UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SZ DJI TECHNOLOGY CO., LTD., Petitioner

v.

AUTEL ROBOTICS USA LLC, Patent Owner

> Case No. IPR2019-00846 Patent No. 9,260,184

SECOND DECLARATION OF DR. CHARLES F. REINHOLTZ

TABLE OF CONTENTS

Page

I.	INTRODUCTION				
II.	BACKGROUND AND QUALIFICATIONS				
III.	RELEVANT LEGAL STANDARDS				
	A.	ANTICIPATION	3		
	B.	OBVIOUSNESS	3		
IV.	DOC	UMENTS	5		
V.	SUM	MARY OF OPINIONS	6		
VI.	SUM	MARY OF THE ALLEGED INVALIDATING PRIOR ART	6		
	A.	SASAKI	6		
	B.	SOKN	6		
	C.	PHILISTINE	6		
	D.	EP067	8		
	E.	OBRIST	9		
VII.	THE THE	REVISED PROPOSED CLAIMS ARE PATENTABLE OVER ALLEGED INVALIDATING PRIOR ART	11		
	В.	A POSA WOULD NOT MODIFY SASAKI OR COMBINE IT WITH ANY OF SOKN, PHILISTINE, EP067 OR OBRIST	11		
	C.	EVEN IF COMBINED, THE ALLEGED PRIOR ART DOES NOT DISCLOSE OR TEACH THE REVISED PROPOSED CLAIMS	21		
	D.	LONG-FELT AND UNMET NEED	23		
VIII.	CON	CLUSION	24		

I, Charles F. Reinholtz, declare as follows:

I. INTRODUCTION

1. I have been retained as an expert in this matter by counsel for Patent Owner Autel Robotics USA LLC ("Autel"). I have been asked to investigate and opine on the validity/patentability of claims of U.S. Patent No. 9,260,184 ("184 patent") (Ex. 1001) in the above captioned *inter partes* review ("IPR"), in view of the Petition filed by Petitioner SZ DJI Technology Co., Ltd. ("DJI").

2. On January 10, 2020, I previously submitted a declaration in this IPR ("First Declaration") (Ex. 2001) that sets forth my opinions relating to the validity/patentability of substitute claims 12 and 13 as set forth in Autel's Motion to Amend dated January 10, 2020.

3. I understand that Autel is filing a revised motion to amend with revised substitute claims 12 and 13 (changes over original claims 3 and 4 underlined and strikethrough):

Claim 12. (Proposed substitute for claim 3) The apparatus of claim 1 wherein the blade lock portion of the clockwise lock mechanism <u>is configured to engage with</u> <u>the shaft lock portion of the clockwise lock mechanism by partial is rotated</u> counterclockwise <u>rotation</u> with respect to the shaft lock portion <u>thereof of the</u> <u>clockwise lock mechanism</u> to releasably attach the clockwise rotor blade to the first driveshaft.

Claim 13. (Proposed substitute for claim 4) The apparatus of claim 12 wherein the counterclockwise lock mechanism comprises a shaft lock portion attached to the second driveshaft and a blade lock portion attached to the counterclockwise rotor blade, and wherein the blade lock portion of the counterclockwise lock mechanism is configured to engage with the shaft lock portion of the counterclockwise lock mechanism by partial is rotated-clockwise rotation with respect to the shaft lock portion of the counterclockwise lock mechanism thereof-to releasably attach the counterclockwise rotor blade to the second driveshaft.

I will refer to revised proposed claims 12 and 13 as the "Revised Proposed Claims".

4. I was asked to provide my opinion as to the patentability of the Revised Proposed Claims in view of the prior art cited by DJI in its Opposition to Patent Owner's Motion to Amend.

5. In forming my opinions, I relied upon my education, knowledge, and experience and considered the level of ordinary skill in the art as discussed below.

II. BACKGROUND AND QUALIFICATIONS

6. My relevant background and qualifications are set forth in my First Declaration.

7. Attached as Appendix A is a copy of my current curriculum vitae, which further sets out my academic and professional background and qualifications.

8. I am being compensated for my time in connection with this IPR at my standard consulting rate, which is \$400 per hour. My compensation is not dependent in any way upon the outcome of this matter.

III. RELEVANT LEGAL STANDARDS

A. Anticipation

9. I understand that a patent claim is unpatentable and invalid if the claim is anticipated. I understand that anticipation occurs when a single piece of prior art describes every element of the claimed invention, either expressly or inherently, arranged in the same way as in the claim. I understand that, for inherent anticipation, it is required that the missing descriptive material is necessarily present in the prior art.

B. Obviousness

10. I understand that a patent claim is unpatentable and invalid if the subject matter of the claim as a whole would have been obvious to a person of ordinary skill in the art at the time of the invention at issue. I understand that obviousness may be shown by considering more than one item of prior art. I understand that the following factors should be evaluated to determine whether the claimed subject matter is obvious: (1) the scope and content of the prior art; (2) the

Second Declaration of Dr. Charles F. Reinholtz – U.S. Patent No. 9,260,184 difference or differences, if any, between each claim of the patent and the prior art; and (3) the level of ordinary skill in the art at the time the patent was filed.

11. I understand that "objective indicia of non-obviousness," also known as "secondary considerations," are also to be considered when assessing obviousness if present including: commercial success; long-felt but unresolved needs; failure of others to solve the problem that the inventors solved; unexpected results; copying of the invention by others; and industry recognition or expressions of disbelief by experts in the field of the claimed invention. I understand that any of these factors provide objective evidence that a claimed invention was not obvious at the time of its invention. I also understand that objective indicia of non-obviousness must be commensurate in scope with the claimed subject matter. I also understand that there must be a nexus between the secondary considerations and the claimed invention.

12. I understand that the test of obviousness is whether the claimed invention, as a whole, would have been obvious to one of ordinary skill in the art as of the date of the invention in light of the prior art.

13. I understand that a claim is not proved obvious merely by demonstrating that each of the elements was independently known in the prior art. I understand that most, if not all, inventions rely on building blocks long since uncovered, and claimed discoveries, almost of necessity will likely be combinations of what is already known. I understand that it is important to identify whether a

reason existed at the time of the invention that would have prompted a person of ordinary skill in the art in the relevant field to combine the known elements in the way the claimed invention does. I understand that the use of hindsight must be avoided when considering whether the alleged invention would have been obvious to the person of ordinary skill in the art. In assessing obviousness, I have been instructed to consider the distortion caused by hindsight bias, guard against slipping into the use of hindsight, be cautious of arguments that rely upon after-the-fact reasoning, and avoid the temptation to read into the prior art the teachings of the invention in issue.

IV. DOCUMENTS

14. I have referenced and/or reviewed the following documents in connection with this Declaration: (1) DJI's Opposition to Patent Owner's Motion to Amend and the exhibits thereto, in particular Dr. Ducharme's declaration (Ex. 1003), (2) the documents referenced or cited in my First Declaration and (4) any additional documents cited herein. I have considered those documents and apply them in light of the general knowledge in the art and the knowledge of a person of ordinary skill in the art.

Autel Ex. 2007, p.7

V. SUMMARY OF OPINIONS

15. It is my opinion, as set forth in detail in this declaration, that the Revised Proposed Claims are patentable in view of the prior art cited by DJI in their IPR Petition.

VI. SUMMARY OF THE ALLEGED INVALIDATING PRIOR ART

A. Sasaki

16. Sasaki is summarized in my First Declaration, and I include that summary and my opinions regarding Sasaki here by reference.

B. Sokn

17. Sokn is summarized in my First Declaration, and I include that summary and my opinions regarding Sokn here by reference.

C. Philistine

18. Philistine (Ex. 1026) relates to a twist-lock mount for a blower motor for a system that provides filtered air. As shown and described below, the Philistine mount achieves a rigid and secure locking arrangement with two basic components, a mounting member, and a receiving member, that are designed to interlock when one is twisted relative to the other:

> FIGS. 1 and 2 show perspective views from the top and bottom, respectively, of an embodiment of a twist lock mount 100 according to the present invention. The twist lock mount 100 includes two basic components, a mounting member 110 that is secured to or integrated with a device to be mounted, and a receiving member 116 that is secured to or integrated with a mounting surface or

support. Receiving member 116 provides a channel 123 for receiving and engaging mounting member 110. Mounting member 110 is configured to slide into the channel 123 when it is in one rotational orientation and to lock securely into place when it is in another. To mount a device with the twist lock mount 100, the user needs only to orient the mounting member so that it will slide into the channel and then to rotate the device in the channel until it locks securely in place. A rotation in the opposite direction will unlock the device so that the mount can be slid out of the channel quickly and easily.



Philistine at 2:33-49, Fig. 1.

19. Philistine does not relate to UAVs or UAV design, and is not related to a locking mechanism for UAV propeller blades. Philistine does not depict different configurations for its lock mechanism to accommodate the proper fitting of components based on the direction of rotation. There is no discussion in Philistine Second Declaration of Dr. Charles F. Reinholtz – U.S. Patent No. 9,260,184 regarding clockwise or counterclockwise rotating rotor blades and the critical need to prevent interchangeably mounting such blades.

D. EP067

20. EP067 (Ex. 1028) relates to a mechanism for attaching motor boat propeller blades to a hub that includes a pitch-control mechanism. EP067 at [0001]-[0003]. The mechanism includes a blade support plate with claws that engage with grooves and projections on a blade base as the propeller is rotated within the blade support. EP067 at [0016]-[0021] and Figures 1-3. After rotation, the position of the blade must still be secured by a screw. EP067 at [0021] and Figure 4. EP067 does not relate to UAVs or UAV design, and is not related to a locking mechanism for UAV propeller blades. The boat propeller blades in EP067 are fixed to the hub, as shown below in EP067 Figure 5, and do not rotate around the axis of the driveshaft like a UAV propeller blade. EP067 does not depict different configurations for its lock mechanism to accommodate the proper fitting of components based on the direction of rotation. There is no discussion in EP067 regarding clockwise or counterclockwise rotating rotor blades and the critical need to prevent interchangeably mounting such blades.

Autel Ex. 2007, p.10



E. Obrist

21. Obrist (Ex. 1017), like EP067, relates to pitch control and does not at all relate to clockwise and counterclockwise rotating blades. Specifically, Obrist "relates to a variable-pitch propeller for ships, aircraft and centrifugal machines, provided with cranks for varying the pitch of the propeller blades, each of the cranks being formed integral with its correlated blade root." Obrist 1:1-5. Obrist primarily concerns the following elements: blades 1; blade root 2 detachably connected to blade by bolts; hub 3; crank 5 cast-on to blade root 2 and operationally connected to an adjusting mechanism; projections 6; bores 7; recesses in each bore 8; trunnion 9; and journal 10. Obrist 2:12-22, Figs. 1-5.

22. In Obrist, the projections 6 resist radial force, i.e., the centrifugal force, that tries to sling the blade radially outward from the hub as shown in Figure 2 below:



See also Obrist 2:55-3:4. The projections 6 must allow the blade to rotate about its radial axis to adjust pitch. This adjustment must be provided by the undisclosed adjusting mechanism that is operationally connected to Crank 5. Obrist 2:23-27 ("The various cranks 5 are operatively connected to an adjusting mechanism known per se an which has nothing to do with the essential features of the invention so that it is neither shown in the drawing nor hereinafter described."). This same mechanism must necessarily control both the pitch angle and the location of projections 6 in the "arcuate seat formed therefor on the internal face of the hub." Obrist 2:47-54. In other words, unless there is a separate mechanism connected to crank 5 and controlling the pitch angle of the blade, the blade would be free to rotate so that projections 6 could align with recesses 8 and the blades would fly off. Hence

the mechanism that retains the blades must include projections 6, bores 7, an arcuate seat formed on the internal face of the hub, and a separate mechanism connected to crank 5 to control the pitch angle of the blade and to keep projections 6 within the arcuate groove.

23. Obrist does not depict different configurations for its lock mechanism to accommodate the proper fitting of components based on the direction of rotation. There is no discussion in Obrist regarding clockwise or counterclockwise rotating rotor blades and the critical need to prevent interchangeably mounting such blades.

VII. THE REVISED PROPOSED CLAIMS ARE PATENTABLE OVER THE ALLEGED INVALIDATING PRIOR ART

24. As explained in my First Declaration, including at paragraphs 58-71, a POSA would not modify Sasaki or combine it with Sokn. Below I address particular issues raised by Dr. Ducharme in his Second Declaration (Ex. 1028) and explain why his opinions do not alter my conclusion that the Revised Proposed Claims are patentable.

