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## **Richard O. Stroman, Ph.D.**

*Mechanical Engineer, NP-III*

U.S. Naval Research Laboratory

Alternative Energy Section, Chemistry Division

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### **EDUCATION**

**Ph.D., Mechanical Engineering** 2013

*University of Maryland, College Park*

Dissertation Title: "Understanding Direct Borohydride – Hydrogen Peroxide Fuel Cell Performance"

**M.S., Mechanical Engineering** 2002

*Pennsylvania State University, University Park*

Thesis Title: "A Study of Capacitors for Damping Inverter Generated Ripple Currents on the Direct Current Bus: Experiment and Modeling"

**B.S., Physics** 2000

*Pennsylvania State University, University Park*

### **EXPERIENCE**

**Mechanical Engineer** (2005 – Present)

*U.S. Naval Research Laboratory, Alternative Energy Section*

Principal investigator and/or lead engineer on programs developing energy analysis and simulation tools, autonomous vehicles, and propulsion systems. Research funding raised in the last three years: \$1.8M.

- Principal investigator for a program simulating next-generation soldier and Marine power systems at the individual and unit levels. Developing energy analysis codes and software applications to support in-field mission planning and scenario analysis by the acquisition community.
- Chief scientist and energy system lead, developing a novel hybrid solar/fuel cell/soaring power system to achieve extremely long endurance in small unmanned air vehicles (UAVs).
- Principal investigator developing CFC/reacting flow simulations to improve the performance of direct borohydride fuel cells.
- Principal investigator (energy subsystem) developing task-specialized autonomous ground vehicles that share harvested energy and information to accomplish more as a group than they could individually.
- Technical lead developing a lightweight cryogenic liquid hydrogen fuel storage system for UAVs. Our first prototype enabled a record 48 h endurance flight of the NRL Ion Tiger UAV.
- Lead for standing up a R&D laboratory for 100 kW scale fuel cell engines and electric vehicle propulsion systems. Feasibility analysis for a related UUV propulsion system.
- Lead systems engineer and flight test support for the Ion Tiger fuel cell powered UAV, which set a flight endurance record of 26 h.
- Technical lead and pilot/operator for DragonEye UAV flight demonstrations, including the first UAV launch from a submarine.

**Mechanical Engineer** (2004 – 2005)

*Geo-Centers, Inc.*

Technical lead and design engineer supporting payload development for the DragonEye UAV. Designed electromechanical components for a novel short-wave infrared zoom lens and integrated the completed camera system with a DragonEye UAV. Flew DragonEye UAVs for demonstrations and payload evaluations.

## Mechanical Engineer

(2003 – 2004)

*ILC Dover, Inc.*

Engineering research contractor. Designed, built, and demonstrated a novel inflatable rigidizable repair system for Space Shuttle wing tiles. Developed spacesuit glove heater concepts and then fabricated and evaluated proof-of-concept devices. Analyzed the thermal performance of a new spacesuit cooling system (LCVG).

## Graduate Research Assistant, Electrical Engineering Department

(2000 – 2002)

*Pennsylvania State University, University Park*

Principal investigator and/or lead engineer on programs developing energy analysis and simulation tools, autonomous vehicles, and propulsion systems. Research funding raised in the last three years: \$1.8M.

## PUBLICATIONS

### Refereed Journal Articles

1. R. W. Atkinson III, M. W. Hazard, J. A. Rodgers, **R. O. Stroman**, and B. D. Gould, "An Open-Cathode Fuel Cell for Atmospheric Flight", *Journal of the Electrochemical Society*, 164, F46-F54 (2017).
2. **R. O. Stroman**, M. W. Schuette, K. Swider-Lyons, J. A. Rodgers, and D. J. Edwards, "Liquid hydrogen fuel system design and demonstration in a small long endurance air vehicle", *International Journal of Hydrogen Energy*, 39, 11279-11290 (2014).
3. **R. O. Stroman**, G. S. Jackson, Y. Garsany, and K. Swider-Lyons, "A calibrated hydrogen-peroxide direct-borohydride fuel cell model", *Journal of Power Sources* 271, 421-430 (2014).
4. **R. O. Stroman** and G. S. Jackson, "Modeling the Performance of an Ideal  $\text{NaBH}_4 - \text{H}_2\text{O}_2$  Direct Borohydride Fuel Cell", *Journal of Power Sources* 247, 756-769 (2014).
5. O. Baturina, Y. Garsany, K. Swider-Lyons, B. D. Gould, **R. O. Stroman**, A. Korovina, P. Northrup, "Products of  $\text{SO}_2$  Adsorption on Fuel Cell Electrocatalysts by Combination of Sulfur K-Edge XANES and Electrochemistry", *Langmuir*, 27, 14930-14939 (2011).
6. E. Furman, S. Zhang, N. Kim, T. R. Shrout, H. Hofmann, **R. O. Stroman** and M. Lanagan, "High-Temperature, High-Power Capacitors: the Assessment of Capabilities", *SAE Int. J. Aerospace*, 1, 822-831 (2009).

