Value Sensitive Design of a Humanitarian Cargo Drone & Danish Healthcare Drone

Presented by: Dylan Cawthorne

Based on work by: Dylan Cawthorne, Alessandra Cenci, and Aimee van Wynsberghe

Value Sensitive Design in the Drone Domain Workshop

https://vsdinthedronedomain.sdu.dk/

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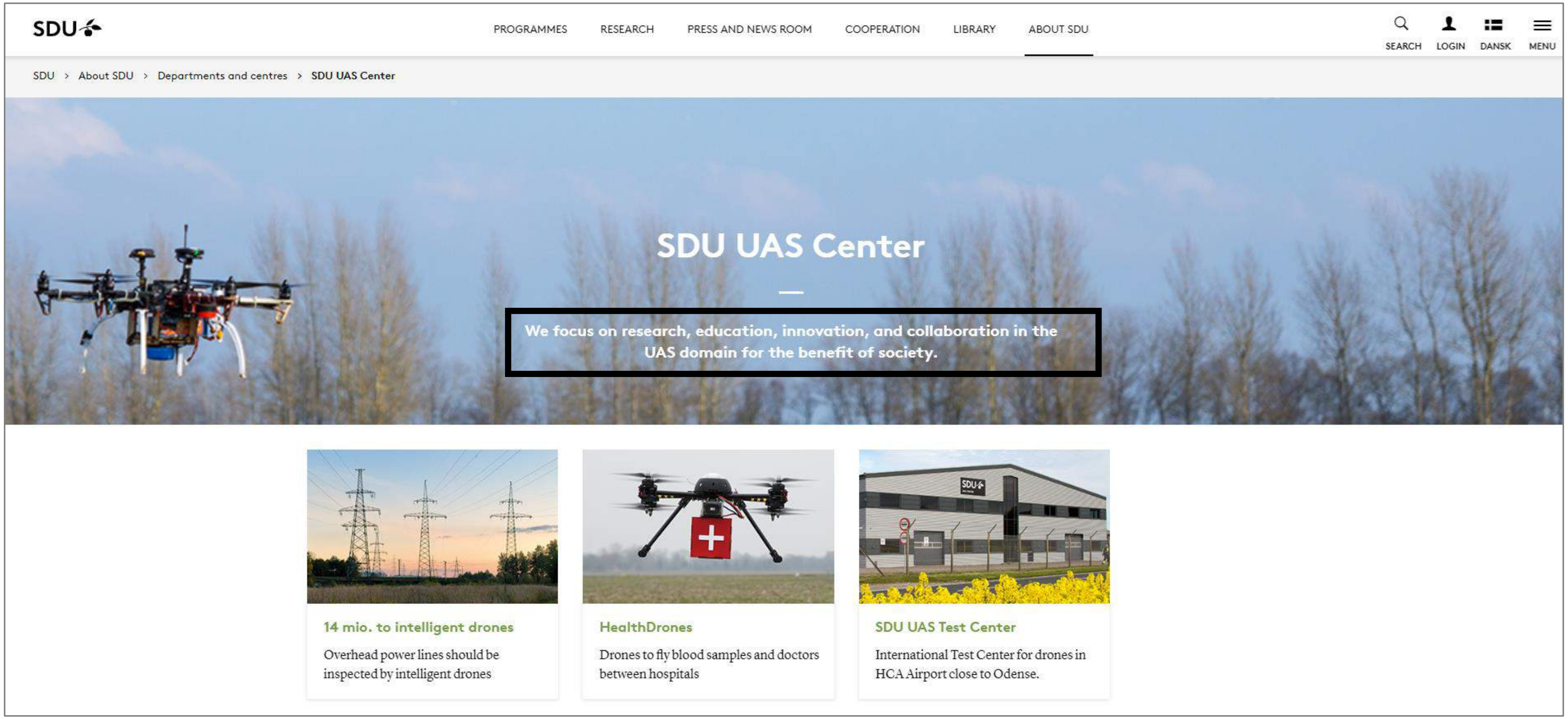
Context

- How can, and why should, engineers design “ethical” drones?



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Introduction: Embodied values

The embodied values approach states that technologies such as drones are not morally neutral, but enhance or limit the expression of certain human values.

Introduction: Non-epistemic values

'[A]n epistemic value is one we have reason to believe will, if pursued, help toward the attainment of... knowledge'. All other values are non-epistemic ones.

Sven Diekmann and Martin Peterson. The role of non-epistemic values in engineering models. Science and engineering ethics, 19(1):207–218, 2013.