B. A POSA Would Not Modify Sasaki Or Combine It With Any Of Sokn, Philistine, EP067 Or Obrist

25. For the reasons I already stated in my First Declaration, and those stated herein, I disagree with Dr. Ducharme's opinion that a POSA would have looked to Sokn when designing an attachment mechanism for UAV blades. Ex. 1028 \P 45. Sokn discloses a method for resiliently mounting one end of a non-rotating motor

body to the fan housing of a machine such as a clothes dryer. The "Field of Invention" of Sokn is described as follows:

The present invention generally involves the field of technology pertaining to devices for mounting or supporting electric motors relative to an associated structure. More particularly, the invention relates to an improved assembly for mounting a fan motor to the fan housing of a domestic clothes dryer.

Sokn at 1:5-11. Figure 1 below shows Sokn's first embodiment with the disclosed

motor mount assembly shown highlighted in green and shown as item 1.



Motor mount assembly 1 secures the left end of the motor to fan housing 15 through resilient ring 21, shown in Fig. 3 below. As described by Sokn, it is an object of the invention to have an "internal resilient ring" and "ring 21 is preferably integrally formed from a resilient material, such as rubber, capable of absorbing and Second Declaration of Dr. Charles F. Reinholtz – U.S. Patent No. 9,260,184 dampening the transmission of torsional and radial vibrations normally realized from the operation of motor 3." Sokn 1:59-63, 3:5-10.



26. Sokn further discloses that, "The opposite end of motor 3 is mounted on a conventional sheet metal support structure 17." Sokn at 2:56-58. The support 17 is shown in the right side of Figure 1 above and highlighted in orange. The invention disclosed by Sokn is a resilient mounting for attaching one end of a motor to a fan housing. There is no disclosure of mounting rotor blades or even fan blades to the shaft of a motor. There is also no consideration of rotational direction of the rotor and no possibility of mounting the wrong blade to the motor shaft. There is no mention in Sokn of rotor blades, clockwise and counterclockwise rotation, lift, axial forces that are inherently associated with the design of a multi-rotor UAV. In addition, the resilient mounting disclosed in Sokn is inappropriate for UAV applications. A POSA would not be motivated to use a resilient mounting in a UAV

Second Declaration of Dr. Charles F. Reinholtz – U.S. Patent No. 9,260,184 application because it would inhibit the precise control of rotor rotation needed to balance lift and maintain stable flight.

27. Dr. Ducharme contends that Sokn's coupling mechanism is easily detached with a 90° turn, but his support for this position is based primarily on his previous declaration. Ex. 1028 ¶ 46. Sokn, however, does not teach detachment, nor does Sokn discuss the torque needed to attach or detach the motor from the fan housing. As already explained in my First Declaration, a POSA would understand that a system for mounting the motor of a clothes dryer to a fan housing would not require easy and quick detachment for transport or storage. Thus, a POSA would not look to clothes dryer connection mechanisms to achieve the quick and convenient partial rotation lock mechanism embodied in the Revised Proposed Claims.

28. In addition, Dr. Ducharme points to the stop features, 45, in Sokn and implies that, because there are four separate stop members, and because they are called stop members, they are not frictional stops. Ex. $1028 \P 48$. This is incorrect. Positive, non-frictional stops require stop elements that abut radially rather than axially. The interaction of the lugs 25 and notches 27 in the '184 patent provides an example of a radial stop that cannot be overtightened. As shown in '184 patent Fig 5, the faces of lugs 25 and notches 27 abut (as highlighted in red) to create a positive stop feature.



29. An examination of Fig. 4 from Sokn, reproduced with highlighting below, shows that Sokn requires frictional contact between the stops 45 (shown as part of the housing in green) and the resilient ring 21 (shown in red) to terminate rotation. There is nothing that inherently limits the travel of the thread segments 37 (shown in blue) and 49 (shown in yellow).

Autel Ex. 2007, p.17



30. In other words, the motor, including the motor mount assembly 1, can be tightened with increasing torque, and this will cause the same frictional "overtightening" problem inherent in the screw-on type prior art discussed in Sasaki. A POSA would understand that an axial stop, such as a screw reaching the end of a blind hole, the lid of a jar or the assembly disclosed by Sokn are frictional stops that can easily be over tightened due to the mechanical advantage offered by the threads.

31. In addition, as shown below, Petitioners and Dr. Ducharme propose to shrink the diameter of Sokn in an attempt combine it with the screw-on blade shown as prior art in Sasaki. This would eliminate the primary advantages of Sokn, namely the resilient ring to dampen vibration and the large, easily aligned target area between the ring and the socket. Sokn at 3:53-57. The result is a small diameter

Second Declaration of Dr. Charles F. Reinholtz – U.S. Patent No. 9,260,184 screw-on blade with correspondingly small threads that only has about 90 degrees of thread engagement, which is clearly not an improvement.



32. Accordingly, for all the reasons stated herein and in my First Declaration, it is my opinion that a POSA would not be motivated to combine Sokn with Sasaki.

33. For similar reasons to those addressed in my First Declaration and discussed herein as to the combination of Sasaki and Sokn, a POSA would not combine Sasaki with any of Philistine, EP067, or Obrist. Dr. Ducharme opines that a POSA "would understand how to apply the teachings of Obrist and EP067 to the rotational forces experienced by the blades in a UAV, such as Sasaki. Ex. 1028 ¶ 56. But he but he fails to demonstrate how these combinations would be implemented.

34. Dr. Ducharme also opines that a POSA would have been motivated to use Philistine, EP067, or Obrist "to mount a UAV blade onto a driveshaft for several

reasons." Ex. 1028 ¶ 57. Dr. Ducharme states that those reasons include "allow[ing] for easy installation and de-installation while being secure enough." Ex. 1028 ¶ 57. I disagree with Dr. Ducharme's opinions. As explained above, none of Philistine, EP067, and Obrist disclose UAVs or UAV propellers. In addition, none of Philistine, EP067, or Obrist disclose clockwise and counterclockwise mounting configurations, or different configurations for their connection mechanisms, and a POSA would not be motivated to modify Sasaki with those references to achieve directionally specific lock mechanisms. In addition, in EP067 a screw is still required to connect the blade to the hub. In Obrist, a separate pitch-control mechanism is required to control blade pitch in operation and to prevent the blade from twisting out of its mounting socket. EP067 at Fig. 5-6; Obrist at 2:23-27, Fig. 1-5. The screw in EP067 and the pitch control mechanism in Obrist are necessary elements that must be connected to prevent free rotation of the blade. Without these elements, the blade will freely rotate and detach. These additional elements greatly complicate the attachment process and result in a solution that would be much less suitable for field replacement of rotor blades. I address particular issues relating to a lack of motivation to combine Sasaki with each of Philistine, EP067, and Obrist below.

35. As to Philistine, a POSA would not be motivated to combine Sasaki with Philistine for the same reasons as a POSA would not combine Sasaki with

EP067 or Obrist. Philistine relates to a slide and twist-lock mount for a blower motor for a system that provides filtered air. Like EP067 and Obrist, Philistine does not relate to UAVs or UAV design, is not related to a locking mechanism for UAV propeller blades, and does not disclose blades that produce a vertical lift force. Philistine does not depict different configurations for its lock mechanism to accommodate the proper fitting of components based on the direction of rotation. There is no discussion in Philistine regarding clockwise or counterclockwise rotating rotor blades and the critical need to prevent interchangeably mounting such blades. Accordingly, a POSA would not be motivated to combine Sasaki with Philistine to achieve a UAV with lock mechanisms dependent on the direction of a rotor blade.

36. As to EP067, the boat propeller blades in EP067 will not generate a "vertical lift force" as required of both the clockwise and counterclockwise rotating blades in the '184 patent. EP067 is not related to a locking mechanism for UAV propeller blades. The boat propeller blades in EP067 are fixed to the hub and rotate only through a fraction of a revolution to adjust the pitch of the blade. In EP067, the axis of the drive motor is perpendicular to the blade. EP067 does not depict different configurations for its lock mechanism to accommodate the proper fitting of components based on the direction of rotation of a propeller blade. Dr. Ducharme relies on Figures 1 and 3 of EP067 in his declaration (Ex. 1028 ¶ 53), but these figures represent the interacting components for the single mechanism that locks the

boat propeller to the hub. There is no different configuration of these components in EP067 such that they would be used to ensure proper placement of clockwise and counterclockwise rotors on a UAV. There is no discussion in EP067 regarding clockwise or counterclockwise rotating rotor blades, because there is no need for such an arrangement in the intended application, which is distinctly different than the critical need to prevent interchangeably mounting such blades in multi-rotor UAVs. A POSA would thus not be motivated to use EP067 in combination with a UAV to achieve different clockwise or counterclockwise locking mechanisms.

37. A POSA would not be motivated to combine Sasaki with Obrist for the same reasons explained above with EP067, which, like Obrist, relates to a pitch-control blade mount in ships, aircraft and centrifugal machines. Like EP067, Obrist does not relate to UAVs or UAV design, is not related to a locking mechanism for UAV propeller blades, and does not disclose blades that produce a vertical lift force. Obrist does not depict different configurations for its lock mechanism to accommodate the proper fitting of components based on the direction of rotation. There is no discussion in Obrist regarding clockwise or counterclockwise rotating rotor blades and the critical need to prevent interchangeably mounting such blades. Accordingly, a POSA would not be motivated to combine Sasaki with Obrist to achieve a UAV with lock mechanisms dependent on the direction of a rotor blade.

38. In addition, EP067 requires a separate attaching screw and Obrist requires a separate pitch-control mechanism to prevent the blade from twisting out of its mounting socket. The screw in EP067 and the pitch control mechanism in Obrist are necessary elements that must be included in the attachment process to prevent free rotation of the blade and detachment.

C. Even If Combined, The Alleged Prior Art Does Not Disclose Or Teach The Revised Proposed Claims

Dr. Ducharme addresses an "error" in the threading of figure 3 of Sokn. 39. I initially pointed out this error in my deposition. Ex. 1027 at 166-167. Regardless of any error in figure 3 of Sokn, Sokn discloses only a single configuration for its connection mechanism, and thus, even if combined with Sasaki, there would still be a lack of a device that has clockwise and counterclockwise lock mechanisms and that prevents the engagement of a clockwise rotor in a counterclockwise lock mechanism (and vice versa) as required in revised claims 12 and 13. In addition, even if a POSA were to combine Sasaki with the connection mechanism of Sokn, and further modify Sokn to achieve clockwise and counterclockwise connection mechanisms with different configurations, such a combination would still result in a threaded-type connection mechanism. As I explained in my First Declaration (¶¶ 52-54), such connection mechanisms do not prevent a user from attaching a blade to the wrong driveshaft.

40. For reasons similar to those set forth in my First Declaration and above with regard to the combination of Sasaki and Sokn, the combination of Sasaki with any of Philistine, EP067, and Obrist would not reach the elements of the Revised Claims even if a POSA would have been motivated to combine the references (it is my opinion that a POSA would not be motivated to do so). As to Philistine, Dr. Ducharme relies on mirrored designs of Philistine's Figure 1 "to form a 'counterclockwise lock mechanism' for blades that spin in counterclockwise." Ex. 1028 ¶59. The mirror image mechanism described by Dr. Ducharme is not actually a part of the Philistine disclosure, and only serves to illustrate that Philistine lacks any disclosure teaching the use of directionally specific lock mechanisms. Accordingly, even if Sasaki were combined with Philistine there would still be a lack of a device that has clockwise and counterclockwise lock mechanisms and that prevents the engagement of a clockwise rotor in a counterclockwise lock mechanism (and vice versa) as required in revised claims 12 and 13.

41. As to EP067, Dr. Ducharme implies that the combination of Sasaki and EP067 teaches the claimed engagement of a clockwise rotor in a counterclockwise lock mechanism (and vice versa). Ex. 1028 ¶ 62. As explained above, however, EP067 discloses only a single configuration and thus, even if combined with Sasaki, there would still be a lack of a device that has clockwise and counterclockwise lock mechanisms and that prevents the engagement of a clockwise rotor in a

Second Declaration of Dr. Charles F. Reinholtz – U.S. Patent No. 9,260,184 counterclockwise lock mechanism (and vice versa) as required in revised claims 12 and 13.

42. As to Obrist, Dr. Ducharme similarly implies that the combination of Sasaki and Obrist teaches the claimed engagement of a clockwise rotor in a counterclockwise lock mechanism (and vice versa). Ex. 1028 \P 61. As explained above, however, Obrist discloses only a single configuration and thus even if combined with Sasaki, there would still be a lack of a device that has clockwise and counterclockwise lock mechanisms and that prevents the engagement of a clockwise rotor in a counterclockwise lock mechanism (and vice versa) as required in revised claims 12 and 13.

D. Long-Felt And Unmet Need

43. There is a vast time difference between the prior art references and the patented solution. Sasaki was published in 1991, Sokn in 1992, Philistine in 2005, EP067 in 1999, and Obrist in 1944. Exs. 1006, 1007, 1026, 1018, and 1017. The '184 patent was filed in 2013.

