ROBO-CROP: THE IMMINENCE OF AUTONOMOUS TECHNOLOGY IN AGRICULTURE

Joshua Krank†

I. INTRODUCTION

We live in a world of fast-paced innovation.[1] The last century alone has improved our lives in most, if not all conceivable areas and industries.[2] We enjoy the internet, the wonders of biotechnology, and even a developing wireless presence.[3] This innovation consists of technological advances applied to even the most basic situations, which are emerging faster than some institutions can adapt.[4]

Wonders of technological advancement are not without their consequential risks. These risks may present themselves in varying forms, even beyond the indented impact of the technology itself.[5]

† J.D., Drake University Law School, 2021; B.S., North Dakota State University, 2017; The author would like to thank his family, friends, and mentors for their continued support throughout his educational endeavors.

1. Darrell West, *Technological Progress and Potential Future Risks*, *in* THE NEXT STEP: EXPONENTIAL LIFE 193-211, 196 (B.B.V.A. ed. 2017).

2. Gregory N. Mandel, *History Lessons for a General Theory of Law and Technology*, 8 MINN. J.L. SCI. & TECH. 551, 551 (2007).

3. *Id.*

4. *See* Marina Gorbis, *Innovation Is Happening Faster Than We Can Adapt*, N.Y. TIMES (July 22, 2015, 3:31 AM), https://www.nytimes.com/roomfordebate/2015/07/22/is-silicon-valley-saving-the-world-or-just-making-money/innovation-is-happening-faster-than-we-can-adapt [https://perma.cc/P5BN-YXX4].

5. *See generally* West, *supra* note 1, at 196.

What many of these new issues have in common is the legal system will be responsible for a solution when problems arise. One major problem has been with new technologies causing difficulties in our legal field due to inadequate preparation on the part of legislators and regulatory agencies.

For example, the National Security Agency (NSA) has the responsibility of gathering signal intelligence.[6] This responsibility specifically includes "'attempt[s] to collect terrorist communications wherever they traverse global infrastructure.'"[7] If a terrorist is using a regular cellular phone that has the same encryptions as the devices used by the general population, the NSA will attempt to intercept that call, even if it means breaking the encrypted communication.[8] Inevitably, this has raised public privacy concerns that courts have to determine based on minimal policy, which frustrates regulators and causes lawmakers to retroactively respond to.[9]

We examine examples to learn lessons and reduce repeated mistakes for future policy. As Joel Brenner, former NSA general counsel, stated in facing these NSA issues:

> The technology is moving very fast . . . [l]egislation moves very slowly. Policy moves pretty slowly. The people who write policy don't always understand technology, and the people who write legislation almost never understand technology. And so in an era when the technology is moving quickly, it's really hard for the policy to keep up with it.[10]

One such form of technological advancement that is more present in public life is in the realm of autonomy.[11] New technologies in autonomy are beginning to expand to industrial areas ranging from commercial drones in aviation to self-driving cars from companies like Google, Uber, and Tesla.[12] "Over the next decade, 'self-driving' as . . . [an accessory feature], . . . will become as

6. Morning Edition, *Privacy and Security: Technology Outpacing Policymaker, Need of NSA*, NPR (Nov. 19, 2013), https://www.npr.org/sections/alltechconsidered/2013/11/19/246049281/technology-outpacing-policymakers-needs-of-nsa [http://perma.cc/TSP3-RZ8E] [hereinafter *Privacy and Security*].

7. *Id.*

8. *Id.*

9. *See generally In re* Apple, Inc., 149 F. Supp. 3d 341 (E.D.N.Y. 2016) (showing disputes regarding new technologies create conflict between individual rights and regulatory governmental authority).

10. *Privacy and Security*, *supra* note 6.

11. Daniel Araya, *The Big Challenges In Regulating Self-Driving Cars*, FORBES (Jan. 29, 2019, 9:00 AM), https://www.forbes.com/sites/danielaraya/2019/01/29/the-challenges-with-regulating-self-driving-cars/#63be0572b260 [https://perma.cc/TJA8-VZNX].