### Conference Proceedings

1. R. W. Atkinson III, Y. Garsany, J. A. Rodgers, M. W. Hazard, **R. O. Stroman**, and B. D. Gould, "Influence of Cathode Catalyst Layer Ionomer on Air-Cooled, Open-Cathode Fuel Cells," *ECS Transactions*, 80 (8) 461-475 (2017).
2. R. M. E Hjelm, Y. Garsany, R. W. Atkinson III, **R. O. Stroman**, K. Swider-Lyons, C. Lafforgue, and M. Chatenet, "Sodium Borohydride Oxidation on Pt and/or Pd-Based Electrodes in Hydrogen Peroxide Direct Borohydride Fuel Cells ( $\text{H}_2\text{O}_2$ -DBFCs)," *ECS Transactions*, 80 (8) 1033-1042 (2017).
3. R. W. Atkinson III, M. W. Hazard, J. A. Rodgers, **R. O. Stroman**, and B. D. Gould, "Gas Diffusion Media for Open-Cathode Fuel Cells in Atmospheric Flight," *ECS Transactions*, 75 (14) 531-545 (2016).
4. **R.O. Stroman**, D. J. Milliken, E. A. Leadbetter, K. Swider-Lyons, J. Novoa, "Energy-Informed Soldier Mission Planning Through Simulation," *Proc. of 47th Power Sources Conference*, Orlando FL, (2016).
5. **R.O. Stroman**, W. Adams, K. Sullivan, J. Palmisano, R. Schur, K. Swider-Lyons, A. C. Schultz, "Autonomous Vehicles Achieving Long Endurance through Collaboration," *Proc. of 47th Power Sources Conference*, Orlando FL, (2016).
6. B.D. Gould, M.W. Hazard, J.A Rodgers and **R.O. Stroman**, "An Open-Cathode Fuel Cell for Atmospheric Flight," *ECS Transactions*, 69 (17) 497-507 (2015).
7. **R. O. Stroman** and G. S. Jackson, "Understanding Direct Borohydride – Hydrogen Peroxide Fuel Cell Performance with a Calibrated Numerical Model", *ECS Transactions*, 64 (3) 989-998 (2014).
8. K. E. Swider-Lyons, **R. O. Stroman**, J. A. Rodgers, B. Gould, J. Mackrell, M. Schuette, and G. Page, "Hydrogen Fuel Cells for Small Unmanned Air Vehicles", *ECS Transactions*, 64 (3) 963-972 (2014).

9. **R. O. Stroman**, G. S. Jackson, Y. Garsany, and K. Swider-Lyons, "A Calibrated Direct Borohydride – Hydrogen Peroxide Fuel Cell Model", 2013 12<sup>th</sup> Fuel Cell Science, Engineering & Technology Conference at the Annual Meeting of the *American Society of Mechanical Engineers*, Boston MA (2014).
10. **R. O. Stroman**, M. W. Schuette, K. Swider-Lyons, J. Rodgers and D. J. Edwards, "Design and Demonstration of a Liquid Hydrogen Storage System for Small Air Vehicles", 12<sup>th</sup> Fuel Cell Science, Engineering & Technology Conference at the Annual Meeting of the *American Society of Mechanical Engineers*, Boston MA (2014).
11. K. Swider-Lyons, **R. O. Stroman**, J. Rodgers, D. Edwards, J. MacKrell, M. Schuette and G. Page, "Liquid Hydrogen Fuel Systems for Small Unmanned Air Vehicles", *Proceedings of the 51<sup>st</sup> AIAA Aerospace Sciences Meeting* (2013).
12. **R. O. Stroman** and J. S. Jackson, "Modeling the Performance Limits of a Direct Borohydride Fuel Cell", 2013 11<sup>th</sup> Fuel Cell Science, Engineering & Technology Conference at the Annual Meeting of the *American Society of Mechanical Engineers*, Minneapolis MN (2013).
13. **R. O. Stroman**, M. Schuette, "Design Challenges and Modeling for an Efficient Liquid Hydrogen Storage Tank for Autonomous Systems", Annual Meeting of the *American Institute of Chemical Engineers*, Minneapolis MN (2012).
14. K. Swider-Lyons, **R. O. Stroman**, G. S. Page, J. F. Mackrell, J. A. Rodgers, M. W. Schuette, "The Ion Tiger Fuel Cell Unmanned Air Vehicle", *Proceedings of the 44<sup>th</sup> Power Sources Conference*, 25.4, pp. 561-563, Las Vegas NV, (2010).
15. I. Peek, **R. O. Stroman**, K. Swider-Lyons, M. Schuette, G. Page, "Investigation of the Efficiencies of an Integrated PEM Fuel Cell System Operating in a Naval Environment", *43<sup>rd</sup> Power Sources Conference*, Philadelphia PA, (2008).
16. **R. O. Stroman**, A. D. Kahn, "Development and Integration of Controls for a PEMFC Powered Aircraft", *ECS Transactions*, 11 (1) 1493-1504 (2007).
17. **R. O. Stroman**, J. C. Kellogg, K. Swider-Lyons, "Testing of a PEM Fuel Cell System for Small UAV Propulsion", *42<sup>nd</sup> Power Sources Conference*, Philadelphia PA (2006).
18. K. Splawn, D. Graziosi, **R. O. Stroman**, "Phase VI Glove TMG Evolution", *SAE 34<sup>th</sup> International Conference on Environmental Systems (ICES)*, Colorado Springs CO (2004).
19. H. Hofmann, **R. O. Stroman**, M. Lanagan, "Closed-Form Frequency Model of 3-Phase Inverter Drive for DC Distribution System Analysis", *SAE International Power Systems Conference*, Coral Springs FL, (2002).

