**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

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FOIL BOARDING COMPANY, INC.
Petitioner,

v.

MHL CUSTOM, INC.
Patent Owner

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U.S. Patent No. 9,586,659
IPR Case No.: IPR2024-00085

# DECLARATION OF TIMOTHY TAKAHASHI IN SUPPORT OF PATENT OWNER'S RESPONSE

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## I. INTRODUCTION

1. My name is Timothy Takahashi. I have been retained by MHL Custom, Inc. ("MHL") as an independent expert witness for the above captioned *Inter Partes* Review ("IPR") of MHL Custom, Inc.'s U.S. Patent No. 9,586,659 ("the '659 Patent" or "the Patent-at-Issue"), and to provide my opinions regarding Foil Boarding Company, Inc.'s ("Petitioner's") Petition for *Inter Partes* review of the '659 Patent, including the Declaration of Dr. Stefano Brizzolara and other information contained in the exhibits thereto. I have also reviewed the Board's Decision Granting Institution of *Inter Partes* Review and the transcript of Dr. Brizzolara's deposition testimony.

2. Based on my analysis and investigation, I have reached certain conclusions and opinions on the issues that I discuss in this report. This report is based on information currently available to me. I reserve the right to continue my investigation and study, which may include a review of documents and information that recently may have been produced, as well as deposition testimony for which transcripts are not yet available or that may yet be taken in this matter.

3. I also reserve the right to expand or modify my opinions as my investigation and study continues, and to supplement my opinions in response to any additional information that becomes available to me, any matters raised by

Petitioner and/or opinions provided by their expert(s), or in light of any relevant Orders from the Board. Therefore, I reserve the right to prepare a supplemental expert report based on, for example, additional deposition testimony and/or additional information that becomes available after this report is issued.

4. I also understand I may be asked to elaborate further on my positions in this report and to provide opinions on other issues. I reserve the right to form and report such additional opinions and the bases for any such opinions.

## II. QUALIFICATIONS AND EXPERIENCE

5. The following is a brief summary of my background and qualifications. My background and qualifications are more fully set out in my curriculum vitae (CV), attached as **Exhibit 1**.

6. I earned my B.S. in Mechanical Engineering in 1988 from the University of Rochester. In 1993 the University of Rochester awarded me a PhD in Mechanical and Aerospace Sciences for my thesis "Flow Beneath a Spinning Disk."

7. I spent 15 years as a full-time engineer working in Aerospace and Defense for NASA, Lockheed Martin, Raytheon and Northrop Grumman.

8. As a part of this work in 2000/2001 I was Chief Engineer at Lockheed Martin for an Office of Naval Research sponsored study on the feasibility of long-range hydrofoil ships. For this project, I led an interdisciplinary team to configure a

stabilizable and controllable hydrofoil transport ship suitable to transport military cargo across the oceans. Two peer reviewed conference papers arose from this work:

- Takahashi, T.T. and Coopersmith, R.M., "Hydrofoil Wing Section Development with High Lift Devices," AIAA 2002-0833, 2002.
- Takahashi, T.T., Coopersmith, R.M., Novak, C.J. and Olliffe, R., "A Multidisciplinary Design Optimization of a Long-Range Hydrofoil Transport," AIAA 2001-1106, 2001.

9. In 2010, I returned to study and completed a J.D. from Santa Clara University. I have never sat for a bar exam in any state or other jurisdiction.

10. Since 2012, I have worked as Professor of the Practice, a full-time faculty member, in the Fulton Schools of Engineering at Arizona State University.

11. My work as an engineering faculty member has included research considering the design of flying machines to achieve superior stability and controllability. My research funding is provided by both commercial as well as governmental aerospace and defense customers including the United States Air Force.

12. As set forth in my CV (**Exhibit 1**), my record of professional service includes recognitions from several professional organizations in my field of

expertise, including the American Institute of Aeronautics and Astronautics and the Royal Aeronautical Society.

13. For the past 7 years, I have worked as an expert witness. I have not provided deposition testimony as an expert.

14. I am being compensated for my time at $350 for each hour of service that I provide in connection with this IPR. This compensation is not contingent upon my performance, my opinions, the outcome of this IPR, or any issues involved in, or related to, this IPR.

## III. INFORMATION CONSIDERED

15. Attached as **Exhibit 2** is a list of the information I reviewed and considered in preparing my opinions contained in this report.

## IV. CLAIM CONSTRUCTION

16. In forming my opinions in this case, I used the claim constructions set forth below.

| TERM | CONSTRUCTION |
|---|---|
| "wherein a user can be disposed on the top surface of the flotation device in a prone, kneeling, or standing position" – Claim 1 | "prone, kneeling, or standing" are alternatives. Paper 12 at 12. |
| "A passively stable, weight-shift controlled personal hydrofoil watercraft" – Claim 1 | "a weight-shift controlled personal watercraft having a hydrofoil that does not have any moveable components and which, when disturbed, (1) has an initial tendency to return to its original condition and (2) eventually returns to its original condition" |

17. For all claim terms for which I have not provided a construction for in the table presented above, I used the plain and ordinary meaning of each term to a person of ordinary skill in art at the time of the invention.

## V. LEGAL UNDERSTANDINGS

18. In this section, I describe my understanding of certain legal standards I have relied on in forming my opinions in this Declaration. I have been informed of these legal standards by attorneys for MHL. I have not independently researched the law on patent validity/invalidity.

### A. Person of Ordinary Skill in the Art ("POSITA")

19. I understand that a person having ordinary skill in the art is a hypothetical person who is used to analyze the prior art without the benefit of hindsight.

20. I understand that the hypothetical person of ordinary skill is presumed to have knowledge of the relevant prior art.

21. Having reviewed the '659 Patent, and its prosecution history, in my opinion, a person of ordinary skill in the art would have had at least a Bachelor's degree in engineering or physics with experience in fluid dynamics and experience with watercraft, aircraft, or hydrofoil craft, or at least a Bachelor's degree in the field of engineering specializing in naval architecture and substantial experience with naval architecture including some experience with watercraft, aircraft, or

hydrofoil craft. I understand that the Board adopted this definition of a person of skill in the art. Paper 12 at 9. For this Declaration, I understand the time of invention to be October 10, 2013. I consider myself to be a person of ordinary skill in the art to which the '659 Patent pertains at the time of the invention. As illustrated by my background outlined above, I have extensive experience in aircraft configuration aerodynamics for performance, stability and control, as well as advanced hydrofoil design experience.

**B. Legal Standard for Prior Art**

22. I understand that a reference must qualify as prior art under the patent laws to be considered for purposes of anticipation or obviousness. I also understand that the Patent Act includes several provisions that determine whether a reference qualifies as prior art, including whether a reference was publicly available at the time of the invention. I further understand that determining whether a reference qualifies as prior art is usually a legal question that may depend on underlying factual issues.

**C. Burden**

23. I understand that the Petitioner has the burden of proving the invalidity of each claim by preponderance of the evidence. I understand that preponderance of the evidence is to prove that something is more likely than not. I also understand

that the Patent Act provides that a patent is presumed valid, and that each patent claim is presumed valid independently of the validity of other claims.

### D. Legal Standard for Obviousness

24. I understand that a patent claim is invalid for obviousness if the differences between the claimed subject matter (as construed) and the prior art are such that the claimed subject matter as a whole would have been obvious to a POSITA at the time the invention was made.

25. I understand that a POSITA provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents one from using his or her own hindsight in deciding whether a patent claim is obvious.

26. I understand that an obviousness determination must include the consideration of factors including (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the pertinent art, and (4) the existence of what are called secondary considerations of non-obviousness, which include, among other things:

- evidence of copying;
- commercial success;
- peer recognition;

- articles, awards, and other public statements praising the claimed invention's merits;
- failure of others;
- long-felt but unmet need; and/or
- others taking licenses.

27. I further understand that there must be a nexus between the secondary consideration and the claimed invention's novel features for the secondary consideration to have probative value.

28. **Motivation to combine and hindsight.** I understand that to prove a claim would have been obvious, the Petitioner must demonstrate that a POSITA would have been motivated to combine or modify the prior art to achieve the claimed invention and had a reasonable expectation of success. I understand that the suggestion to modify or combine relevant prior art references may come from:

- a teaching or suggestion in the prior art references;
- the common sense of a POSITA;
- any need or problem known to a POSITA and addressed by the claimed invention, including, but not limited to, the problem addressed by the patent; and/or
- design incentives and other market forces.

29. I further understand that obviousness should not be evaluated using the benefit of hindsight, what is known today, or what is taught by the Patent-at-Issue.

30. I understand all the elements of a challenged claim may be found in multiple prior art references, and that combination of references may render a challenged claim obvious to a POSITA. However, I am also informed that the mere fact that all of the elements of a challenged claim may be located in different prior art references does not make the challenged claim obvious. There must be a reason and motivation apparent to the POSITA to combine or modify the different references, and a reasonable expectation of success at arriving at the claimed invention.

## VI. BACKGROUND INFORMATION

### A. Equilibrium and Stability

31. In aerodynamics and hydrofoil design, the term "stability" has a meaning which differs somewhat from that given colloquially. The broad term stability includes both static stability and dynamic stability. Static stability describes the initial tendency (in this instance, of a hydrofoil) to return towards its original condition after it experiences a disturbance that alters its motion. Dynamic stability describes the tendency (in this instance, of a hydrofoil) to eventually return to its original condition after it experiences a disturbance that alters its

motion. A vehicle cannot be dynamically stable without also being statically stable; in other words, dynamic stability requires static stability.

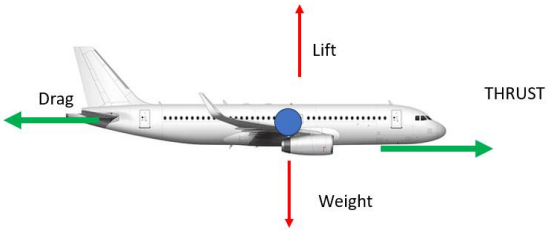
32. Petitioner's Expert, Dr. Brizzolara, does not clearly articulate these concepts for stability in his initial report, *see generally* EX 1002. However, in his deposition, Dr. Brizzolara states a definition of stability congruent with my understanding. He asserts that "[i]f the forces in moment will tend to restore the vehicle to the initial referenced equilibrium condition, then you say that it's stable, statically stable," and that with respect to dynamic stability, "you follow all the transient that will eventually, eventually bring you back to the initial equilibrium condition." Deposition of Dr. Brizzolara, EX2043, pp. 39-40.

33. Passive stability means that there will be an initial tendency (in this instance, of a hydrofoil) to return to its original condition after experiencing a disturbance and that it eventually returns to its original condition without any active mechanism to facilitate control. Without stability the vehicle will not only deviate from its original condition, but the deviations may grow with time – leading to an upset, a spin-out, or overturn in roll.

34. To illustrate these concepts, the following works through the three criteria (limited to the longitudinal plane for simplification), for considering stable, steady, level flight of an airplane.

35. For an airplane to be in equilibrium (*i.e.*, a steady or balanced state), the forces and torques must equal zero. With respect to force balance:

- LIFT = WEIGHT, *i.e.*, forces in the up-down direction are in equipoise.
- THRUST = DRAG, *i.e.*, forces in the fore-aft direction are in equipoise.

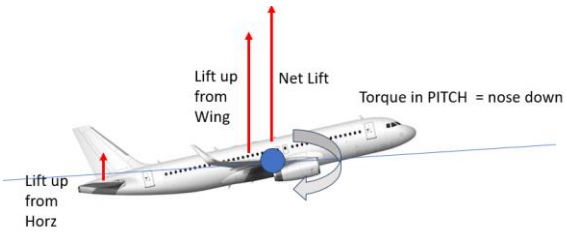



Additionally, the torques must also balance at the "undisturbed position." In other words, the torques pitching the aircraft nose-up or nose-down must also sum to zero.

36. It is not uncommon for the trailing horizontal tail to have a downward force ("lift down") at the equilibrium or trim point. That is to make sure that the torques sum up to zero under the following circumstances: if the main wing's center of lift is aft of the center-of-gravity, it produces a nose-down torque which needs to be opposed by the horizontal tail. To do so, the horizontal tail must be configured to lift down to make an equal and opposite nose-up torque. Together the torques cancel one another; hence, producing a "trimmed" equilibrium.

37. Next, we must consider what forces and moments are necessary to promote stable flight; that is to ensure an inherent resistance to disturbances. In

practice, longitudinal stability means that when the aircraft is disturbed to a nose-up attitude above and beyond the initial equilibrium, the aerodynamics must work (create restoring moments) to develop a nose-down torque. Sufficiently disturbed, the horizontal tail will be inclined to a positive angle of attack and will develop an upwards force (creating a nose-down torque) whether or not the center of lift from the wing at the equilibrium point was behind or coincident with the center-of-gravity. Either way it is the horizontal tail which develops the primary restoring torque.




38. Similarly, when disturbed to a nose-down attitude, the aerodynamics must develop a nose-up torque. Sufficiently disturbed, the horizontal tail will be inclined to a negative angle of attack and will develop a downwards force (creating a nose-up torque) whether or not the center of lift from the wing at the equilibrium point was behind or coincident with the center-of-gravity. It is the horizontal tail incidence (which changes as the airplane, as a whole, noses up or down) relative to the wind that controls its individual contribution to net lift and, hence, develops the restoring torque.

39. It is important to note, however, that in the above airplane examples, the wings, thrust, and center of gravity are all approximately in line with one another.

40. A famous example of instability is the "inverted pendulum" problem -- how to balance a top-heavy moving object. The '659 Patent realizes that a physical embodiment of fixed hydrofoil elements could statically stabilize such a system wherein, unlike the airplane, the center of gravity is well above the lifting (hydrofoil) elements.

41. For the purposes of this matter, it is useful to understand that all hydrofoils include submerged elements that develop hydrodynamic forces as a result of the vehicle's motion through water. Simple hydrofoil designs concentrate only on the need for the hydrofoil elements to generate forces in the vertical direction to oppose the weight of the rider in combination with the vehicle and elevate the flotation device above the water.

42. As mentioned previously, it is important to note that stability can include both static (*i.e.*, an initial tendency to return to its original condition – which may be satisfied with a general oscillatory motion about the original, equilibrium point) and dynamic stability (*i.e.*, it eventually returns to its original condition – any oscillations driven by a disturbance die down). Dynamic stability can only exist if a system is statically stable. Furthermore, it is also important to

note that a hydrofoil controllable by a human operator is not necessarily statically stable.

43. Given the "top heavy" nature of the hydrofoil vehicle described in the '659 Patent, the hydrofoil elements are configured to ensure that the vehicle is passively stable and controllable through weight shift. It is my opinion that it would not be obvious to a POSITA how to create such a passively stable and controllable device without an active control system.

**B. Research**

44. A POSITA if encouraged to perform independent research regarding watercraft design is likely to use academically focused search tool such as s*cholar.google.com, scopus.com or sciencedirect.com*. These search engines would lead a POSITA to discover documents intentionally published in a manner designed to be indexed. These include typical academic articles published by the major scientific printing houses (e.g., Elsevier) or by professional societies (e.g., American Society of Mechanical Engineers – ASME). Consumer publications are not typically indexed on scholarly search databases.

45. The above is consistent with numerous university libraries' guides regarding conducting engineering research. *See e.g.*, EX2035-EX2039. For example, a "Guide to Engineering Research" from Northern Arizona University states that "[e]ngineers share their research findings primarily through journal

articles and conference papers, but also through technical reports, patents, standards, websites, trade publications, and dissertations and theses." EX2037.

46. Designing a novel watercraft is a technical endeavor; accordingly, a POSITA would look to the types of sources I have outlined above. It is extremely unlikely that a POSITA would, when embarking on the technical process of designing a watercraft, look to a boating magazine such as Båtnytt that is (i) directed to a lay (consumer) audience, (ii) has a relatively small circulation (e.g., 104,000 readers at the relevant time frame in the case of Båtnytt), (iii) has a narrow geographic focus (e.g., Sweden, in the case of Båtnytt), and/or (iv) is not typically indexed in Google Scholar or similar academic search engines.

47. Even assuming the Båtnytt article was indexed and searchable, it does not include many of the key terms of art that a POSITA would have included in a search in looking to designing a novel personal watercraft, such as what is disclosed in the '659 Patent, at the relevant time. For example, some terms a POSITA might search for, including through the use of various terms and connectors to narrow the search, include, but are not limited to,: "control", "passive," "passive stability", "passively stable", "weight shift", "pitch", "pitching moment", "roll", "rolling moment", "yaw", "yawing moment", "trim", "lift", "restoring moment", "hydrofoil geometry", "hydrodynamic surface", "airfoil",

"twist", "spanwise twist", "sweep", and "electric hydrofoil". None of these terms appear in the Båtnytt article.

**VII. THE '659 PATENT**

48. The '659 Patent relates to powered personal hydrofoil watercraft that are controlled by the weight shift of a user. *See, e.g.*, EX1001, Col. 1, ln. 14-16. Generally, the watercraft described and illustrated in the '659 Patent has a surfboard-like flotation device, a strut that extends below the flotation device, and hydrofoil wing(s). *See, e.g.*, EX1001, Col. 3, ln. 7-14. The '659 Patent further describes the watercraft as powered by a propulsion system and battery-operated, electric motor. EX1001, Col. 3, ln. 7-14. In using the watercraft, a user initially lies prone (or face down) on the flotation device and engages the trigger on the hand-held throttle module, causing the watercraft to accelerate. As the craft gains speed, the user can move to a kneeling or standing position. EX1001, Col. 4, ln. 43-48.

49. Under operation, the vehicle as described in the '659 Patent will function where the hydrofoil elements elevate the floatation device completely clear of the water for a sustained period of time. During such operation, the movement of the user solely controls the device; for example, a user can control the altitude of the flotation device above the water by leaning back to gain altitude and leaning forward to lose altitude. EX1001, Col. 4, ln. 48-49. The craft is steered to the left or right through a user leaning in the appropriate direction. EX1001, Col.

4, ln. 50-51. The ‘659 Patent teaches that the shape or geometry of the hydrofoil provides stability without the need for the hydrofoil to have control systems including moveable control surfaces like the rudder, elevator or ailerons of an airplane. EX1001, Col. 2, ln. 7-12 and col. 6, ln. 7-11.

50. The teachings of the ‘659 Patent describe the construction of a passively stable self-propelled hydrofoil watercraft. These characteristics are desirable; and revealed as physically possible through the ‘659 Patent. While there are other devices, such as the Evolo device, that may look superficially similar, careful examination and attention to detail illustrate that these devices are designed and function in a very different manner.

51. The ‘659 Patent describes a system that demonstrates positive longitudinal (pitch) stability ($dCm/d\alpha < 0$); positive directional stability ($dCn/d\beta > 0$) and positive lateral-directional stability (a combination of $dCn/d\beta > 0$ and $dCl/d\beta < 0$). EX1001, Col. 6, ln. 63 – col. 7, ln. 5.

52. The ‘659 Patent passive stability teachings include three distinct things: (1) that forces balance at equilibrium; (2) that torques balance at equilibrium; and (3) that torques (restoring moments) create an initial tendency to return to its original condition when disturbed (static stability) and cause it to eventually return to that condition (dynamic stability).

## VIII. SCOPE/CONTENT OF PRIOR ART AND DIFFERENCES FROM CLAIMED INVENTION

### A. Evolo Report

53. The Evolo Report resulted from the graduate courses Lightweight Design and Marine Design at Kungliga Tekniska Högskolan ("KTH"). *See generally* EX1003. It additionally appears that the Evolo Report was drafted by different individuals and at different points in time. *See generally* EX1003. The structure of the Evolo Report makes it difficult to understand and interpret, in particular because of the range of technical specifications due to the numerous designs and prototypes that are discussed in the Evolo Report.

54. The Evolo Report describes the device as "a new type of watercraft that travels on a hydrofoil and is intended for one person. It is powered by an electric motor and is controlled only by means of center-of-gravity movement." EX1003, p. 546. The device described in the Evolo Report is self-propelled.

55. Dr. Brizzolara states that "EvoloReport discloses that both pitch stability and rolling stability are factors in the design of the EvoloReport hydrofoil." EX 1002, ¶38. Upon a closer inspection of the Evolo Report, it does not directly define positive stability in pitch or roll as a design requirement – the project goals are merely to "perform[] in a controlled manner … by means of center of gravity shift." EX 1003, p. 29.

2. Stability:

2.1. Be able to float and balance in a stationary position with the driver.
2.2. Performed in a controlled manner.
2.3. Controlled by means of center of gravity shift.

56. Thus, the Evolo Report does not disclose a watercraft that is passively stable in either pitch (longitudinal) or roll and yaw (lateral-directional). The Evolo Report asserts that the rationale for the leading wing planform is to increase the rolling mass moment inertia of the vehicle to improve "roll stability". EX1003, p. 96.

57. The Evolo Report further discusses that the "stability in the stomping direction" (*i.e.*, pitch or longitudinal mode) was allegedly to be remedied through their design, though the Evolo Report does not provide any evidence of this.

58. Rolling stability is mentioned only in passing in the Evolo Report, EX1003, p. 98, but does not mention any quantitative analytical criteria. In addition, the Evolo Report concedes that the rolling stability of their prototype was "insufficient", could not be remedied, and remained a "clear problem." EX1003, p. 142. Thus, neither by analysis nor application does the Evolo Report teach either the criteria or demonstrate a working embodiment which achieves static lateral/directional stability.

59. Further, the language of the Evolo Report implies a lack of an understanding of how to distinguish between a passively stable system and a human controllable but otherwise passively *unstable* system. A passive, statically

stable system will have an initial tendency to return to its original condition. A passively *unstable* system may prove controllable using some sort of active control system (e.g., through the use of moveable hydrodynamic control surfaces) or prove uncontrollable.