44. As I have previously stated, there has been a need in the UAV industry for many years for UAV rotor blade attachment mechanisms, like the invention of the '184 patent, that can be quickly and easily detached and that prevent the misplacement of rotor blades. IPR No. 2019-00343, Ex. 2010 ¶ 95 (my prior declaration relating to '184 patent); Ex. 2009 at Appendix A.2, p. 26 (Dr. Alonso's

prior expert report). DJI has recognized that a POSA would have understood the need, since as early as the Sasaki reference, for simpler, faster, and mistake proof rotor blade attachment mechanisms. *Id.* Dr. Ducharme agrees. Ex. 1003 ¶ 100. By mistake-proof, Dr. Ducharme is referring to a design that prevents a user from attaching a blade to the wrong drive shaft.

45. In my opinion, the inventions embodied in the Revised Proposed Claims solved the long-felt needs for (1) simpler and faster and (2) mistake-proof blade attachment mechanisms. The lock mechanisms of the Revised Claims, that include blade lock portions and shaft lock portions configured to engage by partial rotation are simple and fast. In addition, the Revised Claims require clockwise and counterclockwise lock mechanisms that prevent the attachment of a blade on the wrong drive shaft. Thus, there is a direct connection between elements of revised claims 12 and 13, and the solutions to the long-felt needs acknowledged by Drs. Alonso and Ducharme.

VIII. CONCLUSION

46. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

24

Autel Ex. 2007, p.26

Date: <u>15 May 2020</u>

Chipa

APPENDIX A

Autel Ex. 2007, p.28

Charles F. Reinholtz

<u>Business Address</u> Embry-Riddle Aeronautical University Department of Mechanical Engineering 600 S. Clyde Morris Blvd. Daytona Beach, FL 32114 (386) 323-8848 reinholc@erau.edu Home Address 236 Quay Assisi New Smyrna Beach, FL 32169 (540) 230-7225 (mobile)

Education

Doctor of Philosophy, University of Florida, Mechanical Engineering, 1983 Master of Engineering, University of Florida, 1980 Bachelor of Science, University of Florida, 1976

Full-time Industrial Experience

1978, Burroughs Corporation, Orlando, Florida, Design Engineer, Non-impact Printing Group 1989-1996 Milliken and Company, Spartanburg, South Carolina, summer employment and consulting involving textile equipment design

Academic Employment Experience

Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Assistant Professor, September 1983 to August 1988, Tenure Granted
Associate Professor, August 1988 to August 1993
Professor, August 1993 to 2007
W. S. White Chair for Innovation in Engineering Education, Aug. 1996 to Aug. 1999
Assistant Department Head and ABET Review Chair, 1996-2002
Alumni Distinguished Professor, 2002-2007
Embry-Riddle Aeronautical University, Daytona Beach, Florida
Professor and Chair, Department of Mechanical Engineering, 2007-2017

Professor, Department of Mechanical Engineering, 2017-

Membership in Professional Organizations and Honor Societies

<u>Society</u>	Membership Grade
ASME	Fellow
SAE	Member
American Nuclear Society	Member 1995-1997
Tau Beta Pi	Member
Pi Tau Sigma	Member
Sigma Xi	Member
Epsilon Lambda Chi	Member
ASEE	Member, 1984-1987, 1998-99
AUVSI	Member

Professional Honors and Awards

Benton Engineering Council Service Key, University of Florida, 1976-1977.
Procter and Gamble Best Paper Award, 9th Applied Mechanisms Conference, October 1985.
Presidential Young Investigator Award, 1987-1992, National Science Foundation
Certificate of Teaching Excellence, Virginia Polytechnic Institute and State University, 1987-88, 1997-98 and 2001-02.
ASME Outstanding Faculty Advisor Award, 1989-1990 and 1991-92

- Procter and Gamble Best Paper Award of Merit, 2nd National Applied Mechanisms and Robotics Conference, November 1991.
- George Wood Best Applied Mechanism Design Paper Award, 2nd National Applied Mechanisms and Robotics Conference, November 1991.

Wine Award for Excellence in Teaching, Virginia Polytechnic Institute and State University, 1992. Virginia Tech Academy of Teaching Excellence, Inducted 1992

- Procter and Gamble Best Paper Award of Merit, 22nd ASME Mechanisms Conference, Scottsdale, Arizona, September 1992
- ASME National Faculty Advisor Award, 1995.
- Applied Mechanism Conference "Beyond the Call of Duty" Award for prodigious contributions to mechanism science, 1995.
- W. S. White Chair for Innovation in Engineering Education, Aug. 1996 to Aug. 1998
- Dean's Award for Excellence in Teaching, Virginia Tech College of Engineering, 1998
- South-Pointing Chariot Award, 1999 Applied Mechanisms and Robotics Conference, for lifetime contributions to the mechanism's community
- Ingersoll-Rand Faculty Award for Outstanding Contributions to the Mechanical Engineering Department, 2000
- National Instruments Award for Best Application of Measurement and Automation for the Development of a Tele-Operated CASE CX-160 Excavator Using FieldPoint, National Instruments Week 2002, Austin Texas, Aug 12-15, 2002.
- Virginia Tech Alumni Distinguished Professor, 2002-
- Outstanding Faculty Member Award selected and awarded by the students in Mechanical Engineering, April 2003.
- Fellow, American Society of Mechanical Engineers, 2003
- Alumni Teaching Award, Virginia Polytechnic Institute and State University, 2004
- National Instruments Virtual Instrumentation Applications Best Control Paper Award,

Developing a Fully Autonomous Vehicle for Virginia Tech's Entry in the DARPA Grand Challenge," National Instruments NI Week 2006, Austin Texas.

ASME Distinguished Service Award, 2005

College of Engineering Certificate of Teaching Excellence, 2006-2007 Volusia Manufacture's Association "Friend of Industry" Award, 2013

Funded Research

- "Design Optimization of Spatial Mechanisms Subject to Real-World Constraints," National Science Foundation Grant MEA-8404313, June 15, 1984 through November 30, 1986, \$47,979, 100% Responsibility.
- "Presidential Young Investigator Award: Interactive Spatial Mechanism Synthesis," National Science Foundation, Grant No. DMC 8657828, June 15, 1987 through January 31, 1993, \$312,000, 100% Responsibility.
- 3. "High-Speed Bearing Research," supported by the Industrial Drives Division of Inland Motor Corporation, Jan. 1, 1987 through Dec. 31, 1987, \$15,000, 100% Responsibility.
- "Analysis of Warhead Structures," Department of the Navy, July 24, 1987 to November 15, 1987, \$99,348, Project Director with J. B. Kosmatka, R. H. Fries, A. L. Wicks, and L. D. Mitchell, Responsible for \$19,535.
- "Analysis of Warhead Structures, Year 2," Department of the Navy, October 30, 1987 to March 31, 1988, \$174,000, Project Director with J. B. Kosmatka, R. H. Fries, A. L. Wicks, and L. D. Mitchell, Responsible for \$12,908.
- 6. "Hull Joint Model Test," Georgia Institute of Technology, May 16, 1988 to Aug. 16, 1988, \$10,141, Principal Investigator with R. H. Fries, Responsible for \$5,071.
- 7. "Design of Variable-Geometry Truss Manipulators," Virginia Center for Innovative Technology (CIT), 10/1/88 to 9/31/89, \$30,000, 100% Responsibility.

- 8. "Active Structures for Space Applications," 1/1/89 to 12/31/90, \$200,000, Principal Investigator with H. H. Robertshaw, Responsible for \$80,000.
- 9. "Computer-Aided Design of Fully-Wiped, Co-rotating Extruder Screws," Windward International and CIT, January 1, 1989 through December 31, 1989, \$44,029, Principal Investigator with Sanjay Dhande, Responsible for \$22,015.
- 10. "Construction of a NASP Mock-up," NASA Langley Research Center, February 1, 1989 to July 15, 1989, \$51,692, Principal Investigator with W. F. O'Brien, A. L. Wicks, and J. Marchman.
- "Design of Advanced Manipulators for Steam Generator Maintenance," Babcock & Wilcox Co., November 1, 1989 to August 15, 1990, \$20,000, Principal Investigator with Sanjay Dhande, Responsible for \$15,000.
- "Calibration, Control and Menu Design for an Advanced Steam-Generator Maintenance Manipulator," Babcock and Wilcox Co., February 1, 1991 through January 31, 1992, \$41,408, Principal Investigator with Sanjay Dhande, Responsible for \$31,056.
- "Calibration, Control and Menu Design for an Advanced Steam-Generator Maintenance Manipulator," Virginia Center for Innovative Technology, February 1, 1991 through January 31, 1992, \$29,663, Principal Investigator with Sanjay Dhande, Responsible for \$22,247.
- 14. "Computer-Aided Design and Manufacture of Extruder Screw Elements," Windward International and CIT, July 1, 1990 through June 30, 1991, \$30,984, Principal Investigator with Sanjay Dhande, Responsible for \$15,492.
- 15. "Design of a Cellulose Acetate Preconditioning Heat Exchanger," Tennessee Eastman Co., October 1990 through July 1991, \$25,560, Principal Investigator with D. J. Nelson, Responsible for \$9,876.
- "Continued Steam Generator Manipulator Support Based on Kinematic Control and Investigation of Vision Based Approach," Babcock and Wilcox Co., October 1, 1991 through September 31, 1992, \$40,000, Principal Investigator with A. L. Abbott, Responsible for \$32,000.
- 17. "Cellulose Acetate Packaging Study," Tennessee Eastman Co., October 1991 through July 1992, \$51,120, Principal Investigator with D. J. Nelson, Responsible for \$19,752.
- "Continued Steam Generator Manipulator Support Based on Kinematic Control and Investigation of Vision Based Approach," Virginia CIT, January 1, 1992 through December 31, 1992, \$35,570, Principal Investigator with A. L. Abbott, Responsible for \$28,456.
- 19. "Preliminary Design of a Medical Waste Processing Machine," Virginia Center for Innovative Technology, June 1, 1992 through August 31, 1992, \$14,386, 100% Responsibility.
- 20. "Preliminary Design of a Medical Waste Processing Machine," Bioconversions Technologies, May 1, 1992 through January 31, 1993, \$16,377, 100% Responsibility.
- 21. "Conceptual Design of an Advanced Reactor Vessel Inspection Manipulator," B&W Nuclear Services Company, March 1, 1992 through February 28, 1993, \$30,000, 100% Responsibility.
- 22. "Engineering Development of a Medical Waste Processing Machine," Bioconversions Technologies, Aug. 15, 1992 to May 15, 1994, Principal Investigator with A. A. Kornhauser, \$93,088, responsible for \$46,544.
- 23. "Engineering Development of a Medical Waste Processing Machine," CIT, Aug. 15, 1992 to Aug. 14, 1993, Principal Investigator with A. A. Kornhauser, \$90,988, responsible for \$45,494.
- 24. "Enhancing the Capability and Performance of Nuclear Service Robots with Kinematic Analysis and Computer Vision," B&W Nuclear Services Co., Dec.1, 1992 to Nov. 30, 1993, with A. L. Abbott, \$50,000, responsible for \$40,000.
- 25. "Design of a Reactor Vessel Inspection Manipulator," B&W Nuclear Services, June 16, 1992 through June 15, 1993, \$100,146, 100% responsibility.