12. *Id.*

commonplace as cruise control."[13] Forecasts provided by Strategy Analytics predict that within the next thirty years the autonomous vehicle industry could be worth almost seven trillion dollars.[14] With all of these rapid technological advances, issues often present themselves in novel variations.[15] This challenges current understandings of law, even where the confines of applicable scientific knowledge are not impactful on the resolution.

Autonomous farming is one of these novel variations in respect to autonomous technology. The agricultural industry is progressing quickly in a technological context, with little attention or preparation provided by lawmakers to handle new issues.[16] To put it into perspective, Emerging Prairie, a North Dakota based company, intends to build what they call the "Grand Farm."[17] The Grand Farm will be a fully autonomous farming operation, and Emerging Prairie plans to have a functioning prototype by 2025.[18]

As a response, this Note addresses the most significant legal obstacles facing autonomous farming vehicles as they begin to enter the market and individual farms. This Note will also discuss concerns regarding the application of current law and technology to autonomous farming vehicles and note where the creation of new law is essential to successful integration. Specifically, this note will present policy considerations for prioritizing expansion of the definitions and classifications of autonomous vehicles to simplify the implementation of all subsequent regulations. These concepts will be addressed in three parts: (1) reviewing the progress of autonomous vehicle technology and analyzing a timeline for implementation and application of this technology to farm vehicles; (2) addressing the pre-existing state and federal legal definitions that may no longer apply to new autonomous farming vehicles; and (3) analyzing considerations and suggestions lawmakers should address regarding new vehicle classifications. These considerations are critical to avoid being overtaken by novel, autonomous capabilities in agriculture and the ensuing legal disputes that can arise.

13. *Id.*

14. ROGER LANCTOT, STRATEGY ANALYTICS, ACCELERATING THE FUTURE: THE ECONOMIC IMPACT OF THE EMERGING PASSENGER ECONOMY 5 (2017), https://newsroom.intel.com/newsroom/wp-content/uploads/sites/11/2017/05/passenger-economy.pdf [https://perma.cc/38RS-TTQW].

15. Araya, *supra* note 11.

16. *Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation*, NAT'L CONF. ST. LEGISLATURES (Feb. 18, 2020), https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx [https://perma.cc/6LEQ-QMH4].

17. *What is Grand Farm*?, EMERGING PRAIRIE (Aug. 24, 2020, 1:44 PM), http://www.grandfarm.com [https://perma.cc/H5YA-VW9M].

18. *Id.*

II. WHERE AUTONOMOUS VEHICLE TECHNOLOGY IS TODAY

A. Cars

Autonomous cars in existence today are essentially built using a combination of three technologies: sensors, connectivity, and software control algorithms.[19] The sensors are mainly used in the operational features, including radar blind spot indicators, lane keeping guides, and collision warning sensors.[20] Connectivity refers to the continuous internet networks, which give autonomous cars access to updated maps, traffic, and weather conditions.[21] This information tracks the car's surroundings and helps avoid hazardous conditions when mapping a route.[22] Last, software and control algorithms are used to gather data from the sensors and connectivity to then make reliable, calculated decisions in regard to steering, braking, acceleration, and direction.[23] This is the most complex part of self-driving cars as the decision-making of the algorithms must be able to flawlessly handle instantaneous, complex driving situations.[24] Two of the most talked about self-driving advancements come from Google and Tesla, which each use a different approach.[25]

For example, Google started in 2009 and continues to develop their self-driving passenger car.[26] They now have a new version of their driverless car with the claim of being 100% autonomous, which has no steering wheel, gas pedal, or brake pedal.[27] This car is named WAYMO, which stands for "a new way forward in mobility".[28] WAYMO uses Light Detection and Ranging (LIDAR)—a

19. David Silver, *How Self-Driving Cars Work*, UDACITY (Dec. 14, 2017), https://medium.com/udacity/how-self-driving-cars-work-f77c49dca47e [https://perma.cc/74KZ-HACH].

20. *Id.*

21. *Id.*

22. Nancy Gupton, *The Science of Self-Driving Cars*, FRANKLIN INST. (Aug. 1, 2016), https://www.fi.edu/science-of-selfdriving-cars/ [https://perma.cc/9SGF-JTQP].