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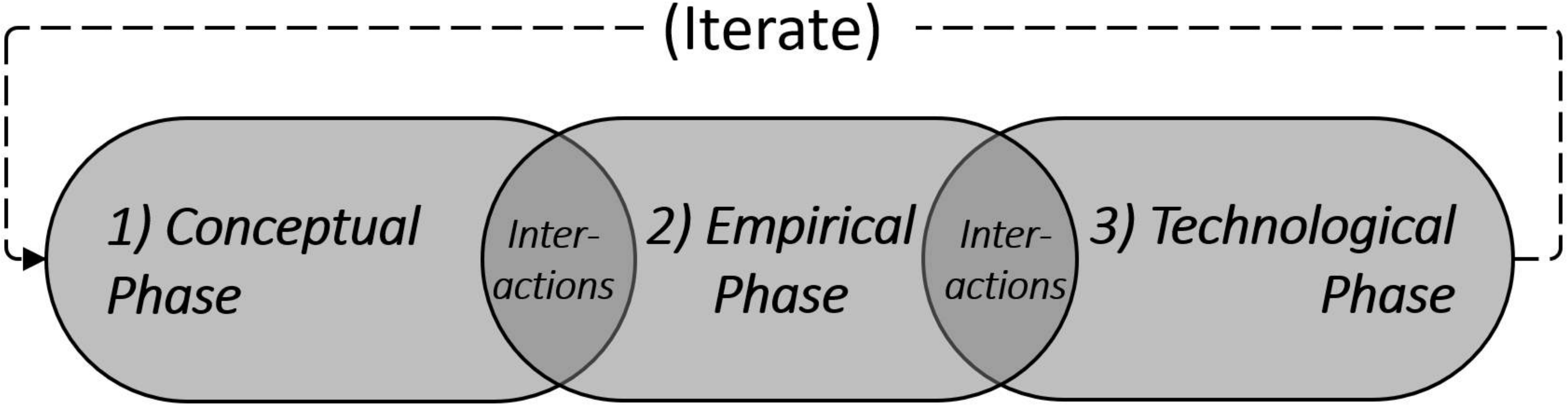
Introduction: Non-epistemic values

- Examples of non-epistemic values:
  - Ethics
  - Safety
  - Environmental sustainability
  - Equality
  - Wellbeing

Methodology: Value sensitive design



1) Conceptual phase:
Relevant human values are identified and an ethical analysis can take place.

2) Empirical phase:
Social impacts of the technology are taken into account.

3) Technological phase:
Technical capabilities are explored, specifically, those which support the chosen human values/social impacts.

Graphic by the authors, based on:

Batya Friedman, Peter H Kahn, Alan Borning, and Alina Huldtgren. Value sensitive design and information systems. In Early engagement and new technologies: Opening up the laboratory, pages 55–95. Springer, 2013.

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Case #1: Humanitarian cargo drone

Still image from WeRobotics video:
https://www.youtube.com/watch?v=doD71kdeJXM&t=51s

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Case #1: Humanitarian cargo drone

2019 International Conference on Unmanned Aircraft Systems (ICUAS)
Atlanta, GA, USA, June 11-14, 2019

Value Sensitive Design of a Humanitarian Cargo Drone*

Dylan Cawthorne[1] and Alessandra Cenci[2]

***Abstract*— Value Sensitive Design (VSD) is an interdisciplinary approach to technological development that systematically incorporates ethical considerations and social impacts as design inputs. Here, the VSD methodology is described, and elements of VSD are applied with a technological focus to analyze an existing prototype humanitarian cargo drone. Then, a new proposed drone design that better supports the values of human welfare (physical, psychological, and material welfare), and environmental sustainability is developed. The new drone is a high-speed fixed-wing drone which uses internal combustion engines and drops its payload via parachute to minimize transportation time and maximize patient physical welfare. It uses lower levels of automation such as manual flight monitoring to increase reliability and safety (physical welfare), and support the local workforce (material welfare). The drone uses much less energy than the technology it replaces, and is therefore much more environmentally friendly, supporting environmental sustainability. This work contributes by being the first to apply VSD methods to the technological development of a specific drone platform, and by demonstrating how drone engineers can use VSD to develop "ethical" drones.**

I. INTRODUCTION

In this section, the VSD methodology is briefly described, foundational concepts that underlay the method are introduced, and prior research relevant to this work is discussed.

A. Background

Value Sensitive Design (VSD) was first introduced over 20 years ago, and "is considered by many as the most comprehensive approach to account for human values in technology design" [1] (e.g. [2]; [3]). VSD is an interdisciplinary approach to technological development that accounts for human values in a principled and comprehensive manner throughout the design process [4]. It does so by way of an iterative analysis consisting of three main phases: a conceptual phase, an empirical phase, and a technological phase [5]. In the conceptual phase, relevant human values are identified. In the empirical phase, social impacts of the technology are taken into account. In the technological phase, technical capabilities are explored which best support the identified human values and positive social impacts. The technological phase of VSD is usually performed by engineers, the conceptual phase by ethicists, and the empirical phase by social scientists.

