

# Andrew Ning | Jul 2015

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## Research Interests

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Multidisciplinary Optimization, Aerodynamics, Wind Turbine Design, Aircraft Design, Aero/Structural Modeling, Uncertainty Quantification, Renewable Energy, Software Design, High Performance Computing

## Education

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### Stanford University

Stanford, CA

Ph.D., Aeronautics and Astronautics

Sep 2011

M.S., Aeronautics and Astronautics

Apr 2008

- National Defense Science and Engineering Graduate Fellow
- Advisor: Ilan Kroo
- PhD Dissertation: Aircraft Drag Reduction Through Extended Formation Flight
- GPA: 4.07/4.0

### Brigham Young University

Provo, UT

B.S., Applied Physics with University Honors

Aug 2006

- Emphasis: Mechanical Engineering
- Minor: Mathematics
- Honors Thesis: Creation of an Intermediate Environment and Utilizing Switchable Microwave Absorbent Material to Aid in Performing Work on Mars
- Rocky Mountain NASA Space Grant Fellowship
- BYU Office of Research and Creative Activities Grant Recipient (2X)
- GPA: 3.97/4.0 (magna cum laude)

## Publications

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### Journal Articles

11. Fleming, P., **Ning, A.**, Gebraad, P., and Dykes, K., "Wind Plant System Engineering through Optimization of Layout and Yaw Control," *Wind Energy*, Mar. 2015.
10. Damiani, R., **Ning, A.**, Maples, B., Smith, A., and Dykes, K., "Sensitivity Study of Offshore Wind Support Structure Optimization in U.S. Waters," 2015, (in review).
9. **Ning, A.**, and Petch, D., "Integrated Design of Downwind Land-based Wind Turbines using Analytic Gradients," 2015, (in review).

8. **Ning, A.**, Damiani, R., and Moriarty, P., "Objectives and Constraints for Wind Turbine Optimization," *Journal of Solar Energy Engineering*, Vol. 136, No. 4, Nov. 2014.
7. **Ning, A.**, "A Simple Solution Method for the Blade Element Momentum Equations with Guaranteed Convergence," *Wind Energy*, Vol. 17, No. 9, Sep. 2014, pp. 1327–1345.
6. **Ning, A.**, Kroo, I., Aftosmis, M. J., Nemec, M., and Kless, J. E., "Extended Formation Flight at Transonic Speeds," *Journal of Aircraft*, Vol. 51, No. 5, Sep. 2014, pp. 1501–1510.
5. **Ning, A.**, and Dykes, K., "Understanding the Benefits and Limitations of Increasing Maximum Rotor Tip Speed for Utility-Scale Wind Turbines," *Journal of Physics: Conference Series*, Vol. 524, No. 012087, Jun. 2014.
4. Xu, J., **Ning, A.**, Bower, G., and Kroo, I., "Aircraft Route Optimization for Formation Flight," *Journal of Aircraft*, Vol. 51, No. 2, Mar. 2014, pp. 490–501.
3. Kless, J., Aftosmis, M., **Ning, A.**, and Nemec, M., "Inviscid Analysis of Extended-Formation Flight," *AIAA Journal*, Vol. 51, No. 7, Jul. 2013, pp. 1703–1715.
2. **Ning, A.**, Flanzer, T., and Kroo, I., "Aerodynamic Performance of Extended Formation Flight," *Journal of Aircraft*, Vol. 48, No. 3, May 2011, pp. 855–865.
1. **Ning, A.**, and Kroo, I., "Multidisciplinary Considerations in the Design of Wings and Wing Tip Devices," *Journal of Aircraft*, Vol. 47, No. 2, Mar. 2010, pp. 534–543.

