

University of Toronto  
Faculty of Applied Science and Engineering  
**Final Examination, December 07, 2018**  
Duration: 2.5 hours  
**APS111H1 F and APS113Y1 Y - Engineering Strategies & Practice 1**

Calculator Type: 4 (No electronic or mechanical devices permitted)  
Exam Type: A (Closed book, no aids permitted)  
Course Coordinator: Jason Bazylak  
Communication Coordinator: Peter Weiss  
Instructors: Susan McCahan, Ted Nolan, Jason Bazylak, and Peter Weiss

*Instructions:*

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This is a closed book exam; no calculators or aids are permitted, except a translation-only non-electronic dictionary, i.e., direct word-to-word translations with no definitions.

To start: Fill out both the answer sheet (scan sheet) and the exam booklet (blank lined booklet) with:

- Your name: on the back of the scan sheet and on the front of the exam booklet
- Your student number (bubble your number on scan sheet; write number on booklet)
- Your course: APS111 or APS113
- Today's date: 07-Dec-2018
- You **do not** need to fill out the course instructor or form code

There are two parts to the exam: (1) multiple-choice questions, and (2) a writing component.

*Multiple-Choice (60%):*

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- There are a total of 40 multiple-choice questions, each of which is worth about 1.5 marks, for a total of 60 marks worth 60% of the exam.
- **Answer this part on the answer sheet (scan sheet with bubbles):** do not answer the multiple-choice questions on these question pages or in the exam booklet.
- Read each question carefully and choose the most correct answer.
- **Only one answer is to be given for each question.**
- There is no penalty for incorrect answers.
- Be sure to fill out the answer sheet **clearly and darkly with no overlaps**, using a pencil.
- Erase any errors completely.

*Writing Component (40%):*

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- The writing component has a total of 40 marks worth 40% of the exam.
- **Answer this part in the exam booklet (blank lined booklet):** do not answer the written component questions on these exam question pages.
- Carefully follow the instructions.

When you are done the exam, insert the answer sheet (scan sheet) into the exam booklet and hand in both together. You may keep the question pages.

**Part 1: Multiple Choice Questions (60%)**

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1. In preparing your Project Requirements document your team may use Functional Decomposition to:
  - a. Generate Secondary Functions.
  - b. A Morph Chart.
  - c. Possible solutions.
  - d. Assign individual tasks to team members.
2. When using the Black Box method to generate functions for the design of a camping stove what is **NOT** a valid input?
  - a. Mass - User
  - b. Mass - Fuel
  - c. Information – Desired temperature
  - d. Energy – Ignition source
3. Your team is generating survey questions to use when conducting a test to include in your Measure of Success section of your CDS. Your team member proposes the survey question depicted in Figure 1 below. You explain to your team member that this is not a good survey question because:
  - a. The answers are biased towards a positive response.
  - b. Useable is not a good objective.
  - c. They should say “*easy to use*” instead of “*useable*.”
  - d. Survey questions are never useable.

**Survey Question:** How useable is the interface?

**Possible survey responses:**

Extremely Useable

Very Useable

Useable

*Figure 1: Survey question referred to in question 3*

4. If your TA makes no comments on a section of your draft document, that means the section is:
  - a. Good to go, meets the TA’s approval.
  - b. Not one that the TA commented on.
  - c. The fallacy of common sense so you need more research.
  - d. Likely plagiarized and so the TA cannot comment.

5. The purpose of a Conceptual Design Specification (CDS) is to:
  - a. Reflect on the design process to improve in the future.
  - b. Clarify what the team knows or does not know about the project.
  - c. Set a target everyone can work toward.
  - d. Generate multiple solutions and criteria to evaluate them.
6. You are designing the baggage claim system for a major international airport. You have determined that user satisfaction (travelers claiming bags) is of the utmost importance. This has developed into an objective, "Minimize time before baggage appears on the baggage carousel." When determining an acceptable goal for this objective you researched the time it takes baggage to appear at other similar international airports. This is an example of:
  - a. Design bias
  - b. Benchmarking
  - c. Common sense
  - d. All of the above
7. To gather information on baggage handling system at major international airports, you watch baggage handlers go through their daily work. You make notes about what they do and how they do it. This is an example of:
  - a. Task analysis
  - b. Black box method
  - c. Story boarding
  - d. Benchmarking
8. In designing a baggage handling system for a major international airport, your design team decides to take a human-centered approach. The baggage handlers at the airport all belong to the same labour union. You research the work guidelines that are part of the employment agreement between the union and the organization that runs the airport. This is an example of:
  - a. Considering the user group at a physical level
  - b. Considering the user group at a psychological level
  - c. Considering the user group at a social level
  - d. Considering the user group at an organizational level