B. Embodied values

Value Sensitive Design is grounded in an embodied values paradigm, a well-established approach within the field of philosophy of science. The embodied values approach states that technologies such as drones are not morally neutral, but enhance or limit the expression of certain human values. "Technical artefacts (i.e. products) are not morally neutral because their functions and use plans pertain to the objectives of human actions, and those actions are always morally relevant" [6]. Technology increases the power to perform certain actions or reduce the power to perform others; thereby "technologies can destroy certain values...and make others virtually certain to be realized" [7]. Therefore, VSD provides an opportunity to bring to the fore a proactive integration of ethics in the design of technology [8]. A consequence of the embodied values paradigm is that unique technologies are required to support different values for different stakeholders within different social contexts; a one-product-fits-all approach is not appropriate. For example, drones developed within a civilian context necessitate different features than those for military or policing [9]. The embodied values paradigm is in contrast to the neutrality thesis, which states that technology is neutral, and can be "good" or "bad" depending *only* on how it is used [10] (i.e. products design does not play a role).

C. Technology in a social context

The way in which technology is used - by people, within a social context - contributes to its ethical relevance. Technical products, and drones in particular, can be misused - used in ways which they were not intended by the designer [6]. According to leading VSD scholars, most misuses can be avoided by including "good" values as design inputs [11]. That is, the incorporation of desirable values into the design will necessarily lead to "ethical" technologies which prevent, or at least makes it more difficult, for them to be misused. Engineers have a responsibility to envision likely misuses of their designs, and mitigate these appropriately [12].

D. Non-epistemic values

In recent years, the importance of non-epistemic values (e.g. ethics, safety, sustainability, equality, reliability, well-being) has become evident in science and engineering [13]. The analysis presented here contributes to this as a practical example of the direct involvement of non-epistemic or ethical-social values in he technological design and scientific knowledge-production processes - specifically, to create an "ethically" embodied, value sensitive drone.

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Supplementing value sensitive design with Amartya Sen's capability approach: Insights from a case study of a humanitarian cargo drone

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Abstract

Fundamental questions in value sensitive design include whether and how high-tech products/artefacts could embody values and ethical ideals, and how plural and incommensurable values of ethical and social importance could be chosen rationally and objectively at a societal-group level. By using the case study of a cargo drone as a starting point, this paper tackles the challenges that VSD's lack of commitment to a specific ethical approach generates in practical applications. Accordingly, the second part of the paper clarifies how VSD's ethical import could substantially be improved by espousing the procedural-deliberative approach to value and welfare entailed by Amartya Sen's capability approach. What is argued is that the normative and meta-ethical foundations of Sen's capability approach manage to better handle agents' diversity, value and goal pluralism, conflicting vested interests, and the moral disagreement typical of contemporary complex democracies. Procedural-deliberative tenets guarantee an increased attention to agents' positive freedom, their autonomy and self-determination in an objective-impartial choice procedure aimed at orienting normative choices and selecting a plurality of values and goals in concrete political-socio-cultural-policy environments. Unlike mainstream ethical-political theories, vital economic aspects are also essentially addressed. This results in an equal concern for economic-efficiency and fairness-equity, which are of fundamental importance to fulfil vital democratic and justice desiderata. Conclusions suggest that some major advantages of complementing VSD with this particular ethical view are at an applied level. Indeed, this espousal corroborates a more extended adoption of deliberative-participative methods as preferential ways to deliver socially justified technologies and ethical high-tech products/artefacts.

Keywords

Value sensitive design (VSD), capability approach, drone technology, human diversity, value and goals pluralism, conflicting vested interests, procedural-deliberative ethical theory, participatory-deliberative methods.

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Methodology: Human values relevant within technological design

Human welfare	Includes physical, material, and psychological well-being Physical well-being deals with bodily welfare, such as physical health Psychological welfare concerns mental health, such as stress Material welfare refers to physical circumstances, and is related to economics and employment
Ownership and property	The right to possess an object (or information)
Privacy	The ability to determine what information about one's self can be communicated to others
Freedom from bias	Systematic unfairness perpetrated on individuals or groups, including preexisting social bias, technical bias, and emergent social bias
Universal usability	Technology that can be successfully used by all people

Trust	The expectation to experience goodwill from others
Autonomy	The ability to decide, plan, and act in ways that allow one to achieve their goals
Informed consent	Garnering voluntary agreement, such as in the use of information systems
Accountability	Ensure that actions may be traced uniquely to the person, people, or institution responsible
Calmness	A peaceful and composed psychological state
Identity	The understanding of who one is over time, embracing both continuity and discontinuity over time
Environmental sustainability	Sustaining ecosystems such that they meet the needs of the present without compromising future generations

Graphic by the authors, based on:

Batya Friedman, Peter H Kahn, Alan Borning, and Alina Huldtgren. Value sensitive design and information systems. In Early engagement and new technologies: Opening up the laboratory, pages 55–95. Springer, 2013.