- 26. "Design of an Automated Needle/Armature Tray Loader," Siemens Automotive, Sept. 1, 1993 to Aug. 31, 1994, \$24,925, 100% Responsibility.
- "Enhancing the Design and Performance of Nuclear Service Robots with Flexure Analysis, Computer Vision, and Optimization Techniques," B&W Nuclear Technologies, Dec.1, 1993 to Nov. 30, 1994, with A. L. Abbott, \$40,000, responsible for \$30,000.
- "Enhancing the Design and Performance of Nuclear Service Robots with Flexure Analysis, Computer Vision, and Optimization Techniques," Center for Innovative Technology, Feb. 1, 1994 to Jan. 31, 1995, with A. L. Abbott, \$47,023, responsible for \$35,000.
- 29. "Design Studies for Nautilus," Nautilus, Inc, Jan.1, 1994 to Oct. 15, 1994, \$7,723, 100% responsibility.
- 30. "Design Studies for Nautilus," Center for Innovative Technology, Jan.1, 1994 to Dec. 31, 1994, \$13,795, 100% Responsibility.
- 31. "Rod Formation Dynamics," R. J. Reynolds Co., Jan. 1, 1994 to Dec. 31, 1994, with D. J. Nelson, 116,557, 50% Responsibility.
- 32. "A Short-term Proposal to Develop Cam-Design Software for Cadkey, Inc.," June 16, 1994 to Sept 15, 1994, \$9,981, 100% Responsibility.
- "Design of an Automated Injector Body Tray Loader," Siemens Automotive, Sept. 1, 1994 to Aug. 31, 1995, \$20,744, 100% Responsibility.
- 34. "Design Studies for Nautilus," Nautilus, Inc, Dec 1, 1994 to Nov. 30, 1995, \$23,731, 100% Responsibility.
- 35. "Design Studies for Nautilus," Center for Innovative Technology, Dec.1, 1994 to Dec. 31, 1995, \$25,924, 100% Responsibility.
- 36. "Preliminary design and Equipment Selection for a Mulch-Making Machine," Fred Whitaker Co., June 1, 1995 to Dec. 31, 1995, \$10,920, %100 Responsibility.
- 37. "Improving the Kinematic Control of Robots with Computer Vision," NSF, July 15, 1995 to June 30, 1996, \$22,026, %100 Responsibility.
- "Proposal to Increase Funding in Siemens Valve-Body Loader Project, "Siemens Automotive, \$7,018, 100% Responsibility.
- 39. "Preliminary Design and Equipment Selection for a Mulch-Making Machine," CIT, June 1, 1995 to August 31, 1995, \$8,185, %100 Responsibility.
- 40. "Design of a Personal Smith Machine," Nautilus, Inc, July 1, 1995 to Oct. 31, 1995, \$12,273, 100% Responsibility.
- "Development of Advanced Control Strategies for Variable Geometry Truss Manipulators," Batelle -Pacific Northwest Laboratory, Jan. 1, 1995 to June 31, 1995, \$10,000, with R. J. Salerno, 10% Responsibility.
- 42. "Curriculum Renewal in Mechanical Engineering at Virginia Tech," NSF SUCCEED, Sept. 15, 1995 to Dec. 15, 1995, with Paul Tidwell, \$4,500 (NSF), \$4,677 (Cost Sharing), 50% Responsibility.
- 43. "Development of a Parallel Architecture Robotic Wrist," Triad Investors, Jan. 1, 1996 to May 31, 1997, \$51,707, 100% Responsibility.
- 44. "Development of Advanced Control Algorithms for Variable Geometry Truss Manipulators," Batelle-Pacific Northwest Laboratory, Jan. 1, 1996 to June 31, 1996, \$10,000, 100% Responsibility.
- 45. "Curriculum Renewal in Mechanical Engineering at Virginia Tech Year 5," NSF SUCCEED, June 16, 1996 to June 15, 1997, \$10,000 (NSF), \$10,000 (Cost Sharing), 100% Responsibility.

- 46. "Technology Assessment for a Robotic Vacuum Cleaner," Servus Robots Incorporated, Sept.1, 1998 to Feb. 28, 1999 with John Bay, Bob Sturges, and Mike Deisenroth, \$8,333, 25% Responsibility.
- 47. "Technology Assessment for a Robotic Vacuum Cleaner," Virginia CIT, Oct. 1, 1998 to March 31, 1999 with John Bay, Bob Sturges, and Mike Deisenroth, \$25,000, 25% Responsibility.
- 48. "MBC Guidance Project," Long-Airdox Company, August 1998 to July 1999, P.I.: R.H. Sturges, Co-P.I.'s: M. P. Deisenroth, C.F. Reinholtz. \$100,000.
- 49. "MBC Guidance Project," Virginia Center for Innovative Technology (matching), August 1998 to July 1999, P.I.: R.H. Sturges, Co-P.I.'s: M. P. Deisenroth, C.F. Reinholtz. \$100,000.
- "Vertical Integration of Mechatronics at Virginia Tech," NSF SUCCEEED, Aug 1999 to July 2002, P.I.: W. R. Saunders, Co-P.I.'s: J. S. Bay, D. J. Leo, C.F. Reinholtz, \$18,000/year for three years.
- Development of a Remote-Controlled CASE CX-160 Excavator, Naval Surface Warfare Center, Dahlgren G-64 Division, February 2003 to September 2003, Co-PI with A. L. Wicks, \$17,000
- 52. Investigation of Adaptive Structures for Morphing Aircraft, NASA Langley Research Center, \$65,078, July 1,2002 to June 30, 2003, 25% (with H. Robertshaw and D. Inman).
- 53. Increased Scope for Delivery Orders 0019, Remote Control Excavator, Naval Surface Warfare Center, with Al Wicks, PI, \$21,223.
- 54. Develop the Joint Unmanned Systems Experimentation and Research (JOUSTER) Site, U.S Army RDECOM STTC, Orlando, FL, June 10, 2004 to June 9, 2007, \$12,200,000, C. Reinholtz, PI (55% Responsibility), A. Wicks, Co-PI (43% Responsibility), Carstensen Co-PI (2% Responsibility).
- 55. Virginia First Lego League 2004 Pilot High School Robotics Program, NASA Langley Research Center, Education Grant NNL04AA65G, \$20,000, July 9, 2004 to July 8, 2005, 100% Responsibility
- 56. Virginia First Lego League NIA Outreach Program, National Institute of Aerospace, Grant No. VT-03-1, \$8,000, February 1, 2005 to August 31, 2005, 100% Responsibility.
- Heterogeneous Teams Of Autonomous Vehicles: Advanced Sensing And Control, Office of Naval Research, Dennis W. Hong, Naira V. Hovakimyan, Marty E. Johnson, Charles F. Reinholtz, Daniel J. Stilwell, A. L. Wicks, Craig A. Woolsey, Christopher L. Wyatt, 07/01/05 – 6/30/06, Total Funding: \$1,050,000, C. F. Reinholtz share: \$52,752.
- Coordinated Sensing and Control for Surveillance and Tracking by Heterogeneous Autonomous Vehicle Teams, Daniel J. Stilwell, Christopher L. Wyatt, Craig A. Woolsey, Naira V. Hovakimyan, A. L. Wicks, Andy Kurdila, Charles Reinholtz and Michael Roan, Office of Naval Research 5/15/06 – 9/14/07, \$1,417,500, Reinholtz share: \$184,275.
- Development Of An Autonomous Vehicle For The DARPA Urban Challenge, with Al Wicks and Dennis Hong, the Defense Advanced Research Projects Agency, 10/1/06 to 12/31/07, \$999,274.
- 60. Development of a Drive-by-Wire Commercial Vehicle, General Dynamics Robotics Systems (GDRS), \$54,256, 1-11-07 to 6-30-07.
- 61. Navigation And Autonomous Control For Nemesis, Applied Research Associates, Inc. (ARA), \$61,513, 7-1-06 to 6-30-07
- 62. Dynamic Model of CAT 777-797 Haul Trucks for Autonomous Operation, Caterpillar, \$74,303, 7-1-06 to 6-30-07

- 63. Boeing Digitally Manufactured UAV Project, \$22,740, The Boeing Company, 10-15-2010 to 12-31-2010.
- 64. Reconnaissance and Autonomy for Small Robots Canine (RASR-K9), Robotic Research, \$17,951.50, 1-1-2011 to 4-30-2012
- 65. Proposal to Develop an Autonomous Maritime System to Compete in the International Maritime Robotics Competition, AUVSI and the Office of Naval Research, \$30,000, 10-1-13 to 12-31-14.
- 66. Robotic Tool Kit (RTK) Logistics Automation, (OTA) #W15QKN-14-9-1002, U.S. Army TARDEC via Great Lakes Systems & Technology LLC, \$75,000, August 2018 through September 2019, with Patrick Currier and Eric Coyle.
- 67. Continued Development of Robotic Tool Kit (RTK) Logistics Automation and RTK Training, (OTA) #W15QKN-14-9-1002, U.S. Army GVSC via Great Lakes Systems & Technology LLC, \$100,000, November 2019 through November 2020, with Patrick Currier and Eric Coyle.

Refereed Papers in Major Technical Journals

- 1. Snorri Gudmundsson, Vladimir Golubev, Sergey Drakunov and Charles Reinholtz, "Bio-Inspired Methodologies for Energy Conservation and Harvesting Flight-Path Modeling for Unmanned Aerial System," AIAA Journal of Aerospace Information Systems, Volume 16, Number 7, July 2019, https://doi.org/10.2514/1.I010597.
- 2. Christine M. Dailey, Charles Reinholtz, Thais Russomano, Michael Schuette, Rafael Baptista, Rodrigo Cambraia, "Resistance Exercise Machine within Lower Body Negative Pressure for Counteracting Effects of Microgravity", *Gravitational and Space Research*, Vol 2, No. 1ISSN: 0898-4697, 2014.
- 3. Hockley, C. J., Zuercher, T.A., Patel, H.V., Gamble, G.A., Kennedy, C.L. Coyle E.J., P.N. Currier, and C.F. Reinholtz, The Development of the ERAU Maritime RobotX Challenge Autonomous System, AUVSI North America, May 2014.
- 4. Jesse Hurdus, Andrew Bacha, Cheryl Bauman, Stephen Cacciola, Ruel Faruque, Peter King, Chris Terwelp, Patrick Currier, Dennis Hong, and Alfred Wicks and Charles Reinholtz, "VictorTango Architecture for Autonomous Navigation in the DARPA Urban Challenge," *AIAA Journal of Aerospace Computing, Information, and Communication*, Vol. 5, December 2008, DOI: 10.2514/1.40547.
- 5. Andrew Bacha, Cheryl Bauman, Ruel Faruque, Michael Fleming, Chris Terwelp, Charles Reinholtz, Dennis Hong, Al Wicks, Thomas Alberi, David Anderson, Stephen Cacciola, Patrick Currier, Aaron Dalton, Jesse Farmer, Jesse Hurdus, Shawn Kimmel, Peter King, Andrew Taylor, David Van Covern, Mike Webster, "Odin: Team VictorTango's entry in the DARPA Urban Challenge," *Journal of Field Robotics*, Vol. 25, No. 8, pg 467-492, 2008
- 6. David G. Schmale III, Benjamin R. Dingus, Charles Reinholtz, "Development and Application of an Autonomous Unmanned Aerial Vehicle for Precise Aerobiological Sampling Above Agricultural Fields," *Journal of Field Robotics*, Vol. 25. No. 3, pg 133-147, 2008, Copyright 2008 Wiley Periodicals, Inc.
- 7. Michael J. Furey, Charles F. Reinholtz, and Brian Vick, "Metal Transfer, Film Formation and Surface Temperatures on a Cam in an Automotive Engine," *Tribologia*, ISSN 0208-7774, June 2007.
- 8. Leedy, B., Putney, J., Bauman, C., Cacciola, S., Webster, J. M., Reinholtz, C. F., "Virginia Tech's Twin Contenders: A Comparative Study of Reactive and Deliberative Navigation," *Journal of Field Robotics*, 23(9), 709-727, September 2006.

- 9. Gombar, B., Terwelp, C., Fleming, M., Wicks, A. L. and Reinholtz, C.F., "JOUSTER: Joint Unmanned Systems Test, Experimentation and Research Facility," *International Test and Evaluation (ITEA) Journal*, December 2004/January 2005, pp. 9-13.
- 10. Stephen L. Canfield, R. Randall Soper, Charles F. Reinholtz, "Creating Highly Dexterous Manipulators Using Nonlinear Input Transmission," *ASME Journal of Mechanical Design*, Vol. 120, 1999.
- Canfield, S. L., Soper, R. R., and Reinholtz, C. F., "Velocity Analysis of Parallel Manipulators by Truss Transformations," *Mechanism and Machine Theory*, No. 34, 1999, pp. 345 – 357.
- 12. Roman, Chris and Reinholtz, C. F., "Robust Course-Boundary Extraction Algorithms for Autonomous Vehicles", *IEEE Intelligent Systems*, Nov./Dec. 1998, pp.32-39.
- 13. Lee, H. Y., and C. F. Reinholtz, "Inverse Kinematics of Serial-Chain Manipulators," *ASME Journal of Mechanical Design*, Vol. 118, No. 3, September 1996, pp. 396 404.
- Lee, H. Y., Fallon, J. B., Cordle, W. H., and Reinholtz, C. F., "Inverse Kinematic Analysis of a Mobile Underwater Inspection Robot," Journal of Applied Mechanisms and Robotics, Vol. 2, No. 3, July 1995.
- 15. Canfield, S. L. and Reinholtz, C. F., "Development of an All-Revolute-Jointed Constant-Velocity Coupling," *Journal of Applied Mechanisms and Robotics*, Vol. 2, No. 3, July 1995, pp.13-19.
- Shooter, S. B., West, R. L. and Reinholtz, C. F., A Unified Approach to Teaching Analytical Cam Design Using Conjugate Geometry, *The International Journal of Mechanical Engineering Education*, Vol. 23, No. 2, April 1995, pp 145-156.
- Voruganti, R. S., Dhande, S. G., and Reinholtz, C. F., "Symbolic and Computational Method for Design and Flat-Pattern Development of Bifurcation, Trifurcation- Type Transition Surfaces," *Transactions of the North American Manufacturing Research Institution of SME*, Volume XXII, pp 225-232, 1994.
- Tidwell, P. H., Glass, S. W., Hildebrand, J. J., Reinholtz, C. F., and Shooter, S. B., "COBRA -Design and Development of a Manipulator for Nuclear Steam Generator Maintenance," *Journal* of Applied Mechanisms and Robotics, Vol. 2, No. 2, April 1994.
- Padmanabhan, B., V. Arun, and C. F. Reinholtz, "Closed-Form Inverse Kinematic Analysis of Variable Geometry Truss Manipulators," *Journal of Mechanical Design*, ASME Transactions, Vol. 114, No. 3, September 1992, pp. 438-443.
- Arun, V., C. F. Reinholtz, and L. T. Watson, "Application of New Homotopy Techniques to Variable Geometry Trusses," *Journal of Mechanical Design*, ASME Transactions, Vol. 114, No. 3, September 1992, pp. 422-427.
- 21. Voruganti, R. S., Dhande, S. G., and Reinholtz, C. F., "Symbolic and Computational Conjugate Geometry for the Manufacture of Helically Swept Surfaces," *Transactions of the North American Manufacturing Research Institution of SME*, Volume XX, pp 277-282, 1992.
- 22. Salerno, R. J., Reinholtz, C. F., and Dhande, S. G., "Kinematics of Long-Chain Variable Geometry Truss Manipulators," *Advances in Robot Kinematics*, pp. 179-187, Edited by S. Stifter and J. Lenarcic, Springer-Verlag Wien, New York, 1991.
- 23. Kosmatka, J. B., R. F. Fries, and C. F. Reinholtz," Tension and Bending Stress Concentration Factors in U, V, and Opposed U-V Notches," *The Journal of Strain Analysis for Engineering Design*, Vol. 25, No. 4, 1990, 233-240.
- 24. Rogers, C. A., H. H. Mabie, and C. F. Reinholtz, "Design of Spur Gears Generated with Pinion Cutters," *Mechanism and Machine Theory*, Vol. 25, No. 6, 1990, pp. 623-634.