9. A reason for using formal creativity methods (idea generation methods) is:
- Minimize the impact of personal bias.
  - Avoid design fixation.
  - To generate a diverse set of design alternatives.
  - All of the above
10. Which of the following is an example of a prototype?
- Design of a sorting process for a food bank: A flow chart of a proposed food-sorting work flow with time estimates for each stage and an estimated total sort time.
  - Design of a solar powered water sterilization device: A spreadsheet that accepts a range of solar insulations (solar radiation that reaches the Earth for a given area) and calculates the energy generated and stored by a photovoltaic system.
  - Design of an automated gate opening system: A model of a spring driven opening system constructed of cardboard, tape, popsicle sticks and elastic bands.
  - All of the above
11. The essential difference between a novice designer and an expert designer is:
- Time spent formally defining the problem.
  - The quality of the designs.
  - Use of prototypes.
  - All of the above
12. In Engineering writing, complex/compound sentences are:
- Written in a way that ensures the reader does not get lost.
  - Written in list form because paragraphs are only for related ideas.
  - Never used because they are too long to read quickly.
  - Always used because the information presented is always complex.

**Multiple-choice questions continue on next page.**

13. The following sentence, “the technology must be green” is an example of:<sup>1</sup>

- a. An objective
- b. A metaphor
- c. A constraint
- d. An action verb

14. A reflective document:

- a. Uses figurative language to enable readers to identify with an experience.
- b. Assigns blame for things that went wrong in the team.
- c. Is never used in business to evaluate a project upon completion.
- d. Is used to develop strategies to repeat successes when they happen.

15. The legal requirement for the inclusion of automated doors for easier wheelchair access to Myhal 150 is captured under which level of Human Interaction?

- a. Physical
- b. Social
- c. Political
- d. Constraints

16. Prof. St-Cyr defined user experience as the way people

- a. Feel about a product or system and their pleasure and satisfaction when using it.
- b. Use a product or system and how they interact with it.
- c. Experience the world and the technology with which they interact.
- d. Think about the technology they are using and understand how it is supposed to be used.

17. User experience

- a. Can only be measured using performance metrics.
- b. Can only be measure using task analysis.
- c. Can be measured using performance and self-reported metrics.
- d. Cannot be measured in any objective way.

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<sup>1</sup> This is a student generated question. This does not affect the question and is mentioned here only as an example of ESP students taking responsibility for their own learning.

18. If you were tasked to design a water treatment plant for a remote Indigenous community, the most pertinent design methodology you should utilize is:

- a. Universal design
- b. Participatory design
- c. User Experience design
- d. Human Factors design

19. An example of you doing Due Diligence in your CDS project is:

- a. Making sure your team is large enough for the work load.
- b. Messaging all team members to confirm that you have successfully submitted the CDS.
- c. Using every tool taught in this course.
- d. Delegating tasks to ensure the team delivers on the due date.

20. Which of the following is **NOT** part of the basic engineering process?<sup>2</sup>

- a. Iteration
- b. Problem Identification
- c. Solution Generation
- d. Marketing

21. A student cuts and pastes material from a website into a team document without references or quotation marks. The stakeholders are:

- a. The Government of Canada because they set the laws for Intellectual Property.
- b. World Trade Organization because they are responsible for the international treaty on Intellectual Property.
- c. The University of Toronto because its reputation is based on the quality of original information generated there.
- d. The WiFi service provider because they are responsible for providing the original material.