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Retrospective analysis

1) Conceptual phase:

1. Human welfare – physical
2. Human welfare – psychological
3. Human welfare – material
4. Environmental sustainability

Analysis of WeRobotics' mission statement:

”The benefit of all” = Human welfare; Universal usability

”Sustainably” = Environmental sustainability; Material welfare

”Aid” = Human welfare (Physical, Psychological, and Material welfare)

”Development” = Material welfare

”Environmental efforts” = Environmental Sustainability

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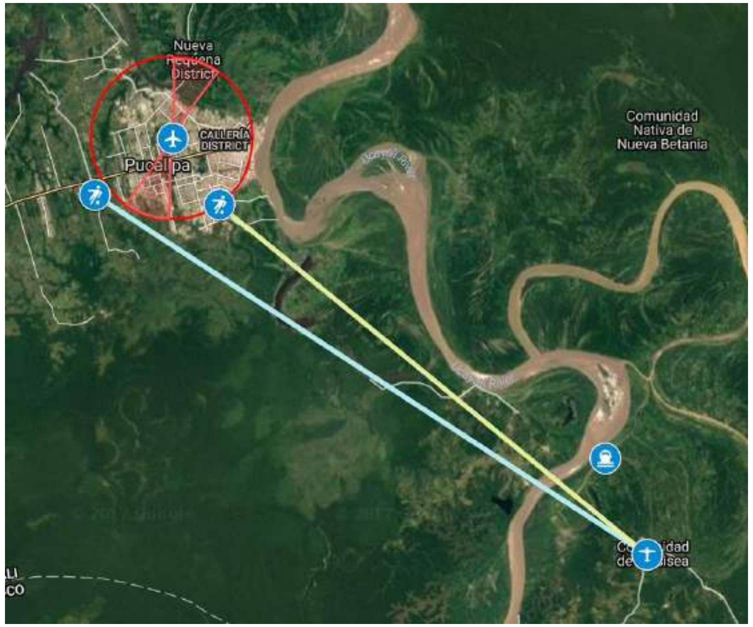
Retrospective analysis

2) Empirical phase:

- Amazon of Peru, flying between the village of Masisea (12,000) and the city of Pucallpa (200,000)
- Transporting patients to the hospital, typically by charter boat
- The boat trip takes 2-4 hours, and run 1 or 2 times per day leading to wait times up to 24 hours
- Adoption of the drone could lead to significant changes in healthcare practice (f.x. despite being logistically challenging, it is possible that **in-person care** is better for the patient
- Unemployment rates in Peru are low at 3.7% but local employment rates, conditions, and skills would be impacted; key to understand what skills exist, and what skills the residents wish to develop
- An assessment of the financial impacts to the local economy would be beneficial
- Cultural norms and values should be understood and fed into the analysis
- The intensification of cargo drone services could have far-reaching implications regarding infrastructure investments such as roads and bridges



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Retrospective analysis

3) Technological phase:

- Event 38 model E384 fixed-wing, electric powered mapping drone
- Manufactured in Akron, Ohio U.S.A.
- Modified to carry medical samples instead of a camera
- Wingspan of 190 cm
- Maximum take-off weight of 3.5 kg
- Maximum payload capacity of 0.8 kg
- Flight range of up to 70 km
- Cruise speed of 47 km/hr
- Cost of 3,000 USD

Graphic from:
WeRobotics. Cargo drones tested in amazon rainforest, 2017, URL: https://www.youtube.com/watch?v=doD71kdeJXM, accessed 24-02-2019.

Results: retrospective analysis

- The desired values **are embodied and supported** by the drone
  - Physical welfare (i.e health) of patients increased due to reduced transportation time (max 24 hours to under 1 hour)
  - Physical welfare (i.e. safety) of those exposed to the drone not substantially reduced since safety risks are low
  - Environmental sustainability
    - Very small payload and cleaner electrical power system make the drone more environmentally sustainable
    - Maximum 0.45 kWh energy per round trip VS the river boat which uses fossil-fuels and consumes around 40-80 kWh

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Results: retrospective analysis

- Main risks - material welfare (i.e. jobs, economics) of some of the local population, in particular the river boat operators
- The drone will initiate changes in the workforce
- Possible negative implications with respect to infrastructures investments such as the building of roads and bridges

Results - prospective analysis

- [Second iteration of the VSD process]
- Internal combustion engines
  - High flight speed (100 km/hr)
  - Longer range; low energy consumption
- Redundant engines, actuators, and passive safety features
- Modular components (design for end-of-life)
- Low levels of automation - ELOS flight with multiple safety spotters
  - Maximize high-quality jobs
- Local design and manufacturing?

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Conclusion - contribution

- First known application of the VSD methodology to a specific drone platform
- Demonstration of how drone engineers can use VSD to develop ”ethical” technologies

Case #2: Danish healthcare drone

- Retrospecitve analysis of Wingcopter drone
- Prospective analysis of FrugalDrone

Wingcopter drone
Image: https://geo-matching.com/uas-for-mapping-and-3d-modelling/wingcopter-178-heavy-lift