#### Conference Publications

13. Barrett, R., Freeman, I., and **Ning, A.**, "Effect of Airfoil and Composite Layer Thicknesses on an Aerostructural Blade Optimization for Wind Turbines," *IEEE Conference on Technologies for Sustainability*, Ogden, UT, Jul. 2015.
12. Tingey, E., Thomas, J., and **Ning, A.**, "Wind Farm Layout Optimization Using Sound Pressure Level Constraints," *IEEE Conference on Technologies for Sustainability*, Ogden, UT, Jul. 2015.
11. Thomas, J., Tingey, E., and **Ning, A.**, "Comparison of Two Wake Models for Use in Gradient-based Wind Farm Layout Optimization," *IEEE Conference on Technologies for Sustainability*, Ogden, UT, Jul. 2015.
10. **Ning, A.**, Hayman, G., Damiani, R., and Jonkman, J., "Development and Validation of a New Blade Element Momentum Skewed-Wake Model within AeroDyn," *33rd ASME Wind Energy Symposium*, Kissimmee, FL, Jan. 2015.
9. Gray, J., Hearn, T., Moore, K., Hwang, J., Martins, J., and **Ning, A.**, "Automatic Evaluation of Multidisciplinary Derivatives Using a Graph-Based Problem Formulation in OpenMDAO," *15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference*, Atlanta, GA, Jun. 2014.
8. Dykes, K., **Ning, A.**, King, R., Graf, P., Scott, G., and Veers, P., "Sensitivity Analysis of Wind Plant Performance to Key Turbine Design Parameters: A Systems Engineering Approach," *32nd ASME Wind Energy Symposium*, National Harbor, Maryland, Jan. 2014.
7. **Ning, A.**, Damiani, R., and Moriarty, P., "Objectives and Constraints for Wind Turbine Optimization," *31st ASME Wind Energy Symposium*, Grapevine, TX, Feb. 2013.

6. Kless, J., Aftomis, M., **Ning, A.**, and Nemec, M., "Inviscid Analysis of Extended Formation Flight," *7th International Conference on Computational Fluid Dynamics*, Big Island, Hawaii, Jul. 2012.
5. Xu, J., **Ning, A.**, Bower, G., and Kroo, I., "Aircraft Route Optimization for Heterogeneous Formation Flight," *53rd AIAA Structures, Structural Dynamics and Materials Conference*, Honolulu, Hawaii, Apr. 2012.
4. **Ning, A.**, and Kroo, I., "Compressibility Effects of Extended Formation Flight," *29th AIAA Applied Aerodynamics Conference*, Honolulu, Hawaii, Jun. 2011.
3. **Ning, A.**, Flanzer, T., and Kroo, I., "Aerodynamic Performance of Extended Formation Flight," *48th AIAA Aerospace Sciences Meeting*, Orlando, Florida, Jan. 2010.
2. **Ning, A.**, and Kroo, I., "Tip Extensions, Winglets, and C-Wings: Conceptual Design and Optimization," *26th AIAA Applied Aerodynamics Conference*, Honolulu, Hawaii, Aug. 2008.
1. Chipman, D., **Ning, A.**, and Allred, D., "Intermediate Martian Atmospheric Study and Demonstrator," *SpaceOps 2006 Conference*, Rome, Italy, Jun. 2006.

## Other Publications

7. Dykes, K., Platt, A., Guo, Y., **Ning, A.**, King, R., Parsons, T., Petch, D., Veers, P., and Resor, B., *Effect of Tip-Speed Constraints on the Optimized Design of a Wind Turbine*, Golden, CO, National Renewable Energy Laboratory, Oct. 2014.
6. Dykes, K., **Ning, A.**, King, R., Graf, P., Scott, G., and Veers, P., *Sensitivity Analysis of Wind Plant Performance to Key Turbine Design Parameters: A Systems Engineering Approach*, Golden, CO, National Renewable Energy Laboratory, Feb. 2014.
5. **Ning, A.**, *pBEAM Documentation*, National Renewable Energy Laboratory, Sep. 2013.
4. **Ning, A.**, *CCBlade Documentation*, National Renewable Energy Laboratory, Sep. 2013.
3. **Ning, A.**, *AirfoilPrep.py Documentation*, National Renewable Energy Laboratory, Sep. 2013.
2. **Ning, A.**, "Aircraft Drag Reduction through Extended Formation Flight," PhD thesis, Stanford University, 2011.
1. **Ning, A.**, "Creation of an Intermediate Environment and Utilizing Switchable Microwave Absorbent Material to Aid in Performing Work on Mars," Undergraduate Honors Thesis, Brigham Young University, 2006.