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<sup>2</sup> This is a student generated question. This does not affect the question and is mentioned here only as an example of ESP students taking responsibility for their own learning.

**Questions 22 to 24 pertain to the team situation described in the following paragraph.**

***Team Situation Case Study - Dealing with Dysfunctional Project Teams***

*Alfred, Joe, Ahmed, George, and Tian are working on their first-year design project. Joe, as team leader, assigned each team member sections of the report to write according to the format requested of the course. Ahmed completed the section he was assigned by the requested deadline and placed it in the team's Google Doc. He did not hear anything from the group thereafter, and went to bed. The next morning after the document had been submitted, Joe approached Ahmed and asked him why he did not complete his section. Ahmed argued that he did and showed evidence from the Google Docs history that he included work under his assigned section. George, listening in on this conversation, asked Ahmed how he could have thought it was completed as there were still missing references and no links to other sections in the text. Ahmed responded that he did what was asked of him, and that if it was not sufficient why the rest of the team did not contact him to tell him that they were not happy with his work. The three men end up insulting and yelling at each other while the other two team members play on their phones.*

22. What was the primary source of conflict in this situation?

- a. Ahmed did not include references.
- b. Alfred and Tian should not be on their phones during a team discussion.
- c. Joe, Ahmed, and George yelling at each other.
- d. The team did not communicate expectations to Ahmed.

23. What actions could Tian have taken to improve the situation?

- a. Focus on the problems not the people, and calmly mediate a discussion where Ahmed, Joe, and George explain what their expectations are.
- b. Convince Alfred to side with Ahmed to even things out and promote productive discussion.
- c. Give Ahmed, Joe, and George each 3 minutes where only they are allowed to talk when they can declare their positions.
- d. Record the conflict on his phone for evidence.

**Multiple-choice questions continue on next page.**

24. If you were coaching this team through this period, which of the following strategies would be the best one to recommend to them?

- a. Make the team go out to lunch together to rebuild comfort and trust.
- b. Remove writing tasks from Ahmed in future assignments.
- c. The team should ban use of cellphones during team meetings.
- d. Revise their Team Charter to explicitly state how the team will communicate expectations.

**Questions 25 to 40 pertain to the case study: Heads Up Display (HUD) for Truck Fleets in Appendix A.**

25. Which of the following are stakeholders in the project?

- a. Innovation Online Industries.
- b. Drivers of delivery trucks installed with the design.
- c. Drivers of other vehicles on the road.
- d. All of the above

26. Which of the following statements would be best to include in your Service Environment section?

- a. Innovation Online Industries is a major supplier of IOT technologies.
- b. In Ontario, deaths from collisions caused by distracted driving have doubled since 2000 [2].
- c. Truck drivers have an interest in earning a livable wage.
- d. The design will make use of the 5G networks that will soon be available in Toronto.

27. By researching Ontario traffic laws, you discover that use of a hand-held communication device while driving is against the law, but use of a mounted device is legal to use as long as it is not moving around while driving. Which is the best way to include this information into your design report?

- a. Constraint: The design must not break traffic laws.
- b. Function: The design will prevent driver deaths.
- c. Objective: The design will maximize safety.
- d. Constraint: Any part of the design accessible to the driver must be not be moveable.

28. Which of the following statements is a fully formed Constraint?

- a. Should be reliable.
- b. Needs to allow for information input in at least three languages.
- c. Must not cover more than 10% of the windshield.
- d. The design will reduce distracted driver accidents by at least 15%.

29. Which of the following statements is a fully formed Objective?

- a. Should minimize the percentage of the windshield covered by the interface with a successful target being 5%.
- b. Should be accessible and not violate the Ontarians with Disabilities Act.
- c. Must minimize cost not exceeding the current cost of a deluxe GPS unit.
- d. Should be easy to navigate the functions of the design.

30. Limiting the design to a Heads-Up Display is:

- a. The result of a Client Constraint.
- b. An Implied Solution.
- c. Scope Creep.
- d. The Primary Function.