60. Because the center of gravity of the Evolo Report vehicle lies above its hydrodynamic surfaces, it cannot rely on any sort of pendulum stability to keep itself upright.

61. With respect to longitudinal stability, the Evolo Report indicates only a vague awareness of longitudinal stability. EX1003, p. 58-64. However, the Evolo Report states that their "analysis has not straightened out whether this [was a pitch stable] configuration." EX1003, p. 64

62. As the '659 Patent discloses, when a three-axis statically stable system is disturbed to attain a positive angle of attack above and beyond its equilibrium point, ($\alpha > \alpha_{trim}$) (*i.e.*, a nose-up disturbance), the slope of the pitching moment when $dCm/da < 0$ (negative) will cause an oscillatory motion to develop, where its frequency in radian/sec may be estimated by:

$$\omega_{SP} \approx \sqrt{\frac{-57.3\ dCm/d\alpha\ \bar{q}\ Sref\ c}{I_{yy}}}$$

$I_{yy}$ is the mass moment of inertia of the vehicle about its center of gravity in pitch. The faster the frequency, $\omega_{sp}$, the more "stable" the vehicle is. So long as it

oscillates about an equilibrium point, the vehicle will remain upright – even with inverted pendulum mass properties. Conversely, if $dCm/d\alpha > 0$ (positive), the frequency becomes an imaginary number; the watercraft will no longer oscillate but will only pitch up or down and overturn.

63. If a three-axis statically stable watercraft encounters an initial disturbance that gives it a positive sideslip angle ($\beta > 0$) (*i.e.*, a leftward disturbance), the aerodynamic rolling ($dCl/d\beta < 0$) and yawing ($dCn/d\beta>0$) moments due to sideslip will cause the right wing to rise and the nose will swing to the right. Oscillations will continue until aerodynamic damping cause the motion to die away; thus, satisfying positive dynamic stability.

64. The Dutch-Roll frequency in radians/sec may be estimated by:

$$\omega_{DR} \approx \sqrt{\frac{57.3\ C_{n\beta dynamic}\ \bar{q}\ Sref\ b}{I_{zz}}}$$

where $C_{n\beta dynamic} = \frac{dCn}{d\beta}\ cos(\alpha) - \frac{dCl}{d\beta} sin(\alpha) \left(\frac{Izz}{Ixx}\right)$. If $C_{n\beta dynamic}$ goes negative, the vehicle will not oscillate, instead will overturn. We can see that $C_{n\beta dynamic}$ is a function of both static directional stability ($dCn/d\beta$); and the dihedral effect ($dCl/d\beta$ ). $I_{zz}$ is the mass moment of inertia of the vehicle in yaw about its center of gravity. The faster the frequency, the more "stable" the vehicle is. Once again, so long as the system oscillates about an equilibrium point, the vehicle will remain upright – even with inverted pendulum mass properties. For such a system, the

designer would seek to increase $C_{n\beta dynamic}$ or reduce the mass moment of inertia in roll to improve stability.

65. If $C_{n\beta dynamic}$<0 the system is unstable. We would compute the level of instability of the system in terms of its "Time-to-Double" – how many seconds it takes for the effect of a disturbance to double in the absence of outside control. The smaller the value, the more unstable the system. Humans can control lightly unstable systems, where the time to double is on the order of several seconds or more. For the Dutch Roll mode, we estimate the time to double as:

$$\tau_{DR} \approx \sqrt{-\frac{I_{zz}}{57.3\left(C_{n_\beta}\right)_{dynamic}\bar{q}\,Sref\,b}}$$

66. Thus, we can see how the students at KTH drafting the Evolo Report tried to compensate for an overly unstable system rather than designing a statically stable system. By increasing the mass moment of inertia in roll, $I_{xx}$, they made $C_{n\beta dynamic}$ less negative (*i.e.*, closer to zero). As $C_{n\beta dynamic}$ approaches zero, the term under the square root in the time-to-double equation grows larger and the time-to-double rises from an uncontrollably short time period to one which a human pilot may be able to physically compensate for.

67. The Evolo Report indicates that the students had only vague understandings of combined roll/yaw motions (*see* EX1003, p. 143) by a lack of usage of the known term of art "Dutch Roll" (an understanding of which is

necessary to teach how to configure a vehicle with inverted pendulum mass properties to have positive lateral/directional stability). Thus, at no point did the KTH students recognize a need for static lateral-directional stability; this demonstrates a clear lack of insight.

**B. Evolo Videos**

68. The Petitioner relies on three separate videos, collectively referred to as "Evolo Videos". These videos include: Evolo prototype run (EX1006); Evolo movie (EX1008); and Torqeedo (EX1010) and appear to be videos of a boat similar to that described in the Evolo Report. The boat(s) (it is unclear if the boats in the two videos are the same crafts) in the Evolo prototype run (EX1006) and Evolo movie (EX1008) is uncontrollably unstable longitudinally in operation, in particular at the time where the hydrofoil struggles to elevate its hull above the water. The watercraft(s) clearly exhibits a porpoising motion and cannot be operated in hydrofoil mode for any extended period of time. EX1006 at 1:15-1:45. The commentary (in EX1008) states that the boat is "a handful to ride", which is a clear commentary on its exhilarating undulating (*i.e.*, unstable motions). EX1008 at 0:20. These videos do not show a stabilizable hydrofoil system, and in my opinion, it is uncontrollable as a hydrofoil for any period of time. Furthermore, I disagree with the Petitioner and Dr. Brizzolara that the watercraft shown in these

videos is stabilizable by the rider given how it porpoises when operating in hydrofoil mode.

### C. *Woolley* (U.S. Patent No. 6,234,856)

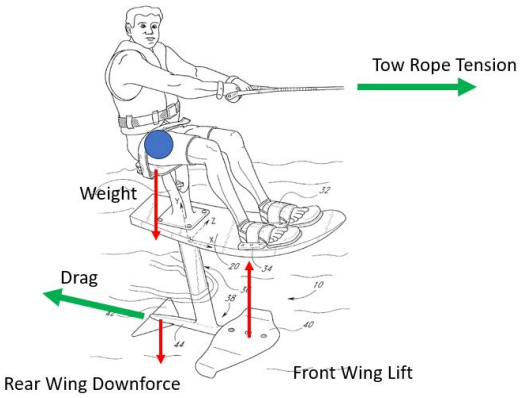
69. U.S. Patent No. 6,234,856 (hereinafter "Woolley") is titled "Flying Ski" and was filed on September 23, 1999 and issued on May 22, 2002. Woolley describes certain improvements to a flying ski, including a safety belt that secures the rider to the ski and supports a seated human rider while the rider and the device are towed behind a powered watercraft. EX1011, 1:31-37; 1:53-60. The flying ski of Woolley includes an elongate board and a seat that extends generally perpendicular to and upward from the board in order to support the seated rider. *Id.* at Abstract.

70. More specifically, Woolley describes a hydrofoil ski designed to be towed behind a boat. EX1011, Abstract; 1:10-20; 1:53-55; 2:48-51; 3:44-47; 4:4-8; Fig. 1. The rider of the flying ski of Woolley has limited control over the watercraft. As the Woolley ski is towed, it is the tow rope that defines the position of the ski, as the trajectory of the ski must always lie within an arc behind the towing watercraft. In other words, it is the tow rope and the powered boat towing the Woolley watercraft that function to primarily control the Woolley watercraft. Furthermore, since the rider's legs and feet are belted into the ski (see EX1011, 6:7-18; 8:48-9:12), there is only a limited ability for the rider to shift weight.

71. Dr. Brizzolara makes the following statements regarding Woolley: "Woolley discloses the ability to adjust the planform and angle of attack of the rear planing blade, based upon the level stability desired between a beginner through professional rider;" "Woolley discloses a front planing blade . . . which causes an upward lifting force on the forward blade;" and "Woolley discloses the use of the rear blade with a negative angle of attack, so that the rear blade creates a downward force on the rear blade. … The use of counteracting forces between the upward force caused by the forward blade of the hydrofoil and the downward force caused by the rear blade of hydrofoil is a well-known method for increasing pitch stability." EX 1002, ¶42-44.

72. It is apparent from these statements that Dr. Brizzolara confuses or conflates trim (an equilibrium position) with stability (the need to develop restoring torques when the watercraft is disturbed from its equilibrium).

73. The following again works through the conditions for equilibrium and passive stability, but this time with the Woolley device. We may draw the free-body-diagram as such:




74. For equilibrium to exist, the forces and moments must balance or sum to zero:

- Force Balance: The weight of the rider and the ski act downward upon the center of gravity. The net lift of the front wing and rear wing must equal the downward force of the weight of the rider and ski to place the forces in equipoise. Similarly, in steady operation, the tow rope tension must be in equipoise with the drag of the submerged structure.

- Torque Balance: The weight of the rider and ski act downward upon the center-of-gravity; together, they develop no torque. The tow rope tension acts above or near the center of gravity and causes a nose down torque. The drag force acts below the center of gravity and also makes a nose down torque. The front wing is forward of the center of gravity and lifts up; it makes an opposing nose up torque. The rear wing is aft of the center of gravity and lifts down; it also makes an opposing nose up torque. Thus, the nose up torque produced by the wings must be equal to the nose down torque caused by the tow rope and drag force.

75. Resistance to Disturbance: As to stability, Woolley does not explain stability in a recognizable manner. And, through his statement that Woolley's hydrofoil arrangement is a "well-known method for increasing pitch stability," Dr. Brizzolara apparently confuses or conflates equilibrium (trim) with stability. EX1002, ¶42. Dr. Brizzolara's assertion is also inconsistent with his later testimony where he discussed the distinction between the mechanisms to attain equilibrium from those needed to attain stability. EX2043, p. 26-28; 50-52.

76. If Woolley were to be longitudinally stable, it would need to account for the hydrofoil design criteria to develop, for example, an overall nose down torque when disturbed nose up. Woolley does not teach the importance of the positional relationship of the wings relative to the center of gravity, it only teaches that the rear wing should produce downward lift. Thus, Woolley is only describing a design feature that may aid in achieving equilibrium (*i.e.*, the "counteracting" forces of the wings together produce a nose up torque to oppose the nose down torques produced by the tow rope and drag force). Woolley does not describe any design criteria to make the overall system develop a sufficient nose down torque when disturbed in order to be statically stable. Therefore, in following Woolley, a POSITA is likely to design a watercraft where, when disturbed nose up, the increased lift of the front wing and decreased downward force from the rear wing

will both contribute to a net nose up torque. This is destabilizing and will result in the watercraft overturning.

77. In Woolley, to produce **equilibrium,** the downforce generated by the rear wing (causing a nose up torque) is needed to counteract the nose down torque imposed by the tow rope tension and drag, which cannot be opposed by the nose up torque generated by the front wing alone. In other words, the "counteracting forces" between Woolley's front and rear wings work together to generate a nose up torque to oppose the nose down torque of the tow rope and drag to aid in achieving equilibrium. However, whether or not Woolley can achieve equilibrium is not determinative of stability.

78. To achieve stability, restoring moments must be generated and Dr. Brizzolara's so-called "well-known" method does not speak to being able to produce such restoring moments. In fact, as a POSITA is aware, hydrofoils are not designed in a vacuum to achieve passive stability, other factors must be taken into consideration such as the design of the hydrofoil and the location of the center of gravity (relative to the tow rope and submerged hydrofoil elements), among other things. Woolley's specification does not teach a POSITA how to achieve stability, nor does it convey to a POSITA that the Woolley device is stable.

## IX. RESPONSE TO PETITION AND DR. BRIZZOLARA'S ALLEGATIONS THAT THE '659 PATENT IS OBVIOUS IN VIEW OF PATENTS/PUBLICATIONS

### A. Ground 1 – Evolo Report + Woolley.

79. Petitioner and Dr. Brizzolara assert that the Evolo Report in combination with Woolley renders obvious claims 1, 2, 4-5, 7-11, 13, and 15 of the '659 Patent. I disagree, at least for the reasons discussed below.

*i.* *Claim 1*

80. Claim 1 recites: A passively stable, weight-shift controlled personal hydrofoil watercraft, comprising:

- a flotation device that has a fore-aft length greater than a lateral width, the flotation device having a top surface and a bottom surface, wherein a user can be disposed on the top surface of the flotation device in a prone, kneeling, or standing position, the flotation device having a forward section, a middle section, and a rear section;
- a strut having a upper end and a lower end, the upper end fixedly interconnected with the flotation device between the middle section and the rear section of the flotation device;
- a hydrofoil fixedly interconnected with the lower end of the strut, the hydrofoil having no movable surface;

- a propulsion system for propelling the watercraft in a body of water, wherein the propulsion system is connected to the hydrofoil; and
- the watercraft having no movable steering system.

81. The Evolo Report and Woolley fail to teach or suggest the features of claim 1, nor is there a motivation to make the combination and reasonably expect to arrive at the claimed invention, at least for the reasons discussed herein.

*a. A passively stable, weight-shift controlled personal hydrofoil watercraft, comprising:*

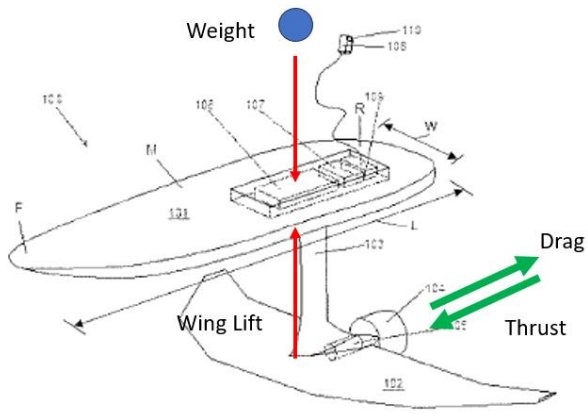
82. Petitioner and Dr. Brizzolara assert that the EvoloReport discloses a "a weight-shift controlled personal hydrofoil watercraft" and that "[t]he term 'stable' as used by the EvoloReport was being used to mean passive stability". EX1002, ¶37,39. Petitioner and Dr. Brizzolara further assert that "[a] POSITA would have been motivated to combine the EvoloReport with Woolley along with their knowledge in the art to provide for a passively stable hydrofoil." EX1002, ¶40.

83. I disagree with the assertions of Petitioner and Dr. Brizzolara with respect to these features. It is my opinion that the Evolo Report describes a vehicle which lacks passive stability. Based on my review of the Evolo Report, the students were unsuccessful in an attempt to design their watercraft to display positive pitch stability and also admitted that rolling stability remained an unsolved

problem. *See* EX1003, p. 142. Attempts were made by the Evolo students at the design stage to address longitudinal stability (*see* EX1003, p. 58-64), though the Evolo Report does not provide any evidence that they designed their hydrofoil to be stable; "this analysis has not straightened out whether this [was a pitch stable] configuration." EX1003, p. 64. Additionally, rolling stability remained an unsolved problem in their watercraft design. *See* EX1003, p. 142. Specifically, the Evolo Report indicated that factors that can affect the rolling stability were to be investigated at a later stage. *See* EX1003, p. 142. In view of the lack of both pitching and rolling stability in the Evolo design, the watercraft of Evolo cannot be said to be "passively stable".

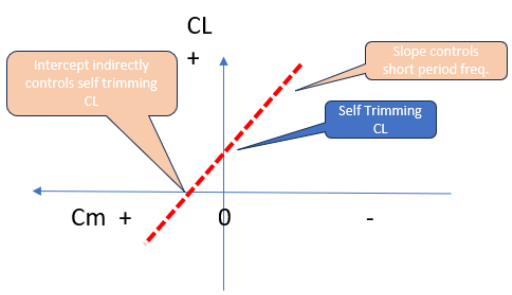
84. Contrary to the assertions of Petitioner and Dr. Brizzolara, a POSITA would not have been motivated to combine the EvoloReport with Woolley along with their knowledge in the art to provide for a passively stable hydrofoil. In my opinion, an insightful design is required to have hydrofoil elements: 1) generate forces in the vertical direction in order to oppose the weight of the rider and vehicle and elevate the flotation elements above the water, 2) provide stability and 3) be weight-shift controlled. This process cannot follow standard aircraft design guidelines because of the "top heavy" (*i.e.*, inverted pendulum) nature of the vehicle. Coming to such a problem, it would not have been obvious to me that such a design would be possible without an active control system.

85. Returning to the longitudinal (pitch) plane force and torque balance discussion, consider the ‘659 Patent teachings as to how to make a self-propelled watercraft stable.




86. The ‘659 Patent teaches that the system is to be designed so that the slope of the pitching moment ($dCm/d\alpha$) is negative at the equilibrium point. Because

*LIFT = WEIGHT = CL * (1/2) * density * forward_speed^2 * wing_area*, a stable equilibrium occurs at a positive *CL* (lift coefficient) value when *Cm*=0.




87. Returning to the sketch of the ‘659 Patent, the following works through the conditions for stable operation in the longitudinal plane. With a rider

on board, we may surmise that the center of gravity in hydrofoil operation is somewhere above the water (and the surface of the board).

88. Force Balance: The weight of the rider and the watercraft act downwards upon the center of gravity. At the equilibrium attitude, the wing(s) will generate lift. Lift must oppose weight and sum together to place the forces in equipoise. This weight carried in proportion to the square of the forward speed will define the wing lift-coefficient, *CL*.

89. Torque Balance: The weight of the rider and the watercraft is opposed by the lift of the wing element. Together, these opposing forces develop no torque. The drag force acts below the center of gravity and makes a nose down torque. In steady operation, the propulsive force must match the drag force; it will make a nose up torque which opposes the nose down torque from the drag force. Thus, the torques all sum to zero; Cm = 0 where CL has lift = weight.

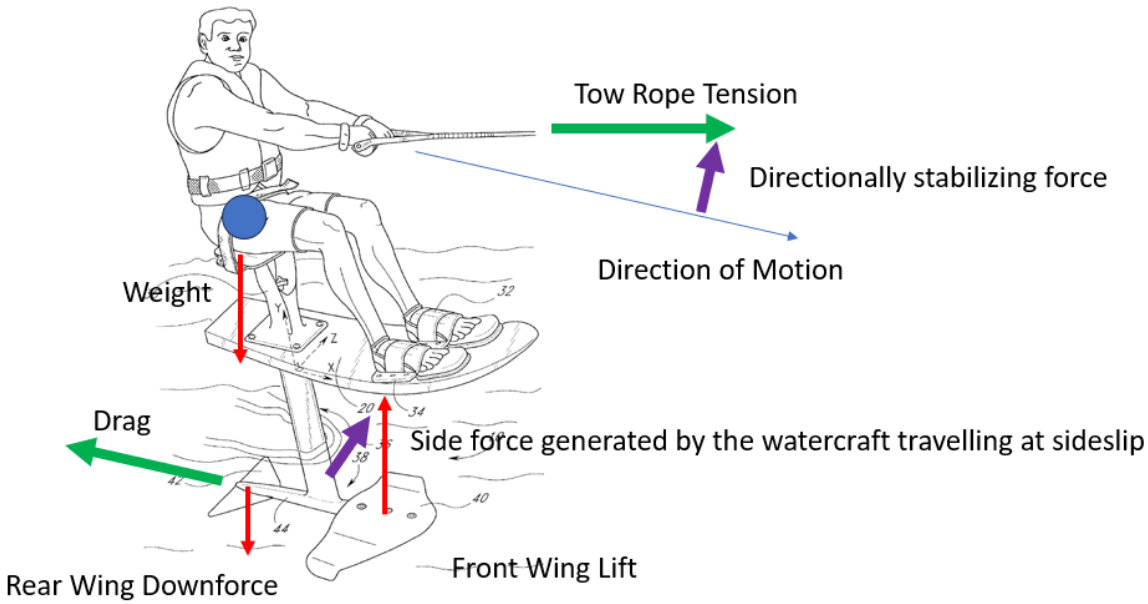
90. Resistance to Disturbance: The '659 patent teaches the lifting surface to be configured so that $dCm/da < 0$. This means that if the watercraft were to nose up above its equilibrium attitude, the center of lift would need to move aft to provide a restoring nose down torque. Similarly, if the watercraft were to nose down below the equilibrium attitude, the center of lift would need to move forward to provide a restoring nose up torque. The '659 patent teaches that a hydrofoil can exhibit these properties. Indeed, it is possible to configure a wing to have its center

of lift move aft with increasing incidence to develop positive zero-lift-moment and "self-trim." It is also possible to configure a series of wings (two or more) to have a similar propensity; there is no general requirement for this characteristic to require that the leading wing lift up and the trailing wing lift down.

91. The '659 Patent teaches that a single physical hydrodynamic configuration can be designed (without any active control mechanism) that exhibits the desired equivalent low order system characteristics (trim and positive stability about that equilibrium point) with the extreme inverted pendulum center of gravity position, operation over a range of speeds, and operation over a wide range of rider weights.

92. Further, it is my opinion that Woolley, as discussed above in paragraphs 69-78, does not teach longitudinal (pitch) stability or differentiate between the means to achieve a longitudinal equilibrium trim point and stability about that trim point, and, thus, fails to cure these deficiencies of the Evolo Report.

93. Dr. Brizzolara further states that "In addition to disclosing a hydrofoil that is stable in the longitudinal (pitch) plane, Woolley discloses a hydrofoil designed to be passively stable in the yaw and roll (lateral plane)." EX 1002, ¶43.