## Funded Research Grants

- "Quantitative Characterization of Essential Tremor for Future Tremor Suppression," National Institutes of Health, PI: Steven Charles, Co-PIs: Jon Blotter, Andrew Ning, Mark Hallett, \$423,245, 04/01/2015–03/31/2018.
- "Vertical Axis Wind Turbine Wake Model Development," BYU Office of Research & Creative Activities Mentoring Environment Grants, PI: Andrew Ning, \$20,000, 01/01/2015–12/31/2016.
- "Systems Engineering of Wind Turbines and Plants," National Renewable Energy Laboratory, PI: Andrew Ning, \$63,472, 09/01/2014–08/31/2015.

## Invited Presentations

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16. "Multidisciplinary Design Optimization in Wind Energy and Aeronautics," Chemical Engineering Department Graduate Seminar, BYU, Feb 2015.
15. "Downwind Wind Turbine Optimization," Wind Energy Systems Engineering Workshop, NREL, Boulder, CO, Jan 2015.
14. "Optimization within Integrated Design," DOE A2e Wind-Plant System Design and Analysis (IWPSDA) Assessment Meeting, Jan 2015.
13. "Wind Energy: Today and Into the Future," BYU Energy Club, Provo, UT, Dec 2014.
12. "Optimization-Driven Design of Wind Turbines with High Tip Speeds," Colorado State University, Department of Mechanical Engineering Seminar, Apr 2014.
11. "Optimization-Driven Design of Wind Turbines for High Tip Speeds," Brigham Young University, Mechanical Engineering Department Graduate Seminar, Feb 2014.
10. "Wind Turbine Optimization," University of Michigan, Ann Arbor, MI, Oct 2013.
9. "Design Optimization of Downwind Rotors with Segmented Blades," Boulder Fluid Dynamics Seminar, University of Colorado, Boulder, CO, Oct 2013.
8. "Nonlinear Optimization for Engineers: An Overview of the Fundamentals," National Renewable Energy Laboratory, Boulder, CO, Sep 2013.
7. "TWISTER Physics-Based Rotor and Tower Models," Tutorial, NREL Wind Energy Systems Engineering Workshop, Boulder, CO, Feb 2013.
6. "Objectives and Constraints for Wind Turbine Optimization," NREL Wind Energy Systems Engineering Workshop, Broomfield, CO, Jan 2013.
5. "Aircraft Drag Reduction Through Extended Formation Flight," Airbus, Filton UK, Dec 2011.
4. "Aircraft Drag Reduction Through Extended Formation Flight," National Wind Technology Center, Boulder, CO, Sep 2011.
3. "Compressibility Effects of Extended Formation Flight," Army Aeroflightdynamics Directorate, Moffett Field, CA, Aug 2011.
2. "Aircraft Drag Reduction Through Extended Formation Flight," Applied Modeling & Simulation (AMS) Seminar Series, NASA Ames, Moffett Field, CA, July 2011.
1. "Aerodynamics of Extended Formation Flight," Sandia, Albuquerque, NM, Apr 2011.

## Conference Presentations

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5. "Development and Validation of a New Blade Element Momentum Skewed-Wake Model within AeroDyn," 33rd ASME Wind Energy Symposium, Kissimmee, FL, Jan. 2015.
4. "Impact of Increasing Rotor Tip Speed," The Science of Making Torque From Wind, Lyngby, Copenhagen, Jun. 2014.