31. A Secondary Function for this design is best described as:

- a. Receive GPS data.
- b. Project Augmented Reality images onto windshield.
- c. Be easy to retrofit into existing trucks.
- d. Drive the vehicle autonomously.

32. The Primary Function of this design is best described as:

- a. Optimize the routes of the drivers.
- b. Receive multiple data streams, such as traffic information.
- c. Reduce distracted driver fatalities.
- d. Communicate vehicle and route related information to the driver.

**Multiple-choice questions continue on next page.**

33. Several months into the project you have a non-functional mockup of a recommended design. Driver distraction has developed into a major consideration. You are set to present your recommended design to representatives from Innovative Online Industries and you want to give solid evidence supporting your recommendation. Which of the following Measures of Success would likely have the highest validity?
- Load images of the interface mockup onto tablets, then ask more than 1000 people at Union Station if they feel that a HUD would be distracting in a vehicle.
  - Conduct a survey of Engineering Undergraduate students whether they think occupying 5% of the windshield would be distracting.
  - Use [www.speedtest.net](http://www.speedtest.net) a 5G networked device and show that the speed is sufficient to load navigation data from Google Maps.
  - Contract a research group to use eye tracking software to create a heat map of where a driver looks while driving on a driver simulator when exposed to the proposed design.
34. The Functional Basis for this design is best described as:
- Separate Mass
  - Transmit Information
  - Transmit Mass
  - Control Energy
35. Which of the following would NOT be part of the scope?
- Research into driver distraction.
  - User Experience design regarding simplifying interfaces.
  - Receiving and transmission of GPS signals.
  - Voice recognition technology.
36. Specifically for this project, which of the following is the best metric for an Objective: Easy to Navigate?
- All data is available on the root screen minimizing the number of clicks needed for navigation tasks.
  - Data is available in as many different languages as possible.
  - Screen must have high contrast font options for visually impaired users.
  - Should minimize the time the driver has to focus on initiating a navigation task.

37. What would be an appropriate research question for this project?

- a. What is an acceptable design alternative for this project?
- b. What is an acceptable timeframe for implementation of the design?
- c. What is the current state-of-the-art for HUD technologies?
- d. All of the above

38. What would be an appropriate client question for IOI?

- a. What is an acceptable design alternative for this project?
- b. What is an acceptable timeframe for implementation of the design?
- c. What is the current state-of-the-art for HUD technologies?
- d. All of the above

39. Which of the following is a properly formed credible engineering statement?

- a. 5G technology will be transformative for Internet of Things technology.
- b. Internet of Things technology will see an explosion in demand once 5G becomes a reality.
- c. The high speeds and low network latency will be a great benefit for companies in the Internet of Things industrial (IOT) space [4].
- d. All of the above

40. The purpose of using IEEE referencing in your CDS is to:

- a. Increase efficiency by avoiding in-text citations.
- b. Show the difference between an idea and the expression of an idea.
- c. Indicate when you have used an idea from a source.
- d. Create an alphabetical reference list.

*End of questions pertaining to the case study: Heads Up Display (HUD) for Truck Fleets in Appendix A.*

*End of multiple-choice questions.*

*Long-answer questions start on the next page.*

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*Part 2: Long Answer Questions (40%)*

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**Questions 41 to 43 pertain to the Case Study: Fully Functional Flying Robot (FFFR) in Appendix B.**

INSTRUCTIONS: This section requires 3 written answers. Use an exam booklet, and write your name, student number, course number, and date of examination on the booklet's cover page. You may use as many pages as you need for your preliminary work, but the final answers for all three questions must not total more than four (4) pages single-spaced or eight (8) pages double spaced. Clearly indicate the final copy to be graded by writing "Final Copy" at the start of it. Use full sentences and paragraphs and bullet lists where appropriate.

This section of the exam evaluates your ability to:

- Read, understand, and analyse engineering-related material under time pressure.
- Communicate in clear, concise, well-organized sentences and paragraphs with minimal error.
- Structure a logical argument, making clear claims and supporting them with the evidence currently available to you.
- Recognize the kinds of information you would need, moving forward, to validate and better support your claims and generate specific questions to help you find that information.