94. However, Woolley teaches the design of a towed system; refer to the revised free-body diagram above where the towed body has moved to the right of the towing boat. Let us consider the force and torque balances needed to make such a system passively stable in the lateral plane:

95. <u>Force Balance</u>: The weight of the rider and the ski act downward upon the center-of-gravity. The front wing' lift and rear wing's negative lift (downforce is negative lift) must sum together to oppose the downward force of the weight such that they are in equipoise. The cosine of the tow rope tension must be equipoise with the drag of the submerged structure. The sine of the tow rope tension (in the left-right plane) provides a directionally stabilizing force that (if

unopposed) will accelerate the watercraft to the left, bringing it back in line with the towing boat.

96. Torque Balance: The weight of the rider and the watercraft acts downwards upon the center of gravity; together, they develop no torque. The offset tow rope develops a side force acting near or above the center-of-gravity. Unopposed, this will act to overturn the towed body. If the watercraft envisioned in the Woolley patent does not overturn, the submerged strut must produce a side force which acts below the center of gravity in order to keep the rider upright; this force will be in the same direction as the side force developed by the offset tow rope. To develop this force, the towed body would need to sideslip (yaw) in the direction of the tow rope. However, the cause-and-effect and need to sideslip the ski in the direction of the towing boat is not otherwise described anywhere in the Woolley patent.

97. To cause this effect requires the rider to actively control the longitudinal and lateral position of the tow rope end with his/her hands – moving the crossing point of the vector of the tow rope to cause the appropriate sideslip to develop. Note from the drawings that the rider of the Woolley ski is expected to be belted onto the seat with feet located in restraining straps on the board; thus, any further ability to significantly control the hydrofoil through weight shift must be limited to upper body and/or arm movements.

98. Resistance to Disturbance: Woolley does not express "stability" in terms of either pitch, lateral or directional effects; instead, the patent leaves the wording very vague. As noted in the free-body-diagram force and moment diagram discussions, the Woolley patent does not disclose a passively lateral/directional watercraft as it does not link the tow rope geometry to the vertical blade element size and position. So long as the tow rope is taut and remains held by the rider, the Woolley watercraft must generally follow the path of the boat. However, absent active control, the ski is likely to "limit cycle oscillate" back and forth behind the tow boat and may well overturn.

99. In Woolley, Dr. Brizzolara further points to "a front planing blade containing a chorded upper surface that tapers towards the rear so that the upper surface has a larger surface area than the lower surface, which causes an upward lifting force on the forward blade" as well as "the use of the rear blade with a negative angle of attack, so that the rear blade creates a downward force on the rear blade". Dr. Brizzolara then concludes that "[t]he use of counteracting forces between the upward force caused by the forward blade of the hydrofoil and the downward force caused by the rear blade of hydrofoil is a well-known method for increasing pitch stability by a POSITA." *See* EX1002, ¶¶41-42.

100. While I agree with Dr. Brizzolara that Woolley discloses a front planing blade configured to produce an upward lifting force and a rear planing

blade configured to produce a downward force, I disagree with Dr. Brizzolara's statement that this is "a well-known method for increasing pitch stability." Instead, as described above in paragraphs 69-78, Woolley's configuration of the front planing blade and the rear planing blade only produces a nose up torque to aid in possibly achieving equilibrium; it does not imply either stability or instability.

101. In the watercraft described in Woolley, the tow rope near or above the center of gravity and drag of the submerged structure below the center of gravity produces a nose down torque when the watercraft is in operation; refer to prior discussion in paragraphs 69-78. This nose down torque is counteracted by having the front hydrofoil wing (positioned ahead of the center-of-gravity) lift while the rear hydrofoil wing (positioned behind the center-of-gravity) produces negative lift, which together provide a nose up torque. The specification of Woolley describes the need to adjust "shims" to orient the front hydrofoil wing relative to the rear hydrofoil wing for differing riders. *See, e.g.*, EX1011, Col. 18, lines 23-41; Col. 19, lines 1-6 and 31-36.

102. Additionally, the sole propulsive force is transmitted via a taut tow rope that is actively held (*i.e.*, controlled) by the rider. It is critical to note that the tow rope is not passively affixed to any one position. The rider actively controls the vertical and lateral position of the tow rope to aid in balancing the watercraft as it is towed at varying speeds. For example, if the tow rope is lifted in the vertical

direction above the center of gravity, it will cause the watercraft to nose down; if the tow rope is lowered below the center of gravity, it will cause the watercraft to nose up. In this way, the presence of the controllable, taut tow rope significantly contributes to any active stability of the watercraft described in Woolley.

103. The watercraft of the Evolo Report, on the other hand, differs from that of the watercraft described in Woolley, in the positioning of the propulsive force relative to its center-of-gravity. For example, instead of utilizing a tow rope as in the case of the watercraft described in Woolley, the watercraft of the Evolo Report utilizes an electric motor having a flange that is bolted to the hydrofoil (*see* EX1003, p. 370), and therefore the positioning of the propulsive force differs significantly between the watercraft of the Evolo Report and the watercraft described in Woolley.

104. The hydrofoil elements of Woolley are configured based on the positioning of the propulsive force (i.e., the tow rope) relative to its center-of-gravity (including vertical, fore-aft, and lateral positions) permissible by the sitting, belted in rider. Based on the hydrofoil elements of Woolley being sized and positioned in view of such considerations, and even assuming Woolley is stable (which it is not), it would have been unworkable to combine the hydrofoil elements of Woolley with the watercraft of the Evolo Report.

105. The propulsive force of Woolley is near or above the center of gravity; this produces a nose down torque. The propulsive force in the watercraft depicted in the Evolo Report is positioned far below the center-of-gravity; this produces a nose up torque. Therefore, because Woolley's hydrofoil arrangement is configured to generate a nose up torque, adding it to the Evolo Report craft would result in increasing the nose up torque. Thus, it cannot even be said that an Evolo Report/Woolley craft combination would achieve equilibrium, let alone stability.

106. Additionally, there is nothing in the references that teach or disclose how one would counteract the destabilizing nature of the combination and, thus, nothing that discloses that such a combination would provide a restoring moment if the craft were disturbed from any sort of equilibrium. Using the hydrofoil elements of Woolley that are configured based on the positioning of the propulsive force near or above the center-of-gravity with the watercraft depicted in the Evolo Report would result in a longitudinally unstable and lateral/directionally unstable hydrofoil and would not yield "[a] passively stable, weight-shift controlled personal hydrofoil watercraft".

107. Further, it is my opinion that in light of the destabilizing effects that would result from combining the Evolo Report watercraft with the hydrofoil of Woolley (and the lack of any teaching in the references as to how to overcome such effects), a POSITA would not be motivated to make the combination (nor

would they reasonably expect success in arriving at the claimed invention) but would instead be led to use some sort of active control system (*e.g.*, through the use of moveable hydrodynamic control surfaces) in an attempt to stabilize the craft.

108. Dr. Brizzolara further states that, "To the extent that the disclosed hydrofoil in Woolley could be found to not be designed to provide passive static stability, a POSITA would have sufficient knowledge to modify the disclosed hydrofoil in Woolley such that it would be designed to provide passive static stability." *See* EX1002, ¶47.

109. I disagree with this assertion of Dr. Brizzolara. It is my opinion that it would not have been obvious to a POSITA how to modify the hydrofoil of Woolley to provide passive static stability, particularly in view of the top heavy mass properties of the watercraft described in the Evolo Report and the significant difference in locations of the thrust lines of Woolley and the Evolo Report (*i.e.*, the thrust line in Woolley being near or above the center-of-gravity and the thrust line disclosed in the Evolo Report being well below the center-of-gravity).

110. The combination of the Evolo Report and Woolley also fails to teach or suggest "[a] passively stable, weight-shift controlled personal hydrofoil watercraft". A watercraft controlled by weight shift of a user is reliant either upon its inherent positive stability or its instability being cured through some sort of active control system (*e.g.*, a movable hydrodynamic control surface). Since the

watercraft described in the Evolo Report is not "passively stable" for the reasons discussed above and its instability does not appear to be able to be cured through some sort of active control system over any sustained period of time, I conclude that the watercraft described in the Evolo Report is fundamentally uncontrollable during hydrofoil operation. Further, as discussed above, to the extent Woolley is able to provide stability, the tow rope would be a significant contributing factor. Accordingly, the combination of the Evolo Report and Woolley does not teach or suggest "[a] passively stable, weight-shift controlled personal hydrofoil watercraft".

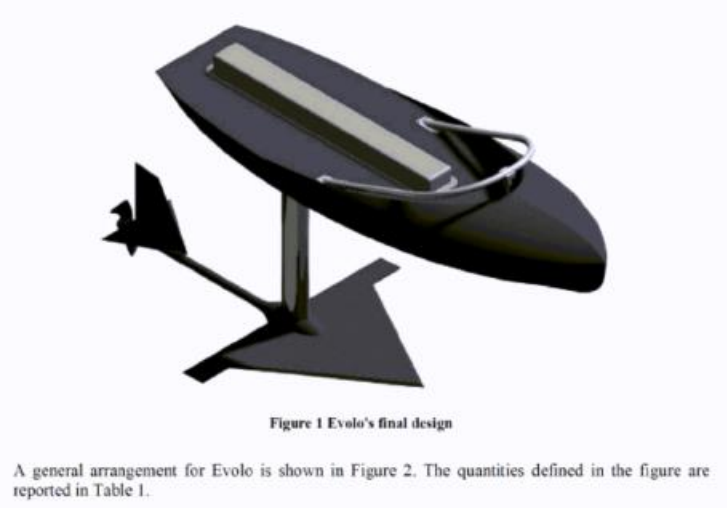
111. Based my conclusion that the watercraft described in the Evolo Report is not "passively stable" and is uncontrollable during hydrofoil operation. At least for these reasons, the combination of the Evolo Report and Woolley does not teach or suggest "[a] passively stable, weight-shift controlled personal hydrofoil watercraft".

*ii. Claim 8*

112. Claim 8 requires "wherein the battery and motor speed controller are contained in a water-tight compartment integrated into the flotation device." EX1001, Col. 8, ln. 4-6. It is my understanding that a dependent claim, such as claim 8, includes all the elements of the independent claim from which it depends (in this instance, claims 2 and 1). Petitioner admits that the Evolo Report does not

explicitly teach a motor speed controller being contained in a waterproof container integrated into the floatation device. Petition, p. 41. Petitioner argues that Evolo's use of a Torqeedo commercial-off-the-shelf (COTS) system renders these sorts of features obvious, but then contradicts itself when it suggests that such systems need to be "modified to work on Evolo." Petition, p. 41.

113. The portions of the Evolo Report to which Petitioner points regarding disposition of the battery do not mention anything about the waterproof compartment being *integrated into the flotation device*. Rather, the portions of the Evolo Report merely state that the "floating body should also have room for batteries". EX1003, p. 550. There is no teaching in the Evolo Report that the compartment be *integrated into the floatation device*. In fact, in some images of the Evolo device (an example of which is reproduced herein), the compartment referenced by Petitioner is disposed on top of the craft. *See* EX1003, p. 3.




114. For at least the reasons outlined above (and with reference to claim 1), a POSITA would not be motivated to combine the Evolo Report with Woolley, nor do I believe a POSITA have a reasonable expectation of achieving the claimed

invention with such combination. Accordingly, it is my opinion that the Evolo Report in combination with Woolley does not teach or suggest claim 8.

*iii.* *Claim 11*

115. Claim 11 requires the personal hydrofoil watercraft to additionally include "a wireless handheld controller having a transmitter, and a throttle interface having a receiver, wherein the transmitter is adapted to send wireless signals to the receiver that cause an output of the propulsion system to change." EX1001, col. 8, ln. 14-19. The Evolo Report describes a watercraft where the kneeling user *must* hold on to handles to achieve weight balance. EX1003, p. 550. While Evolo' s "throttle" and "deadman" switch may or may not require wired connections to the motor/controller and propeller assembly, the presence of hand grips describes functionality similar to a motorcycle (with handlebar operated controls). The '659 patent describes a vehicle where the users hands do not grip a handlebar at all. It would not be obvious to incorporate a handheld throttle, as an operator needs to grip the handle in the Evolo design to retain balance and keep from being ejected from the vehicle.

116. It is my understanding that a dependent claim, such as claim 11, includes all the elements of the independent claim from which it depends (in this instance, claims 8, 2, and 1). For at least the reasons outlined above, a POSITA would not be motivated to combine the Evolo Report with Woolley, nor would a

POSITA have a reasonable expectation of achieving the claimed invention with such combination. Accordingly, it is my opinion that the Evolo Report in combination with Woolley does not teach or suggest claim 11

*iv.* *Claims 2, 4-5, 7, 9, 10, 13, and 15*

117. It is my understanding that a dependent claim, such as each of claims 2, 4-5, 7, 9, 10, 13, and 15 includes all the elements of the independent claim from which it depends (in this instance, claim 1). Accordingly, for at least the reasons outlined above with respect to claim 1, neither the Evolo Report nor Woolley alone, or in combination teach the claimed elements. Nor would a POSITA be motivated to combine the Evolo Report with Woolley and have a reasonable expectation of achieving the claimed invention with such combination.

**B.Ground 2 – Evolo Videos + Woolley.**

118. Petitioner and Dr. Stefano Brizzolara assert that the Evolo Videos in combination with Woolley renders obvious claims 1, 4-5, 7, and 15 of the '659 Patent. I disagree, at least for the reasons discussed below.

*i.* *Claim 1*

119. The Evolo Videos and Woolley fail to teach or suggest the features of claim 1, nor is there a motivation to make the combination and reasonably expect to arrive at the claimed invention, at least for the reasons discussed below.

*a. A passively stable, weight-shift controlled personal hydrofoil watercraft, comprising:*

120. Petitioner and Dr. Brizzolara assert that "[a] POSITA would have been motivated to combine the watercraft disclosed in the EvoloVideos with Woolley to provide for a passively stable hydrofoil". Petition, p. 53.

121. I disagree with the assertions of Petitioner and Dr. Brizzolara with respect to these features. It is my opinion that the Evolo Videos depict a vehicle which is not "passively stable." Based on my review of the Evolo Videos, the watercraft depicted therein is not passively stable when operating as a hydrofoil. In the Evolo Videos, the watercraft depicted therein is not passively stable, lacking both pitching stability and rolling stability when operating as a hydrofoil. I further note that the watercraft lunges and plunges into and out of the water, despite the apparent efforts of the rider to stabilize it. *See, e.g.*, EX1006, from 1:15 to 1:45.

122. The screen captures below are taken from one of the Evolo Videos, namely, EX1006, at 1:42 and 1:43, respectively. In these two screen captures, I note that the watercraft is porpoising in calm waters, despite the rider's apparent attempt to use weight shift to stabilize and control the watercraft. In view of this porpoising, the watercraft of the Evolo Videos cannot be said to be "passively stable" or "weight-shift controlled".

0:01:42
0:00:41
EX1006-EvoloPrototypeRun

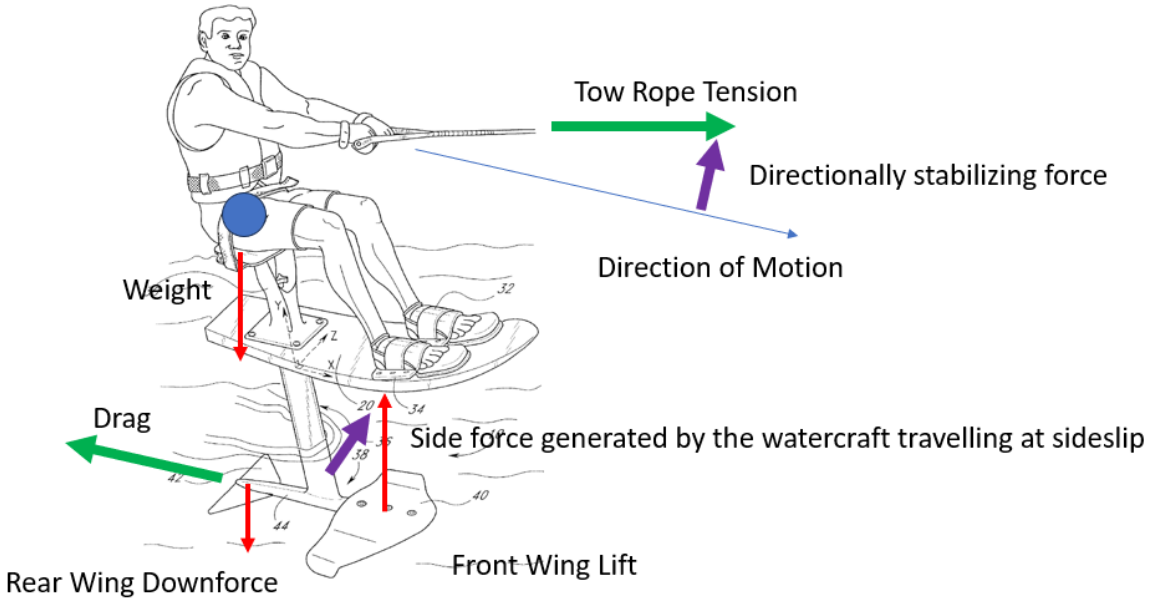
0:01:43
0:00:40
EX1006-EvoloPrototypeRun

123. Furthermore, it is my opinion that the Evolo Videos would have lead a POSITA to use some sort of active control system (e.g., through the use of moveable hydrodynamic control surfaces) in an attempt to stabilize the craft.

124. Contrary to the assertions of Petitioner and Dr. Brizzolara, and for all the reasons set for the above in paragraphs 82-112, a POSITA would not have been "motivated to combine the watercraft disclosed in the EvoloVideos with Woolley to provide for a passively stable hydrofoil". EX1002, ¶100. In my opinion, an insightful design is required to design the hydrofoil elements to: 1) generate forces in the vertical direction in order to oppose the weight of the rider and vehicle and elevate the flotation elements above the water, 2) provide stability and 3) be weight-shift controlled. This process cannot follow standard aircraft design guidelines because of the "top heavy" nature of the vehicle. Coming to such a problem, it would not have been obvious to a POSITA that such a design would be possible without an active control system.

125. It is my opinion that Woolley fails to cure these deficiencies of the Evolo Videos. As discussed above in paragraphs 69-78, Woolley does not teach longitudinal (pitch) stability or differentiate between the means to achieve a longitudinal equilibrium trim point and stability about that trim point.

126. Dr. Brizzolara further states that "In addition to disclosing a hydrofoil that is stable in the longitudinal (pitch) plane, Woolley discloses a hydrofoil designed to be passively stable in the yaw and roll (lateral plane)." EX1002, ¶43.




127. However, Woolley teaches the design of a towed system; refer to the revised free-body diagram above where the towed body has moved to the right of the towing boat. The force and torque balances needed to make such a system passively stable are discussed above in paragraphs 94-98.

128. Furthermore, as discussed above, Woolley's configuration of a front planing blade and a rear planing blade only produces a nose-up torque; it does not imply either stability or instability.

129. In the watercraft described in Woolley, the tow rope near or above the center of gravity and drag of the submerged structure below the center of gravity produces a nose down torque when the watercraft is in operation; refer to prior discussion in paragraphs 69-78; 103-109. This nose down torque is counteracted by having the front hydrofoil wing (positioned ahead of the center-of-gravity) lift while the rear hydrofoil wing (positioned behind the center-of-gravity) produces negative lift, which together provide a nose up torque. The specification of Woolley describes the need to adjust "shims" to orient the front hydrofoil wing relative to the rear hydrofoil wing for differing riders. *See, e.g.*, EX1011, Col. 18, lines 23-41; Col. 19, lines 1-6 and 31-36. The rider actively controls the position of the tow rope to balance the watercraft as it is towed at varying speeds. In this way, the manner that the rider manipulates the handles to the tow rope significantly contributes to any stability of the watercraft described in Woolley.

130. The watercraft of the Evolo Videos, on the other hand, differs from that of the watercraft described in Woolley, in the positioning of the propulsive force relative to its center-of-gravity. For example, instead of utilizing a tow rope as in the case of the watercraft described in Woolley, the watercraft of the Evolo Videos utilizes an electric motor having a flange that is bolted to the hydrofoil (*see* EX1010, 0:23 to 0:28), and therefore the positioning of the propulsive force differs

significantly between the watercraft of the Evolo Videos and the watercraft described in Woolley.

131. In Woolley, the sole propulsive force is transmitted via a taut tow rope that is held (*i.e.*, controlled) by the rider. It is critical to note that the tow rope is not passively affixed to any one position. The vertical and lateral position of the tow rope is actively controlled by the rider to aid in balancing the watercraft as it is towed at varying speeds. For example, if the tow rope is lifted in the vertical direction above the center of gravity, it will cause the watercraft to nose down; if the tow rope is lowered below the center of gravity, it will cause the watercraft to nose up. In this way, the presence of the controllable, taut tow rope significantly contributes to any active stability of the watercraft described in Woolley.

132. The hydrofoil elements of Woolley are configured based on the positioning of the propulsive force (i.e., the tow rope) relative to its center-of-gravity (including vertical, fore-aft, and lateral positions) permissible by the sitting, belted in rider. Based on the hydrofoil elements of Woolley being sized and positioned in view of such considerations, it would have been unworkable to combine the hydrofoil elements of Woolley with the watercraft of the Evolo Videos.

133. The propulsive force in the watercraft depicted in the Evolo Videos is positioned far below the center-of-gravity; it will cause the watercraft to nose up.

Accordingly, using the hydrofoil elements of Woolley that are configured based on the positioning of the propulsive force near the center-of-gravity with the watercraft depicted in the Evolo Videos would be unworkable. Because Woolley's hydrofoil arrangement is configured to generate a nose up torque, adding it to the Evolo Videos craft would result in increasing the nose up torque. Thus, it cannot even be said that an Evolo Videos/Woolley craft combination would achieve equilibrium, let alone stability. A POSITA would not be motivated to make the combination (nor would they reasonably expect success in arriving at the claimed invention) because such a combination would be expected to result in a lateral/directionally unstable and longitudinally unstable hydrofoil and would not yield the claimed "passively stable, weight-shift controlled personal hydrofoil watercraft".