- 25. Mabie, H. H., C. A. Rogers, and C. F. Reinholtz, "Design of Spur Gears Cut by a Hob," *Mechanism and Machine Theory*, Vol. 25, No. 6, 1990, pp. 635-644.
- 26. Williams, II, R. L., and C. F. Reinholtz, "Proof of Grashof's Law Using Polynomial Discriminants," *Journal of Mechanisms, Transmissions and Automation in Design*, ASME Transactions, Vol. 109, No. 2, June 1987, pp. 178-182.
- 27. Reinholtz, C. F., G. N. Sandor, and J. Duffy, "Branching Analysis of Spherical RRRR and Spatial RCCC Mechanisms," *Journal of Mechanisms, Transmissions and Automation in Design,* ASME Transactions, Vol. 108, No. 4, Dec. 1986, pp. 481-486.
- 28. Williams, II, R. L., and C. F. Reinholtz, "Mechanism Link Rotatability and Limit Position Analysis Using Polynomial Discriminants," *Journal of Mechanisms, Transmissions and Automation in Design*, ASME Transactions, Vol. 108, No. 4, Dec. 1986, pp. 562-564.
- 29. Myklebust, A., M. J. Keil and C. F. Reinholtz, "MECSYN-IMP-ANIMEC: Foundation for a New Computer-Aided Spatial Mechanism Design System," *Mechanism and Machine Theory*, Vol. 20, No. 4, 1985, pp. 257-269.
- 30. Reinholtz, C. F., S. G. Dhande, and G. N. Sandor, "Kinematic Analysis of Planar Higher-Pair Mechanisms," *Mechanism and Machine Theory*, Vol. 13, No. 6, 1978, pp. 619-629.

Notes, Review Articles, and Shorter Communications in Major Technical Journals

- 1. Fallon, J. B., and C. F. Reinholtz, "Simple Machine," short article published in the 1993 Edition of <u>Academic American Encyclopedia</u>, Deluxe Library Edition, Grolier, Inc., Vol. S, p. 316. Also published in the 1994 New Grolier Multimedia Encyclopedia, CD ROM Edition.
- Fallon, J. B., and C. F. Reinholtz, "Machine," article published in the 1993 Edition of <u>Academic American Encyclopedia</u>, Deluxe Library Edition, Grolier, Inc., Vol. M, pp. 19-21. Also published in the 1994 New Grolier Multimedia Encyclopedia, CD ROM Edition.
- 3. Sandor, G. N., S. G. Dhande, and C. F. Reinholtz, discussion of "Reduction of Noise and Vibration in Roller Chain Drives," by S. W. Nicol and J. N. Fawcett, *Proceedings of the Institution of Mechanical Engineers*, Vol. 191 39/77, 1978.
- 4. Sandor, G. N., S. G. Dhande, and C. F. Reinholtz, discussion of "The Influence of Lubrication on Tooth-Roller Impacts in Chain Drives," by J. N. Fawcett and S. W. Nicol, *Proceedings of the Institution of Mechanical Engineers*, Vol. 191 21/77, 1978.
- 5. Reinholtz, C. F., review of the book Mechanics and Design of Cam Mechanisms, Pergamon Press, authored by F. Y. Chen, review published simultaneously in *Mechanism and Machine Theory*, Vol. 24, No. 4, 1985, and in *Shock and Vibration Digest*, Vol. 17, No. 12, 1985.

Books and Book Chapters

Mabie, H. H., and C. F. Reinholtz, <u>Mechanisms and Dynamics of Machinery</u>, 4th edition, with Solutions Manual, John Wiley and Sons, New York, 1987.

<u>Teaching Excellence at a Research-Centered University</u>, Edited by E. Scott Geller and Phil Lehman, Pearson Custom Publishing, Chapter 30: BRINGING THE BEST OUT OF STUDENTS: Teaching beyond the Classroom, 2006

Proceedings and Textbooks Edited

- "Robotics, Spatial Mechanisms, and Mechanical Systems," Proceedings of the 22nd ASME Mechanisms Conference, DE-Vol. 45, September 1992, 644 Pages, Edited by G. Kinzel, C. Reinholtz, H. Lipkin, L. W. Tsai, G. R. Pennock and R. J Cipra.
- "Mechanism Design and Synthesis," Proceedings of the 22nd ASME Mechanisms Conference, DE-Vol. 46, September 1992, 672 Pages, Edited by G. Kinzel, C. Reinholtz, G. R. Pennock, G. J. Wiens, R. J. Cipra, B. B. Thompson and T. R. Chase.
- 3. "Flexible Mechanisms, Dynamics, and Analysis," Proceedings of the 22nd ASME Mechanisms Conference, DE-Vol. 47, September 1992, 662 Pages, Edited by G. Kinzel, C. Reinholtz, H. Lipkin, L. W. Tsai, G. R. Pennock, R. J Cipra and B. B. Thompson.
- 4. Sandor, G. N., C. F. Reinholtz, and K. Soldner, errata to the book, *Mechanics and Design of Cam Mechanisms*, authored by F. Y. Chen, Pergamon Press, Inc., Elmsford, N.Y., 1982, 10 pages.

Conference Publications

- 1. Gudmundsson, Snorri, Vladimir Golubev, Sergey Drakunov, Charles Reinholtz, "Bio-Inspired Opportunistic Approaches in Energy-Conserving/Harnessing Flight-Path Modeling for UAS," AIAA Modeling and Simulation Technologies Conference, AIAA Aviation and Aeronautics Forum and Exposition 2016.
- 2. Christopher Hockley, Timothy Zuercher, Christopher Kennedy, Gene Gamble, Hitesh Patel, Patrick Currier, Eric Coyle, Charles Reinholtz, "System Architecture, Development and Results of the Embry-Riddle Aeronautical University Maritime RobotX Platform," Control ID#: 2028351, Session: UMS-02, Unmanned Systems: Technologies and Applications, AIAA Science and Technology Forum 2015.
- 3. Jesse Farmer and Charles Reinholtz, "Kinematic Analysis and Design of a Two-Body Articulated Robotic Vehicle," Proceedings of ASME 2009 International Mechanical Engineering Congress & Exposition, November 13-19, 2009, Lake Buena Vista, Florida, USA
- 4. Gerald R. Lane, Charles Reinholtz, Mohan Khrishnan, Mark J. Paulik, Nassif Rayess, "Articulated Unmanned Ground Vehicles (UGVs) Controlled with Complimentary Semi- & Autonomous Mobility Behaviors," NATO symposium on "Platform Innovations and System Integration for Unmanned Air, Land and Sea Vehicles", Florence, Italy," May 14-18, 2007.
- Brett M. Leedy and Charles Reinholtz, "Developing a Fully Autonomous Vehicle for Virginia Tech's Entry in the DARPA Grand Challenge," National Instruments NI Week 2006, Austin Texas, (winner, Virtual Instrumentation Applications Paper Contest Best Control Paper Award).
- Sean Baity, Charles F. Reinholtz and Alfred L. Wicks, "Kinematic Design of a Novel Allwheel Drive Multi-Body Articulated Unmanned Ground Vehicle," AUVSI Unmanned Systems North America 2006.
- Grant Gothing, Jesse Hurdus, Al Wicks and Charles Reinholtz, "Implementation of JAUS on a 2004 Cadillac SRX Using a Potential Fields Architecture", AUVSI Unmanned Systems North America 2006.
- 8. Benjamin Dingus, Elizabeth Hoppe, Jansen Lee, Nicholas Misyak, David Pape, Justin Ryan, Matthew Schivikas, Steven Ross Shake, Christopher Veraa, Rachael Ramirez, Charles Reinholtz, "Development of a Fixed-Wing Autonomous Aerial Vehicle at Virginia Tech," AUVSI UAV Competition Journal Paper, http://www.bowheadsupport.com/paxweb/seafarers/default.htm, June, 2006.
- 9. Ruél Faruque, Andrew Bacha, Charles Reinholtz, "Implementing a JAUS Design Process on Two Autonomous Robots for the Intelligent Ground Vehicle Competition," 6th Annual Intelligent Vehicle Systems Symposium, Grand Traverse Resort & Spa-Traverse City, MI,

June 2006.

- Sean Baity, Jonathan Frentzel, Brett Gombar, Michael Fleming, Chris Terwelp, Al Wicks, Charles Reinholtz and Andrew Bacha, "Portable Wireless Site Instrumentation for Unmanned System Experimentation" AUVSI Unmanned Systems North America 2005, June 28-30, 2005, Baltimore, MD
- 11. Shane Barnett, Sean Baity, Ben Hastings, Chris Terwelp, Charles Reinholtz, Bill McBride, Andrew Moore, Development of a Tow Capacity Test Device for Small Unmanned Vehicles, AUVSI Unmanned Systems North America 2005, June 28-30, 2005, Baltimore, MD
- 12. Gregg Vonder Reith, Ken Meidenbauer, Imraan Faruque, Chris Sharkey, Jared Cooper, Shane Barnett, Charles Reinholtz, "Development of an Autonomous Aerial Reconnaissance Platform at Virginia Tech," AUVSI UAV Competition Journal Paper, http://www.bowheadsupport.com/paxweb/seafarers/default.htm, June 14-18, 2005.
- Andrew Bacha, Michael Fleming, Chris Terwelp, Charles Reinholtz and Al Wicks, "A Behavior Based Approach to Autonomous Lane Following," 5th Annual Intelligent Vehicle Systems Symposium, Grand Traverse Resort & Spa-Traverse City, MI, June 13-16, 2005
- Sean Baity, Brett Gombar, Michael Fleming, Charles Reinholtz, "Design for the Intelligent Ground Vehicle Competition," 5th Annual Intelligent Vehicle Systems Symposium, Grand Traverse Resort & Spa-Traverse City, MI, June 13-16, 2005
- 15. Whittier, W. B., Reinholtz C. F., and Stubbs, M. D., "Single Degree-of-Freedom Morphing Wing: Design and Synthesis,", Proceedings of the ASME Design Engineering Technical Conference and Computers and Information in Engineering Conference, September 28-October 2, 2004, Salt Lake City, Utah, DETC2004-57019
- 16. L. D. Wiggins, Stubbs, M. D., Johnston, C. O., Robertshaw, H. H., Reinholtz, C. F., and Inman, D. J., "Design and Analysis of a Morphing Hyper-Elliptic Cambered Span (HECS) Wing," American Institute of Aeronautics and Astronautics Structural Dynamics & Materials Conference, Palm Springs, California, 19-22 April, 2004
- Wicks, A. L., Fleming, M., Terwelp C. and Reinholtz, C. F., "Development of a Remote-Controlled CASE CX-160 Excavator Using FieldPoint," National Instruments NI Week 2002, Austin Texas, Aug 12-15, 2002. (winner of the Best Application of Measurement and Automation Award)
- Kedrowski, P. R., Conner, D. C., Reinholtz, C. F., Global Map Building and Look-Ahead Implementation on an Outdoor Autonomous Vehicle, Proceedings of the SPIE Photonics Conference, Symposium on Intelligent Systems for Advanced Manufacturing, Vol. 4573, number16, 29-30 October 2001, Boston, MA
- Kedrowski, P. R., Conner, D. C., Reinholtz, C. F., Optimized Parametric Calibration of Autonomous Vehicles, Proceedings of the SPIE Photonics Conference, Symposium on Intelligent Systems for Advanced Manufacturing, Vol. 4573, number 18, 29-30 October 2001, Boston, MA
- 20. Kedrowski, P. R., Reinholtz, C. F., Abbott, M. S., Conner, D. C., Biplanar bicycle as a base vehicle for Autonomous applications. SPIE Mobile Robots XV, 2000, Boston, MA.
- 21. Conner, D. C., Kedrowski, P. R., Reinholtz, C. F., Bay, J.S., Improved dead reckoning using caster wheel sensing on a differentially steered 3-wheeled autonomous vehicle. SPIE Mobile Robots XV, 2000, Boston, MA.
- 22. Conner, D. C., Kedrowski, P. R., Reinholtz, C. F., Multiple camera, laser rangefinder, and encoder data fusion for navigation of a differentially steered 3-wheeled autonomous vehicle. SPIE Mobile Robots XV, 2000, Boston, MA.
- 23. Soper, R. R., Anderson, J. M., Jacobs, D. C., James, M. M., Reinholtz, C. F., "Analytical

Synthesis of Cams Conjugate to Elliptical Followers," *Proceedings of the 6th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, December 13-15, 1999.