23. *Id.*

24. *Id.*

25. *Id.*

26. Bernard Marr, *Key Milestones of Waymo - Google's Self-Driving Cars*, FORBES (Sept. 21, 2018, 1:14 AM), https://www.forbes.com/sites/bernardmarr/2018/09/21/key-milestones-of-waymo-googles-self-driving-cars/" \l "38f357fe5369/ [https://perma.cc/PX47-DQD2].

27. Liz Gannes, *Google's New Self-Driving Car Ditches the Steering Wheel*, VOX (May 27, 2014, 7:59 PM), https://www.vox.com/2014/5/27/11627262/googles-new-self-driving-car-ditches-the-steering-wheel/ [https://perma.cc/9TTP-YPF2].

28. *FAQ*, WAYMO (Sept. 6, 2020, 12:48 PM), https://waymo.com/faq/ [https://perma.cc/UD4D-S2E4].

technology similar to radar, but LIDAR uses the reflection of light waves instead of radio waves as the basis for the sensor information.[29]

Tesla is also deeply invested in developing autonomous technologies and takes a different approach than Google. Although not completely capable of full autonomy as of yet, Tesla CEO Elon Musk has stated "[a]ll cars being produced all have the hardware necessary — computer and otherwise — for full self-driving, . . . [a]ll you need to do is improve the software."[30] Tesla's current software system is called Autopilot, which uses high-tech camera sensors as a car's detection system.[31] Musk describes the cameras as the car's "eyes" and every Tesla on the market is currently equipped with it.[32]

B. Drones

The word drone is a general term and is commonly used to describe unmanned aerial vehicles (UAVs).[33] As of 2020, The United States Department of Defense has transitioned to using the term "unmanned aircraft" (UA) and defines a UA as "[a]n aircraft that does not carry a human operator and is capable of flight with or without human remote control."[34] The technological accessories included in an UA depend on the intended purpose of the device. Currently, marketed civilian drones incorporate more basic technology and are often only controlled remotely over short distances from the ground.[35] The conventional use of unlicensed spectrum technologies connect these types of drones to their respective

29. Gupton, *supra* note 22.

30. Kirsten Korosec, *Tesla's full self-driving computer is now in all new cars and a next-gen chip is already 'halfway done'*, TECHCRUNCH (Apr. 22, 2019, 3:00 PM), https://techcrunch.com/2019/04/22/teslas-computer-is-now-in-all-new-cars-and-a-next-gen-chip-is-already-halfway-done/ [https://perma.cc/EJ38-RBR4].

31. Gupton, *supra* note 22.

32. *Id.*

33. Elizabeth Howell, *What is a Drone?*, SPACE.COM (Oct. 3, 2018), https://www.space.com/29544-what-is-a-drone.html [https://perma.cc/VDQ2-C43X].

34. U.S. DEP'T OF DEF., DOD DICTIONARY OF MILITARY AND ASSOCIATED TERMS: UNMANNED AIRCRAFT 226 (June 2020), https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf [https://perma.cc/ES64-XY9M].

35. Fintan Corrigan, *How Do Drones Work And What Is Drone Technology*, DRONEZON (June 7, 2020), https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or-how-does-drone-technology-work/ [https://perma.cc/C3TE-SER3]; Jack Brown, *Toy Drones Overview: The Most Suitable Products for Children and Beginners*, MYDRONELAB (Oct. 7, 2020, 3:17 PM), https:www.mydronelab.com/best-pick/toy-drones.html [https://perma.cc/4F6H-JAB6].

remotes wirelessly.[36] While this is sufficient for basic drone operations, these drones lack the power and technology to support beyond visual line of sight (BVLOS) operations.[37] Some more sophisticated communication technologies are included in advanced drones to maintain constant contact with the controller.[38] For example, drones may use satellite receivers as part of their navigation and control systems when communicating over long distances.[39]

Drone software works like a central processing unit (CPU).[40] It manages hardware, tracks telemetry, and analyzes the data received from the drone's GPS, infrared and LIDAR cameras, vision sensors, and any other added options to stabilize functionality and relay information back to the controller.[41] As drones begin to operate with greater levels of autonomy, this software must also be able to implement instantaneous and complex decision processing.[42]