3. "Objectives and Constraints for Wind Turbine Optimization," 31st ASME Wind Energy Symposium, Grapevine, TX, Jan. 2013.
2. "Compressibility Effects of Extended Formation Flight," 29th AIAA Applied Aerodynamics Conference, Honolulu, HI, Jun. 2011.
1. "Aerodynamic Performance of Extended Formation Flight," 48th AIAA Aerospace Sciences Meeting, Orlando, FL, Jan. 2010.

## Professional Experience

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### Brigham Young University

Assistant Professor, Mechanical Engineering Department

**Provo, UT**

July 2014–present

- Leading a research group in multidisciplinary optimization and aerodynamics as applied to aircraft and wind energy systems.
- Teaching courses in applied fluid dynamics, multidisciplinary optimization, and machine design.

### National Renewable Energy Laboratory

Senior Engineer

**Golden, CO**

Mar 2014–July 2014

Postdoctoral Researcher

Nov 2011–Mar 2014

- Derived a new methodology to solve the blade element momentum equations that unlike existing methods is guaranteed to converge. The methodology is also much faster than existing solution approaches, and for the first time enables numerically exact gradients. This algorithm has been incorporated into industry-standard design codes.
- Lead the wind energy systems engineering research team as Co-PI using multidisciplinary physics and cost modeling, nonlinear optimization, and uncertainty quantification.
- Collaborated on an open-source software framework for industry-wide multidisciplinary wind turbine analysis built on the NASA OpenMDAO framework.
- Developed modular open-source aeroelastic simulation capabilities for both horizontal-axis and vertical-axis wind turbines.

### Stanford University

Research Assistant

**Stanford, CA**

Apr 2007–Sep 2011

- Developed a simplified wake model for formation flight analysis that agrees well with Navier–Stokes calculations, but is orders of magnitude faster.
- Used uncertainty quantification methods to understand the sensitivity of formation flight fuel-burn savings to key parameters.
- Developed a bi-level optimization strategy to determine minimum fuel-burn and minimum cost formation flight route networks.
- Designed methodology and a platform to fly unmanned aerial vehicles autonomously and robustly using machine learning.

### National Aeronautics and Space Administration

Visiting Researcher

**Mountain View, CA**

Jan 2011–July 2011

- Collaborated with NASA researchers to integrate my wake model into an existing Euler code (Cart3D) and assessed the impact of formation flying at transonic speeds.

**Complete Solar Solution**

Lead Developer

**Daly City, CA**

Apr 2010–Sep 2011

- Created an industry-leading software platform to design and price custom solar energy systems for residential customers.
- Developed methodology to analyze solar energy systems accounting for electricity usage, seasonal effects, roof geometry, supplier inventory, and financing method.

**Orbital Sciences**

Aerodynamics Analyst, Intern

**Chandler, AZ**

Summer 2007

- Conducted high-fidelity CFD analysis for various missiles and reentry vehicles.
- Created comprehensive aerodynamic models by intelligently fusing data from CFD, wind tunnel experiments, and missile DATCOM.

**Honeywell International**

Jet Engine Bearing Housing Designer, Intern

**Phoenix, AZ**

Summer 2006

- Designed a bumper, spring cage, and oil passageway for the main bearing housing in the HTF7000 Jet Engine (awarded U.S. Patent 7,699,526).
- Created finite element models to analyze the design to meet stiffness, stress, temperature, material, weight, and vibration requirements.
- Created detail drawings and manufacturing operations and tooling procedures to support procurement of research hardware.