FrugalDrone
Image by the authors

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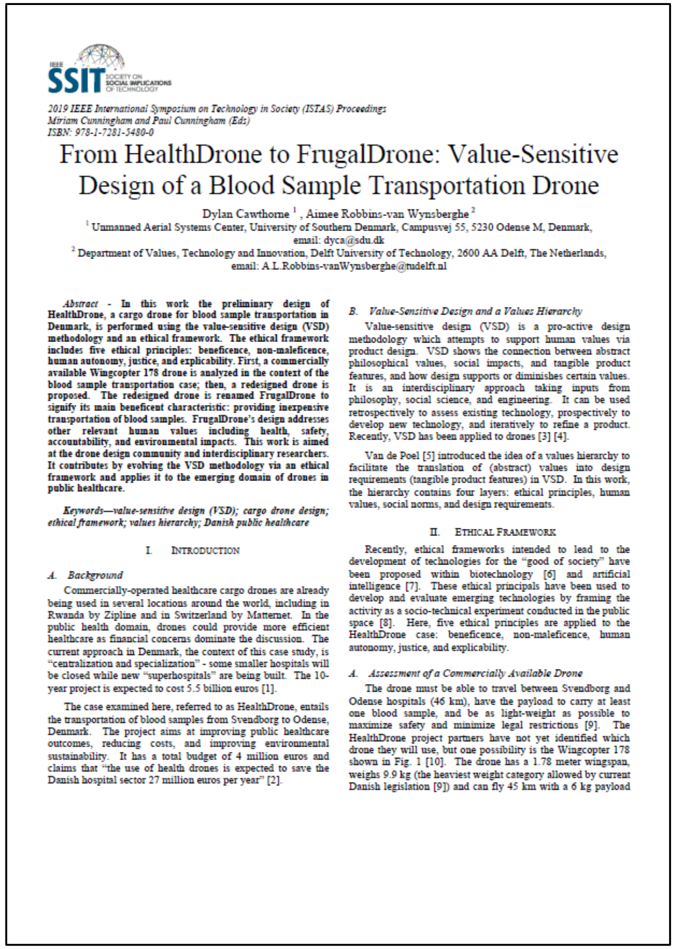
Case #2: Danish healthcare drone



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From HealthDrone to FrugalDrone: Value-Sensitive Design of a Blood Sample Transportation Drone

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***Abstract* - In this work the preliminary design of HealthDrone, a cargo drone for blood sample transportation in Denmark, is performed using the value-sensitive design (VSD) methodology and an ethical framework. The ethical framework includes five ethical principles: beneficence, non-maleficence, human autonomy, justice, and explicability. First, a commercially available Wingcopter 178 drone is analyzed in the context of the blood sample transportation case; then, a redesigned drone is proposed. The redesigned drone is renamed FrugalDrone to signify its main beneficent characteristic: providing inexpensive transportation of blood samples. FrugalDrone's design addresses other relevant human values including health, safety, accountability, and environmental impacts. This work is aimed at the drone design community and interdisciplinary researchers. It contributes by evolving the VSD methodology via an ethical framework and applies it to the emerging domain of drones in public healthcare.**

Keywords—value-sensitive design (VSD); cargo drone design; ethical framework; values hierarchy; Danish public healthcare

I. INTRODUCTION

A. Background

Commercially-operated healthcare cargo drones are already being used in several locations around the world, including in Rwanda by Zipline and in Switzerland by Matternet. In the public health domain, drones could provide more efficient healthcare as financial concerns dominate the discussion. The current approach in Denmark, the context of this case study, is "centralization and specialization" - some smaller hospitals will be closed while new "superhospitals" are being built. The 10-year project is expected to cost 5.5 billion euros [1].

The case examined here, referred to as HealthDrone, entails the transportation of blood samples from Svendborg to Odense, Denmark. The project aims at improving public healthcare outcomes, reducing costs, and improving environmental sustainability. It has a total budget of 4 million euros and claims that "the use of health drones is expected to save the Danish hospital sector 27 million euros per year" [2].

B. Value-Sensitive Design and a Values Hierarchy

Value-sensitive design (VSD) is a pro-active design methodology which attempts to support human values via product design. VSD shows the connection between abstract philosophical values, social impacts, and tangible product features, and how design supports or diminishes certain values. It is an interdisciplinary approach taking inputs from philosophy, social science, and engineering. It can be used retrospectively to assess existing technology, prospectively to develop new technology, and iteratively to refine a product. Recently, VSD has been applied to drones [3] [4].

Van de Poel [5] introduced the idea of a values hierarchy to facilitate the translation of (abstract) values into design requirements (tangible product features) in VSD. In this work, the hierarchy contains four layers: ethical principles, human values, social norms, and design requirements.