The capabilities of drone autonomy continue to progress even further. The most advanced military drones function with software and communication technology that enable them to perform pre-programmed missions on their own, with only human controlled initiation and, if needed, termination.[43] Some of these UAs are programmed with non-reactive failsafe features as well.[44] For example, circumstances may arise that cause a loss of communication with the drone. The program allows the drone to fly autonomously in preset circles or return to base until the link can be reconnected.[45]

36. Phil Marshall, *Deciphering hype from reality for autonomous drones*, TECHTARGET (Apr. 6, 2017), https://internetofthingsagenda.techtarget.com/blog/IoT-Agenda/Deciphering-hype-from-reality-for-autonomous-drones [https://perma.cc/ET9B-GAME].

37. *Id.*

38. *See* Alberto Cuadra & Craig Whitlock, *How drones are controlled*, WASH. POST (June 20, 2014), https://www.washingtonpost.com/wp-srv/special/national/drone-crashes/how-drones-work/ [https://perma.cc/P4CE-JVBV].

39. *See id.*

40. Boris Shiklo, *Tips and Predictions for Drone Software Development*, SCIENCESOFT (Sept. 26, 2019), https://www.scnsoft.com/blog/drone-software-development#Architecture [https://perma.cc/BEN7-VF2H].

41. *Id.*

42. *See* WILLIAM C. MARRA & SONIA K. MCNEIL, UNDERSTANDING "THE LOOP": HUMANS AND THE NEXT DRONE GENERATIONS, ISSUES IN GOVERNANCE STUDIES 4, 5 (Aug. 2012).

43. *See* RUI ZHANG, NAT'L UNIV. OF SING., WIRELESS COMMUNICATIONS WITH UNMANNED AERIAL VEHICLES: OPPORTUNITIES AND CHALLENGES 7 (2016).

44. *See* Corrigan, *supra* note 35.

45. Cuadra & Whitlock, *supra* note 38.

C. Farm Vehicles

The development of autonomous farming vehicles has finally started to take shape by applying technology from today's autonomous cars and drones to improve and take agriculture into the future. Two major companies, John Deere Corporation and Case IH Corporation, are already involved in autonomous farm vehicle development.[46]

John Deere has already produced two autonomous concept tractors over the course of a few years. The first was developed as a powerful, autonomous, and fully electric tractor.[47] Featuring no cab and no batteries, this concept is based on a John Deere 6210R tractor.[48] The tractor is powered using a long, electric cable with the potential of providing up to 400 horsepower.[49]

This concept prefers a cable over batteries because it lowers operating costs by almost 50%.[50] A large drum fixed to the tractor feeds 1,000 meters of the cable, which has the option to be extended if needed.[51] In the field, the cable is fed and reeled in while guided by a robot arm in order to keep the operation at low friction and load.[52] An advanced guidance software system is used to prevent the tractor from running over or destroying the cable.[53] Capable of an autonomous operating speed of twelve miles per hour, the vehicle can also be guided manually using a remote control.[54] The total weight of the working prototype is eight and one-half metric tons, similar to the weight of the original tractor.[55] John Deere's second concept tractor lacks the cables and has a rated battery power output of almost 680

46. Adam Belz, *A breakthrough to bring driverless tractors into the mainstream?*, STARTRIBUNE (Oct. 28, 2018, 9:00 PM), https://www.startribune.com/driverless-tractors-long-on-the-cusp-still-not-widely-used/498707561/ [https://perma.cc/RQ23-9WRB].

47. Nora Manthey, *John Deere premiers electric tractor in action: The first time the all-electric autonomous machine quite literally roams the land*, ELECTRIVE.COM (Dec. 12, 2018, 1:16 PM), https://www.electrive.com/2018/12/12/video-john-deere-premiers-electric-tractor-in-action/ [https://perma.cc/8KM9-ZEJE].

48. James Allen, *John Deere Develops Fully Electric, Autonomous Tractor*, INT'L INDUS. VEHICLE TECH. (Feb. 7, 2019), https://www.ivtinternational.com/news/agriculture/john-deere-develops-fully-electric-autonomous-tractor.html#prettyPhoto [https://perma.cc/8GGX-FHJ4].