- Abbott, M. S., Carr, A., Soper, R. R., Reinholtz, C. F., "Hamiltonian Dynamics and Numerical Optimization of the Trebuchet," *Proceedings of the 6th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, December 13-15, 1999.
- Soper, R. R., Abbott, M. S., Reinholtz, C. F., "Coupled Camera Stabilization and Propulsion Mechanism and Control Law Development for an Autonomous Biplanar Bicycle," *Proceedings* of the 6th National Applied Mechanisms and Robotics Conference, Cincinnati, OH, December 13-15, 1999.
- Coleman, P. K., Mayhew, D. M, Bay, J. S., Reinholtz, C. F., "Enhancing Engineering Education using an Interdisciplinary Team-Oriented Approach to Autonomous Robot Design," ASEE Annual Conference and Exposition, Charlotte NC, June 20-23, 1999.
- Reinholtz, C. F., Bay, J., Soper, R. R., Abbott, M., and Grove, D., 1999, "The Biplanar Bicycle," Proceedings of the 1999 ASME International Mechanical Engineering Congress and Exposition, Nashville, TN, Nov. 14-19, *Innovations in Vehicle Design and Development*, DE-Vol.101, pp.157-160.
- Abbott, M. S., Soper, R. R., Grove, D. E., and Reinholtz, C. F., 1999, "Planar Dynamics and Control of a Two-Wheeled Single-Axle Vehicle," Proceedings of the 1999 ASME International Mechanical Engineering Congress and Exposition, Nashville, TN, Nov. 14-19, *Innovations in Vehicle Design and Development*, DE-Vol.101, pp.161-169.
- Grove, D. E., Soper, R. R., Abbott, M. S., and Reinholtz, C. F., 1999, "Orientation-Regulated Platforms for Use on Biplanar Bicycles," Proceedings of the 1999 ASME International Mechanical Engineering Congress and Exposition, Nashville, TN, Nov. 14-19, *Innovations in Vehicle Design and Development*, DE-Vol.101, pp.171-177.
- Soper, R. R., Reinholtz, C. F., Canfield, S. L., and Williams, R. L. III, 1999, "Contention-Free Control of Over-Constrained Variable Geometry Trusses," Proceedings of the 1999 ASME Design Engineering Technical Conferences, 25th Design Automation Conference, Las Vegas, NV, Sept. 12-15, ASME Paper No. DETC99/DAC-8668.
- Bay, J., Saunders, W., Reinholtz, C. F., Pickett, P., Johnston, L., "Mechatronics Education at Virginia Tech," SPIE International Symposium on Intelligent Systems and Advanced Manufacturing, Nov. 1998.
- 32. R. Randall Soper, Charles F. Reinholtz, Stephen L. Canfield, "Synthesis of Multi-Degree-of-Freedom Force Generating Linkages," *Proceedings of the ASME Design Engineering Technical Conferences*, Atlanta, Georgia, September 1998, CD ROM Proceedings, paper DETC98/MECH-5975
- 33. Stephen L. Canfield, R. Randall Soper, Charles F. Reinholtz, "Creating Highly Dexterous Manipulators Using Nonlinear Input Transmission," *Proceedings of the ASME Design Engineering Technical Conferences*, Atlanta, Georgia, September 1998, CD ROM Proceedings, paper DETC98/MECH-59756
- Burgiss, M. J., Reinholtz, C.F, and Bay, J., "Education and Research Experience of the Autonomous Vehicle Team at Virginia Tech," SPIE Conference on Intelligent Systems and Automated Manufacturing, Pittsburgh, PA, Oct. 1997, pp. 295-305.
- Soper, R. R., Reinholtz, C. F., Gao, D., Canfield, S. L., "The Mathematics of Manipulator Statics: Minimum Principles, Duality, and Underlying Linear Symmetry," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997
- Soper, R. R., Reinholtz, C. F., and Scardina, M. T., "Synthesis of Linkage-Based Selectorized Weight Machines," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997

- Soper, R. R., Reinholtz, C. F., and Canfield, "Maximum Number of Precision Positions in Nonclassical Linkage Synthesis," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997.
- Coombs, D. J., Canfield, S. L., Soper, R. R., and Reinholtz, C. F., "Design of User-Weight-Based Exercise Machines," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997
- Canfield, S. L., Soper, R. R., and Reinholtz, C. F., 1997, "Dynamic Force Analysis of the Carpal Wrist," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-3970, 1997.
- Canfield, S. L., Soper, R. R., and Reinholtz, C. F., "Uniformity as the Guide to Evaluation of Dexterous Manipulator Workspaces," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-3969, 1997
- 41. Shooter, S.B. and C.F. Reinholtz, "AutoCam A Modular Decision Support System for the Design of Cam Mechanisms", Proceedings of the 1997 ASME Design Automation Conference, Sacramento California, September 1997. September 15-20, 97-DETC/DAC.
- Soper, R. R., Canfield, S. L., Reinholtz, C. F., and Mook, D. T., "New Matrix-Theory-Based Definitions for Manipulator Dexterity," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-4410, 1997.
- Soper, R. R., Mook, D. T., and Reinholtz, C. F., "Vibration of Nearly-Perfect Spring Equilibrators," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-3768, 1997.
- 44. Canfield, S. L., Reinholtz, C. F., "Development of the Carpal Robotic Wrist" Proceedings of the ISER97, June 15-18, 1997
- 45. Tidwell, P. H., Soper, R. R., and Reinholtz, C. F., "Synthesis of Force-Generating Mechanisms," *Proceedings of the 24th Biennial Mechanisms Conference*, Irvine, California, August 18-22, 1996, paper 96-DETC/MECH-1211.
- Canfield, S. L., Soper, R. R., Hendricks, S. L., and Reinholtz, C. F., "Velocity Analysis of Truss-Type Manipulators," 24th Biennial Mechanisms Conference, Irvine, California, August 18-21, 1996, paper DETC/MECH-1158.
- 47. Canfield, S. L., Ganino, A. J., Salerno, R. J., and Reinholtz, C. F., 1996, "Singularity and Dexterity Analysis of the Carpal Wrist," 24th Biennial Mechanisms Conference, Irvine, California, August 18-21, 1996, paper DETC/MECH-1156.
- Glass, S. W., Ranson, C. C., Reinholtz, C. F. and Calkins, J. M., "Modular Robotics Applications in Nuclear Power Plant Maintenance," *Proceedings of the 58th American Power Conference*, April 9-11, 1996.
- 49. Calkins, J. M., Canfield, S. L., Salerno, R. J. and Reinholtz, C. F., "An Optimization-Based, Matrix Operator Approach to Real-Time Compensation of Static Deflections in Robotic Manipulators," Proceedings of the 4th National Applied Mechanisms and Robotics Conference, December 10-14, 1995, Cincinnati, Ohio, Paper AMR 95-019.
- Canfield, S. L., Voruganti, R.S. and Reinholtz, C. F., "Minimizing Pose Errors in Robotic Systems Through Calibration," Proceedings of the 4th National Applied Mechanisms and Robotics Conference, December 10-14, 1995, Cincinnati, Ohio, Paper AMR 95-017.

- Scardina, M.T., Soper, R. R., Calkins, J. M. and Reinholtz, C. F., "Optimal Synthesis of Force-Generating Planar Four-Link Mechanisms," Proceedings of the 4th National Applied Mechanisms and Robotics Conference, December 10-14, 1995, Cincinnati, Ohio, Paper AMR 95-003.
- Canfield, S. L., Salerno, R. J. and Reinholtz, C. F., "Design of an All-Revolute, Constant-Velocity Coupling," SAE International Off-Highway & Powerplant Congress & Exposition, September 11-13, 1995, Milwaukee, Wisconsin, ISSN 0148-7191, Paper no. 952133.
- 53. Soper, R. R., Scardina, M., Tidwell, P., Reinholtz, C. F. and Lo Presti M. A., "Closed-Form Synthesis of Force-Generating Planar Four-Bar Linkages," DE-Vol. 82, Advances in Design Automation, Proceedings of the 1995 ASME Design Technical Conferences, Boston, MA, September 17-21, 1995, pp. 845-851.
- Salerno, R. J., Canfield, S. L., Ganino, A. J. and Reinholtz, C. F., "A Parallel, Four-Degree-of-Freedom Robotic Wrist," DE-Vol. 82, Advances in Design Automation, Proceedings of the 1995 ASME Design Technical Conferences, Boston, MA, September 17-21, 1995, pp. 765-771.
- Glass, S. W, Fallon, J. B., Reinholtz, C. F., Abbott, A. L. "Machine Vision Calibration for a Nuclear Steam Generator Robot," Proceedings of the 1994 ANS Winter Annual Meeting, Washington D.C, November 1994.
- Fallon, J. B., Shooter, S. B., Reinholtz, C. F. and Glass, S. W., "URSULA: Design of an Underwater Robot for Nuclear Reactor Vessel Inspection," Proceedings of the ASCE Specialty Conference, Albuquerque, NM, Feb. 26 to March 3, 1994, pp. 311-319.
- Canfield, S. L., Salerno, R. J., and Reinholtz, C. F., "Kinematic Design of a Large-Angular-Motion Constant-Velocity Coupling," DE-Vol.70, Mechanism Synthesis and Analysis, Proceedings of the 1994 ASME Design Technical Conferences, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
- Shooter, S. B., Tidwell, P, H. and Reinholtz, C. F., "Analytical Approach to Cam-Modulated Linkage Synthesis Using Conjugate Geometry, " Mechanism Synthesis and Analysis, Proceedings of the 1994 ASME Design Technical Conferences, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
- Salerno, R. J. and Reinholtz, C. F., "A Modular, Long-Reach Truss-Type Manipulator for Waste Storage Tank Remediation," DE-Vol.70, Mechanism Synthesis and Analysis, Proceedings of the 1994 ASME Design Technical Conferences, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
- Fallon, J. B., Reinholtz, C. F., Vallance, R. R., and Voruganti, R. S., "Improving Robot System Performance Using Computer Vision," Mechanism Synthesis and Analysis, Proceedings of the 1994 ASME Design Technical Conferences, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
- Garg, A. K., Reinholtz, C. F., Kornhauser, A. A., Voruganti, R. S., Douglass, C. H. and Walker, T. E., "Design and Development of a Bioremediation-Based System for Treating Medical Waste," Proceedings of the 26th Mid-Atlantic Industrial Waste Conference, Aug, 7-10, 1994, pp.53-60.
- 62. Glass, S. W, Fallon, J. B., Reinholtz, C. F., Abbott, A. L. and Asher, J. D. "Machine Vision Independent Position Verification for a Nuclear Steam Generator Robot," Proceedings of the 1994 EPRI Conference, Washington D.C, November 1994.
- Canfield, S. L. and Reinholtz, C. F., "Development of and All-Revolute-Jointed Constant-Velocity Coupling, Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-081.
- 64. Tidwell, P. H., Hendricks, M. W., Fallon, J. B., Stulce, J. R., Beisgen, L. C. V., Reinholtz, C. F., and Maples, A. B., "Acoustic Pose Determination Applied to an Underwater Mobile Robot," Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-084.