134. The combination of the Evolo Videos and Woolley also fails to teach or suggest "weight-shift control[]". Controllability by weight shift of a user over a period of time is reliant upon its inherent positive static stability or its instability being cured through some sort of active control system (e.g., a movable hydrodynamic control surface). Since the watercraft depicted in the Evolo Videos is not "passively stable" for the reasons discussed above and its instability does not appear to be able to be cured through some sort of active control system over any sustained period of time, I conclude that the watercraft depicted in the Evolo

Videos is fundamentally uncontrollable during hydrofoil operation. Accordingly, the combination of the Evolo Videos and Woolley does not teach or suggest "[a] passively stable, weight-shift controlled personal hydrofoil watercraft".

135. Based my conclusion that the watercraft depicted in the Evolo Videos lacks passive stability and is uncontrollable during hydrofoil operation, I conclude that the hydrofoil of the watercraft described in the Evolo Report is not "[a] passively stable, weight-shift controlled personal hydrofoil watercraft".

*ii. Claims 4-5, 7, and 15*

136. It is my understanding that a dependent claim, such as each of claims 4-5, 7, and 15, includes all the elements of the independent claim from which it depends (in this instance, claim 1). Accordingly, for at least the reasons outlined above with respect to claim 1, neither the Evolo Videos nor Woolley alone, or in combination teach the claimed elements. Nor would a POSITA be motivated to combine the Evolo Videos with Woolley and have a reasonable expectation of achieving the claimed invention with such combination.

**C. Ground 3 – Evolo Videos + Woolley + Torqeedo Manual.**

137. Ground 3 asserts dependent claims 2, 9 and 10. The Petitioner alleges that the combination of the Evolo Videos, Woolley, and Torqeedo Manual renders these claims obvious.

*i. Claim 10*

138. Claim 10 requires "wherein the electric motor is integrated into a waterproof, streamlined pod and the watercraft comprises a cooling system for cooling the electric motor." EX1001, Col. 8, ln. 12-14. Petitioner and Dr. Brizzolara summarily conclude that the Evolo Torqueedo Video (EX1010) "depicts installation of the Torqueedo motor into a streamlined pod". Petition, p. 81. The specification of the '659 Patent describes the streamlined pod as "perform[ing] two main structural functions: it transmits propulsion forces to the strut 103 and it transmits lift forces from the hydrofoil 102 to the strut 103. It may also contain provisions for cooling the electric motor 105." EX1001, Col. 4, ln. 63-67. There is no teaching (or suggestion) of a streamlined pod as described in the '659 Patent in this video.

139. Accordingly, it is my opinion that the Evolo Videos in combination with Woolley and the Torqueedo Manual do not teach or suggest claim 10. Further, for at least the reasons outlined above (and with reference to claim 1), a POSITA would not be motivated to combine the Evolo Report with Woolley, nor would a POSITA have a reasonable expectation of achieving the claimed invention with such combination.

*ii. Claims 2 and 9*

140. It is my understanding that a dependent claim, such as each of claims 2 and 9, includes all the elements of the independent claim from which it depends. Accordingly, for at least the reasons outlined above with respect to claim 1, the Evolo Videos, Woolley, and Torqeedo Manual alone, or in combination, do not teach the claimed elements. Nor would a POSITA be motivated to combine the Evolo Videos with Woolley and Torqeedo Manual and have a reasonable expectation of achieving the claimed invention with such combination.

**D. Ground 4 – Evolo Videos + Woolley + Torqeedo Manual + Gleason.**

141. Ground 4 asserts only dependent claim 8. The Petitioner alleges that the combination of the Evolo Videos, Woolley, Torqeedo Manual, and Gleason renders claim 8 obvious. Claim 8 requires "wherein the battery and motor speed controller are contained in a water-tight compartment integrated into the flotation device." 'EX1001, Col. 8, ln. 4-6. It is my understanding that a dependent claim, such as claim 8, includes all the elements of the independent claim from which it depends. Accordingly, it is my opinion that the Evolo Videos in combination with Woolley, the Torqueedo Manual, and Gleason do not teach or suggest claim 8. Further, for at least the reasons outlined above (and with reference to claim 1), a POSITA would not be motivated to combine the Evolo Videos with Woolley, nor

would a POSITA have a reasonable expectation of achieving the claimed invention with such combination.

### E. Ground 5 – Evolo Videos + Woolley + Torqeedo Manual + Gleason + Manning

142. Ground 5 asserts dependent claims 11 and 13. The Petitioner alleges that the combination of the Evolo Videos, Woolley, Torqeedo Manual, Gleason, and Manning renders claims 11 and 13 obvious.

#### *i. Claim 11*

143. Claim 11 requires the personal hydrofoil watercraft to additionally include "a wireless handheld controller having a transmitter, and a throttle interface having a receiver, wherein the transmitter is adapted to send wireless signals to the receiver that cause an output of the propulsion system to change." EX1001, Col. 8, ln. 15-19. Petitioner alleges that a POSITA would combine wireless handheld control of Manning with the device of the Evolo Videos. Petition, p. 81-84. Petitioner further elaborates that Evolo Videos show "a handle mounted throttle […that], the user must constantly grip the handle at the specific location of the throttle [… and] [b]y removing this limitation, a user would be able to grip the handles in whatever location is most comfortable and offers the most support and control." Petition., p. 83. It is my opinion that if an operator were to remove their hand(s) from the handles of the device of the Evolo Video in order to

use a wireless handheld controller as claimed, it would be nearly impossible for a user to pilot the device and remain onboard. Accordingly, it is my opinion that the Evolo Videos in combination with Woolley, the Torqeedo Manual, Gleason, and Manning do not teach or suggest claim 11. Further, for at least the reasons outlined above, a POSITA would not be motivated to combine the Evolo Videos with Woolley, nor would a POSITA have a reasonable expectation of achieving the claimed invention with such combination.

*ii. Claim 13*

144. Claim 13 recites "wherein the strut has an internal passage and electrical wires extend from the electric motor to the watertight compartment inside the strut through the internal passage for controlling the electric motor." EX1001, Col. 8, ln. 23-27.

145. Petitioner alleges that the Evolo Video EX1010 teaches that "a strut having an internal passage and electrical wires extending from the electric motor to the waterproof compartment inside the strut through the internal passage for controlling the electric motor". Petition, p. 84. All the Evolo Video EX1010 demonstrates is that wires extend out of an end of a cylindrical rod that Petitioner alleges is the strut. There is no evidence in the Evolo Videos that the opposing end of these wires connect to or control the electric motor. Petitioner has also not

shown that the cylindrical rod in EX1010 it refers to as the strut is the same strut of the EX1006 video.

146. Accordingly, it is my opinion that the Evolo Videos in combination with Woolley, the Torqeedo Manual, Gleason, and Manning do not teach or suggest claim 13. Further, for at least the reasons outlined above, a POSITA would not be motivated to combine the Evolo Videos with Woolley, nor would a POSITA have a reasonable expectation of achieving the claimed invention with such combination.

## X. SECONDARY CONSIDERATIONS

147. I have been informed by counsel that there are what is referred to as secondary considerations of non-obviousness; these considerations include: evidence of copying; commercial success; articles, awards, and other public statements praising the claimed invention's merits; failure of others; and others taking licenses. I have considered these secondary considerations and discuss them below.

148. **Nexus.** I understand that there must be a nexus between the secondary consideration and the claimed invention's novel features for the secondary consideration to have probative value. I have reviewed the tables that Professor Langelaan put together showing that each portion of claim 1 is found in MHL's commercial embodiments (*e.g.*, the LIFT3 eFoil). I agree with Dr.

Langelaan's analysis that the MHL products, specifically the LIFT3 eFoil, includes each limitation of claim 1.

149. **Evidence of Copying.** I understand that the Waydoo Flyer, Flyer One, and Flyer One Plus were found to willfully infringe the '659 Patent by a jury. *See MHL Custom, Inc. v. Waydoo USA, Inc., et al.* (D. Del. 1:21-cv-00091), DN 220. I also understand that Foil Boarding Company, Inc. (Petitioner in this matter) has also been accused of infringement. *See MHL Custom, Inc. v. Foil Boarding Company, Inc.* (N.D. Fla. 3:22-cv-21258). Further, I am aware of others entering the market, including Avante, which was accused of infringement of the '659 Patent and settled. Therefore, the secondary consideration of evidence of copying supports my opinions concerning non-obviousness.

150. **Commercial Success.** It is my understanding that the commercial success of MHL's Lift eFoil Products is due to their use of the novel features, including at least passive static stability, outlined in the '659 Patent. This is evidenced by numerous YouTube videos of the Lift eFoils (MHL's commercial embodiment) that show smooth riding by adult riders of varying sizes in real world conditions. The statically stable and controllable system of the Lift eFoil is the reason for the product's success. Without this static stability, the Lift eFoil would not be easily ridable, and accordingly not successful in the marketplace. Therefore,

the secondary consideration of commercial success supports my opinions concerning non-obviousness.

151. **Public Statements of Praise and Peer Recognition.** There have been several written articles discussing and praising MHL's Lift products. MHL YouTube Channel, https://www.youtube.com/c/LiftFoils; EX2012-EX2022. In these articles, and elsewhere, MHL's eFoils have received extensive industry praise, including for their being easy to ride. Therefore, the secondary consideration of public statements of praise and peer recognition supports my opinions concerning non-obviousness.

152. **Failure of Others.** To the extent that the Petitioner alleges that the Evolo Report sought to teach a passively stable watercraft with various claimed features of the '659 Patent, the Evolo Report is evidence of the failure of others. The Evolo videos (EX1006, EX1008) show an uncontrollable porpoising watercraft which at any moment could have upset its rider into the water. In contrast, the Lift eFoil YouTube videos show smooth riding by adult riders of varying sizes in real world conditions. Therefore, the secondary consideration of failure of others supports my opinions concerning non-obviousness.

## XI. SUPPLEMENTATION

153. I reserve the right to supplement this report based on additional information that becomes available to me and/or in response to any reports submitted on behalf of Foil Boarding Company, Inc.

I declare under penalty of perjury that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both (18 U.S.C. § 1001).

Dated: September 16 2024

Timothy Takahashi, PhD

# EXHIBIT 1

# Timothy Takahashi

Professor of Practice - Aerospace Engineering
School for Engineering of Matter, Transport and Energy
Arizona State University, PO Box 876106, Tempe, AZ 85287
https://labs.engineering.asu.edu/aircraft-design/

## Education

**Santa Clara University School of Law, Santa Clara, CA**
J.D. in Law — May 2013
Certificate in High-Tech Law – with Honors
Thesis: "Drones and Privacy"

**University of Rochester, Rochester, NY**
PhD in Mechanical and Aerospace Sciences — October 1993
Thesis: "Flow Beneath a Spinning Disk"
M.S. in Mechanical and Aerospace Sciences — October 1990
B.S. with Distinction in Mechanical Engineering — May 1988
Tau Beta Pi
Phi Beta Kappa

## Professional Experience

Aug. 2012 – May 2024 **Professor of Practice - Aerospace Engineering**
40 hrs/wk acad yr Arizona State University, Tempe, AZ

A teaching focused appointment for advanced undergraduate and graduation aeronautics curriculum. I supervise undergraduate and graduate student research in aeronautical design, including take-off and landing performance, structural design, propulsion (including some subsonic wind tunnel testing) and aerodynamic design (including some subsonic wind tunnel testing). I advise several student organizations, including the AIAA Design Build Fly team.

- MAE 564 – Advanced Aerodynamics (F2013, F2014, F2015, F2016, F2018, F2019, F2020,F2021,F2022,F2023)
- AEE/MAE 468 – Aerospace Systems Design – The Senior Capstone Design Class (F2012,S2013,F2013,S2014,F2014,S2015,F2015,S2016,F2016,S2017,F2017,S2018,F2018, S2019,F2019, S2020,F2020,S2021,F2021,S2022,F2022,S2023,F2023,S2024)
- MAE 400 – Engineering Profession (F2012,S2013,S2014,Sum2014,Sum2015,F2015,Sum 2016, F2016, Sum2017,F2017,S2018,Sum2018,F2018,S2019,F2019,S2020,Sum2020,F2020,S2021, Sum2021,F2021,S2022,F2022,S2023,F2023,S2024)
- MAE 394 – Special Topics: Aeronautics in England (Sum2014, Sum2015, Sum2016, Sum2017,Sum2018)
- MAE 374 – Fluid Mechanics for Mechanical Engineers (S2016,S2017)
- AEE 344 – Fundamentals of Aircraft Design – Performance & Sizing (S2015, S2016,S2017,S2018, S2019,S2020,S2021,S2022,S2023,S2024)
- AEE/MAE 325 – Aerospace Structures & Materials (F2012, S2013, F2013, S2014, F2014,S2015)
- ASU 101 – The ASU Experience (F2012,F2013,F2014,F2015,F2016,F2017,F2018,F2019,F2020, F2021,F2022,F2023)

## Professional Experience (cont'd)

Aug 2021-present **USAF/AFIT Summer Faculty / Visiting Faculty Fellowship**
Contractor through Oak Ridge Institute for Science & Education
Contractor through Systems Plus, Inc.

Short term appointments to enhance aircraft mission performance simulation codes to support hypersonic vehicle analysis. Due to COVID-19, I had to work remotely S2021. In person 40/hr wk at AFIT in Dayton, OH for S2022, S2023 and S2024; remote part-time during academic year.

May 2020– Aug. 2020 **Consultant – Department of Mechanical & Aerospace Engineering**
June 2021–Aug. 2021 Royal Military College of Canada, Kingston, ON, CANADA

Short term, part time appointments to assess aging aircraft penalties to CC-130 performance and flying qualities. Due to COVID-19, I had to work remotely.

May 2019 – Aug. 2019 **Visiting Scholar – Royal Military College of Canada**
Contractor through Calian Ltd., Kingston, ON, CANADA

A short-term in-person 40/hr wk appointment to assess aging aircraft penalties to CC-130 performance and flying qualities. In addition, supervised wind tunnel testing of concept airfoils and wings for a high-altitude unmanned aircraft concept design.

July 2013 **USAF/AFRL Summer Faculty Fellowship**
Contractor through Universal Technology Corp., Dayton, OH

A short-term 40 hr/wk appointment to assess aircraft aerodynamics and performance of an "Efficient Supersonic Air Vehicle" (ESAV).

May 2011 – Aug. 2011 **Law Clerk – Office of the Chief Counsel**
NASA/Ames Research Center, Moffett Field, CA

A short-term 40/hr wk appointment to assess intellectual property rights of NASA/Ames Research center sponsored projects. Assisted in public release, grant and contract monitoring, patent preparation.

Mar. 2011 – May 2011 **Quarterly Term Professor - Dept. of Mechanical Engineering**
Santa Clara University, Santa Clara, CA

Engaged part-time to teach MECH 145, Introduction to Aerospace Engineering. (S2011)

Sep. 2008 – July 2010 **Engineer 5 – Northrop Grumman**
Config. & Integration – Northrop Grumman Aerospace Systems, El Segundo, CA
Aerodynamics - Northrop Grumman Aerospace Systems, El Segundo, CA

A 40/hr wk full-time position to form Multi-Disciplinary Analysis & Optimization group in advanced flight sciences with applications to future military projects.

Aug. 2007 – May 2008 **Adjunct Lecturer - Dept. of Aerospace Engineering**
Wichita State University, Wichita, KS

Engaged part-time to teach AE 527 - Numerical Methods (S2008) and AE 703 - Rotor Aerodynamics (Propeller/Helicopter) (F2007)

Aug. 2004 – May 2007 **Adjunct Lecturer - Dept. of Mechanical and Aerospace Engineering**
University of Arizona, Tucson, AZ

Engaged part-time to teach Senior Capstone Design for Aerospace Engineering:

- AME 420 – Aero Senior Capstone Design I (F2004, F2005, F2006)
- AME 422 – Aero Senior Capstone Design II (S2007)

## Professional Experience (cont'd)

June 2002 – Sep. 2008 **Principal Engineer / Manager II / Sr. Principal Engineer - Raytheon**
Advanced Design - Raytheon Aircraft / Hawker Beechcraft, Wichita, KS
GN&C Systems Design / AeroMechanics - Raytheon Missile Systems, Tucson, AZ

A 40 hr/wk full-time position where I formed a Multi-Disciplinary Analysis & Optimization group in the AeroMechanics Design Department and served as a deputy Department Manager (payroll & promotion).

Extensive wind tunnel testing of prototype aircraft and weapons systems at:

- Boeing Transonic Wind Tunnel (BTWT), Seattle, WA
- Wichita State University (Walter Beech), Wichita, KS
- Rockwell Tri-Sonic Wind Tunnel, El Segundo, CA
- Calspan Transonic Wind Tunnel, Buffalo, NY
- NASA/Glenn Research Center (Abe Silverstein Supersonic), Cleveland, OH

Sep. 1996 – Mar. 2002 **Staff Engineer / Sr. Engineer Specialist / Sr. Engineer – Lockheed-Martin**
Advanced Design - Lockheed Martin Aeronautics Co., Marietta, GA
Aerodynamics - Lockheed Martin Aeronautics Co., Marietta, GA
Aerodynamics – Lockheed Martin Skunk Works, Palmdale, CA

A 40 hr/wk full-time position. Early member of the Rapid Conceptual Design team at the Lockheed Martin Skunkworks. Aerodynamic. Propulsion. Performance code development and integration for aircraft sizing & synthesis.

Extensive wind tunnel testing of prototype aircraft at:

- Lockheed Martin Subsonic Wind Tunnel, Marietta, GA
- US Air Force AEDC 16T Wind Tunnel, Tullahoma, TN
- NASA/Langley Research Center 16T Wind Tunnel, Hampton, VA
- NASA/Langley Research Center Mach 25 Helium Wind Tunnel, Hampton, VA
- NASA/Marshall Tri-Sonic Wind Tunnel, Huntsville, AL

Apr. 1994 – Sep. 1996 **NRC Postdoctoral Research Associate**
Low Speed Aerodynamics Branch, NASA/Ames Research Center, Moffett Field

A 40 hr /wk full-time position. Developed wake survey system for the 7x10-ft low speed, low turbulence wind tunnel. Extensive wind tunnel test experience at that facility including USAF/AFRL and Boeing.

1993-1995 **Research Consultant**
Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY

A part-time position developing numerical analysis techniques to support data reduction of ocean / air interface chemical data.

