/Astro department.
- Juan J. Alonso
 - Associate Professor in the Aero/Astro department.
 - Aerospace Design Laboratory (ADL) Director.





Why is SU² important?

- Cutting-edge research from Stanford available in real-time.
- Enables advanced Computational Fluid Dynamics research in places that don't have the resources or expertise.
- Making the state-of-the-art in computational fluid dynamics freely availability will help companies create faster and greener aircraft, cars, boats, etc.
- Perfect tool for facing some of the future challenges for aviation: achieving supersonic flight over land, and reducing fuel burn, emissions, and noise.