## Technical Reports

1. **R. O. Stroman**, E. Leadbetter, and C. Buesser, "IPOWER: Energy Analysis and Mission Planning Tools for Dismounted Soldiers", NRL Memorandum Report NRL/MR/not yet assigned, 28 November 2017.
2. A. E. Cohen, **R. O. Stroman**, and M. A. Rugar. "Balloon Borne Relays for Ship-to-Shore Communications" NRL Memorandum Report NRL/MR/not yet assigned, 31 July 2017.
3. **R. O. Stroman** and K. E. Swider-Lyons. "Soldier Power Simulation Program – Year 2 Report," NRL Memorandum Reports, NRL/MR/6113–16-9688, (2016).
4. **R. O. Stroman** and K. Swider-Lyons, "Soldier Power Simulation Program – Year 1 Final Report", NRL Memorandum Reports, NRL/MR/6113–15-9616, (2015).
5. **R. O. Stroman**, "Understanding Direct Borohydride-Hydrogen Peroxide Fuel Cell Performance", University of Maryland PhD Dissertation, 316p, (2014).
6. **R. O. Stroman**, M. Schuette, K. Swider-Lyons, J. Rodgers and D. Edwards, "Liquid Hydrogen Storage for UAVs: Final Report of the Ion Tiger Cryogenic Fuel Tank Program", NRL Formal Report NRL/FR/5740--14-10,252 (2014).
7. **R. O. Stroman**, M. W. Schuette and G. S. Page, "Cooling System Design for PEM Fuel Cell Powered Air Vehicles", NRL Memorandum Report NRL/MR/6110--10-9253 (2010).
8. **R. O. Stroman**, "Mechanical Design Report, DARPA BOSS Program", NRL Memorandum Report NRL/MR/6110--08-9116 (2007).
9. **R. O. Stroman**, "Actuator Trade-Off Analysis for BOSS Camera Prototype II", NRL Memorandum Report NRL/MR/6110-06-9009 (2005).

## Books and Book Chapters

1. **R.O. Stroman** and G.S. Jackson, "Transport in Liquid-Phase Electrochemical Devices," in *Springer Handbook of Electrochemical Energy*, Springer, Berlin, (2016).

## TECHNICAL PRESENTATIONS

### Invited Talks

1. **R. O. Stroman**, "Selected Energy and Autonomy Research at the US Naval Research Laboratory", Department of Mechanical Engineering, Colorado School of Mines, Golden CO, 3 November 2017.
2. **R. O. Stroman** and D. Edwards, "The Hybrid Tiger: A Long Endurance Solar/Fuel Cell, Soaring Unmanned Air Vehicle", NREL/DoD Tech Exchange, National Renewable Energy Laboratory, Golden CO, 2 November 2017.
3. **R. O. Stroman**, K. E. Swider-Lyons, Y. Garsany, and G. Jackson, "Direct Borohydride Fuel Cells and Liquid Hydrogen Storage for Unmanned Vehicle Applications," Xerox PARC, Palo Alto CA, 30 March 2017.
4. **R. O. Stroman**, "Selected Energy and Autonomy Research at the US Naval Research Laboratory", Department of Chemical Engineering Graduate Research Seminar, University of Kansas, Lawrence KS, 25 April 2017.
5. **R. O. Stroman**, "Fuel Cell Power Systems for Naval Applications," Department of Mechanical Engineering, U.S. Naval Academy, Annapolis MD, 1 April 2015.
6. **R. O. Stroman**, "Fuel Cell Powered UAV Programs at the Naval Research Laboratory". University of Maryland Mechanical Engineering Department Graduate Student Seminar, College Park MD, 29 July 2008.