## Teaching Evaluations

AEE/MAE 468 – Aerospace Engineering Capstone Design – Fixed Wing Aeronautics Track

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| AEE 468 | 2024 Spring | 5.00 | 5.00 | 5.00 | 19 |
| AEE 468 | 2023 Fall | 3.20 | 4.00 | 4.00 | 18 |
| AEE 468 | 2022 Spring | 4.67 | 4.50 | 4.50 | 22 |
| AEE 468 | 2022 Fall | 4.35 | 4.52 | 4.00 | 27 |
| AEE 468 | 2021 Spring | 4.28 | 4.55 | 4.29 | 22 |
| AEE 468 | 2021 Fall | 4.45 | 4.89 | 4.67 | 18 |
| AEE 468 | 2020 Spring | 4.86 | 4.93 | 4.60 | 13 |
| AEE 468 | 2020 Fall | 4.79 | 4.91 | 4.40 | 14 |
| AEE 468 | 2019 Spring | 4.84 | 4.84 | 4.80 | 18 |
| AEE 468 | 2019 Fall | 4.61 | 4.69 | 4.25 | 16 |
| AEE 468 | 2018 Spring | 4.44 | 4.71 | 4.60 | 21 |
| AEE 468 | 2018 Fall | 3.87 | 3.70 | 3.56 | 28 |
| AEE 468 | 2017 Spring | 4.60 | 4.74 | 4.78 | 25 |
| AEE 468 | 2016 Spring | 4.40 | 4.71 | 4.25 | 36 |
| AEE 468 | 2016 Fall | 4.57 | 4.81 | 4.75 | 22 |
| AEE 468 | 2015 Spring | 4.41 | 4.80 | 4.60 | 19 |
| AEE 468 | 2015 Fall | 4.44 | 4.60 | 4.22 | 25 |
| AEE 468 | 2014 Fall | 4.75 | 4.79 | 4.82 | 34 |
| MAE 468 | 2014 Spring | 4.65 | 4.66 | 4.53 | 28 |
| MAE 468 | 2013 Fall | 4.58 | 4.87 | 4.67 | 18 |
| MAE 468 | 2013 Spring | 4.12 | 3.75 | 3.43 | 16 |
| MAE 468 | 2012 Fall | 4.09 | 4.56 | 4.13 | 21 |

## Teaching Evaluations (cont'd)

MAE 564 – Advanced Aerodynamics

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| MAE 564 | 2023 Fall | 4.6 | 4.67 | 4 | 23 |
| MAE 564 | 2022 Fall | 4.44 | 4.76 | 4.67 | 31 |
| MAE 564 | 2021 Fall | 4.87 | 4.96 | 4.9 | 21 |
| MAE 564 | 2020 Fall C | 4.83 | 4.96 | 5 | 23 |
| MAE 564 | 2019 Fall | 4.74 | 4.98 | 4.83 | 15 |
| MAE 564 | 2018 Fall | 4.64 | 4.93 | 4.4 | 16 |
| MAE 564 | 2016 Fall | 4.93 | 4.78 | 4.5 | 9 |
| MAE 564 | 2015 Fall | 4.62 | 4.89 | 4.86 | 26 |
| MAE 564 | 2014 Fall | 4.58 | 4.61 | 4.54 | 21 |
| MAE 564 | 2013 Fall | 4.51 | 4.65 | 4.23 | 25 |

AEE 344 – Fundamentals of Aircraft Design (Performance & Sizing)

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| AEE 344 | 2024 Spring | 4.36 | 4.53 | 3.85 | 73 |
| AEE 344 | 2023 Spring | 4.12 | 4.57 | 4.17 | 46 |
| AEE 344 | 2022 Spring | 4.06 | 4.28 | 3.80 | 51 |
| AEE 344 | 2021 Spring | 4.60 | 4.54 | 4.22 | 55 |
| AEE 344 | 2020 Spring | 4.81 | 4.87 | 4.80 | 49 |
| AEE 344 | 2019 Spring | 4.57 | 4.61 | 4.36 | 47 |
| AEE 344 | 2018 Spring | 4.64 | 4.73 | 4.67 | 59 |
| AEE 344 | 2017 Spring | 3.80 | 3.99 | 2.86 | 55 |
| AEE 344 | 2016 Spring | 4.59 | 4.63 | 4.33 | 45 |
| AEE 344 | 2015 Spring | 4.50 | 4.69 | 4.44 | 74 |

MAE 372 – Fluid Mechanics for Mechanical Engineers

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| MAE 372 | 2017 Spring | 4.31 | 4.62 | 4.46 | 58 |
| MAE 372 | 2016 Spring | 4.52 | 4.70 | 4.41 | 68 |

MAE 394 – AeroMechanics Summer in England

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| MAE 394 | 2015 Summer | 4.73 | 4.93 | 4.82 | 22 |
| MAE 394 | 2014 Summer | 4.61 | 4.97 | 4.63 | 18 |

## Teaching Evaluations (cont'd)

MAE 400 – Engineering Profession (Systems Engineering & Engineering Ethics)

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| MAE 400 | 2024 Spring | 4.17 | 4.45 | 4.09 | 85 |
| MAE 400 | 2024 Spring | 4.59 | 4.83 | 4.53 | 74 |
| MAE 400 | 2023 Fall | 4.60 | 4.72 | 4.62 | 72 |
| MAE 400 | 2023 Spring | 4.36 | 4.60 | 4.28 | 64 |
| MAE 400 | 2023 Spring | 4.22 | 4.66 | 4.36 | 55 |
| MAE 400 | 2023 Fall | 4.60 | 4.72 | 4.62 | 72 |
| MAE 400 | 2022 Spring | 4.17 | 4.69 | 4.15 | 68 |
| MAE 400 | 2022 Spring | 3.98 | 4.07 | 3.29 | 63 |
| MAE 400 | 2022 Fall | 4.04 | 4.30 | 3.75 | 75 |
| MAE 400 | 2021 Summer | 4.85 | 4.97 | 5.00 | 28 |
| MAE 400 | 2021 Spring | 4.61 | 4.80 | 4.72 | 70 |
| MAE 400 | 2021 Spring | 4.47 | 4.76 | 4.53 | 69 |
| MAE 400 | 2021 Fall | 4.51 | 4.85 | 4.68 | 74 |
| MAE 400 | 2020 Summer | 4.57 | 4.89 | 4.67 | 26 |
| MAE 400 | 2020 Spring | 4.24 | 4.53 | 4.09 | 70 |
| MAE 400 | 2020 Fall | 4.55 | 4.69 | 4.43 | 75 |
| MAE 400 | 2019 Spring | 4.28 | 4.51 | 4.04 | 69 |
| MAE 400 | 2019 Fall | 4.51 | 4.73 | 4.36 | 41 |
| MAE 400 | 2018 Spring | 4.33 | 4.64 | 4.39 | 70 |
| MAE 400 | 2018 Fall | 4.24 | 4.31 | 4.07 | 60 |
| MAE 400 | 2017 Summer | 3.88 | 4.41 | 3.67 | 15 |
| MAE 400 | 2017 Fall | 4.18 | 4.55 | 4.13 | 70 |
| MAE 400 | 2017 Fall | 4.23 | 4.45 | 4.09 | 69 |
| MAE 400 | 2016 Fall | 4.57 | 4.85 | 4.64 | 36 |
| MAE 400 | 2015 Summer | 4.77 | 4.96 | 4.90 | 22 |
| MAE 400 | 2015 Fall | 4.39 | 4.56 | 4.13 | 35 |
| MAE 400 | 2014 Summer | 4.64 | 4.94 | 4.75 | 17 |
| MAE 400 | 2014 Spring | 4.51 | 4.82 | 4.69 | 51 |
| MAE 400 | 2013 Spring | 4.11 | 4.39 | 3.95 | 51 |
| MAE 400 | 2012 Fall | 4.05 | 4.55 | 3.89 | 49 |

AEE/MAE 325 – Aerospace Structures & Materials

| Course | Semester | Course | Instructor | Overall | # Students |
|---|---|---|---|---|---|
| AEE 325 | 2015 Spring | 4.61 | 4.62 | 4.58 | 25 |
| AEE 325 | 2014 Fall | 4.56 | 4.75 | 4.68 | 64 |
| MAE 325 | 2014 Spring | 4.47 | 4.87 | 4.5 | 23 |
| MAE 325 | 2013 Fall | 4.4 | 4.77 | 4.74 | 54 |
| MAE 325 | 2013 Spring | 4.21 | 4.74 | 4.64 | 25 |
| MAE 325 | 2012 Fall | 4.01 | 4.28 | 3.67 | 76 |

## Awards, Activities and Professional Affiliations

Awards

| | |
|---|---|
| 2023 | Royal Aeronautical Society – Bronze Award – for Best Written Paper |
| 2022 | American Institute of Aeronautics & Astronautics (AIAA) – Sustained Service Award |
| 2017-8 | Arizona State University – Outstanding Fulton School Faculty Advisor – Air Devils |
| 2017 | Ford Faculty Fellow Award – included award stipend |
| 2013-4 | Arizona State University – Outstanding Fulton School Faculty Advisor – Air Devils |
| 2013 | Santa Clara University School of Law - High Tech Law Certificate with Honors |
| 2012 | Santa Clara University School of Law - High Tech Excellence Award for the 2011-2012 AY. |
| 2012 | Santa Clara University School of Law - Witkin Award for Academic Excellence - Privacy Law |
| 2009 | France Beaupré Award (as a team-member for the "Development of a Propulsion Design Optimisation Tool") for TTCP Activities |
| 2006 | American Institute of Aeronautics and Astronautics (AIAA) - Associate Fellow |
| 2006 | Raytheon Engineering Honors (Sr. Principal Engineer w/ Honors) |
| 2004 | Raytheon Engineering Honors (Principal Engineer w/ Honors) |
| 2003 | Raytheon Excellence in Technology Award (for Multi-Disciplinary Optimization) |

Professional Society Affiliations

| | |
|---|---|
| 1994-present | American Institute of Aeronautics and Astronautics (Life Member) |
| 2018-present | Society of Aircraft Performance and Operations Engineers |

Peer Review / Journal Editor

| | |
|---|---|
| 2012-13 | Santa Clara Computer and High Technology Law Journal, Lead Articles Editor. |
| 2020-present | AIAA Journal |
| 2008-present | Reviewer for AIAA Journal of Aircraft |
| 2013-present | Reviewer for The Aeronautical Journal |
| 2015-present | Reviewer for CEAS Aeronautical Journal |
| 2015-present | Reviewer for Aerospace Science & Technology |
| 2013-present | Textbook reviewer for John Wiley & Sons |

Government and Industrial Committees

| | |
|---|---|
| 2022-present | AIAA History Program Committee |
| 2006-present | AIAA Conceptual Aircraft Design Working Group (CADWG) – chair (2009→) |
| 2005-present | AIAA Aircraft Design Technical Committee (Non-Voting 2005-12; Voting 2013→) |
| 2008-10 | USAF AFRL Multi-Disciplinary Science & Technology Center @ Virginia Tech Steering Com. |
| 2005-07 | US/UK/Canada/Australia/New Zealand Technical Cooperation Weapons Group (TTCP WTP-4/KTA 4-30-03) |
| 2004-17 | AIAA Multidisciplinary Optimization Technical Committee |

Conference Chair

| | |
|---|---|
| 2024 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2023 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2022 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2021 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2020 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2019 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2018 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2017 | Organizing Committee – AIAA AVIATION Conference – Aircraft Design Sessions |
| 2015 | Organizing Committee – AIAA Sci Tech Meeting – MDO Sessions |
| 2014 | Organizing Committee – AIAA Sci Tech Meeting – MDO Sessions |
| 2013 | Organizing Committee – AIAA Aerospace Sciences Meeting – MDO Sessions |
| 2012 | Organizing Committee – AIAA ATIO/MAO Conference – Joint MDO/Aircraft Design Sessions |
| 2012 | Organizing Committee – AIAA Aerospace Sciences Meeting – MDO sessions |
| 2010 | Track Lead – AIAA ATIO/MAO Conference – Joint MDO/Aircraft Design Sessions |
| 2008 | Track Lead – AIAA Aerospace Sciences Meeting – MDO Applications Sessions |
| 2005-present | Reviewer for AIAA Conference Papers (various technical committees, various conferences) |

## Awards, Activities and Professional Affiliations (cont'd)

Student Sections of Professional Organizations

2012-present Team Advisor for the ASU Air Devils AIAA DBF Competition Team

| | | |
|---|---|---|
| 2014 | Wichita, KS | 17/80 teams |
| 2015 | Tucson, AZ | 23/100 teams |
| 2016 | Wichita, KS | 14/145 teams |
| 2017 | Tucson, AZ | 32/138 teams |
| 2018 | Wichita, KS | 41/ 138 teams |
| 2019 | Tucson, AZ | 17/ 142 teams |
| 2020 | VIRTUAL | |
| 2021 | VIRTUAL | 14/ 117 teams |
| 2022 | Wichita, KS | 7 / 127 teams |

2016-present Faculty Advisor for AIAA @ ASU (Student Chapter)

2015-present Faculty Co-Advisor for Tau Beta Pi (Engineering Honor Society)

## Grants, Funding and Consulting

Consulting: LitExpert, Cupertino, CA – Expert Witness Aviation, 2023 → present

Consulting: Grey, Ice & Higdon, LLP, Louisville, KY – Expert Witness Aviation, 2023 → present

Consulting: Rubin/Anders Scientific, Boston, MA – Expert Witness Aviation, 2020 → present

Consulting: Hermeus LLC, Atlanta GA – Aircraft Stability & Control, 2023 → present

Consulting: NIAR/WERX Wichita State University, Wichita, KS – Aircraft Systems Design, 2021 → 2022

Consulting: Otto Aviation LLC– Aircraft Performance, 2020 → present

Consulting: NOAA – Contracted through University of Colorado CIRES (Cooperative Institute for Research in Environmental Sciences) – UAV Design for Atmospheric Science, 2018 → 2021

Consulting: DeltaZee Technologies, Tucson, AZ – UAV Systems Design, 2015 → 2021

Consulting: Jenner & Block, LLP, Chicago, IL – Expert Witness Aviation, 2017 → 2018

Grant: DragonFly Aeronautics, LLC (Division of Net Jets), Alpharetta, GA – Grant for Modeling & Simulation of Aircraft Performance, 2016-2017 - $75,000

Contract: United States Air Force Test Pilot School, Edwards AFB, CA – Teaching Methods for Aircraft Handling Qualities, 2015-2016 –$25,000.

Consulting: DragonFly Aeronautics, LLC (Division of Net Jets), Alpharetta, GA – Aircraft Performance, 2015-2017

Consulting: Aerion, Inc, Reno, NV –Aircraft Performance & Design Certification, 2014-2016.

CATALYST Award – Arizona State University – Compact Residential Wind Power System – proof of concept construction, 2013-2014 – approx. $11,000.

Consulting: MD Helicopters, Mesa, AZ – Helicopter Rotor Aerodynamics and Mechanical Design, 2013→

Consulting: YAM Captial, Scottsdale, AZ – Consultant – Wind Energy Technology Concept Evaluation, 2013.

Extensive industrial experience with government contractor proposals.
Typical government customers: USAF, USN, DARPA, ONR, USAF-AFRL, and other agencies.

USAF/AFRL Revolutionary Concepts in Energy Efficiency (RCEE) – Northrop Grumman
Co-investigator – Phase I Technical Lead - contract awarded 2009

ONR/DARPA RATTLRS Phase I – Raytheon Missile Systems
Air Vehicle Design Lead – contract awarded 2005

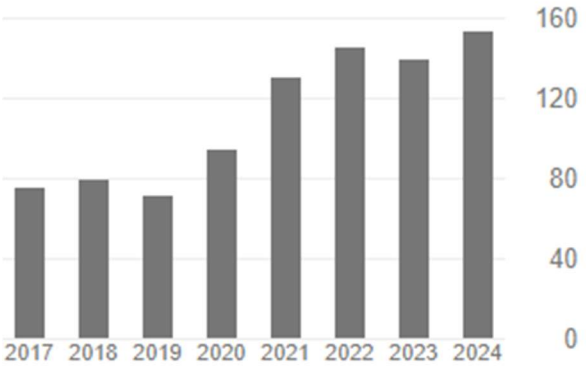
ONR FastShips Program Phase II – Lockheed Martin Aeronautical Systems – ADP "Skunk Works"
Chief Engineer – contract awarded 2000

Northrop Grumman Internal Research and Development Manager
Multi-Disciplinary Analysis & Optimization Disciplines (MDAO) – approx. $1,100,000 (2009)
Multi-Disciplinary Analysis & Optimization Disciplines (MDAO) – approx. $1,500,000 (2008)

Raytheon Missile Systems Internal Research and Development Manager
Multi-Disciplinary Analysis & Optimization (MDA/MDO) – approx. $500,000 (2006)
Multi-Disciplinary Analysis & Optimization (MDA/MDO) – approx. $500,000 (2005)
Multi-Disciplinary Analysis & Optimization (MDA/MDO) – approx. $500,000 (2004)

## Overall Scholastic Impact

| | All | Since 2019 |
|---|---|---|
| Citations | 2135 | 732 |
| h-index | 17 | 13 |
| i10-index | 34 | 16 |




Current 9/13/2024

## Books

1. **Takahashi, T.T.**, Aircraft Performance & Sizing, Vol. I: Fundamentals of Aircraft Performance, Momentum Press, New York, NY, 2016. 200 pages. **ISBN-13:** 978-1606506837

2. **Takahashi, T.T.**, Aircraft Performance & Sizing, Vol. II: Applied Aerodynamic Design, Momentum Press, New York, NY, 2016. 276 pages. **ISBN-13:** 978-1606509456

## Archival Journal Articles

1. **Takahashi, T.T.**, "Ezra Kotcher: the Father of the Bell X-1 and X-2," Royal Aeronautical Society Journal of Aeronautical History, in press, 2024.

2. McDonald, R.A., German, B.J, **Takahashi, T.T.**, Bil, C., Anemaat, W., Chaput A., Vos, R. and Harrison, N., "Future Aircraft Concepts and Design Methods," Royal Aeronautical Society Aeronautical Journal, p. 1-33, Jan 2022.

3. **Takahashi, T.T.**, "The Rise of the Drones – A Need for the Comprehensive Federal Regulation of Robot Aircraft," Albany Government Law Review, Vol. 8, No. 1, 2015, pp. 63-128.

4. **Takahashi, T.T.**, "Regulatory Changes to Enable the Development of More Efficient Transport Category Aircraft," AIAA Journal of Aircraft, Vol. 50, No. 5, pp. 1353-1368, Sep-Oct 2013. (DOI: 10.2514/1.C031633).

5. **Takahashi, T.T.**, "Drones and Privacy," Columbia Sci. & Tech. Law Rev, Vol. XIV, No. 1, Fall 2012, pp. 72-114.

6. **Takahashi, T.T.**, "Drones in the National Airspace," SMU Journal of Air Law and Commerce, Vol. 77, No.3, Summer 2012, pp. 489-533.

7. **Takahashi, T.T.**, German, B.J., Shajanian, A., Daskilewicz, M., and Donovan, S. "Form Factor and Critical Mach Number Estimation for Finite Wings," AIAA Journal of Aircraft, Vol. 49, No. 1, Jan-Feb 2012. (DOI:10.2514/1.C031466).

8. **Takahashi, T.T.**, "Optimum Transverse Span Loading for Subsonic Transport Category Aircraft," AIAA Journal of Aircraft, Vol. 49, No. 1, Jan-Feb 2012. (DOI:10.2514/1.C031512).

9. **Takahashi, T.T.**, "Optimum Aspect Ratio for Subsonic Air Vehicles," AIAA Journal of Aircraft, Vol.48, No. 6, Nov-Dec 2011, pp. 1984-1993. (DOI:10.2514/1.C031402).

10. Daskilewicz, M. J., German, B.J., **Takahashi, T.T.**, Donovan, S., and Shajanian, A., "Effects of Disciplinary Uncertainty on Multi-Objective Optimization in Aircraft Conceptual Design," Structural and Multidisciplinary Optimization, Vol. 44, No. 6 (2011), pp. 831-846 (DOI:10.1007/s00158-011-0673-4).

11. Takahashi, T., Feely, R. A., Weiss, R., Wanninkhof, R. H., Chipman, D. W., Sutherland, S. C. and **Takahashi, T. T.**, "Global air-sea flux of $CO_2$: an estimate based on measurements of sea-air $pCO_2$ difference," Proc. Nat. Acad. Sci., vol. 94, 8292-8299, 1997.

12. Takahashi, T., **Takahashi, T. T.** and Sutherland, S. C., "An Assessment Of The Role Of The North Atlantic as a $CO_2$ Sink," Phil. Transactions Of The Royal Society Of London, Series B, Vol. 348, pp. 143-152, 1995.

13. **Takahashi, T.T.**, "Flow Beneath a Rotating Annulus," Physics of Fluids, Vol. 6, No. 5, 1994, pp. 1677-83.

14. Benson, R.C. and **Takahashi, T.T.**, "Mechanics of Flexible Disks in Magnetic Recording," ASME Advances in Information Storage Systems, Vol. 1, No. 1, 1991, pp. 15-35.

## Refereed Conference Publications

*Students who were advised primarily by Dr. Takahashi at the time of their graduation are indicated by a solid underline*

1. **Takahashi, T.T.,** Lorenzo, W.P., Gaydusek, B.S. and Griffin, J.A., "VORLAX 2024: Further Upgrades to a Legacy Potential Flow Solver," Accepted paper for AIAA 2025 SciTech Conference.

2. Iyer, A.G. and **Takahashi, T.T.**, "Reexamining Busemann's Wing Sweep Theory – A Modern Explanation of Classic Wartime Test Results," Accepted paper for AIAA 2025 SciTech Conference.

3. Kulkarni, A.S. and **Takahashi, T.T.**, "On the Design Implications of Elliptical and Bell-Shaped Lift Distributions," Accepted paper for AIAA 2025 SciTech Conference.

4. Bryan, B.C., Weissman, E.M., Phung, J.V., Jackson, Z.R., Leo, J.D., Stonemetz, J.E., Caterial, W.G., Hadimani, E., Cana, L.J., Cea, J.A. and **Takahashi, T.T.**, "Aerodynamic Design of an Executive Transport Optimized for Flight Just Beyond Mach One," Accepted paper for AIAA 2025 SciTech Conference.

5. **Takahashi, T.T**, "Climb Performance of Very High T/W airframes," AIAA 2024-3914, 2024.

6. **Takahashi, T.T.**, Camberos, J.A. and Grandhi, R.V., "Landing Field Performance of Low L/D Gliding Airframes," AIAA 2024-3911, 2024.

7. **Takahashi, T.T.**, "Ezra Kotcher and the Configuration Aerodynamics of the Bell X-1 and X-2," AIAA 2024-4136, 2024.

8. **Takahashi, T.T.**, "Standby Rocket Systems to Facilitate Noise Abatement of Future Commercial Aircraft," AIAA 2024-3912, 2024.

9. Lorenzo, W.P. and **Takahashi, T.T.**, "A Reassessment of the Controllable Flight Envelope of the Bell X-1A Rocket Plane," AIAA 2024-4138, 2024.

10. Uribe-Quintero, E. and **Takahashi, T.T.**, "Flight Dynamics Issues of Control Coupling / Inertia Coupling Prone High-Speed Aircraft," AIAA 2024-4048, 2024.

11. Iyer, A., and **Takahashi, T.T.**, "The Impact of Drop-In vs. Dedicated Sustainable Aviation Fuel on Aircraft Performance and Design," AIAA 2024-3986, 2024.

12. Uribe-Quintero, E., Moreno, A., Lehmbeck, T., Anderson, S. and **Takahashi, T.T., "**A Technical Study Demonstrating the Poor Marketability of Near-Sonic Ultra-Long-Haul-Range Airliners," AIAA 2024-4321, 2024.

13. Garcia, J., Asparuhov, B., Stuck, S., Bocek, J. and **Takahashi, T.T.**, "Challenges Designing Bio-Ethanol Fueled Airliners for Sustainable Intercontinental Aviation," AIAA 2024-3748, 2024.

14. **Takahashi, T.T.,** "Noise and Field Performance Impacts of FADEC Speed Scheduled Thrust Derate," AIAA 2024-1705, 2024.

15. Hoopes, C.S, and **Takahashi, T.T.,** "Lateral-Directional Controllability Impacts of Longitudinal Pitch Trim Strategies on the Space Shuttle Orbiter," AIAA 2024-2318, 2024.

