Team Redhawk Report AAVC 2015

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*Abstract*—The following is a report detailing Miami University’s entry vehicle in the Autonomous Aerial Vehicle Competition of 2015. It details the algorithms

# Team Members

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Iami’s team consists of three members: Nick Contini, John Thomas, and Braden Campbell. Work was divided as described. Nick Contini was the primary programmer for any image processing, as well as the primary contributor to the starting code for the laser rangefinder and sonar modules. He also contributed to PWM code to control the flight controller, assisted in quadcopter construction, and was founder of the project. John Thomas was the primary contributor to PWM code and the Raspberry Pi expert. He also 3D printed any extra models that were needed as parts, and assisted in algorithm development. Braden Campbell was in charge of maintaining code and documenting the project.

# List OF Parts

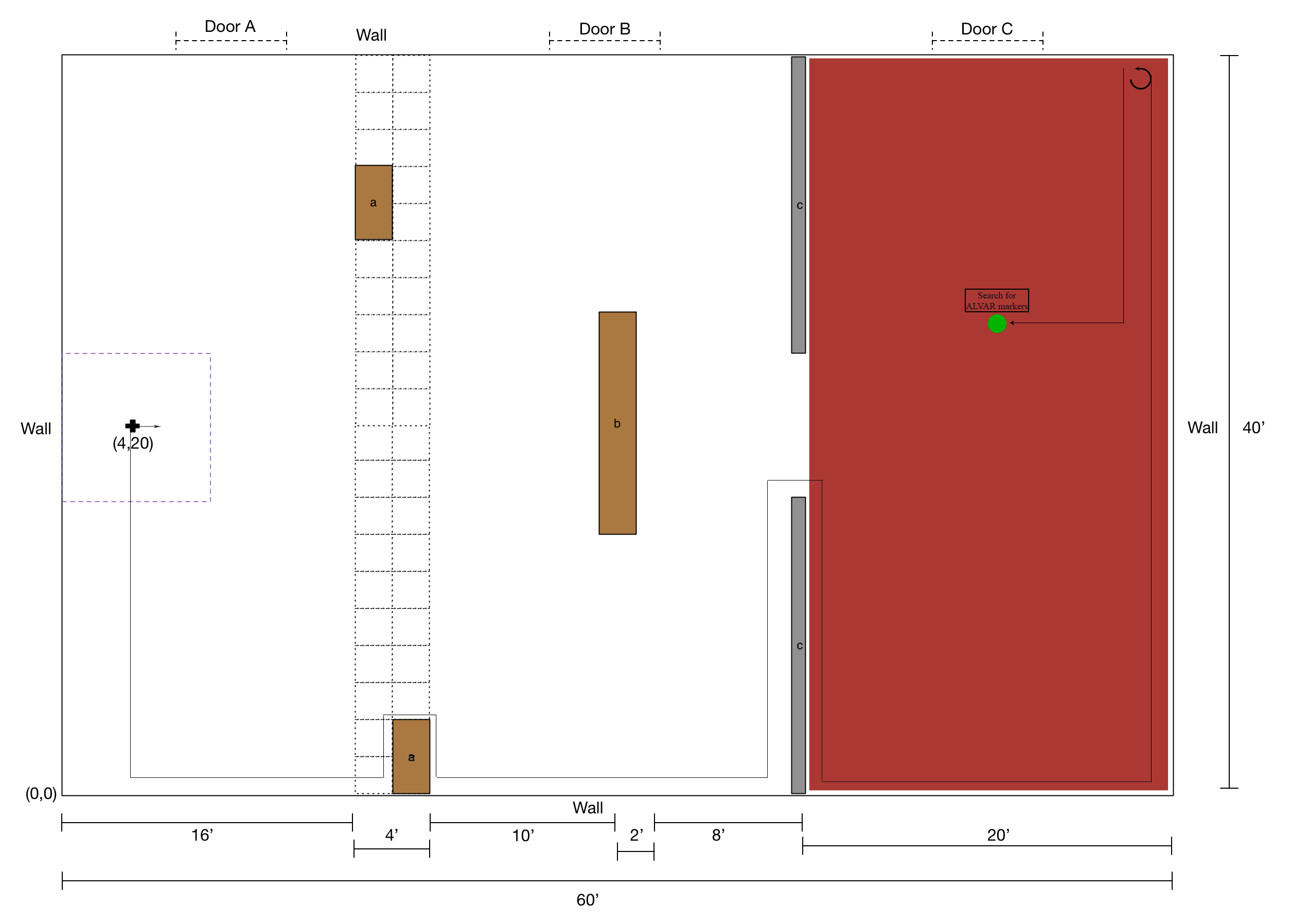
* Raspberry Pi Model B – $44.95



* Arduino Mega ADK - $59.95
* Ardupilot 2.6 - $159.99
* ZIPPY Flightmax 3000mAh 3S1P 20C – $15.71
* 3DR DIY Quad Kit 2014 - $550.00
* HC-SR04 Sonar Modules (4) – $17.98
* [UT390B](http://dx.com/p/uni-t-ut390b-45m-laser-distance-meter-178482?Utm_rid=18166238&Utm_source=affiliate) Laser Rangefinder - $52.99
* Raspberry Pi Camera Board – $29.95
* Ourlink USB Wifi Dongle – $12.95