49. *Id.*

50. *Id.*

51. Chris Mccullough, *Deere's new electric tractor tosses the battery*, W. PRODUCER (Feb. 14, 2019), https://www.producer.com/2019/02/deeres-new-electric-tractor-tosses-the-battery/ [https://perma.cc/C2LS-TDQH].

52. *Id.*

53. Allen, *supra* note 48.

54. Mccullough, *supra* note 51.

55. Allen, *supra* note 48.

horsepower.[56] The tractor has "zero emissions" and has a no human operated steering mechanism. However, no other specifics have been produced on the concept's power train.[57]

Case IH has also developed a concept for their own version of an autonomous tractor.[58] This tractor was built to allow for minimal remote monitoring of preprogrammed operations.[59] An onboard software system automatically calculates the most efficient paths, taking into account terrain, obstructions, and other machines at work in the same field.[60] A remote operator adjusts and controls the tractor via a desktop computer or portable tablet interface.[61] The tractor applies radar, laser, and onboard video cameras, which allow the software to sense stationary or moving obstacles in its path.[62] If a detection is made, the tractor will stop on its own until the operator, who is notified by audio or visual alerts, remotely assigns a new path.[63] The radar is capable of detecting metal, water, or even animals.[64] When it comes to remote operation, a person can control the activities of multiple machines from a single device.[65] Multiple tractors have the potential to work as one fleet or individual sub-fleets assigned to separate fields.[66] Each can be assigned with pre-programmed maps and instructions.[67] As an example, "[y]ou could have one tractor pulling a chisel plow followed closely by another operating a planter."[68]

56. *John Deere Reveals New 'Driverless' Tractor Concept*, FARM EQUIP. (Oct. 1, 2019), https://www.farm-equipment.com/articles/17489-john-deere-reveals-new-driverless-tractor-concept [https://perma.cc/7QM9-PXZ7].

57. *Id.*

58. *Autonomous Concept Vehicle*, CASE IH AGRIC. (Aug. 24, 2020, 2:17 PM), https://www.caseih.com/northamerica/en-us/Pages/campaigns/autonomous-concept-vehicle.aspx [https://perma.cc/2TNJ-HFJE].

59. Michael Burke, *Case IH debuts driverless tractor to rave reviews*, J. TIMES (Sept. 10, 2016), https://journaltimes.com/business/local/case-ih-debuts-driverless-tractor-to-rave-reviews/article_4640c3e3-504c-555c-b91e-069a99e3aeda.html [http://perma.cc/5942-7KTJ].

60. *Id.*

61. *Id.*

62. *Id.*

63. *Id.*

64. *Id.*

65. *Id.*

66. *Id.*

67. *Id.*

68. *Id.*

III. LEGALLY DEFINING AUTONOMOUS FARMING VEHICLES

Novel legal issues created by technology often raise the following questions: (1) is the new technological concept similar enough to a predecessor to be governed by similar, existing rules; and (2) is this new technological advancement distinctive enough to warrant governance by new and/or different rules?[69] These questions "cannot be resolved simply by comparing the function of the new technology to the function of the prior technology."[70] Gregory Mandel, Dean and Professor of Temple Law School, explains, "[r]ather, a decision-maker must consider the rationale for the existing legal categories in the first instance, and then determine whether that rationale applies to the new technology."[71] It is only after an application of such legal categorizations that policy makers can begin to understand the concepts and create effective, unambiguous laws. In the face of technological change, new constructs need to be anticipated to support the fast-paced reality of such advancements.

Farming equipment is highly anticipated because the machinery is unlike any other car or truck, on or off the road. This equipment is usually wider, slower, and often more powerful and dangerous. If you were to ask an individual to distinguish between a combine, drone, and car, there would likely be minimal confusion. However, what these devices have in common is each could be identified as an autonomous vehicle.[72] With the different shapes, sizes, and functions of these machines, how will the law accommodate these individually unique autonomous vehicles?