- 65. Lee, H. Y., Fallon, J. B., Cordle, W. H., and Reinholtz, C. F., "Inverse Kinematic Analysis of a Mobile Underwater Inspection Robot," Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-085.
- Shooter, S. B. and Reinholtz, C. F., "Extrinsic Calibration of Portable Manipulators," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 501-506.
- Shooter, S. B., Reinholtz, C. F. and Dhande, S. G., "On the Kinematic Design of Manipulators for Limited Access Workspaces (LAWS)," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 485-491.
- Tidwell, P. H., Bandukwala, N., Dhande, S. G., Reinholtz, C. F. and Webb, G, "Synthesis of Wrapping Cams," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 46, September 1992, pp. 337-343.
- Padmanabhan, B., Tidwell, Salerno, R. J. and Reinholtz, C. F., "VGT-Based Gimbals: Practical Construction and General Theory," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 47, September 1992, pp. 437-443.
- Arun, V., Padmanabhan, B., Kolady, K., and Reinholtz, C. F., "Determination of the workspace of the 3-DOF Double-Octahedral Variable-Geometry Truss Manipulator," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 493-500.
- 71. Tidwell, P. H., Glass, S. W., Hildebrand, J. J., Reinholtz, C. F., and Shooter, S. B., "COBRA -Design and Development of a Manipulator for Nuclear Steam Generator Maintenance," Proceedings of the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio, (Winner of Proctor and Gamble Best Paper Award and Winner of The George Wood Best Applied Paper Award).
- 72. Stulce, J. R., and Reinholtz, C. F., "Observations on Caterpillar Locomotion and Their Application to a Crawling Robot," Proceedings of the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio.
- 73. Stulce, J. R., W. D. Burgos, S. G. Dhande, and C. F. Reinholtz, "Conceptual Design of a Multibody Passive-Legged Crawling Vehicle," Proceedings of the 1990 ASME Mechanisms Conference, DE-Vol. 26, Cams, Gears Robot and Mechanism Design, Sept. 16-19, 1990, pp. 199-205.
- 74. Arun, V., and C. F. Reinholtz, L. T. Watson, "Enumeration and Analysis of Variable Geometry Truss Manipulators," Proceedings of the 1990 ASME Mechanisms Conference, DE-Vol. 26, Cams, Gears Robot and Mechanism Design, Chicago, IL, Sept. 16-19, 1990, pp. 93-98.
- 75. Dhande, S. G., B. Padmanabhan, C. F. Reinholtz, and R. S. Voruganti, "Computer-Aided Design and Manufacture of Approximate Ruled Surfaces," Proceedings of the Second International Conference on Computer Integrated Manufacturing, IEEE Computer Society Press, Troy, NY, May 21-23, 1990, pp. 137-142.
- Tidwell, P. H., C. F. Reinholtz, H. H. Robertshaw, C. G. Horner, "Kinematic Analysis of Generalized Adaptive Trusses," First Joint US/Japan Conference on Adaptive Structures, Maui, Hawaii, November 13-15, 1990.
- Padmanabhan, B., and C. F. Reinholtz, "Design of Robotic Manipulators Using Variable-Geometry Trusses as Joints," paper 89 AMR-8C-7, Proceedings of the First National Applied Mechanisms and Robotics Conference, Vol. II, 1989.

- Thompson, J. M., C. F. Reinholtz, and A. Myklebust, "Exact Analysis and Synthesis of the RSCR Spatial Mechanism," ASME paper No. 88131, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988.
- 79. Williams, R. L., II, C. F. Reinholtz, "Forward Dynamic Analysis and Power Requirement Comparison of Parallel Robotic Mechanisms," ASME paper No. 88078, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988. (Also accepted for publication in the ASME Journal of Mechanisms, Transmissions and Automation in Design, 1989.)
- Williams, R. L., II, C. F. Reinholtz, "Closed-Form Workspace Determination and Optimization for Parallel Robotic Mechanisms," ASME paper No. 88079, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988.
- Robertshaw, H. H., and C. F. Reinholtz, "Variable Geometry Trusses," Proceedings of the US Army Research Office Workshop on Smart Materials, Structures and Mathematical Issues, Sept. 15-16, 1988.
- Salerno, R. J., C. F. Reinholtz, and H. H. Robertshaw, "Shape Control of High Degree of Freedom Variable Geometry Trusses," presented at the NASA Workshop on Controls/Structures Integration, Williamsburg, VA, July 11-13, 1988.
- Williams, R. L., II, C. F. Reinholtz, "Closed-Loop Planar Manipulators: Part I Forward and Inverse Kinematics; Part 2 - Workspace Optimization," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- Rogers, C. A., H. H. Mabie, and C. F. Reinholtz, "Numerical Determination of Accuracy Points Using Chebyshev Polynomials for Displacement and Velocity Synthesis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- 85. Mabie, H. H., C. F. Reinholtz, and C. A. Rogers, "Determination of Hob Offsets to Maximize the Ratio of Recess to Approach Action and Balance Tooth Strengths for Nonstandard Spur Gears by Limit Analysis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- 86. Mabie, H. H., C. F. Reinholtz, and C. A. Rogers, "Determination of Pinion Cutter Offsets to Maximize Recess to Approach Action or to Equalize Tooth Strengths of Nonstandard Spur Gears with Backlash," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- Reinholtz, C. F., and D. Gokhale, "Design and Analysis of Variable Geometry Truss Robots," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- Reinholtz, C. F., V. Arun, and R. L. Williams, A Reassessment of the Tasks of Kinematic Synthesis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- 89. Arun, V., and C. F. Reinholtz, "Design of the RCCC Spatial Mechanism," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- Klatt, M. A., and C. F. Reinholtz, "Mechanism Optimization Using Zero-Order Methods and Penalty Functions: A Comparison of Incremented Versus Nonincremented Penalty Parameter," DE-VOL. 10-1, Advances in Design Automation, Vol. 1, Proceedings of the 1987 Design Automation Conference, Boston, MA, Sept. 27-30, 1987, pp. 205-213.
- 91. Rogers, C. A., R. E. Cobb, and C. F. Reinholtz, "Incorporating Computer Programming Projects Into the Mechanical Engineering Curriculum," Proceedings of the Fifth National Conference on

University Programs in Computer-Aided Engineering, Design, and Manufacturing (UPCAEDM '87), pp. 176-180.

- 92. Williams, II, R. L., C. F. Reinholtz, and A. Myklebust, "Complete Function-Generation Synthesis and Design of RSSR Spatial Mechanisms," ASME Paper 86-DET-151, presented at the 19th ASME Mechanisms Conference, Columbus, Ohio, October 1986.
- 93. Reinholtz, C. F., "Integrating Computers into Kinematics Courses at VPI&SU," Proceedings of the Fourth National Conference on University Programs in Computer-Aided Engineering, Design and Manufacture, August 1986, pp. 127-130.
- 94. Mabie, H. H., C. F. Reinholtz, D. Puzio, and G. M. Irwin, "Optimum Design of Spur Gear Teeth Cut with a Hob," Proceedings of the Ninth Applied Mechanisms Conference, Kansas City, MO, 1985, Vol. 2, Session VIII.B, Paper VI.
- 95. Keil, M. J., A. Myklebust, and C. F. Reinholtz, "Prediction of Link Interference in Planar Mechanisms," Proceedings of the Ninth Applied Mechanisms Conference, Kansas City, MO, 1985, Vol. 1, Session III.B, Paper V, (Winner of Proctor and Gamble Best Paper Award).
- 96. Myklebust, A., C. F. Reinholtz, W. H. Francis, and M. J. Keil, "Design of a Radar Guidance Mechanism Using MECSYN-ANIMEC," ASME Paper 84-DET-139, presented at the 18th ASME Mechanisms Conference, Cambridge, Massachusetts, October 10, 1984.
- 97. Sandor, G. N., A. G. Erdman, E. Raghavacharyulu, and C. F. Reinholtz, "On the Equivalence of Higher and Lower Pair Planar Mechanisms," Proceedings of the Sixth World Congress of the International Federation for the Theory of Machines and Mechanisms, New Delhi, India, 1983.
- 98. Sandor, G. N., D. Kohli, X. Zhuang, and C. F. Reinholtz," Synthesis of a Five-Link Spatial Motion Generator," ASME paper 82-DET-130, 1982.
- 99. Sandor, G. N., D. Kohli, A. Ghosal, and C. F. Reinholtz," Closed-Form Analytic Synthesis of a Five-Link Spatial Motion Generator," Proceedings of the Seventh Applied Mechanisms Conference, Kansas City, MO, 1981, pp. XXVI-1 to XXVI-7

Patents

- 1. "Spatial, Parallel-Architecture, Robotic Carpal Wrist," U. S. Patent 5,699,695, Inventors: Canfield, S. L., Reinholtz, C. F., Salerno, R. J., and Ganino, Anthony J., Assignee: Virginia Tech Intellectual Properties, Inc., Awarded December 23, 1997.
- 2. "Snubber Profile," U. S. Patent 4,998,942, Inventor: Reinholtz, Charles F. Assignee: Milliken Research Corporation, Spartanburg, S.C., Awarded March 12, 1991.

Invited Presentations at National Meetings

- 1. "Test Drive an Autonomous Vehicle: Experiences from the 2007 DARPA Urban Challenge," Presentation to USAA, 19 January 2009, San Antonio, TX
- 2. "Challenges and Opportunities Offered by the DARPA Grand Challenge," Invited Presentation and Panel Discussion at the 2004 AIAA Unmanned Aerial Vehicle Conference, Chicago, IL, September 2004.
- 3. "Product Safety and Product Liability," Invited Lecture at the 2001 ASME World Congress, New York, NY, Nov.13, 2001
- 4. "Life after Tenure" Invited Speaker and Panelist at the ASEE Annual Conference and Exposition, Charlotte NC, June 20-23, 1999.
- 5. "Reduced Complexity Robotics," Invited presentation at the 1998 ASME Design Technical Conferences, 25th Biennial Mechanisms Conference, Atlanta, GA, September 1998.

- "Trends and Opportunities in Mechanisms Research," Plenary Panel Session Speaker at the 4th National Applied Mechanisms and Robotics Conference, Cincinnati, Ohio, December 10-14, 1995.
- 7. "Trends and Opportunities in Robotics," Opening Plenary Session Lecture at the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
- 8. "Observations on Robotics and Mechanisms Research," Opening Plenary Panel Session Speaker at the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio, November 3-6, 1991.

University Service

Invited Speaker at the following University Events and Alumni Association Chapter Meetings: June 23, 2005, Research Triangle Park Alumni Chapter, Raleigh, NC March 18, 2004, Greensboro, NC Triad Alumni Chapter March 31, 2004, Atlanta Alumni Chapter November 1, 2004, Committee of 100 - Hotel Roanoke November 21, 2004, Class of 1968, Donaldson Brown Advisor to the following Embry Riddle Autonomous Vehicle Teams: Unmanned Aerial Systems Competition, 2007-Present International Aerial Robotics Competition, 2007-Present Intelligent Ground Vehicle Competition, 2007-Present RoboBoat, 2007-Present RoboSub, 2007-Present Maritime RobotX Competition, 2013-Present EcoCAR (CAVs Advisor), 2016-Present Member, College Promotion and Tenure Committee 2018 Fulbright Scholarship Advisory Committee 2005 Advisor to the Virginia Tech Autonomous Aerial Vehicle Competition Team, 2004-Advisor to the Virginia Tech DARPA Grand Challenge Team, 2003-Virginia FIRST Lego League Coordinator, 2002-Advisor to the Virginia Tech Intelligent Ground Vehicle Competition Team, 1995-Advisor to Entering Honors Students 2003-Horton Honors Scholarship Selection Committee 2003-Member, University Strategic Planning Committee, 2001 Chair, Virginia Tech Academy of Teaching Excellence 2000-2001 Vice Chair, Virginia Tech Academy of Teaching Excellence 1999-2000 Member, University Promotion and Tenure Committee 2000-2001 Member, College Promotion and Tenure Committee 2000-2001 Chair, Mechanical Engineering Curriculum Committee 1997-2002 Chair, Mechanical Engineering ABET Review, 1998-2002 Member, College of Engineering Curriculum Committee 1997-2002 Member, 1st Year Special Curriculum Review Committee 1997 Member, Engineering Dean Search Committee, 1993-4 Chairman, Mechanical Engineering Honors and Awards and Publicity Committee, 1993-99 Member, Mechanical Engineering Honors and Awards and Publicity Committee, 1993-99 Chairman, College Wine Teaching Award Committee, 1992-95 Chairman, University Wine Teaching Award Committee, 1995-96 Member, Mechanical Engineering Department Head Search Committee, 1992-93 Member, Mechanical Engineering Curriculum Committee, 1984-87, 1992-2004 Member, Mechanical Engineering Tenure and Promotion Committee, 1989-2004 Member, Mechanical Engineering Graduate Committee, 1987-89 Member, Mechanical Engineering Recruiting Committee, 1992-93