41. Based on the Long Answer Case Study: **Fully Functional Flying Robot (FFFR)** located in Appendix B, in paragraph form (one or more paragraphs) write a concise Problem Statement in your own words. You may, if you wish, add a brief introduction, identifying the client. You are expected to define the scope of your project. DO NOT COPY SENTENCES WORD-FOR-WORD FROM THE CASE STUDY IN YOUR PROBLEM STATEMENT. YOU WILL RECEIVE NO MARKS FOR MATERIAL COPIED WORD-FOR-WORD FROM THE CASE STUDY. (20 marks)
42. Based on the Long Answer Case Study: **Fully Functional Flying Robot (FFFR)** located in Appendix B, generate Functions, Objectives and Constraints for the specific task you have identified in the problem statement. Utilize course tools such as Functional Basis and Functional Decomposition. In total, you should have about 10 items, whether they are Primary Functions, Secondary Functions, Unintended Functions, Objectives or Constraints. Treat this like a section of a design document with a section introduction and sub-sections. Introduce each of the sub-sections (e.g. Functions, Objectives, Constraints) with a few sentences that help the reader understand their nature and significance. (15 marks)
43. Based on the Long Answer Case Study: **Fully Functional Flying Robot (FFFR)** located in Appendix B, identify five key research questions you would want to answer in order to check the validity of your claims and to further develop your three top objectives. These are questions to guide your personal research, NOT questions for the client. (Don't worry about whether the questions are open or closed.) (5 marks)

*End of all questions of this exam.*

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*You may remove these appendices.*

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### **Appendix A: Heads Up Display (HUD) for Truck Fleets**

In the coming year major telecom companies across the globe, such as AT&T (US) [1], Vodafone (UK) [2] and China Telecom [3] have announced the roll out of 5G mobile networks. The high speeds and low network latency will be a great benefit for companies in the Internet of Things industrial (IOT) space [4], such as Innovation Online Industries (IOI) [5].

The IOI in-house engineering team is working hard to design IOT products that will meet the anticipated explosion in demand once 5G becomes a reality. Unable to manage all the projects they are seeking additional design expertise from outside design consultancies. The consulting firm you work for, High Five Product Design, is planning on responding to the RFP.

IOI is interested in developing a Heads-Up Display (HUD) design that projects onto the windshield using Augmented Reality (AR) technology. The design must be able to be retrofitted into existing fleets of delivery trucks. The HUD will be used to support more efficient deliveries by supplying the drivers with information at a glance such as:

- Current and forecasted weather conditions
- Traffic / accident reports
- Road closures
- Vehicle status (fuel, temperature, tires, etc)
- Corporate communications (such as updates from the fleet dispatcher)
- And most importantly GPS navigation instructions with an optimized route

IOI feels there is an amazing opportunity, but there is one major concern, safety. Transport Canada has already expressed concerns about increasing traffic fatalities attributed to driver distraction linked to in-vehicle telemetric screens (dashboard mounted screens) [6]. Projecting the screen onto the windshield will put the distraction closer to the drivers' field of vision and has potential for even more fatalities. Minimizing driver distraction through innovative interface design is a must for this project to succeed.

Other criteria:

- |  |   |
|--|---|
| <ul style="list-style-type: none"><li>• Should be reliable</li><li>• Should be easy to navigate</li><li>• Must be accessible</li></ul> | <ul style="list-style-type: none"><li>• Should have a simple interface</li><li>• Should be easy to input information</li><li>• Must be secure against hacking</li></ul> |
|--|---|

#### Reference List

1. AT&T. (2018 January 04) "AT&T to Launch Mobile 5G in 2018." [Online] Available: [https://about.att.com/story/att\\_to\\_launch\\_mobile\\_5g\\_in\\_2018.html](https://about.att.com/story/att_to_launch_mobile_5g_in_2018.html)
2. Vodafone. (2018 April 12) "Vodafone UK first to test new 5G spectrum across a live network." [Online] Available: <https://mediacentre.vodafone.co.uk/news/first-test-new-5g-spectrum-across-live-network/>