Autonomy, as defined in Black's Law Dictionary, can have one of three meanings.[73] It can mean: (1) "[t]he right of self-government;" (2) "[a] self-governing country;" or (3) "[a]n individual's capacity for self-determination."[74] When analyzing each definition, "rights," "countries" (in the context of nations), and "individuals" are concepts that have always been applied to human beings in

69. Mandel, *supra* note 2, at 556.

70. *Id.*

71. *Id.*

72. *See* U.S. DEP'T. OF TRANSP., PREPARING FOR THE FUTURE OF TRANSPORTATION: AUTOMATED VEHICLES 3.0, at 4 (2018), https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf [https://perma.cc/7MJ2-E3QY].

73. *See Autonomy*, BLACK'S LAW DICTIONARY (11th ed. 2019).

74. *Id.*

self-recognition and collaboration.[75] These basic legal dictionary definitions are not broad enough to encompass the numerous modern uses of the word autonomous. The federal government and some state governments have begun their own attempts to define different autonomous vehicles and their evolution with new technologies. However, current laws are ambiguous and insufficient, lacking important considerations for the coming future.

A. Current Federal Government Laws

As of December 2018, the United States Department of Transportation (DOT) released a publication that included its new definitive terms and other concepts regarding autonomous vehicles.[76] "Automation," as defined by the DOT, involves the "[u]se of electronic or mechanical devices to operate one or more functions of a vehicle without direct human input . . . [and this definition] [g]enerally applies to all modes."[77]

The DOT further defines an "automated vehicle" as "[a]ny vehicle equipped with driving automation technologies."[78] SAE International has provided a breakdown of six levels of an automated vehicle.[79] The DOT has stated its own definition can refer to a vehicle fitted within one of the SAE levels, starting from a level one and going up to a level five.[80]

At level zero there is no automation in the vehicle whatsoever.[81] A level one device will provide limited driver assistance, up to acceleration and deceleration, with the expectation that the driver will perform all remaining tasks of dynamic driving outside of this operational design domain (ODD).[82] An ODD is essentially a description of the environment the device is supposed to function in.[83] Level two provides partial automation, meaning it is capable of both steering and acceleration/deceleration in its ODD with the expectation that the human driver

75. *See Rights*, STANFORD ENCYCLOPEDIA PHIL. (Spring ed. 2020), https://plato.stanford.edu/entries/rights/ [https://perma.cc/F6ZA-TJ3B]; *Nation*, BLACK'S LAW DICTIONARY (11th ed. 2019); *see also Individual*, VOCABULARY.COM DICTIONARY (Aug. 24, 2020, 1:31 PM), https://www.vocabulary.com/dictionary/individual [https://perma.cc/AR7J-4S4R].

76. *See generally* U.S. DEP'T. OF TRANSP., *supra* note 72.

77. *Id.* at 45.

78. *Id.*

79. *Id.* at vi.

80. *Id.*

81. SAE INT'L, SURFACE VEHICLE RECOMMENDED PRACTICE 19 (June 2018).

82. *Id.*

83. *See id.* at 4.

performs all remaining dynamic driving tasks.[84] To reach level three, the vehicle can provide conditional automation under its ODD, meaning the driving program is capable of performing all dynamic driving tasks with the expectation that the human driver will respond appropriately to a request to take control.[85] A level four vehicle will perform all dynamic driving tasks even if the human driver does not respond appropriately to a request to intervene.[86] Last, a level five describes when a vehicle is capable of responding to all environmental roadway conditions that can be managed by a human driver.[87] Essentially, a level 5 encompasses complete and total automation.[88]

Additionally, the DOT has created a separate sub-definition regarding automation and commercial vehicles. A commercial autonomous motor vehicle includes:

Any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle:

> (1) Has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 4,536 kg (10,001 pounds) or more, whichever is greater; or
>
> (2) Is designed or used to transport more than 8 passengers (including the driver) for compensation; or
>
> (3) Is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation; or
>
> (4) Is used in transporting material found by the Secretary of Transportation to be hazardous under 49 U.S.C. 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C. (FMCSA, defined in 49 CFR 390.5).[89]

84. *Id.* at 19.
85. *Id.*
86. *Id.*
87. *Id.*
88. *See id.*
89. U.S. DEPT. TRANSP., *supra* note 72, at 45.