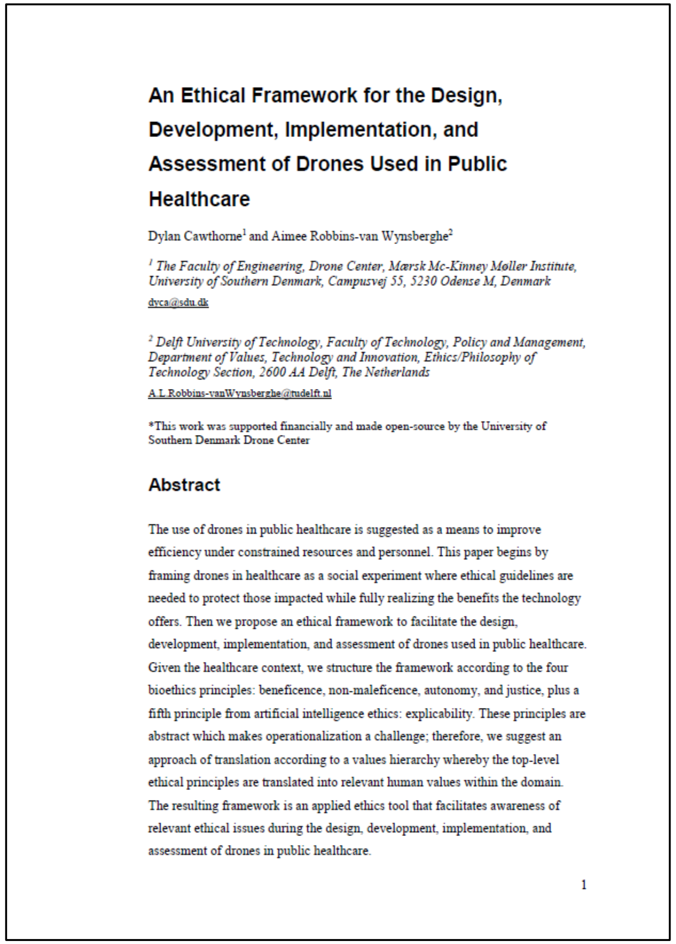
II. ETHICAL FRAMEWORK

Recently, ethical frameworks intended to lead to the development of technologies for the "good of society" have been proposed within biotechnology [6] and artificial intelligence [7]. These ethical principals have been used to develop and evaluate emerging technologies by framing the activity as a socio-technical experiment conducted in the public space [8]. Here, five ethical principles are applied to the HealthDrone case: beneficence, non-maleficence, human autonomy, justice, and explicability.

A. Assessment of a Commercially Available Drone

The drone must be able to travel between Svendborg and Odense hospitals (46 km), have the payload to carry at least one blood sample, and be as light-weight as possible to maximize safety and minimize legal restrictions [9]. The HealthDrone project partners have not yet identified which drone they will use, but one possibility is the Wingcopter 178 shown in Fig. 1 [10]. The drone has a 1.78 meter wingspan, weighs 9.9 kg (the heaviest weight category allowed by current Danish legislation [9]) and can fly 45 km with a 6 kg payload

Presented at the 2019 IEEE International Symposium on Technology in Society (ISTAS)



An Ethical Framework for the Design, Development, Implementation, and Assessment of Drones Used in Public Healthcare

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*This work was supported financially and made open-source by the University of Southern Denmark Drone Center

Abstract

The use of drones in public healthcare is suggested as a means to improve efficiency under constrained resources and personnel. This paper begins by framing drones in healthcare as a social experiment where ethical guidelines are needed to protect those impacted while fully realizing the benefits the technology offers. Then we propose an ethical framework to facilitate the design, development, implementation, and assessment of drones used in public healthcare. Given the healthcare context, we structure the framework according to the four bioethics principles: beneficence, non-maleficence, autonomy, and justice, plus a fifth principle from artificial intelligence ethics: explicability. These principles are abstract which makes operationalization a challenge; therefore, we suggest an approach of translation according to a values hierarchy whereby the top-level ethical principles are translated into relevant human values within the domain. The resulting framework is an applied ethics tool that facilitates awareness of relevant ethical issues during the design, development, implementation, and assessment of drones in public healthcare.