16. Heinz, J.H. and **Takahashi, T.T.,** "Attainable Moment Sets – Approaches to Understanding Trim Capability in Conceptual Design," AIAA 2024-2319, 2024.

17. O'Brien, K.P. and **Takahashi, T.T.,** "Tail Sizing Strategies to Ensure Low-Risk Maneuvering High-Speed Flight," AIAA 2024-2320, 2024.

18. DeRoo, M. and **Takahashi, T.T.,** "A Study of the Economic Viability of Commercial Supersonic Flight," AIAA 2024-2214, 2024.

## Refereed Conference Publications (cont'd)

19. Lorenzo, W.P. and **Takahashi, T.T.,** "Reconstructing and Reassessing Neil Armstrong's "First Man" Flight in the North American X-15," AIAA 2024-2643, 2024.

20. Lorenzo, W.P. and **Takahashi, T.T.,** "Can We Fly it? Yes, We Can: A Comparative Study of Military Airworthiness and Flight Operations" AIAA 2024-2213, 2024.

21. **Takahashi, T.T.,** "Determination of Optimal Cruise Points for General Purpose Hypersonic Airframes," AIAA 2024-2217, 2024.

22. Valenzuela, J.V. and **Takahashi, T.T.,** "Wing Design Strategies for Vehicles Designed to Operate in Ground Effect," AIAA 2024-0003, 2024.

23. Puentes, O.G. and **Takahashi, T.T.,** "Wingtip Treatments for Transonic Wing Planforms," AIAA 2024-0001, 2024.

24. **Takahashi, T.T.**, Griffin, J.A. and Grandhi, R.V., "A Review of High-Speed Aircraft Stability and Control Challenges," AIAA 2023-3231, 2023.

25. **Takahashi, T.T.**, "Introducing the "Entrepreneurial Mindset" into Arizona State University's Aerospace Engineering Capstone Design," AIAA 2023-3661, 2023.

26. **Takahashi, T.T.,** "Whither Gander? A Business Case to Revive a Northern Hub Airport to Reduce Transatlantic Emissions," AIAA 2023-4302, 2023.

27. **Takahashi, T.T.**, "Flying with Eyes Wide Shut - A Reflection on the Hollywood View of Real World Aircraft Performance," AIAA 2023-3518, 2023.

28. O'Brien, K.P. and **Takahashi, T.T.**, "Configuration and Control Strategies for Maneuvering Supersonic Flight," AIAA 2023-3233, 2023.

29. Hoopes, C.S. and **Takahashi, T.T.**, "A Study of High Speed Aerodynamic Configurations Optimized for Lateral-Directional Controllability," AIAA 2023-3235, 2023.

30. Ratnayake, S.S. and **Takahashi, T.T.**, "Low Aspect Ratio High-Lift Wing Design for Automotive Racing Applications," AIAA 2023-4311, 2023.

31. **Takahashi, T.T.,** "Maneuvering Capabilities of Hypersonic Airframes," AIAA 2023-2247, 2023.

32. Heinz, J., O'Brien, K.P., Kosednar, D., Hatch, T. and **Takahashi, T.T.,** "Sky Cruiser – A Design Study in Space Tourism ",AIAA 2023-1355, 2023.

33. Stauffer, M.T. and **Takahashi, T.T.,** "A History and Commentary on Thrust/Drag Bookkeeping," AIAA 2023-1553, 2023.

34. Hoopes, C.S. and **Takahashi, T.T.,** "Developments in the Federal Regulation of Personal Air Vehicle," AIAA 2023-0177, 2023.

35. Griffin, J.A. and **Takahashi, T.T.,** "A Break from Tradition: The "New" 14 C.F.R. Part 23 and Consensus Standards," AIAA 2023-0116, 2023.

36. Griffin, J.A. and **Takahashi, T.T.,** "Hypersonic Aircraft Performance Limitations Arising from Aerodynamic Control Limits," AIAA 2023-2248, 2023.

37. Griffin, J.A., **Takahashi, T.T.** and Rodi, P.E.**,** "Aerothermodynamic Assessment of Conceptual and Detail Configuration Changes to a Rocket Propelled Aircraft," AIAA 2023-0216, 2023.

38. Stauffer, M.T., Backlund, M., Gonzales, Z. and **Takahashi, T.T.,** "Multi-Disciplinary Design of an LH2 Powered Regional Jet" AIAA 2023-0980, 2023.

## Refereed Conference Publications (cont'd)

39. **Takahashi, T.T.,** "Maneuvering Capabilities of High Payload Fraction Airframes," AIAA 2022-3655, 2022.

40. Martinez-Rodriguez, G. and **Takahashi, T.T.,** "Rapid Design of a High-Lift Wing using Potential Flow Methods," AIAA 2022-3584, 2022.

41. Blair, M. and **Takahashi, T.T.,** "Optimal Composite Structural Design of Unmanned Aerial System Wings," AIAA 2022-4009, 2022.

42. Griffin, J. A. and **Takahashi, T.T.,** "Aero-Spaceplane Mission Performance Estimations Incorporating Atmospheric Control Limits," AIAA 2022-3656, 2022.

43. Webb, B.D. and **Takahashi, T.T.,** "An Investigation of Static Aeroelastic Effects on Aircraft Performance," AIAA 2022-3587, 2022.

44. Griffin, J. A. , **Takahashi, T.T.** and Rodi, P.E. **,** "Aerothermodynamic Modeling for a "Mission Code" Approach to Hypersonic Flight," AIAA 2022-3657, 2022.

45. O'Brien, K.P. and **Takahashi, T.T.,** "An Investigation of the Bell X-2 and the Factors that Led to Its Fatal Accident," AIAA 2022-3203, 2022.

46. Hoopes, C., Chaidez, G., Mulkern, W, Heitmann, K., Olszak, P., Ayoub, K., Nagpal, P., Raganathan, A. and **Takahashi, T.T.,** "Design of a N+1 Feeder Aircraft for Regional Cargo Airlines," AIAA 2022-3377, 2022.

47. Chaudhari, B. and **Takahashi, T.T.**, "Reassessing the B2707-100 Supersonic Transport Aircraft," AIAA-2022-0776, 2022.

48. Chaudhari, B. and **Takahashi, T.T.**, "Inlet Diffusor Buoyancy – Its Historical Use in Supersonic Transport Design," AIAA-2022-2566, 2022.

49. Souders, T.J., Heitmann, K. and **Takahashi, T.T.**, "Life in the Fast Lane: Project-Based Learning of Advanced Aerodynamics Using a Rapid Potential Flow Code," AIAA-2022-1350, 2022.

50. Webb, B.D. and **Takahashi, T.T.**, "Emerging Federal Regulatory Framework For Future Supersonic Transport Aircraft," AIAA-2022-0366, 2022.

51. Ratnayake, S.S. and **Takahashi, T.T.,** "New Approaches to Direct Wing Shape Synthesis using Potential Flow Solvers." AIAA-2022-0547, 2022.

52. Armenta, F.X., Plaban, P. and **Takahashi, T.T.**, "Revisiting Neumark's Critical Pressure Coefficient Rule for Aircraft with Finite Wings," AIAA-2022-1157, 2022.

53. Martinez-Rodriguez, G. and **Takahashi, T.T.**, "Reflections On Using Potential Flow Codes to Design High-Lift Systems," AIAA-2022-1155, 2022.

54. **Takahashi, T.T.,** "Empirical Methods to Predict Takeoff Field Requirements for Single-Engine Aircraft," AIAA-2022-0548, 2022.

55. **Takahashi, T.T.,** "Revisiting Roskam's Empirical Predictions for Critical Field Length," AIAA 2021-2446, 2021.

56. **Takahashi, T.T.**, "Revisiting Roskam's Empirical Predictions for Landing Distance," AIAA 2021-2447, 2021.

## Refereed Conference Publications (cont'd)

57. Souders, T.J. and **Takahashi, T.T.**, "VORLAX 2020: Making a Potential Flow Solver Great Again," AIAA 2021-2458, 2021.

58. Souders, T.J. and **Takahashi, T.T.**, "VORLAX 2020: Benchmarking Examples of a Modernized Potential Flow Solver," AIAA 2021-2459, 2021.

59. Kurus, N.J., **Takahashi, T.T.** and Perez, R.E., "Critical Mach Number Predictive Methods for Realistic Supersonic Wing / Body Configurations," AIAA 2021-2432, 2021.

60. Armenta, F.X. and **Takahashi, T.T.**, "Revisiting the Transonic Area Rule for Conceptual Aerodynamic Design," AIAA 2021-2423, 2021.

61. Plaban, P. and **Takahashi, T.T.**, "Aerodynamic Design Challenges of a Thin Transonic Wing," AIAA 2021-2441, 2021.

62. Frost, L., Chia, V., Reuland, J., Namera, S., Moreno, E., and **Takahashi, T.T.**, "Preliminary Design of a Trans-Atlantic High Speed Civil Transport," AIAA 2021-2418, 2021.

63. Kurus, N.J. and **Takahashi, T.T.**, "Aerodynamic Design of a Mach 1.3 Airliner," AIAA 2021-0591, 2021.

64. **Takahashi, T.T.**, "Development of a Semi-Empirical Takeoff & Landing Method for Supersonic Aircraft," AIAA 2021-0462, 2021.

65. **Takahashi, T.T.** and Perez, R.E., "The Assumed Wind Procedure to Increase Dispatch Safety for VMCA Limited Aircraft," AIAA 2021-0459, 2021.

66. Kurus, N.J. and **Takahashi, T.T.**, "Does Your Aircraft's Metabolism Slow with Time? : An Analysis of Flight Performance Degradation Associated with Aging Aircraft," AIAA 2021-0460, 2021.

67. Schierbrock, A. and **Takahashi, T.T.**, "Reconstruction of Flight-Path Dependent Aircraft Point-Performance, Stability & Control from Public Flight Data," AIAA 2021-0325, 2021.

68. Martinez-Rodriguez, G., Fratangelo, D., Fregoso, E.I., Kosloske, T., Kurt, H., Schierbrock, A., Valderama, D. and **Takahashi, T.T.**, "Multi-Disciplinary Design of a Mid-Range Commercial Transport Aircraft," AIAA 2021-0011, 2021.

69. Ratnayake, S S. and **Takahashi, T.T.**, "Improved Synthesis Method to Develop Conceptual Design Wing Lofts," AIAA 2021-0218, 2021.

70. **Takahashi, T.T. and** Thomas, P.R., "The Aerodynamic Design of a High-Altitude Operational-Return Unmanned System for Atmospheric Science," AIAA 2020-2658, 2020.

71. Thomas, P.R. and **Takahashi, T.T.**, "Aircraft Should Not Be Fair Weather Friends – Impact of Winds Aloft on Aircraft Operating Economics," AIAA 2020-2636, 2020.

72. Thomas, P.R. and **Takahashi, T.T.**, "How to Soar Above the Competition – Design Strategies to Improve Airliner Operating Economics in Real Weather," AIAA 2020-2637, 2020.

73. **Takahashi, T.T.** and Perez, R.E., "The Effect of Manufacturing Variation on Aerodynamic Performance and Flight Safety," AIAA 2020-2649, 2020.

74. **Takahashi, T.T.** and Cleary, S.C., "Inlet Diffusor Buoyancy - An Overlooked Term in the Thrust Equation," AIAA 2020-2642, 2020.

## Refereed Conference Publications (cont'd)

75. Kolesov, N. and **Takahashi, T.T.**, "Design and Validation of Buckling Dominated Wing Structure for Small Unmanned Aerial Systems" AIAA 2020-2654, 2020.

76. Vasconcelos, P.E., Lam, Y.-F., Allen, A., Rivera, E. and **Takahashi, T.T.**, "Multidisciplinary Optimization of a Next-Generation Narrow Body Transport" AIAA 2020-2628, 2020.

77. **Takahashi, T.T.** and Perez, R.E., "On the Operational Implications of Traditional Design Rules for Minimum Controllable Airspeed," AIAA 2020-0749, 2020.

78. Halversen, H., Mitchell, R., Spear, M., Vo, B. and **Takahashi, T.T.**, "Optimal Design of an N+1 Narrow-Body Transport Aircraft," AIAA 2020-0270, 2020.

79. Frede, K. and **Takahashi, T.T.**, "Computational Methods for the Preliminary Design of Engine-Nacelle Placement on Transonic Aircraft," AIAA 2020-1956, 2020.

80. Thomas, P.R. and **Takahashi, T.T.**, "Aircraft En-Route Performance Considering Winds-Aloft," AIAA 2020-0748, 2020.

81. **Takahashi, T.T**. and Ou, C.-W., "When Higher Fidelity Models Degrade Our Understanding of Induced Drag - The Tragedy of the Treffetz Plane Integral," AIAA 2020-0276, 2020.

82. Thomas, P.R. and **Takahashi, T.T.**, "The Wild West of Aviation: An Overview of Unmanned Aircraft Systems Regulation in the United States," AIAA 2020-0646, 2020.

83. Burgett, L.M. and **Takahashi, T.T**., "Comparison of Vaneless Counter-Rotating Power Extraction Engines for UAV Propulsion," AIAA 2019-3016, 2019.

**84.** Cullymore, K., Hines, C., Soldevilla, J., Patrick, N., Loo, C., and Takahashi, T.T., "Multi-Disciplinary Optimization of a N+1 Technology Mid-Market Aircraft," AIAA 2019-2881, 2019.

85. **Takahashi, T.T.** and Sobester, A., "Climb Performance Anomalies in 'Real' Atmospheric Conditions," AIAA 2019-3271, 2019.

86. **Takahashi, T.T.** and Thomas, P.R., "WAT's Up with Using the Small-Angle Approximation to Estimated Climb Gradient Limited Departure Weights," AIAA 2019-3273, 2019.

87. Miskin, D.L. and **Takahashi, T.T.**, "Preliminary Design of a Wing Considering Transonic Aerodynamic, Weight and Aeroelastic Behavior," AIAA 2019-3068, 2019.

88. Delisle, M. and **Takahashi, T.T.**, "We Wonder Why We Wallow: Impacts of Trim Error on Speed and Flight Path Stability," AIAA 2019-0559, 2019.

89. **Takahashi, T.T.**, "A Bad Moon Rising: The Puzzling Inaccuracies of the Work-Energy Theorem in Aircraft Performance," AIAA 2019-1305, 2019.

90. Milosavljevic, I., Nuber, B., Swarm, G., **Takahashi T.T.**, et al. "Preliminary Design of a Long Range, Fuel Efficient High Performance Business Jet," AIAA 2019-0555, 2019.

91. **Takahashi, T.T.,** Boccieri, S., Elvig, J., McClure, N., Oroz, J., Spiller, K. and Zurfluh, K, "Puzzling Problems Configuring a Forward Swept Wing Transonic Aircraft," AIAA 2019-0813, 2019.

92. Leader, R. and **Takahashi, T.T.**, "Frosty Weather: The Regulatory History of Aircraft Operations in Freezing Conditions," AIAA 2019-1958, 2019.

93. **Takahashi, T.T.** and Stone, N., "Aircraft Performance Impacts of Power and Bleed Air Extraction on a COTS Engine Powered UAS." AIAA 2019-1309, 2019.

## Refereed Conference Publications (cont'd)

94. Beard, J.E. and **Takahashi, T.T.**, "Wind Accountability and Obstacle Clearance Limited Takeoff for Commercial Transport Aircraft," AIAA 2018-3501, 2018.

95. Delisle, M., Morrow, M.H., Ramirez, A., Padilla, M., Thach, S., Elliott, S., Miller, T. and **Takahashi, T.T.**, "Preliminary Design of a Next Generation Super-Mid-Size Business Jet," AIAA 2018-3024, 2018.

96. **Takahashi, T.T** and Delisle, M., "(Un)stabilized Approach - An Introduction to Dynamic Flight Conditions during Takeoff and Landing Climb," AIAA 2018-3500, 2018.

97. Delisle, M. and **Takahashi, T.T.**, "Speed Stability and Obstacle Clearance During Engine Inoperative Takeoff," AIAA 2018-3502, 2018.

98. Delisle, M. and **Takahashi, T.T.**, "Floating Home: Speed Stability and Inadvertent Stalls During a Balked Landing," AIAA 2018-3059, 2018.

99. Cleary, S. and **Takahashi, T.T.**, "The Effects of Fixed Conical Spike Inlets on the Performance of Higher Bypass Ratio Engines," AIAA 2018-3836, 2018.

100. Miskin, D.L. and **Takahashi, T.T.**, "Stochastic Modeling of Preliminary Wing Box Structural Design for Stiffness," AIAA 2018-4002, 2018.

101. Kallas, D., Brown, K., Remsing, T., Ingham, J., Miskin, D. and **Takahashi, T.T.**, "Design of a Dual-Use Aerobatic Light Jet," AIAA 2018-2030, 2018.

102. Wood, D.L. and **Takahashi, T.T.**, "The Effect of Piloting Practices Upon Actual as Opposed to Scheduled Landing Field Performance," AIAA 2018-1756, 2018.

103. Wood, D.L., Beard, J.E. and **Takahashi, T.T.**, "Real Pilots Don't Go Around: Discontinued Approach and Balked Landing Climb Performance," AIAA 2018-1752, 2018.

104. Beard, J.E. and **Takahashi, T.T**., "(Un)controlled Flight Into Terrain: A History of Obstacle Clearance Regulations," AIAA 2018-1614, 2018.

105. Wood, D.L. and **Takahashi, T.T.**, "Extraordinary Care: A History of Flight Operations Rules for Common Carriers," AIAA 2018-1616, 2018.

**106. Takahashi, T.T.,** Beard, J.E. and Wood, D.L., "The Human Factor: Accounting For "Off Book" Flight Speeds Within Implied Safety Margins," AIAA 2018-0284, 2018.

107. Beard, J.E. and **Takahashi, T.T**., "Optimal Piloting Approaches For Obstacle Clearance Limited Standard Instrument Departures," AIAA 2018-0285, 2018.

108. Hadder, E.M. and **Takahashi, T.T.**, "Minimum Control Speed Estimation for Conceptual Design," AIAA 2017-3764, 2017.

109. Wilson, J. and **Takahashi, T.T.**, "The Doghouse Plot: History, Construction Techniques and Application," AIAA 2017-3266, 2017.

110. Beard, J. and **Takahashi, T.T.**, "Revisiting Takeoff Obstacle Clearance Procedures: An Argument for Extended Second Segment Climb," AIAA 2017-3265, 2017.

111. Anderson, B.K. and **Takahashi, T.T.**, "Conceptual Fuselage Design with Direct CAD Modelling," AIAA 2017-3940, 2017.

112.

## Refereed Conference Publications (cont'd)

113. **Takahashi, T.T.,** D.L. Wood and Bays, L.V., "The Effect of Aerodynamic and Propulsive Uncertainty Upon Certified Takeoff Performance," AIAA 2017-3420, 2017.

114. Wood, D.L., **Takahashi, T.T.,** and Bays, L.V., "Experimental Investigation of Typical Aircraft Field Performance versus Predicted Performance Targets," AIAA 2017-3276, 2017.

115. Wood, D.L., **Takahashi, T.T.,** and Bays, L.V. "The Effect of Piloting Practices Upon Actual as Opposed to Scheduled Takeoff Performance," AIAA 2017-3422, 2017.

116. Wilson, J., Teves, R., Snodgrass, N., Haley, J., and **Takahashi, T.T.,** "Multidisciplinary Design Process for a 100 seat Regional Jet," AIAA 2017-3586, 2017.

117. Verbin, A.J., **Takahashi, T.T.,** and White, D.B. "Detail Design of a Pulsed Plasma Test Stand," AIAA 2017-4523, 2017.

118. **Takahashi, T.T.,** Wood, D.L. and Bays, L.V., "An Introduction to the Impact of Pilot Techniques Upon "Certified" Field Performance," AIAA 2017-0007, 2017.

119. Kirkman, J.J. and **Takahashi, T.T.**, "Critical Mach Number Prediction on Swept Wings," AIAA 2017-0266, 2017.

120. **Takahashi, T.T.,** Kirkman, J.J., Verbin, A.J. and Cotting, M.C., "An Innovative Total-Flight-Envelope Approach to Teach Configuration Aerodynamics," AIAA 2017-0692, 2017.

121. Matthieu, M.S., Marin, A.M., Stephenson, K.J., Beard, J.E., Castillo, E., Weddle-Weaver, C., Teni, D. and **Takahashi, T.T.,** "Preliminary Design of an N+1 Overwater Supersonic Commercial Transport Aircraft," AIAA 2017-1387, 2017.

122. Garnica, I. and **Takahashi, T.T.,** "A Study of Engine Parameters and Shaft Configuration on Transport Aircraft Performance," AIAA 2017-1854, 2017.

123. Benassi, M.S., Hrdina, C.R., Horton, E., Hadder, E. and **Takahashi, T.T.** "Next-Generation Regional Jet Transport Conceptual Design," AIAA 2017-1855, 2017.

124. **Takahashi, T.T.** and Bays, L.V., "Climbing While Turning: Combat Energy Management Principles Applied to Civilian Obstacle Clearance," AIAA 2016-4217, 2016.

125. Palma, R.M. and **Takahashi, T.T.**, "The Effects of Supersonic Inlet Topology on the Installed Performance of Turbofan Engines," AIAA 2016-3563, 2016.

126. Allyn, M. and **Takahashi, T.T.,** "Conceptualizing Active-Load-Alleviation: Impacts on Transport Category Aircraft Wing Structural Design," AIAA 2016-3744, 2016.

127. Kirkman, J.J. and **Takahashi, T.T.,** "Revisiting the Transonic Similarity Rule: Critical Mach Number Prediction Using Potential Flow Solutions," AIAA 2016-4329, 2016.