The Office of Energy Efficiency and Renewable Energy reports the average weight of a tractor trailer combination is between 20,000 and 26,000 pounds.[90] This means, under most circumstances, a majority of farm equipment would or was intended to fall under the federal categorization of a commercial vehicle.[91] However, problems arise with the federal definition, which limits commercial vehicles to those used on highways and roads.[92] Many farm vehicles operate in off-road conditions, especially in fields while performing farming tasks.[93] This example demonstrates insufficiencies in the development of the federal approach that not only fails to expressly include autonomous farm vehicles, but also implicitly excludes them through the narrow categorizations that do exist.

B. Current State Government Laws

Several state legislatures have also taken steps to set up or begin setting their own autonomous vehicle laws unique to their states.[94] Since 2012, at least forty-one states and Washington D.C. have either considered or passed laws pertaining to autonomous vehicles.[95]

> Twenty-nine states [including] Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Michigan, Mississippi, Nebraska, New York, Nevada, North Carolina, North Dakota, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington[,] Wisconsin[,] and Washington D.C. [are among the earlier states to] have enacted legislation related to autonomous vehicles.[96]

In addition, several state governors, including those from "Arizona, Delaware, Hawaii, Idaho, Illinois, Maine, Massachusetts, Minnesota, Ohio, Washington and Wisconsin have issued executive orders related to autonomous vehicles."[97] Each of these states use their own language and style in

90. OFF. ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEP'T ENERGY, *Fact #621: May 3, 2010 Gross Vehicle Weight vs. Empty Vehicle Weight* (May 3, 2010), https://www.energy.gov/eere/vehicles/fact-621-may-3-2010-gross-vehicle-weight-vs-empty-vehicle-weight [https://perma.cc/AP37-V5NS].

91. *See id.*; U.S. DEP'T. TRANSP., *supra* note 72, at 8.

92. U.S. DEP'T TRANSP., *supra* note 72, at 8.

93. *See* Peter Liebhold, *These tractors show 150 years of farming history*, NAT'L MUSEUM AM. HIST. (Mar. 1, 2018), https://americanhistory.si.edu/tractor [https://perma.cc/MH5T-V9YM].

94. *Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation*, *supra* note 16.

95. *Id.*

96. *Id.*

97. *Id.*

generating definitions of autonomous vehicles. North Dakota and Iowa are among two states that have implemented some autonomous vehicle laws, and both states maintain large agricultural economies.[98] In relation to agriculture and autonomous vehicles, these states will likely be among the first to witness the integration of autonomous farm vehicles, and thus their current regulations will be analyzed here.

"Autonomous vehicle" is defined in North Dakota as "a vehicle equipped with an automated driving system."[99] Further analysis shows North Dakota has defined "automated driving system" as "hardware and software collectively capable of performing the entire dynamic driving task for the vehicle on a sustained basis when installed on a motor vehicle and engaged regardless of whether it is limited to a specific operational design domain."[100] In addition, North Dakota, like the federal DOT and other states, defines ODD.[101] The state of North Dakota describes ODD as "[how the] driving system is designed to properly operate, including roadway types, speed range, environmental conditions, and other domain constraints."[102] There exists no further classification or breakdown of autonomous vehicles by North Dakota legislature or agencies, nor any insight into specifics of potential ODDs beyond public highways.

Iowa also recently passed new legislation pertaining to the application of automated vehicles operating within the state.[103] This recent legislation passed in May 2019.[104] These new laws both define and apply certain operational limits on automated vehicles.[105] Currently, Iowa does not use the term "autonomous vehicle" and instead defines a "driverless-capable vehicle" as "capable of performing the entire dynamic driving task within the automated driving system's operational design domain, if any, including but not limited to achievement of a minimal risk condition without intervention or supervision by a conventional human driver."[106] In addition, the Iowa legislature defines what an "automated driving system" means within the confines of driverless capable vehicles.[107] An automated driving system applies to "the hardware and software collectively

98. *See generally* N.D. CENT. CODE § 39-01-01.2 (2019); *see also* IOWA CODE § 321.514 (2019); USDA, 2017 CENSUS OF AGRICULTURE: NORTH DAKOTA STATE AND COUNTY DATA, 1 GEO. AREA SERIES 34 (Apr. 2019).