Member, Sigma Xi High School Teaching Award Committee 1987-88, Chairman 1989 Member, College of Engineering Commencement Committee, 1988-Faculty Advisor to the Virginia Tech Student Section of ANS, 1993-Faculty Advisor to the Virginia Tech Student Section of ASME, 1988-Faculty Advisor to the Virginia Tech Chapter of Tau Beta Pi, 1984-88 Host for the Virginia Tech Academic Challenge, 1991

Professional Service

Society	Positions Held
ASME	Secretary of the Virginia Section 1987-92
	Chairman of the National Student Mechanism Competition 1987-88
	Chairman of the Joint Regional Conference 1989 and 2000
	Virginia Tech Student Section Advisor, 1988-2007
	Member of the ASME Mechanisms Committee, 1990-1993
	Associate Technical Editor, ASME Journal of Mechanical Design, 1991-93
	Paper Review Chairman, 22nd ASME Mechanisms Conference, Sept. 1992
	Conference Arrangements Chairman, 23rd ASME Mechanisms Conference, Sept. 1994
	Member, ASME National Design Contest Committee, 1996-2002
	Virginia Section Newsletter Editor, 1994-2000
	Region IV Senior Representative to the National Student Sections Committee, 1995-2000
Sigma Xi	High School Teaching Award Committee, Member 1987-88, Chair 1989
ANS	Student Section Advisor, Virginia Tech, 1993-95
NAE	Invited review Board member, National Academies' National Research Council (NRC) Army Research Laboratory Technical Assessment Board (ARLTAB), May 2004

Master's Degree Students Completed				
	Degree	Name	Completion Date	Title
1	MS	Robert L Williams, II	8/85	Synthesis and Design of the RSSR Spatial Mechanism for Function Generation
2	MS	Arun Veeraraghavan	3/86	Computer Aided Design of the RCCC Spatial Mechanism
3	MS	Michael A. Klatt	10/86	Design Optimization of Planar Mechanisms
4	MS	Kevin K. Moyers	11/87	A Microcomputer-Based Data Acquisition System for Diagnostic Monitoring of High- Speed Electric Motors
5	MS	Christodoulos S. Demetriou	12/87	A PC Implemented Kinematic Synthesis System for Planar Mechanisms
6	MS	Dipen P. Gokhale	12/87	Kinematic Analysis and Animation of a Variable-Geometry Truss Robot
7	MS	William R. Seith	5/88	Design of a Flying Cutter
8	MS	George M. Clessas	5/88	Direct Calculation of Cable Tension in a Store Separation Program Which Models the Launch of an Aerial Tow Target
9	MS	Mark W. Biegler	8/88	Determination of Stress Concentration Factors Using Experimental Methods
10	MS	Nandan Joshi	2/88	Mobility Analysis of Variable-Geometry Trusses
11	MS	Vasant Marathe	12/88	Design of a Hot Melt Book Binding Machine
12	MS	Babu Padmanabhan	12/88	Design of a Robotic Manipulator Using Variable-Geometry Trusses as Joints
13	MS	Robert J. Salerno	6/89	Shape Control of High Degree-of-Freedom Variable-Geometry Truss Manipulators
14	MS	Ravinder S. Voruganti	8/90	Symbolic and Computational Conjugate Geometry for Design and Manufacturing Applications
15	MS	Steven B. Shooter	12/90	Conceptual Manipulator Design for Limited Access Workspaces
16	MS	Paul Mele	5/91	Mechanical Design of a Stewart Platform-Based Crawling Vehicle
17	M.S.	William K. Carpenter	12/92	Design of Medical Waste Treatment Systems Employing Bioremediation
18	MS	Allen Maples	5/93	Design of a Robust Acoustic Positioning System for an Underwater Nuclear Reactor Vessel Inspection Robot
19	MS	William Cordle	5/93	Numerical Inverse Kinematics for a Six Degree- of-Freedom Manipulator
20	MS	Glenn Melnyk	6/93	Mechanisms for Automated Toolhead Changing in Nuclear Steam Generator Robotics
21	MS	Steve Payne	5/94	A CAD-Interactive Software Package for the Synthesis of Planar Disk Cams
22	MS	Anil K. Garg	8/94	Design, Installation and Testing of a Bioremediation-Based System for Treating Regulated Medical Waste

23	MS	Todd Denkins	12/94	Design Methodology to reduce the Number of Actuators in Complex Mechanisms
24	MS	Joseph Calkins	12/94	Real-Time Compensation of Static Deflections in Robotic Manipulators
25	MS	Randy Soper	8/95	Synthesis of Planar Four-Link Mechanisms for Force Generation
26	MS	Keith Garguilo	8/95	Design and Testing of a Nonlinear Mechanical Advantage Demonstration Mechanism
27	MS	Ganino, A. J.	5/96	Mechanical Design of the Carpal Wrist: A Parallel-Actuated, Singularity-Free Robotic Wrist
28	MS	Larkin, Susan	6/96	Wheeled Autonomous Mobile Robots for use in Harsh Environments: A Survey of Recent Publications
29	MS	Iskandar, Kurnia	6/96	Computer Assisted Synthesis of Wrapping Cam Mechanisms
30	MS	Riutort, Kevin	7/96	Applied Design and Implementation of Straight- Line Mechanisms
31	MS	Saccoccio, Greg	8/96	Error Modeling of the Carpal Wrist
32	MS	Scardina, Mike	10/96	Optimal Synthesis of Force-Generating Planar Four-Link Mechanisms
33	MS	Palmer, Matthew	12/96	Kinematics of Beam-Flexure Four-Bar Linkages with Applications in a Compound Bow
34	MS	Coombs, Dana	2/97	Design of User-Weight-Based Exercise Machines
35	MS	Doyle, Matthew	12/97	The Foundation for CADSPAM
36	MS	Hayes, Thomas J.	12/97	The Creative Entrepreneurs Organization
37	MS	Adler, Alex	5/98	Testing and Understanding Screwdriver Bit Wear
38	MS	Haynie, C. Dean	8/98	Mechanical Design and Navigation Strategies for a Zero-Turn-Radius Autonomous Vehicle
39	MS	Holland, Michael	12/98	Assembly Optimization for Double-Row Ball Bearings
40	MS	Abbott, Michael	6/00	Dynamics and Control of the Biplanar Bicycle
41	MS	Conner, David	8/00	Sensor Fusion, Navigation, and Control of Autonomous Vehicles
42	MS	Jillcha Wakjira	1/01	Design of a SMA Heat Engine
43	MS	Carr, Angela	5/01	Position Control Comparison of Equilibrated and Mass Counterweight Systems
44	MS	Kedrowski, Philip	5/01	Development and Implementation of a Self- Building Global Map for Autonomous Navigation
45	MS	Blackett, Ricardo	5/01	Optimization of Multi-Degree-of-Freedom Force Generating Mechanisms
46	MS	Matthew Thompson	7/01	Design of a Cyclic Sliding, Dynamically Loaded Wear Testing Device for the Evaluation of Total Knee Replacement Materials
47	MS	Rundgren, Brian	12/01	Design and Optimization of Force Generation Linkages to Include Dynamic Effects
48	MS	Schiller, Ean	9/02	Heat Engine Driven by Shape Memory Alloys: Prototyping and Design

49	MS	Gopinath, Sudir	12/02	Using Color and Shape Analysis for Boundary Line Extraction in Autonomous Vehicle Applications
50	MS	Whittier, Will	12/02	Kinematic Analysis of Tensegrity Structures
51	MS	Terwelp, Chris	5/03	Remote Control of Hydraulic Equipment for Unexploded Ordnance Remediation
52	MS	Henshaw, Graham	5/03	Single-Session Design: Design Methodology in Compressed Timeframes Derived from the Robot Rivals Television Series
53	MS	Corey, Chris	12/03	Epicyclic Gear Train Solution Techniques with Application to Tandem Bicycling
54	MS	Fleming, Michael	12/03	Teleoperated Control of Hydraulic Equipment for Hazardous Material Handling
55	MS	Stubbs, Matthew	12/03	Kinematic Design and Analysis of a Morphing Wing
56	MS	Bacha, Andrew	5/05	Line Detection and Lane Following for an Autonomous Robot
57	MS	Frentzel, John	5/05	A Wireless Instrumented Payload for Testing Unmanned Vehicles
58	MS	Naik, Ankur	12/05	Arc Path Collision Avoidance Algorithm for Autonomous Ground Vehicles
59	MS	Barnett, Shane	12/05	Development of a Tow Capacity Test Device for Small Unmanned Vehicles
60	MS	Cooper, Jared	12/05	Modeling of a Small-Scale Remote Controllable Helicopter for Simulation and Control Development
61	MS	Baity, Sean	5/06	Development of a Next-generation Experimental Robotic Vehicle (NERV) that Supports Intelligent and Autonomous Systems Research
62	MS	Leedy, Brett	5/06	Two Minds for One Vehicle: A Case Study in Deliberative and Reactive Navigation
63	MS	Gombar, Brett	5/06	Design and Evaluation of a Mobile Instrumentation Platform for Unmanned Vehicle Testing
64	MS	Putney, Joseph	5/06	Reactive Navigation of an Autonomous Ground Vehicle Using Dynamic Expanding Zones
65	MS	Willis, Christopher Ryan	5/06	A Kinematic Analysis and Design of a Continuously Variable Transmission
66	MS	James Hayward Bittorf	6/06	Mechanical Device to Assist the Landing of Unmanned Aerial Vehicles
67	MS	Ramirez, Rachael	8/06	Computer Vision Based Analysis of Broccoli for Application in a Selective Autonomous Harvester
68	MS	Grant Edward Gothing	7/07	Development of the "Discretized Dynamic Expanding Zones with Memory" Autonomous Mobility Algorithm for the Nemesis Tracked Vehicle Platform
69	MS	David Burns Van Covern	7/07	Collaborative Target Localization and Inspection Using a Heterogeneous Team of Autonomous Vehicles
70	MS	Thomas James Alberi	4/08	A Proposed Standardized Testing Procedure for Autonomous Ground Vehicles

71	MS	Patrick Norman Currier	4/08	Development of an Automotive Ground Vehicle Platform for Autonomous Urban Operations
72	MS	Jesse Lee Farmer	2/08	Kinematic Analysis of a Two Body Articulated Robotic Vehicle
73	MS	Chris Hockley	12/10	Development of an Autonomous Monocopter
74	MS	Katrina Corley	4/11	Supervisory Autonomous Control of Homogeneous Teams of Unmanned Ground Vehicles, With Application to The Multi- Autonomous Ground-Robotic International Challenge
75	MS	Robert Andrew Lister	5/11	Classification of Marine Vessels in a Littoral Environment Using a Novel Training Database
76	MS	Kevin Rigby	8/11	Localization of Aircraft Using Wide-Baseline Stereopsis
77	MS	Lafe Zabowski	8/11	A Low Cost, Computer Vision Based, Target Tracking Hexapod
78	MS	Christine Dailey	5/12	A Novel Resistance Exercise Machine for Use in a Lower Body Negative Pressure Box to Counteract the Effects of Weightlessness

Ph.D. Students Completed				
1	PhD	Robert L. Williams II	5/88	Planar Robotic Mechanisms: Analysis and
				Configuration Comparison
2	PhD	Arun Veeraraghavan	9/90	The Solution of Variable-Geometry Truss
				Problems Using New Homotopy Continuation
				Methods
3	PhD	Shahriar Tavakkoli	6/91	Shape Design Using Intrinsic Geometry
4	PhD	Babu Padmanabhan	12/92	A Study of Isostatic Framework with
				Application to Manipulator Design
5	PhD	Robert J. Salerno	12/93	Positional Control Strategies for a Modular,
				Long-Reach, Truss-Type Manipulator
6	PhD	Paul Tidwell	8/95	Wrapping Cam Mechanisms
7	PhD	J. Barry Fallon	8/95	Improving the Kinematic Control of Robots by
				Estimating the End-Effector Pose Directly with
				Computer Vision
8	PhD	Steven B. Shooter	12/95	Information Modeling in Mechanical Design:
				With Application to Cam Mechanism Design
9	PhD	Ravi S. Voruganti	12/95	Robot System Characterization: Error Modeling,
				Identification, Analysis and Calibration
10	PhD	Canfield, Steve	5/98	Development of the Carpal Wrist
11	PhD	Stulce, John	1/02	Conceptual Design of a Multibody Passive-
				Legged Crawling Vehicle
12	PhD	Calkins, Joseph	8/02	Quantifying Coordinate Uncertainty Fields in
				Coupled Spatial Measurement Systems
13	PhD	Snorri Gudmundsson	12/16	A Biomimetic, Energy-Harvesting, Obstacle-
				Avoiding, Path-Planning Algorithm for UAVs