3. R. Le Maistre. (2018 March 14) "China Telecom Eyes 2M+ Basestation for 5G." [Online] Available: <https://www.lightreading.com/mobile/5g/china-telecom-eyes-2m-base-stations-for-5g/d/d-id/741445>
  4. V. Gandhi. (2018 April 13) "5G to become the catalyst for innovation in IoT." [Online] Available: <https://www.networkworld.com/article/3268668/internet-of-things/5g-to-become-the-catalyst-for-innovation-in-iot.html>
  5. Innovation Online Industries. (2018 January 28) "About Us." [Online] Available: <https://www.ioi.com>
  6. Government of Canada – Transport Canada. (2003 June) "Strategies for Reducing Driver Distraction from In-Vehicle Telematics Devices: A Discussion Document." [Online] Available: <https://www.tc.gc.ca/eng/motorvehiclesafety/tp-tp14133-menu-147.htm>
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**Appendix B: Fully Functional Flying Robot (FFFR)**

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**ESP II - Winter 2018 Project Description**

**Project Number: NCC339T**

<b>Client Information</b>	
<b>First Name:</b>	François
<b>Last Name:</b>	Bellefête
<b>Title:</b>	Chief Technical Officer
<b>Company:</b>	Novel Combinations Co-op (NCC)
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<b>Alternate Contact Telephone:</b>	514-343-7788, ext. 453
<b>Project Description:</b>	<p><u>Fully Functional Flying Robot (FFFR)</u></p> <p>Novel Combinations Co-op is a start-up laboratory in Montreal dedicated to expanding the practical uses of technology through off-the-wall, out-of-the-box design. But when we say “out-of-the-box” we mean it literally. Our designs begin with products that currently exist on the market that we would like to see customized and combined to expand their usefulness.</p> <p>I would like to suggest a project for your Engineering Strategies and Practice students combining multiple existing components but primarily a drone and a robot. We got this idea from a current initiative in Latvia: a window-cleaning drone [1]. What a great idea, we thought. Window washing, particularly on skyscrapers, is a difficult and dangerous enterprise. Sure, there are people who like to dangle on a rope 200 metres in the air, but accidents do happen! If a drone falls 200 metres and smashes to bits, you can just replace the drone. If a person falls 200 metres, it is a human tragedy.</p>

So, too, with wind turbines in the far north. In order to work properly, they have to be de-iced from time to time. The Latvian drones can do this at far less cost than the helicopters and crews that are currently being used.

We recognize that there are, currently, tiny flying robots [2-3] that can generate their own electricity and can be used for such diverse tasks as pollinating flowers in areas where the bee population has dissipated or detecting gas leaks. Moreover, the photovoltaic technology that allows these robots to stay in the air and the microcontroller that allows them to “think” for themselves may provide useful models for our projects.

Drones, however, do not have the mechatronic capabilities to perform manual tasks, such as changing burnt out light bulbs on high ceilings or rescuing pets and the insect-sized tiny flying robots are obviously too small to perform some of these tasks.

So, the first phase of this project is to identify tasks that may be dangerous to perform but can be done by a combination drone-robot, what we call a Fully Functional Flying Robot (FFF.R). In the second phase, what the robot has to do and the specifications related to that have to be identified – that will lead to the third and final phase in which the components that meet those specifications will be identified, as well as any modifications that have to be made to them in order to combine them.

This is a Custom-Off-the-Shelf design and while modifications are expected, it must not require new manufacturing facilities. We are not interested in *any* weaponized design – our co-op of interdisciplinary engineers and designers are interested in helping living beings, not hurting them. Obviously, the design MUST BE user friendly and MUST BE environmentally friendly in order to secure the kinds of dazzling sales we are looking forward to. This is common sense: if users cannot use it or if the environment is going to be totally destroyed by it, who would want to buy it?