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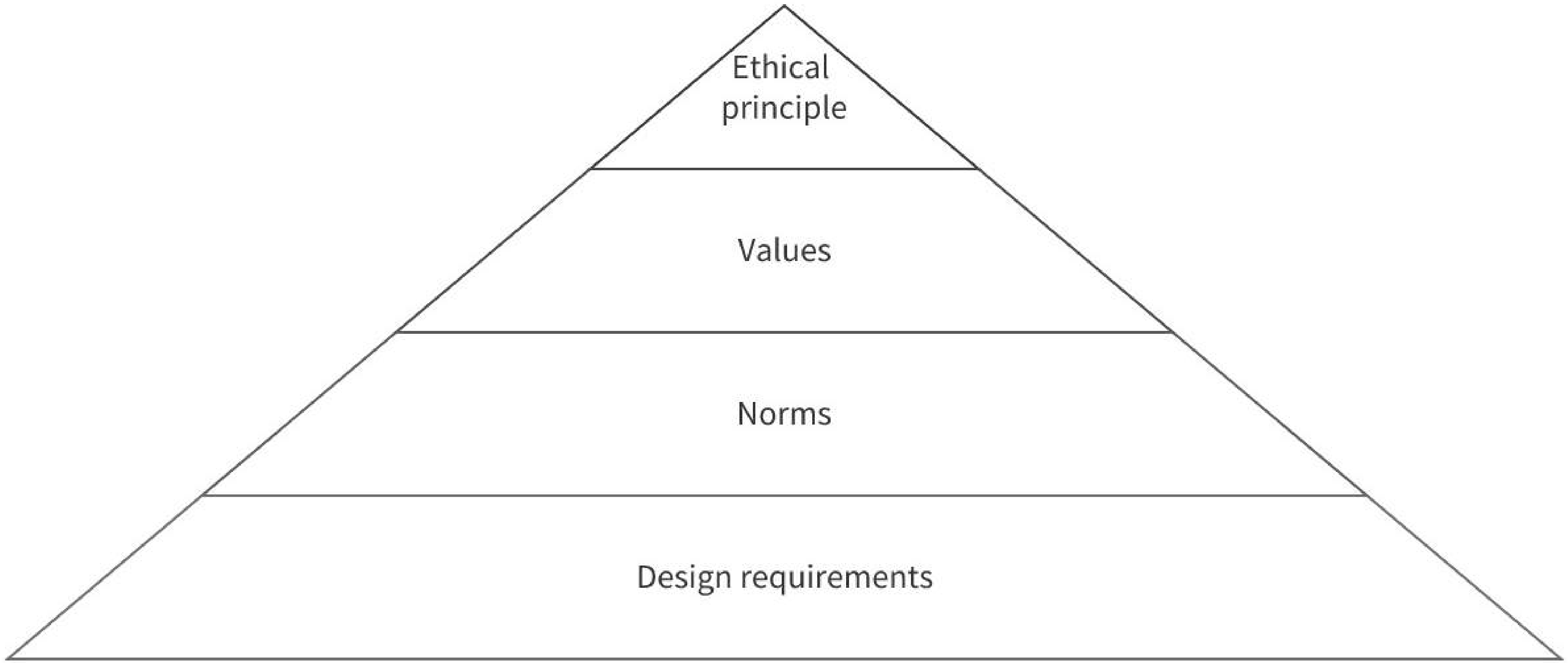
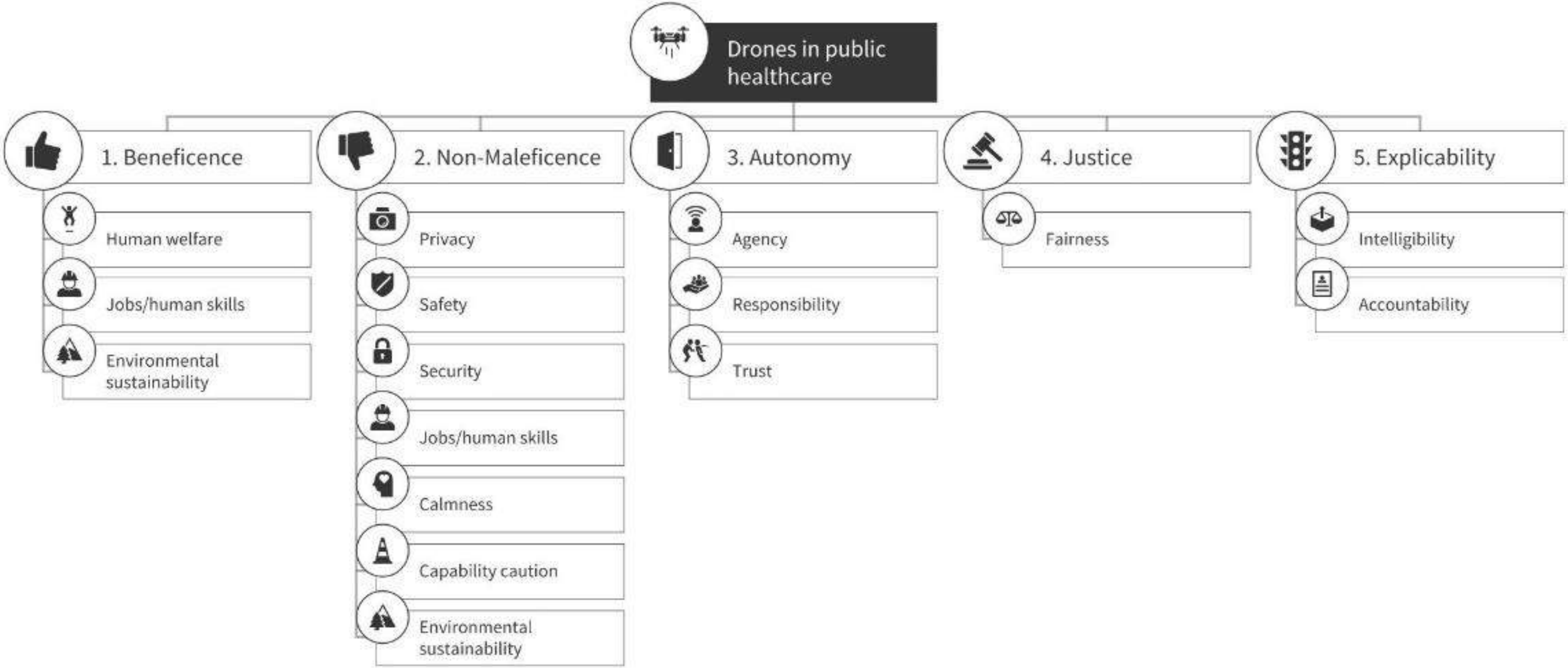
Methodology: VSD + values hierarchy