128. Jensen, J. and **Takahashi, T.T.**, "Wing Design Challenges Explained: A Study of the Finite Wing Effects of Camber, Thickness, and Twist," AIAA 2016-0718, 2016.

129. Dickman, C. and **Takahashi, T.T.**, "Engine/Inlet Matching for Supersonic Aircraft Design," AIAA 2016-0771, 2016.

130. Smith, D. and **Takahashi, T.T.**, "Improved Field Performance through Regulatory Changes to Enable Speed Scheduled Reverse Thrust," AIAA 2016-1280, 2016.

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131. Merrell, M.Q. and **Takahashi, T.T.**, "Rediscovering the Peakey Leading Edge: A Study of the Transonic Properties of Classic Airfoils," AIAA 2016-1564, 2016.

132. Barchfeld, C.A. and **Takahashi, T.T.**, "Beyond the Elliptical Span Load: Optimizing Minimum Induced Drag Using Enhanced Leading Edge Suction," AIAA 2016-0781, 2016

133. Kirkman, J., Wood, D., Knight. T., Gurczak, M., Rothlisberger, C., Pan, K.Z. and **Takahashi, T.T.**, "Design Study for a Highly Fuel Efficient Regional Transport," AIAA 2016-1029, 2016.

134. Palma, R.M., Thomas, M.E., Balasiu, A.C., Takamatsu, L.N., Noonan, W.N., and **Takahashi, T.T.**, "A Multi-Disciplinary Study of Future Fuel Efficient Regional Aircraft," AIAA 2016-1424, 2016.

135. **Takahashi, T.T.** and Lemonds, T., "Prediction of Wing Structural Mass for Transport Category Aircraft Conceptual Design," AIAA 2015-3374, 2015.

136. **Takahashi, T.T.**, "The Impact of ATTCS on Reduced Thrust Takeoff Field Performance, AIAA 2015-2698, 2015.

137. **Takahashi, T.T.,** "Optimal Climb Trajectories Through Explicit Simulation," AIAA 2015-2701, 2015.

138. Mirochnitchenko, V. and **Takahashi, T.T.,** "An Investigation into the Design of an Efficient In-Ground-Effect Flying Vehicle Platform, AIAA 2015-3000, 2015.

139. **Takahashi, T.T.** and Kamat, S., "Revisiting Busemann: The Design Implications of Inconsistencies Found Within Simple Sweep Theory," AIAA 2015-3376, 2015.

140. Swann, M. and **Takahashi, T.T**., "A Total Flight Envelope Approach to Conceptual Design Stability & Control," AIAA 2015-3377, 2015.

141. **Takahashi, T.T.** and Gedeon, C., "The Effect of Propulsion System Scale and Bypass Ratio Upon Optimum Climb Speed," AIAA 2015-1677, 2015.

142. **Takahashi, T.T.** and Lemonds, T., "Transport Category Wing Weight Estimation Using A Optimizing Beam-Element Structural Formulation," AIAA 2015-1898, 2015.

**143.** Dulin, D.J. and **Takahashi, T.T.**, "Design Implications of Elliptical Planform Wings," AIAA 2015-0397, 2015.

144. Mirochnitchenko, V., Swann, M., Stallings, D., Merrell, M., Miller, D. and **Takahashi, T.T.,** "Multi-Disciplinary Optimization of a Near Sonic Airliner," AIAA 2015-0132, 2015.

145. Langley, C., Burt, R., Patel, N., Martinez, I., Leon, A. and **Takahashi, T.T.,** "Conceptual Design of a Mach 0.95 Cruise N+1 Commercial Transport," AIAA 2015-1901, 2015.

146. **Takahashi, T.T.** and Kady, C.T., "Planform Selection for an Efficient Supersonic Air Vehicle," AIAA 2014-2426, 2014.

147. **Takahashi, T.T.** and Creighton, A., "Reforming Field Performance Federal Aviation Regulations for Operational Safety and Consistency," AIAA 2014-2425, 2014.

148. **Takahashi, T.T.**, Dulin, D.J. and Kady, C.T., "A Method to Allocate Camber, Thickness and Incidence on a Swept Wing," AIAA 2014-3172, 2014.

149. Gedeon, C. and **Takahashi, T.T.**, "A Multi-Disciplinary Survey of Energy Maneuverability for Subsonic Endurance Based Aircraft," AIAA 2014-3156, 2014.

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150. Gedeon, C. and **Takahashi, T.T.**, "Multi-Disciplinary Survey of Engine Parameters and the Resulting Impact on Energy Maneuverability," AIAA 2014-2032, 2014.

151. Gibson, G.S. and **Takahashi, T.T.**, "Multi-Disciplinary Design of a Rocket Engine Thrust Augmentation Ejector for Endoatmospheric Flight," AIAA 2014-3091, 2014.

152. Heitzman, N. and **Takahashi, T.T.**, "Comparison of Commercial Flight Fuel Reserves in Regards to FAR, Numerical Simulation, and Pilot Flight Techniques," AIAA 2014-3263, 2014.

153. Bowerman, K., Chandran, P., Ixtabalan, D., Sheets, D.T. and **Takahashi, T.T.**, "A Systems Approach to Aircraft Synthesis and Optimization of a Light Business Aircraft," AIAA 2014-2854, 2014.

154. Kady, C.T. and **Takahashi, T.T.**, "Allocating Section Thickness and Camber for Transonic Wing Design," AIAA 2014-0024, 2014.

155. Mora, N., Heitzman, N., Scoville, S., and **Takahashi, T.T.**, "Conceptual Design of a N+1 Transonic Executive Jet," AIAA 2014-0030, 2014.

156. **Takahashi, T.T.**, "The Public Domain, The National Interest and The Fate of the NASA Technical Reports Server," AIAA 2014-0281, 2014. Revised manuscript under the same title also available at: http://dx.doi.org/10.2139/ssrn.2425190

157. DeStories, J. and **Takahashi, T.T.**, "Fixed Pitch Propeller Design for Electrically Powered Aircraft," AIAA 2014-0537, 2014.

158. Lyddon, J., Nguyen, M., Quackenbush, J., Schadegg, T. and **Takahashi, T.T.**, "Optimum Design of a Fuel Efficient Mid-Size Business Jet," AIAA 2014-1337, 2014.

159. **Takahashi, T.T.**, "Intellectual Property Law and Legacy FORTRAN Code," AIAA 2013-4210, 2013.

160. **Takahashi, T.T.** and Kady, C.T., "Curious Circumstances Surrounding Optimal Non-Planar Wings," AIAA 2013-4203, 2013.

161. Gedeon, C., Huffer, S., and **Takahashi, T.T.**, "Multi-Disciplinary Design of an Advanced Narrow-Body Transport Aircraft," AIAA 2013-4329, 2013.

162. Reed, T., Jaksa, M., Gomez, J., and **Takahashi, T.T.**, "High Altitude Hot Rod – An Energy Efficient N+1 Transport," AIAA 2013-4327, 2013.

163. **Takahashi, T.T.**, "Multi-Disciplinary Effects of Zero-Lift Drag and Drag Uncertainty on Aircraft Performance," AIAA 2013-0281, 2013.

164. **Takahashi, T.T.**, "Aircraft Concept Design Performance Visualization Using an Energy-Maneuverability Presentation," AIAA 2012-5704, 2012.

165. **Takahashi, T.T.**, "Federal Regulation of Electronic Flight Bags," AIAA 2012-5676, 2012. Revised version, titled "iPad's in the Cockpit" available at: http://dx.doi.org/10.2139/ssrn.2035743

166. **Takahashi, T.T.**, "Law and Engineering: An Alternative Approach to Develop More Efficient Transport Category Aircraft," AIAA 2012-0335, 2012.

167. German, B.J., Patterson, M.D. and **Takahashi, T.T.**, "Reachability of Optimal Cruise Operating Points: Implications for Aircraft Design," AIAA 2012-1036, 2012.

168. German, B.J. and **Takahashi, T.T.**, "Planform as Platform: An Approach to Air Vehicle Conceptual Synthesis," AIAA-2011-7015, 2011.

## Refereed Conference Publications (cont'd)

169. **Takahashi, T.T.** and Donovan, S., "Non Planar Span Loads for Minimum Induced Drag," AIAA 2011-0639, 2011.

170. Donovan, S. and **Takahashi, T.T.**, "Wing Twist Design Considerations for Transport Category Aircraft," AIAA-2011-1251, 2011.

171. Shajanian, A., **Takahashi, T.T.**, German, B.J., Daskilewicz, M. and Donovan, S. "Wing Section Thickness and Camber Allocation for Conceptual and Preliminary Aircraft Design," AIAA-2011-0164, 2011.

172. **Takahashi, T.T.** and Donovan, S., "Incorporation of Mission Payload Power and Thermal Requirements into the MDO Aircraft Performance and Sizing Process," AIAA-2010-9169, 2010.

173. Donovan, S. and **Takahashi, T.T.**, "A Rapid Synthesis Method to Develop Conceptual Design Transonic Wing Lofts," AIAA-2010-9025, 2010.

174. Petermeier, J., Radtke, G., Stohr, M., Woodland, A., **Takahashi, T.T.**, Donovan, S. and Shubert, M., "Enhanced Conceptual Wing Weight Estimation Through Structural Optimization and Simulation," AIAA 2010-9075, 2010.

175. Hutchins, C., Missoum, S. and **Takahashi, T.T.**, "Fully Parameterized Wing Model for Preliminary Design," AIAA 2010-9120, 2010.

176. Daskilewicz, M., German, B., **Takahashi, T.T.**, Donovan, S. and Shajanian, A., "Robust Design Considerations in the Multi-Objective Problem of Aircraft Conceptual Design," AIAA 2010-2755, 2010.

177. **Takahashi, T.T.**, German, B., Shajanian, A., Daskilewicz, M., and Donovan, S., "Zero Lift Drag and Drag Divergence Prediction for Finite Wings in Aircraft Conceptual Design," AIAA 2010-0846, 2010.

178. **Takahashi, T.T.**, "Strategies Teaching Configuration Aerodynamics in Aeronautical Engineering Capstone Design," AIAA 2009-1602, 2009.

179. **Takahashi, T.T.**, "The Search for the Optimal Wing Configuration for Small Subsonic Air Vehicles," AIAA 2008-5915, 2008.

180. **Takahashi, T.T.,** "Aeronautical Engineering Capstone Design at the University of Arizona," AIAA 2008-0494, 2008.

181. **Takahashi, T.T.**, Fanciullo, T., and Ridgely, D.B., "Incorporation of Flight Control Design Tools into the Multi-Disciplinary Conceptual Design Process," AIAA 2007-0656, 2007.

182. Cunnington, R., Bays, L.V. and **Takahashi, T.T.**, "Incorporation of Aerothermodynamic Analysis Tools into the Multi-Disciplinary Conceptual Design Process," AIAA 2007-0406, 2007.

183. **Takahashi, T.T.**, "Integrated Propulsion/Airframe Analysis for Mission Effectiveness Driven Systems Design," AIAA 2005-4556, 2005.

184. Turner, D., Birney, M. and **Takahashi, T.**, "The Effect of Mission Requirements on Propulsion Design for Advanced Weapons Systems," AIAA-2005-4196, 2005.

185. **Takahashi, T.T.**, Spall, R.J., Turner, D.C., Birney, M.T. "A Multi-Disciplinary Survey of Advanced Subsonic Tactical Cruise Missile Configurations," AIAA 2005-0709, 2005.

## Refereed Conference Publications (cont'd)

186. **Takahashi, T.T.**, Spall, R.J., Turner, D.C., Otto, J.C. and O'Hagan, P., "A Multidisciplinary Assessment of Morphing Aircraft Structures Applied to a Cruise Missile Configuration," AIAA 2004-1725, 2004.

187. **Takahashi, T.T.** and Coopersmith, R.M., "Wing Section Design for a Long-Range Hydrofoil Transport," AIAA 2002-0834, 2002.

188. **Takahashi, T.T.** and Coopersmith, R.M., "Hydrofoil Wing Section Development with High Lift Devices" AIAA 2002-0833, 2002.

189. **Takahashi, T.T.**, Coopersmith, R.M., Novak, C.J. and Olliffe, R., "A Multidisciplinary Design Optimization of a Long-Range Hydrofoil Transport," AIAA 2001-1106, 2001.

190. **Takahashi, T.T.**, "Measurement of Air Flow Characteristics Using Seven Hole Cone Probes," AIAA 97-0600, 1997.

191. **Takahashi, T.T.**, "On the Decomposition of Drag from Wake Survey Measurements," AIAA 97-0717, 1997.

192. **Takahashi, T.T.**, Eidson, R.C. and Heineck, J.T. "Aerodynamic Characteristics of a Supersonic Transport with Pneumatic Forebody Flow Control," AIAA 97-0043, 1997.

193. Parker, B., Eidson, R.C., **Takahashi, T.T.**, "High Speed Civil Transport Forebody Vortex Control," AIAA 97-0042,1997.

194. **Takahashi, T.T.**, Parker, B., Eidson, R.C., and Heineck, J.T., "Flow Physics of a HSCT Configuration with Pneumatic Forebody Flow Control" NASA High Angle of Attack Conference, Sept. 1996.

195. **Takahashi, T.T.** and Ross, J.C., "On the Development of an Efficient Wake Survey System," SAE Paper 95-1990, 1995.

196. Storms, B.L., **Takahashi, T.T.** and Ross, J.C., "Aerodynamic Influence of a Finite-Span Flap on a Simple Wing," SAE Paper 95-1977, 1995.

## Other Publications

1. **Takahashi, T.T.** and Perez, R.E., "A Procedure to Improve the Operational Safety of the CC-130H by Elevating the Obstacle Clearance Speed," RMC AeroMech Dept Report No. 21-11-20, 2020. (CDRL for Canada DND sponsored project)

2. **Takahashi, T.T.** and Perez, R.E., "Analysis of CC-130 Airframe Asymmetry Impact of Performance & Controllability," RMC AeroMech Dept Report No. 18-11-20 (CDRL for Canada DND sponsored project)

3. **Takahashi, T.T.** and Perez, R.E., "Analysis of CC-130 Engine Inoperative Trim and Minimum Control Speed," RMC AeroMech Dept Report No. 10-12-19, 2019. (CDRL for Canada DND sponsored project)

4. **Takahashi, T.T.** and Perez, R.E., "Analysis of CC-130 Airframe Asymmetry Impact of Performance & Controllability," RMC AeroMech Dept Report No. 11-12-19, 2019. (CDRL for Canada DND sponsored project)

5. Pedersen, J. and **Takahashi, T.T.**, "Electric Propulsion Simulation for the MDO Environment," Raytheon MMTN Conference, El Segundo CA, Sept. 2007. (ITAR restricted)

6. Sanderson, T., **Takahashi, T.T.**, et.al., "Compact Stowable Wings for Missiles and UAVs," Raytheon MMTN Conference, El Segundo CA, Sept. 2007 (ITAR restricted)

7. **Takahashi, T.T.**, "Quantitative Systems Engineering and the Multi-Disciplinary Conceptual Design Process," Raytheon Technology Today, Issue 3/2006, Sept. 2006.

8. **Takahashi, T.T.**, "Multi-Disciplinary Optimization Methods for Air Vehicle Design," Raytheon MMTN Conference, Boston MA, Sept. 2006 (ITAR restricted)

9. Cunnington, G.R., Bays, L.V. and **Takahashi, T.T.**, "Incorporation of Aerothermodynamic Analysis Tools into the Multi-Disciplinary Conceptual Design Process," Raytheon MMTN Conference, Boston MA, Sept. 2006. (ITAR restricted)

10. Sanderson, T., **Takahashi, T.T.**, et al., "Preliminary Design of Span and Chord Morphing Wings," Raytheon MMTN Conference, Boston MA, Sept. 2006. (ITAR restricted)

11. **Takahashi, T.T.** and Ross, J.C., "Wake Survey System," Aerospace Engineering, May 1996, pp. 31-34.

12. **Takahashi, T.T.**, "Measurement of Air Flow Characteristics Using Seven-Hole Cone Probes," NASA TM-112194, May 1997.

13. Storms, B.L, **Takahashi, T.T.**, Horne, C., Ross, J.C., Dougherty, R.P. and Underbrink, J.R., "Flap Tip Treatments for the Reduction of Lift Generated Noise," NASA CDTM-21006, March 1996.

14. **Takahashi, T.T.**, "Flow Beneath a Spinning Disk," Ph.D Dissertation, Department of Mechanical Engineering, University of Rochester, 1993 (available from UMI)

## Other Scholarly Activities

Patents

1. **Takahashi, T.T.**, Campton, C. B., and Wood, D.L., Compact Wind Power Generation System, US Patent 10,151,302, December 11, 2018.

Invited Academic Seminars

1. Queen Mary University of London, London, UK, "Are Winglets for the Birds?," July 2015

2. Royal Military College of Canada, Kingston, ON, CA, "Are Winglets for the Birds?" Mar. 2015

3. Raytheon Missile Systems, Systems Engineering & Analysis Symposium, Tucson, AZ. "Commercialization of Military Robotics Into Civilian Society," Sept. 2014

4. Arizona State University, 2nd Governance of Emerging Technologies: Law, Policy and Ethics Conference, Chandler, AZ. "As Time Drones On," May 2014.

5. University of New Mexico, "Are Winglets for the Birds?" Mechanical Engineering Seminar Series, Feb. 2014.

6. New York University School of Law, DRONESCONFERENCE 2013, Oct. 2013.

7. Arizona State University, 1st Governance of Emerging Technologies: Law, Policy and Ethics Conference, Chandler, AZ. "Federal Regulation of Robotic Aircraft," May 2013.

8. Arizona State University, Center for Science Policy Outcomes, Tempe, AZ. "Drones and US," Feb. 2013.

9. Arizona State University, School for Engineering of Matter, Transport and Energy, Tempe, AZ Sep. 2011.

10. Virginia Polytechnic and State University, Department of Aerospace and Ocean Engineering, Blacksburg, VA. Mar. 2011.

11. Santa Clara University, Department of Mechanical Engineering, Santa Clara, CA. Jan. 2011.

12. University of Rochester, Department of Mechanical Engineering, Rochester, NY. May 2009.

13. Wichita State University, Department of Aerospace Engineering, Wichita, KS. May 2008.

14. California Institute of Technology, GALCIT, Pasadena, CA, Jan. 2006

## Students Advised

Graduate Students - In Process

1. Uribe Quintero, E., High Speed Vehicle Flight Dynamics
2. Wu, E., High Speed Aerodynamic Prediction Methods
3. Iyer, A., Transonic Aerodynamics of Serrated Leading Edge Airfoils
4. Lin, C.-H., Low Speed Aerodynamics

## Students Advised (Cont'd)

M.S. Thesis Advisor

1. Valenzuela, Jose V., M.S. thesis, "Aerodynamic Nuances of Wings Subjected to Ground Effect," Arizona State University, Tempe, AZ, February 2024. (Initial career placement: Grand Canyon University, Phoenix, AZ)

2. Ratnayake, Sajana S., M.S. thesis, "Use of Potential Flow Solvers for Automobile Racing Applications," Arizona State University, Tempe, AZ, November 2023.

3. Lorenzo, William P., M.S. thesis, "Fundamental Assessment of High-Speed Aircraft Stability and Control from Historic Flight Tests," Arizona State University, Tempe, AZ, November 2023. (Initial career placement: United States Air Force AFIT, Dayton, OH)

4. Heinz, Joshua H., M.S. thesis, "Attainable Moment Sets – Approaches to Understanding Trim Capability in Conceptual Design," Arizona State University, Tempe, AZ, August 2023. (Initial career placement: Lockheed Martin Skunk Works, Palmdale, CA)

5. O'Brien, Kevin P., M.S. thesis, "Open Loop Stability & Control Screening of High-Speed Slender Aircraft," Arizona State University, Tempe, AZ, April 2023. (Initial career placement: Northrop/Grumman, Chandler, AZ)

6. Hoopes, Connor S., M.S. thesis, "Increasing Lateral-Directional Controllability and Investigating Elevator-Body Flap Interaction for the Shuttle Orbiter," Arizona State University, Tempe, AZ, April 2023. (Initial career placement: Northrop/Grumman, Chandler, AZ)

7. Webb, Benjamin, M.S. thesis, "The Effects of Static Aeroelastic Properties on Aircraft Performance and Shockwave Formation," Arizona State University, Tempe, AZ, November 2022. (Initial career placement: NASA/Ames Research Center, Moffett Field, CA)

8. Griffin, Jack, A. M.S. thesis, "A "Mission Code" Approach to Conceptual Design of Hypersonic Vehicles," Arizona State University, Tempe, AZ, April 2022. (Initial career placement: United States Air Force AFIT, Dayton, OH)

9. Blair, Martin. M.S. thesis, "Conceptual Composite Wing Design," Arizona State University, Tempe, AZ, July 2021.

10. Souders, Tyler. J. M.S. thesis, "Modernization of a Vortex-Lattice Method with Aircraft Design Applications," Arizona State University, Tempe, AZ, April 2021. (Initial career placement: PhD Student, University of Colorado, Boulder, CO)

11. Martinez-Rodriguez, Gabino. M.S. thesis, "A Study and Design of Multi-Element High Lift Systems for Commercial Transport Aircraft," Arizona State University, Tempe, AZ, April 2021. (Initial career placement: Nammo-Talley, Phoenix, AZ now at NASA/Langley Research Center, Hampton, VA)

12. Plaban, Punya. M.S. thesis, "Revisiting Aerodynamic Modifications to a Thin Transonic Wing & Küchemann's Critical Pressure Co-efficient Rule," Arizona State University, Tempe, AZ, April 2021. (Initial career placement: Skyroot Aerospace, Hyderabad, India, presently PhD student at Penn State)

13. Armenta, Francisco X., Jr., M.S. thesis, "Revisiting the Transonic Area Rule for Conceptual Aerodynamic Design," Arizona State University, Tempe, AZ, April 2021. (Initial career placement: Boeing, Everett, WA)

14. Chaudhary, Bhargav, M.S. thesis, "Assessing Flight Performance of a Supersonic Airliner with Swing Wing Capabilities using Energy Maneuverability Theory," Arizona State University, Tempe, AZ, April 2021.