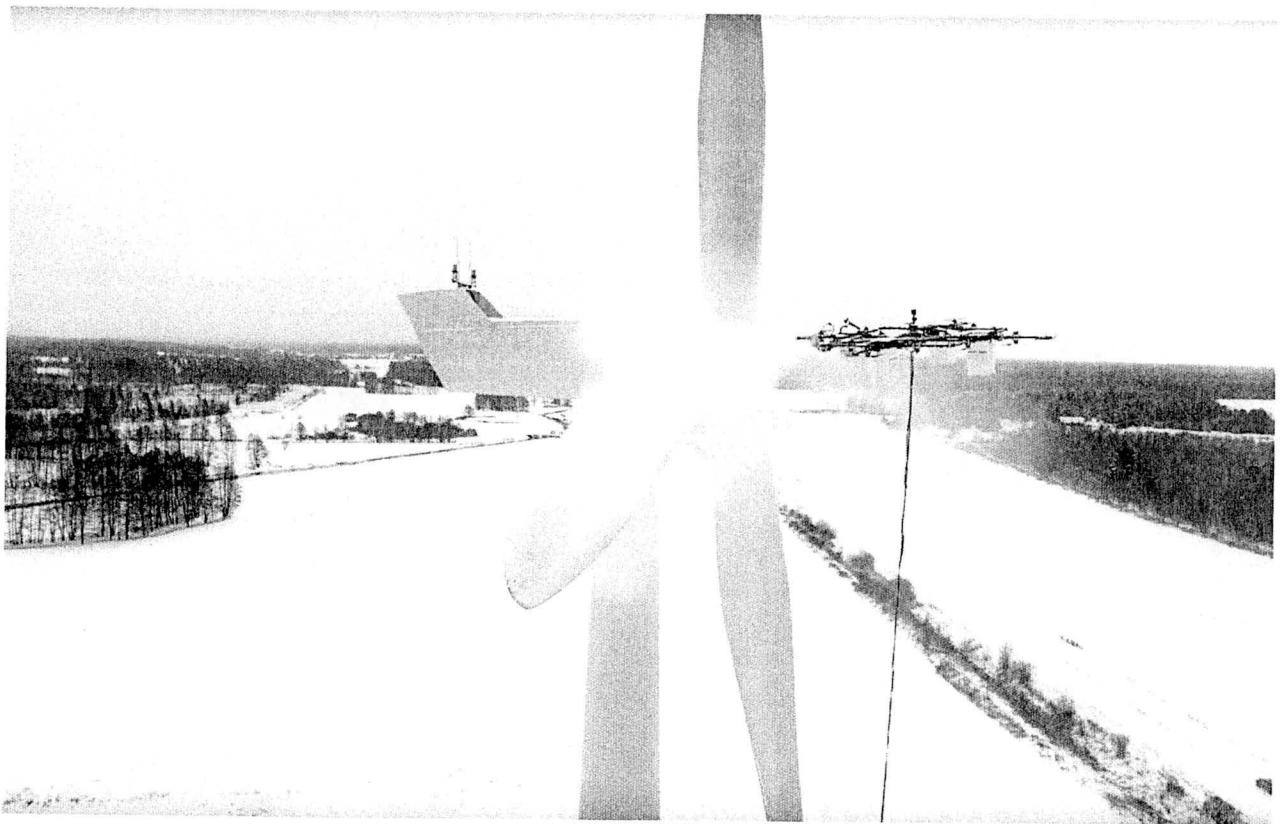


Figure 2: Wind Turbine being cleaned by drone [1]

#### References:

- [1] J. Archer. (2018 Nov 22) "Window Washing Drone Takes Flight" [Online] *The Telegraph* Available: <https://www.telegraph.co.uk/technology/2018/11/22/window-washing-drone-can-used-clean-buildings-extinguish-fires/>
- [2] J. Rothwell. (2018 Oct 9) "Why Tiny Flying Robots could be the Answer to Europe's Bee Crisis." [Online] *The Telegraph* Available: <https://www.telegraph.co.uk/news/2018/10/09/tiny-flying-robots-could-answer-europees-bee-crisis/>
- [3] S. McQuate. (2018 May 15) "The First Wireless Flying Robotic Insect Takes Off." [Online] UW News Available: <https://www.washington.edu/news/2018/05/15/robofly/>