Graphic by the authors, building upon the framework in:
Translating Values into Design Requirements (Van De Poel, 2013)

Values hierarchy - drones in public health



Graphic by the authors

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Results

- **Even "good" drones come with risks**
- **Prioritization of values/design requirements matters**

Wingcopter drone
- VTOL configuration
- 9.9+ kg
- High cost
- High speed
- Potential for misuse
- Less explicable

FrugalDrone
- Fixed wing configuration
- 1.5 kg
- Low cost
- Low speed
- Reduced potential for misuse
- More explicable

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Results

- Informed consent: explicability and fairness enhancing smartphone app

Graphic by the authors

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Future Work

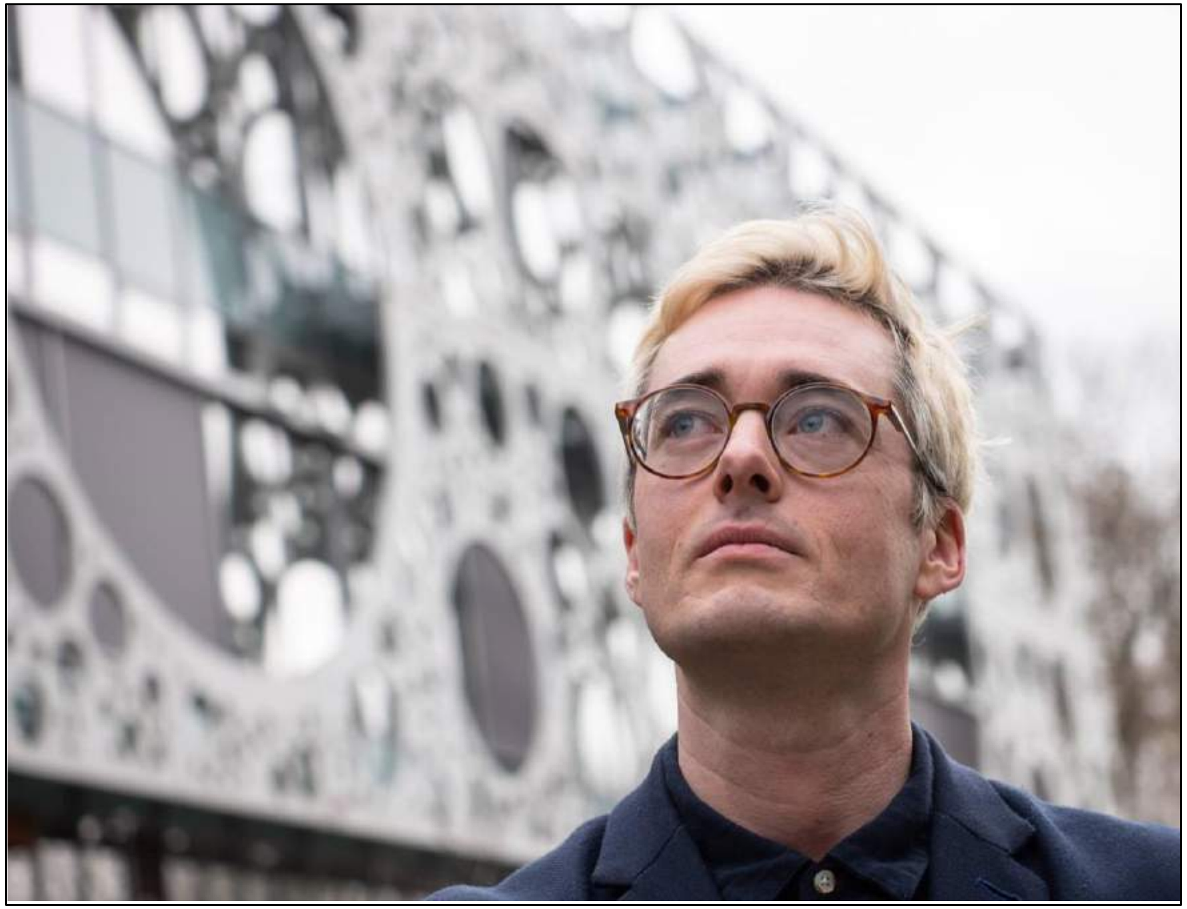
- Refinement of ethical framework
- Collection of empirical data
- Prototype FrugalDrone

Conclusion

- VSD Is a robust methodology by which ethics, human values, and social impacts can be actively incorporated into technology design

Possible next-steps

- Create research group focused on developing ethical technology using VSD methods



Thank you!

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-Dylan

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"The Ethics Drone" was inspired by the drone artwork of artist Axel Wilhite: www.axelwilhite.com

Questions?

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