### Oral Presentations

1. R. Walters, D. Edwards, **R. O. Stroman**, and P. Jenkins, "UAS Solar-Soaring Program", Unmanned Aircraft Systems East, Arlington VA, 7-8 November 2017.
2. **R. O. Stroman**, D. Edwards, P. Jenkins, R. Walters, S. Carter, and D. Newton, "The Hybrid Tiger: A Long Endurance Solar/Fuel Cell/Soaring Unmanned Air Vehicle", American Society of Mechanical Engineers International Mechanical Engineering Conference and Exposition, Tampa FL, 7 November 2017.
3. **R. O. Stroman**, E. Leadbetter, C. Buesser, J. Collazo, and D. Milliken, "iPOWER: Energy-Informed Soldier Mission Planning Through Simulation," NDIA Joint Service Power Expo, Virginia Beach VA, 2-4 May 2017.
4. **R. O. Stroman**, K. Swider-Lyons, J. Palmisano, M. Diaz, and G. Knizhnik, "Collaborative Autonomous Ground Vehicles Achieving Energy Independence", NDIA Joint Service Power Expo, Cincinnati OH, 25-27 August 2015.
5. **R. O. Stroman** and K. Swider-Lyons, "Improving Soldier Power System Performance through Simulation" NDIA Joint Service Power Expo, Cincinnati OH, 25-27 August 2015.
6. **R. O. Stroman**, "Understanding Direct Borohydride-Hydrogen Peroxide Fuel Cell Performance", Doctoral Dissertation Defense, University of Maryland, College Park MD, 11 November 2013.
7. **R. O. Stroman** and G. S. Jackson, "A Design Focused Direct Borohydride Fuel Cell Model", 2012 Fuel Cell Seminar, Uncasville CT, 5-8 November 2013.
8. K. Swider-Lyons and **R. O. Stroman**, "Hydrogen Fuel Cells for Small Long Endurance Unmanned Air Vehicles", NSCB Forum at the National Reconnaissance Office, Chantilly VA, 16 July 2013.
9. O. Baturina, Y. Garsany, K Swider-Lyons, B. Gould, **R. O. Stroman**, A. Korovina, P. Northrup, SO<sub>2</sub> Adsorption on Pt Nanoparticles as a Function of Electrode Potential and Oxidative Properties of Carrier Gas: In-Situ Sulfur K-edge Xanes Approach , 4<sup>th</sup> International Congress on Operando Spectroscopy, Upton NY, 29 April – 3 May 2012.

### Poster Presentations

1. **R. Stroman**, E. Leadbetter, J. Collazo, C. Buesser, and D. Milliken, "iPOWER: Energy-Informed Soldier Mission Planning through Simulation", Defense Innovation Summit, Tampa FL, 3-4 October 2017.
2. **R. Stroman**, D. Edwards, R. Walters, and A. Reinecke, "The Hybrid Tiger Unmanned Air Vehicle: Long Endurance Solar, Fuel Cell, and Autonomous Soaring", Defense Innovation Summit, Tampa FL, 3-4 October 2017.

## PATENTS AND PATENT APPLICATIONS

1. **R. O. Stroman**, D. Edwards, J. Langelaan, J. Bird, and V. Dobrokhodov, "Method for identifying optimal vehicle paths when energy is a key metric or constraint". *In submission process*.
2. **R. O. Stroman**, E. Leadbetter, C. Buesser, and K. E. Swider-Lyons, "Method for estimating the time-varying energy balance of a collection of energy sinks, harvesters, and storage devices", 2017. [Navy Case #105,724]
3. B. D. Gould, J. A. Rodgers, M. Hazard, and **R. O. Stroman**, "Stackless Fuel Cell in a Planar Array Composed of Flexible Printed Circuit Boards, Gas Diffusion Layers, and Catalyst Coated Membrane", 2016. [Navy Case # 103173US1]
4. **R. O. Stroman**, M. W. Schuette and K. E. Swider-Lyons, "Lightweight Zero Ullage Cryogenic Fuel Tank", 2015. [Navy Case #103,138]
5. K. E. Swider-Lyons, R. Foch, M. Schuette, G. Page, A. Kahn, **R. O. Stroman**, "Hydrogen Fuel Cell Propulsion System", 2011. [Navy Case #100,441]

## PROFESSIONAL SOCIETY MEMBERSHIPS

- American Society of Mechanical Engineers (2001 – Present)
- Society of Automotive Engineers (1996 – Present)