15. Kurus, Noah J., M.S. thesis, "An Exploration into the Nuances of Supersonic Transport Design," Aerospace Engineering, Arizona State University, Tempe, AZ, November 2020. (Initial career placement: Honeywell, Phoenix, AZ)

## Students Advised (cont'd)

M.S. Thesis Advisor (cont'd)

16. Gadekar, Vipul P., M.S. thesis, "Design of Wings for Jump Gliding in a Biped Robot," Aerospace Engineering, Arizona State University, Tempe, AZ, August 2020. (Co-Advised with Prof. Daniel Aukes)

17. Thomas, Philip R., M.S. thesis, "Aircraft are not Fair-Weather Friends: An Analysis of Aircraft En-Route Performance and Economy with Real-World Atmospheric Conditions," Aerospace Engineering, Arizona State University, Tempe, AZ, November 2019. (Initial career placement: Engineering Research and Consulting, Inc. Contractor at Eglin AFB, FL)

18. Burgett, Luke M.S. thesis, "Comparison of Traditional Two-Spool and Three-Spool with Vaneless Counter-Rotating Low-Pressure Turbine for Aircraft Propulsion Power Extraction," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2019. (Initial career placement: Williams International, Walled Lake, MI)

19. Ou, Che Wei, M.S. thesis, "The Effect of Leading-Edge Geometry on the Induced Drag of a Finite Wing," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2019. (Initial career placement: National Chung-Shan Institute of Science & Technology, Lung-Tan, Tao-Yuan, Taiwan, R.O.C.)

20. Miskin, Daniel L., M.S. thesis, "Early Wing Structural Design for Stiffness and Frequency Response," Aerospace Engineering, Arizona State University, Tempe, AZ, November 2018. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

21. Raines, Taylor, M.S. thesis, "Propellant Mass Scaling and Decoupling and Improved Plasma Coupling in a Pulsed Inductive Thruster," Aerospace Engineering, Arizona State University, Tempe, AZ, June 2018. (Co-advisor with Daniel B. White) (Initial career placement: General Atomics, San Diego, CA)

22. Delisle, Mathew, M.S. thesis, "Destabilized Aircraft Response: The Implications of Pilot Trim Error," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2018. (Initial career placement: Boeing Commercial Aircraft, Everett, WA)

23. Cleary, Spencer, M.S. thesis, "The Supersonic Performance of High Bypass Ratio Turbofan Engines with Fixed Conical Spike Inlets," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2018. (Initial career placement: Boeing, Huntington Beach, CA)

24. Wilson, John R., M.S. thesis, "The Doghouse Plot: History, Construction Techniques, and Application," Aerospace Engineering, Arizona State University, Tempe, AZ, November 2017 *winner of The Fall 2017 ASU Outstanding Engineering Graduate Student award (Initial career placement: Orbital Sciences, Chandler, AZ)

25. Wood, Donald L., M.S. thesis, "Experimental Investigation of Typical Aircraft Field Performance Versus Predicted Performance Targets," Aviation Management Technology (co-advised with Mary Niemczyk), Arizona State University, Tempe, AZ, May 2017. (Initial career placement: Academic Professional, Arizona State University, Mesa, AZ)

26. Beard, John E., M.S. thesis, "Takeoff Obstacle Clearance Procedures: The Feasibility of Extended Second Segment Climb," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2017. (Initial career placement: Raytheon Missile Systems, Tucson, AZ) * runner up for the 2017 Outstanding SEMTE Graduate Thesis award

27. Anderson, Benjamin K., M.S. thesis, "Conceptual Fuselage Design with Direct CAD Modeling," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2017. (Initial career placement: Textron Aviation, Wichita, KS)

28. Verbin, A.J., M.S. thesis, "Detail Design of a Pulsed Plasma Test Stand," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2017. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

## Students Advised (cont'd)

M.S. Thesis Advisor (cont'd)

29. Hadder, Eric, M.S. thesis, "Predicting Minimum Control Speed On The Ground (VMCG) And Minimum Control Airspeed (VMCA) Of Engine Inoperative Flight Using Aerodynamic Database And Propulsion Database Generators," Aerospace Engineering, Arizona State University, Tempe, AZ, November 2016. (Initial career placement: Earth Air, Mesa, AZ)

30. Kirkman, Jeffrey J., M.S. thesis, "Transonic Flow Around Swept Wings: Revisiting Von Karman's Similarity Rule," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2016. (Initial career placement: Textron Aviation, Wichita, KS)

31. Heitzman, Nicholas, M.S. thesis, "Comparison of Commercial Aircraft Fuel Requirements in Regards to FAR, Flight Profile Simulation, and Flight Operational Techniques," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2014. (Initial career placement: Honeywell, Phoenix, AZ)

M.S. Applied Project Advisor

1. Kulkarni, A., Induced Drag of Wings with Bell-Shaped Lift Distributions, Arizona State University, December 2023.

2. Ratnayake, S.S., Three-Dimensional Geometry Synthesis to Achieve a Wing Target Pressure Distribution, Arizona State University, May 2020. (Now PhD student at ASU)

3. Frede, K., Engine Installation Interference Effects on a Transonic Wing, Arizona State University, Tempe, AZ, May 2019. (Initial career placement: Northrop Grumman, Chandler, AZ)

4. Shillingburg, Ryan. Hypersonic Vehicle Aerodynamic Configuration Studies, Arizona State University, Tempe, AZ, May 2019. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

5. Snodgrass, N. High Speed Propulsion, Arizona State University, Tempe, AZ, December 2018. (Initial career placement: General Dynamics, Tempe, AZ)

6. McCourt, Anthony. Materials Selection and Structural Design for a Hybrid Rocket Combustion Chamber, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: Honeywell, Phoenix, AZ)

7. Leader, Robert. High-Bypass Ratio Turbofan Engine Design Studies, M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: Honeywell, Phoenix, AZ)

8. Winsryg, Benjamin. Aerothermal Environments Developed by High Speed Atmospheric Flight. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: Lockheed Martin Space Systems, Denver, CO)

9. Stone, Nathan. Power and bleed air extraction from small commercial turbofan engines intended to power HALE aircraft. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: General Atomics Aeronautical Systems, Adelanto, CA) *winner of the Spring 2018 SEMTE Outstanding Graduate TA award

10. Garnica, Isaac. Power and bleed air extraction from single and multi-shaft turbofan engines. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2016. (Initial career placement: Honeywell, Phoenix, AZ)

11. Allyn, Mathew. Wing structural design consequences of active load alleviation. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, December 2015. (Initial career placement: Boeing Commercial Airplane Company, Seattle, WA)

## Students Advised (cont'd)

M.S. Applied Project Advisor (cont'd)

12. Quackenbush, Jess, Induced Drag of Sharp Leading Edge Wings. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, December 2015. (Initial career placement: Orbital Sciences, Chandler, AZ)

13. Palma, Ryan M., Inlet / Engine Matching for Supersonic Turbofan Engines. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, December 2015. (Initial career placement: Raytheon Missile Systems, Tucson, AZ now at NASA/Langley Research Center, Hampton, VA)

14. Swann, Matthew, Flight Dynamics Screening Tools. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

15. Dickmann, Christopher A., Installed Performance Modelling of Supersonic Normal Shock Engines using NPSS. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: Northrop/Grumman, El Segundo, CA)

16. Jensen, James C., Spanwise Effects of Wing Thickness. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: NASA/Ames Research Center, Moffett Field, CA)

17. Barchfield, Christopher A., Induced Drag of Low Aspect Ratio Wings. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015.

18. Merrell, Michael Q., Peakey Leading Edge Airfoil Design M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

19. Kamat, Sagar. Wing Speed Theory Validation Through Higher-Order Computation. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: Product Engineer-Vehicle Engineering at Ford Motor Company, Dearborn, MI)

20. Smith, Danis B., Reverse Thrust Certification as a Primary Ground Deceleration Device. M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Current Position: Engineer at Honeywell Aerospace, Phoenix, AZ)

21. Mirochnitchenko, Vladimir, Wing-in-ground-effect Vehicle Concept Design, M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

22. Dulin, Derek J., Fundamental Aerodynamics of Swept Wings, M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2015. (Initial career placement: Raytheon Missile Systems, Tucson, AZ

23. Lemonds, Tyler, Automated Wing Structural Design, M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, December 2014. (Initial career placement: Textron Aerospace, Wichita, KS)

24. Gedeon, Christopher, Energy Maneuverability of Combat Aircraft, M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2014. (Initial career placement: Honeywell Aerospace, South Bend, IN presently at Northrop/Grumman, Baltimore, MD)

## Students Advised (cont'd)

M.S. Applied Project Advisor (cont'd)

25. Kady, Christopher, Aero-Structural Design of Transonic Wings, M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2014. (Initial career placement: Honeywell Aerospace, Phoenix, AZ presently at Boom Aerospace, Denver, CO)

26. DeStories, Jason, "A Method for Optimizing and Evaluating Propeller Performance Established on Airfoil Test Data," M.S. applied project, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2013. (Current Position: Boeing Helicopters, Mesa, AZ)

B.S. Honors Thesis Advisor

1. De Roo, M., "A Feasibility Study of Global Commercial SST, Building a Database on Routing Financials and Logistics for Major Airline Corporations," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, April 2023.

2. Cruz, B.M., "Signal Analysis of High Frequency Binaural Audio," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, April 2023.

3. Marino III, M.A, "Robust Autopilot Control of a Ground Vehicle," ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, October 2022.

4. Stauffer, M.T., "Generalized Propulsion Force Accounting," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, April 2022. (Initial career placement: Northrop-Grumman, Chandler, AZ)

5. Walther, C. & Mazza, S., Automobile Drag Reduction through Vortex Generators, ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, April 2022.

6. O'Brien, K. "An Investigation of the Bell X-2 and the Factors that lead to its Fatal Accident," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, November 2021. (Initial career placement: M.S. Candidate at ASU)

7. Heitmann, K. "Analyzing Internal Stresses in a Dragon Boat Paddle to Optimize First Stroke Technique," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2021. (Initial career placement: Boeing, St. Louis, MO)

8. Ranganathan, A. & Karthikeyan, S. "Exploration of Intercontinental Rocket Travel Using the Commercialization of the Airline Industry," Aerospace Engineering, Arizona State University, Tempe, AZ, April 2021.

9. Olzak, P. "Analytical Drag Analysis of Drafting NASCAR Models," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, April 2021.

10. Roden, M., "Dynamics of Oversteer: Modelling Drift by Solving a System of Equations," ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, August 2020.

11. Blair, M., & Armenta, F. "Modeling Trajectories of Supersonic Projectiles," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2020. (Initial career placement: M.S. Candidates at ASU)

12. Schierbrock, A. "Design of Tool to Predict Flight Envelope Properties," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2020. (Initial career placement: M.S. Candidate at ASU)

## Students Advised (cont'd)

B.S. Honors Thesis Advisor

13. Kolesov, N., "Automated Generation of Aircraft Wing Structure," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, December 2019. (Initial career placement: Contractor at NASA/Ames Research Center, CA)

14. Glynn, Julia, "An Experimental Investigation of Aerodynamic Drag on Different Cycling Outfits," ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, December 2019.

15. Jordan, A. Claire, "Theory vs. Practice: An In-Depth Analysis of Engineering Education and the Careers that Follow," ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2019. (Initial career placement: Texas Instruments, Dallas, TX)

16. Goudamanis, Christy M. and Lai, E. "Future of Patentability for Biotechnology," ASU Barrett Honors College B.S. thesis, BioMedical Engineering, Arizona State University, Tempe, AZ, May 2019.

17. Sanchez, Z. "Effects of Diffusers With and Without Vortex Generators on Overall Flow and Velocity Distribution," ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: Cypress Semiconductors, Austin, TX)

18. McCourt, A. "Aerodynamic Stability of a Small Bluff-Bodied Vehicle," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: M.S. Candidate at ASU)

19. Patrick, N. "A Tool for Parametric Modelling of Aircraft Landing Gear," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2018. (Initial career placement: Northrop Grumman, El Segundo, CA)

20. Morrow, M. "Leading Edge Geometry Effects on Pressure Drag and Pressure Thrust for Various Wing Geometries" ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2017. (Initial career placement: Ph.D candidate in Aerospace Engineering at Georgia Tech)

21. Coote, P.J. "Investigation into the von Karman Vortex Street and the Relationship Between Reynolds and Strouhal Numbers," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2017.

22. Leader, R. "Automatic Area-Ruling of Aircraft Geometries" ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2017. (Initial career placement: M.S. candidate at ASU)

23. Sparks, G. Philip "Planing and The Effect of Bicycle Frame Stiffness on Rider Performance" ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2017.

24. Elliott, S. "A Tool for the Parametric Modeling of Aircraft Bodies" ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2017. (Initial career placement: M.S. candidate at ASU)

## Students Advised (cont'd)

B.S. Honors Thesis Advisor

25. Brausch, M. "Wake Surveys behind Golf Club Heads" ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2016. (Initial career placement: M.S. candidate at ASU)

26. Milroy, M. "How Surface Roughness Contributes to the Overall Drag of Certain Spherical Objects." ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2016. (Initial career placement: Microsoft, Seattle, WA)

27. Sexton, T., "Optimal Modeling of Knots in Wood: A study into the severity of wood-grain defects on beam stiffness," ASU Barrett Honors College B.S. thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2015. (presently M.S. candidate at ASU)

28. Creighton, A., "Analysis of Regulations on the Landing and Take-Off of Commercial Aircraft," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2014. (Initial career placement: Raytheon Missile Systems, Tucson, AZ)

29. Duensing, J., "PID Control Techniques for the Autonomous Quadrotor and a Frequency Approach to Analyzing and Identifying Dynamic Models," ASU Barrett Honors College B.S. thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2014. (Initial career placement: M.S. graduate studies in Aerospace Engineering, Arizona State University, Tempe, AZ)

Undergraduate Research Advisor (ASU Dean's Office – Fulton Undergraduate Research Initiative)

1. Lucas Van Noord, Aircraft Mass Properties Estimation (Spring 2023)
2. Zak Norris, Aircraft Structural Joints (Spring 2022,Fall 2022)
3. Jack Griffin, Aircraft Structural Mass Estimation (Spring 2021)
4. Ivan Pesquiera, Carbon Fibre Aircraft Structures (Spring 2021)
5. Kevin O'Brien, Flight Dynamics of Small Aircraft (Spring 2020, Fall 2020)
6. Nitish Chennjou, Flight Test Data Reduction (Spring 2020, Fall 2020)
7. Maxwell Stauffer, In Flight Propulsion Testing (Spring 2020, Fall 2020)
8. Nikolay Kolesov, Lightweight Structural Design for Strength and Buckling Resistance, (Fall 2018, Spring 2019)
9. Daniel Kosendar, In Flight Propulsion Testing (Spring 2019, Fall 2019)
10. J. Evan Barker, Wind Tunnel Propulsion Testing (Spring 2019)
11. A Claire Jordan, Thermally Induced Buckling of Aerospace Structures, (Spring 2018, Fall 2018)
12. Ivan Milosavljevic, Aircraft Flight Operations (Spring 2017, Fall 2017)
13. Matthew Bajamundi, Electric aircraft propulsion (Fall 2017)
14. Galen Kingsley, Leading Edge Suction Investigation through Wake Surveys (Fall 2017, Spring 2018)
15. Erik Krutchen, Aircraft Flight Operations (Spring 2017)
16. Ivan Kruts, Propeller testing (Fall 2016, Spring 2017)
17. Robert Leader, Parametric CAD of supersonic aircraft (Spring 2016, Fall 2016)
18. Edgar Castillo, Wake Survey Probe (Fall 2015, Spring 2016)
19. Aaron Molina, Wake Survey System (Fall 2015, Spring 2016)
20. Tanguy Toulouse, Propeller Thrust Stand Fixture (Fall 2015, Spring 2016)
21. Steven Elliott, Parametric CAD of subsonic aircraft (Fall 2015, Spring 2016)
22. Michael Benassi, Advanced Materials / Aviation Safety Public Policy (Fall 2014, Spring 2015)
23. Eric Chang, Materials & Fabrication Techniques for Small UAV (Fall 2014, Spring 2015)
24. Garrett Heuer, Field Performance / Aviation Safety Public Policy (Fall 2014, Spring 2015)
25. Eric Horton, Flight Operations / Aviation Safety Public Policy (Summer 2014, Fall 2014)
26. Andrew Creighton, Runway Excursions / Aviation Safety Public Policy (Fall 2013, Spring 2014)
27. Matthew Swann, CAD Integrated Analysis (Spring 2013, Fall 2013)
28. Derek Dulin, CAD Integrated Aerodynamic Analysis (Spring 2013)
29. Zachary Branum, CAD Integrated Aerodynamic Analysis (Spring 2013)

## Students Advised (cont'd)

Undergraduate Research Advisor (ASU NASA Space Grant)

1. Ryan Oppen – Aircraft Loads and Subsystem Design (F 2023, S 2024)
2. Lina Youssfi – Materials Selection of Aerospace Structures (F 2023, S 2024)
3. Lucas Guaglardi – Design of Electric Ducted Fan Propulsors (F 2022, S 2023, F 2023, S 2024)
4. David Ordaz Perez – Design of Rocket Recovery Parachutes (F 2021, S 2022, F 2022, S 2023)
5. Dustin Eilers – Ramjet Propulsion System Design (F 2021)
6. Cole Errico – Design of Launch Vehicle Structures (F 2020, S 2021)
7. Sepideh Jafarzadeh - Rocket Nozzle Testing (F 2014, S 2015)

Outside Committee Member

1. Akondi, V.S.C., "Modeling and Analysis of Flow Over Rooftop Structures in Urban Environment," M.S. Thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, July 2024.

2. Burgett, J.K., "Schlieren Optics and Photoacoustic Imaging," B.S. Honors Thesis, Biomedical Engineering, Arizona State University, Tempe, AZ, 2022.

3. Mulford, P.M., "Environment Sensor Coverage Using Multi-Agent Robot Headings," M.S. Thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, August 2020.

4. Schmollgruber, P., "Enhancement of the Aircraft Design Process Through Certification Constraints Management and Full Mission Simulations," PHD, ISAE – SUPAERO, Toulouse, FRANCE, 2019.

5. Haug, A.J. "Ionic Wind Propulsion," ASU Barrett Honors College B.S. Honors thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2017.

6. Gibson, G.S., "Rocket Engine Nozzle Ejectors," ASU Barrett Honors College B.S. Honors thesis, Aerospace Engineering, Arizona State University, Tempe, AZ, May 2014.

7. Gyllenhall, W., M.S. applied project, Mechanical Engineering, Arizona State University, Tempe, AZ, May 2013.

8. Martinjako, J., "Simple Method for Estimating Shaft-Power Gas Turbine Off-Design Point Performance," B.S. Honors Thesis, Mechanical Engineering, Arizona State University, Tempe, AZ, April 2013.

9. Vallone, M., "Parameter Estimation of Fundamental Technical Aircraft Information Applied to Aircraft Performance," M.S. thesis, Aerospace Engineering, California Polytechnic State University, San Luis Obispo, CA, September 2010

10. Calabretta, J., "A Three Dimensional Vortex Particle-Panel Code for Modeling Propeller-Airframe Interaction," M.S. thesis, Aerospace Engineering, California Polytechnic State University, San Luis Obispo, CA, June 2010.

11. Ramos, A., "Development of a Meshless Method to Solve Compressible Potential Flows, M.S. thesis, Aerospace Engineering," California Polytechnic State University, San Luis Obispo, CA, June 2010.

12. Lane, K.A., "Novel Inverse Airfoil Design Utilizing Parametric Equations," M.S. thesis, Aerospace Engineering, California Polytechnic State University, San Luis Obispo, CA, June 2010.

13. Baukol, C. R., "Development of an Integrated Gaussian Process Metamodeling Application for Engineering Design," M.S. thesis, Aerospace Engineering, California Polytechnic State University, San Luis Obispo, CA, June 2009.

14. Morrisey, B. J., "Multidisciplinary Design Optimization of an Extreme Aspect Ratio HALE UAV," M.S. thesis, Aerospace Engineering, California Polytechnic State University, San Luis Obispo, CA, June 2009.

# EXHIBIT 2

Items Considered:

- Petition for IPR for US Patent No. 9,586,659 (and all associated exhibits)
- US Patent No. 9,586,659
- Prosecution history of US Patent No. 9,586,659
- Claim construction orders from *MHL Custom Inc. v. Waydoo USA, Inc. et al.* (D.Del 1:21-CV-00091)
- MHL YouTube Channel, https://www.youtube.com/c/LiftFoils
- EX2012-EX022
- PTAB's Decision Granting Institution of the *Inter Partes* Review (Paper 12) and all exhibits cited therein.
- Deposition transcript of Petitioner's expert Dr. Brizzolara
- Various university library guides included as exhibits herein
- Etkin, B. and Reid, L.D, Dynamics of Flight, 3rd Edition, Wiley, 1996.
- Yechout, T.R., Introduction to Aircraft Flight Mechanics, 2nd Edition, AIAA, 2014.