# Search Algorithm

The search algorithm allows the vehicle to be as simple as possible. The vehicle starts by facing the second room. It hugs the right wall, making sure to shift left anytime an obstacle is sensed in from of it. It recognizes that it is in the second room once senses a wall on its left after drifting left for some time. It then rotates 180° and then starts drifting to its left. It begins taking pictures in order to find the ball. Once the ball is found, the quadcopter hovers over the ball and begins searching for the ALVAR markers.



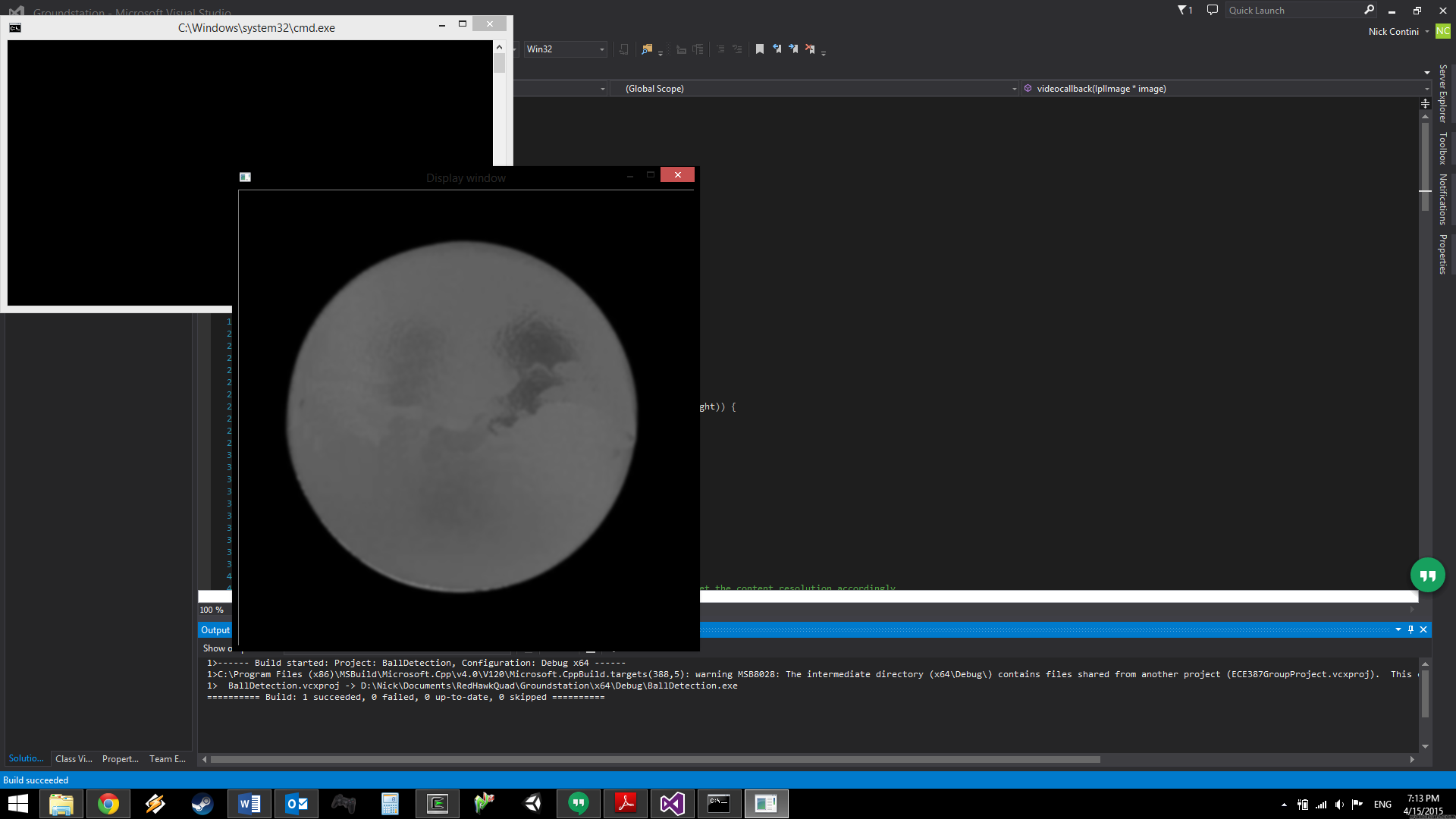
Once an ALVAR is located, the vehicle will measure the distance using the laser rangefinder. Once two ALVARS are found, the quadcopter will use the coordinates of the ALVARS as well as a system of distance formulas to find the ball’s coordinates:

of ALVAR 1

of ALVAR 2

of the quadcopter/ball

# Image Processing

The target identification run by the ground station is relatively simple. Using the OpenCV C++ library, the image sent from the quadcopter is split from one three-channel image to three one-channel images, so that the program can manipulate the red, green, and blue channels independently. Since the object the vehicle is searching for is green, the program’s objective is to block all color but pure green. To accomplish this, the program averages the red and blue channels and subtract the result from the green channel. This effectively removes all white and near white pixels and dampens blue and red pixels. The program then uses OpenCV’s Hough Circles feature to locate a circle. If a circle is found, the vehicle begins to search the room for ALVAR markers.

# Safety

In order to safely disarm the quadcopter in the event of a failure of the system two disarm mechanisms have been added. First, a software disarm feature has been added into the control algorithm that, when the groundstation sends a kill command, will cause the quadcopter to enter into a landing mode. From here the quadcopter will land and be safe to recover. The second kill switch will be a manual switch on the flight controller that when switched will also initiate the landing procedure.

To test the safety system, a controlled environment was set up where the quadcopter would navigate part of the course and the disarm mechanisms were tested. For the software disarm feature the quadcopter was allowed to follow a wall on it right side and when the operator was ready the kill command was sent from the groundstation through wireless communication and the quadcopter initiated landing. This same test was performed with the manual kill switch located on the flight controller to make sure both mechanisms work appropriately.A general IEEE styleguide is available at <http://www.ieee.org/web/publications/authors/transjnl/index.html>

TABLE I

Units for Magnetic Properties

|  |  |  |
| --- | --- | --- |
| Symbol | Quantity | Conversion from Gaussian and  CGS EMU to SI a |
| Φ | magnetic flux | 1 Mx → 10−8 Wb = 10−8 V·s |
| *B* | magnetic flux density,  magnetic induction | 1 G → 10−4 T = 10−4 Wb/m2 |
| *H* | magnetic field strength | 1 Oe → 103/(4π) A/m |
| *m* | magnetic moment | 1 erg/G = 1 emu  → 10−3 A·m2 = 10−3 J/T |
| *M* | magnetization | 1 erg/(G·cm3) = 1 emu/cm3  → 103 A/m |
| 4π*M* | magnetization | 1 G → 103/(4π) A/m |
| σ | specific magnetization | 1 erg/(G·g) = 1 emu/g → 1 A·m2/kg |
| *j* | magnetic dipole  moment | 1 erg/G = 1 emu  → 4π × 10−10 Wb·m |
| *J* | magnetic polarization | 1 erg/(G·cm3) = 1 emu/cm3  → 4π × 10−4 T |
| χ*,* κ | susceptibility | 1 → 4π |
| χρ | mass susceptibility | 1 cm3/g → 4π × 10−3 m3/kg |
| μ | permeability | 1 → 4π × 10−7 H/m  = 4π × 10−7 Wb/(A·m) |
| μr | relative permeability | μ → μr |
| *w, W* | energy density | 1 erg/cm3 → 10−1 J/m3 |
| *N, D* | demagnetizing factor | 1 → 1/(4π) |

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

aGaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

# Ground Station

Communication with the quadcopter is predominately done through SSH protocol over a private WiFi network. Initially the script will be run from the groundstation to takeoff and begin the navigation algorithm.

Figures compiled of more than one sub-figure presented side-by-side, or stacked. If a multipart figure is made up of multiple figure types (one part is lineart, and another is grayscale or color) the figure should meet the stricter guidelines.

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Appendix

Appendixes, if needed, appear before the acknowledgment.

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**Second B. Author** was born in Greenwich Village, New York City, in 1977. He received the B.S. and M.S. degrees in aerospace engineering from the University of Virginia, Charlottesville, in 2001 and the Ph.D. degree in mechanical engineering from Drexel University, Philadelphia, PA, in 2008.

From 2001 to 2004, he was a Research Assistant with the Princeton Plasma Physics Laboratory. Since 2009, he has been an Assistant Professor with the Mechanical Engineering Department, Texas A&M University, College Station. He is the author of three books, more than 150 articles, and more than 70 inventions. His research interests include high-pressure and high-density nonthermal plasma discharge processes and applications, microscale plasma discharges, discharges in liquids, spectroscopic diagnostics, plasma propulsion, and innovation plasma applications. He is an Associate Editor of the journal *Earth*, *Moon*, *Planets*, and holds two patents.

Mr. Author was a recipient of the International Association of Geomagnetism and Aeronomy Young Scientist Award for Excellence in 2008, the IEEE Electromagnetic Compatibility Society Best Symposium Paper Award in 2011, and the American Geophysical Union Outstanding Student Paper Award in Fall 2005.

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