**Honors and Awards**

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- National Defense Science and Engineering Graduate (NDSEG) Fellowship, 2007–2010
- U.S. Patent 7,699,526, "Support Dampers for Bearing Assemblies and Methods of Manufacture," J. W. McMurray, M., Alam, D. K. Spencer, S. A. Ning, 4 Apr 2010
- Airbus "Fly Your Ideas" Competition, Finalist – Top 5 out of 225 teams
- 2009 BASES Social E-Challenge Business Plan Competition, Semi-finalist, 2008
- Honeywell Bravo Award — in recognition of technical excellence provided in the design of a bearing spring-cage to address vibration issues in the HTF7000 engine, 2006
- BYU Honors Program Robert K. Thomas Scholarship, 2006
- Rocky Mountain NASA Space Grant Fellowship, 2005
- BYU Religious Education Student Symposium Writing Contest Winner, 2005
- BYU Office of Research and Creative Activities (ORCA) Grant Recipient, 2004, 2005
- BYU University Scholarship, 2004–2006
- National Merit Scholarship, 2000

**Teaching**

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**ME EN 412, Applications of Fluid Dynamics**

**Description:** A senior-level course covering external flow, compressible flow, turbomachines, and computational fluid dynamics (CFD). Students also learn to use the CFD platform StarCCM+.

**Semesters Taught:** Fall 2015

### ME EN 575, Optimization Techniques in Engineering

**Description:** A graduate course covering gradient-based optimization, sensitivity analysis, gradient-free methods, and advanced topics like robust design and multidisciplinary architectures. I have focused the course around a semester-length project building up towards publishable work.

**Semesters Taught:** Winter 2015

### ME EN 372, Mechanical System Design Fundamentals

**Description:** An undergraduate course on structural combined loads, stress analysis, deflection, buckling, and fatigue for mechanical system. Includes a lab component where the students learn to use ANSYS for finite element modeling and simulation.

**Semesters Taught:** Fall 2014

## Student Mentoring

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- Eric Tingey, M.S. expected 2017, VAWT wakes
- Jared Thomas, M.S. expected 2016, Wind plant optimization, visiting researcher at NREL
- Ryan Barrett, M.S. expected 2016, Free-form blade design
- Undergraduate Students:
  - Nicolas Bons (2014–2015), VAWT wakes, ORCA Grant recipient, accepted into Ph.D. program at University of Michigan.
  - Kevin Moore (2015–), Propellers
  - Dagan Pielstick (2015–), VAWTs
  - Quinn Johnson (2015–), VAWTs
  - Taylor McDonnell (2015–), UAVs

## Citizenship

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- Peer Reviewer for:
  - 2015:** Renewable Energy (2 articles), Journal of Turbomachinery, Aerospace Science and Technology, Journal of the American Helicopter Society, BYU Graduate Fellowships
  - 2014:** Journal of Solar Energy Engineering (2 articles), Wind Energy, Optimization & Engineering, Renewable Energy, Journal of Mechanical Design, Aerospace Science and Technology, Journal of Guidance, Control, and Dynamics, ASME Turbo Exposition, BYU ORCA Grant Proposals
  - 2013:** Wind Energy (4 articles), Renewable Energy (2 articles), The Science of Making Torque from Wind (2 articles), Journal of Defense Modeling and Simulation, Journal of Ocean and Wind Energy
  - 2012:** Wind Energy (3 articles), Journal of Solar Energy Engineering
  - 2010:** Journal of Aircraft
- Reviewer for BYU Graduate Fellowships (2015), BYU ORCA Grant Proposals (2014)

- Thesis Committee for:  
**2015:** Allison Lee (Ph.D), Troy Seletos (M.S.), Junho Park (Ph.D.), Zhihui Zou (Ph.D.), Ron Spencer (M.S.), Cristian Clavijo (Ph.D.), Gary Ellingson (M.S), Sayan Dobronsky (M.S.), Ryan Lundgreen (Ph.D), Joseph Petersen (B.S. Honors)
- Participating in IEA Technical Expert Meetings on Wind Energy Systems Engineering (2015–)

## Professional Memberships

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- American Institute of Aeronautics and Astronautics, Senior Member