99. N.D. CENT. CODE § 39-01-01.2(1)(b).

100. N.D. CENT. CODE § 39-01-01.2(1)(a).

101. N.D. CENT. CODE § 39-01-01.2(1)(f).

102. *Id.*

103. *See generally* Iowa Code §§ 321.514-19 (2019).

104. *See id.*

105. *See generally id.*

106. IOWA CODE § 321.514(3).

107. *Id.* at (1).

capable of performing the entire dynamic driving task on a sustained basis, regardless of whether the system is limited to a specific operational design domain, if any."[108] Last, the ODD of the automated driving systems of driverless capable vehicles in Iowa "means a set of constraints used to define the domain under which an automated driving system is designed to properly operate, including but not limited to types of highways, speed ranges, environmental conditions such as weather or time of day, and other constraints."[109]

Iowa has gone one step further in adding operational limitations to the use of driverless vehicles.[110] Several conditions are placed on the vehicles, which include being specifically limited to public highways if no human operator is present in the vehicle.[111]

Iowa and North Dakota maintain these relatively new automated vehicle laws. These states continue to be large agricultural economies with large quantities of farms and farm equipment.[112] Yet, even with being agriculturally focused, these states fail to consider the ramifications in the applicability of automation to farm equipment and their varying sizes, functions, and potential operations both on and off the road.

C. Propositions for Classifying Autonomous Farm Vehicles

The federal and state legislatures need to adapt and broaden their descriptions to separately and expressly cover various farm vehicles in an autonomous context that are soon to be available for operation in the United States.[113] The issues do not seem to arise in a simple definition of "autonomous vehicle" alone. They arise in the overreach in these ambiguous definitions combined with the narrow restrictions placed upon them. Lawmakers need to be aware that autonomous farming technology is coming, and the current/short-term future models will create legal problems if not restructured prior to the availability of the technology.[114]

This Note will not lay any specific framework for a solution. However, it will offer suggestions regarding general concepts of where, what, when, and how lawmakers should weigh in to build a framework unique to their respective needs.

108. *Id.*
109. *Id.* at (7).
110. IOWA CODE § 321.515(1) (2019).
111. *Id.*
112. *See* USDA, *supra* note 98, at 34.
113. *See* Belz, *supra* note 46.
114. *See Privacy and Security*, *supra* note 6.

First, lawmakers should consider "where" the farming vehicle will be operating. Specifically, they must contemplate if the vehicle will perform its primary function either on the road, off the road, or both. A majority of typical farm vehicles perform most of their tasks off-road, usually in a field. Considering the distinctions between on- and off-road vehicles is essential given current federal and state laws already detailing autonomous vehicle permissions only for public roads and highways.[115] Thus, inferences and arguments may exclude off-road farming vehicles from coverage under current laws. At a minimum, amendments to include off-road autonomous farm vehicles under existing laws is necessary. If that does not happen, establishing clarification regarding these otherwise excluded classifications of autonomous vehicles will be necessary.

Second, lawmakers need to consider what functions the autonomous farm vehicle has and what tasks it will be performing. Historically, farming vehicles have been used for numerous functions, including but not limited to cultivation, transportation, irrigation, sorting, harvesting, haymaking, and loading crops.[116] With a wide variety of purposes, legislators need to consider what the machine is actually doing autonomously. The complexity of the tasks performed is a critical consideration in defining and, thus, regulating autonomous farming vehicles. A tractor, for example, performs the single task of maneuvering while towing.[117] Compare this to a heavyweight combine capable of harvesting, reaping, threshing, winnowing, and maneuvering with several dangerous moving parts.[118] In addition, size, dimension, weight, and speed capabilities are subcategories essential to lawmakers' considerations in defining vehicles.[119] A mobile cable tow irrigation device can have dimensions as narrow as six feet wide, while only being a few feet tall and operating on 1,000 feet of hose.[120] The speed of such a device could be as

115. *See* U.S. DEP'T. OF TRANSP., *supra* note 72, at vi; *see also Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation*, *supra* note 16.

116. *Farm Machinery*, ENCYCLOPEDIA BRITANNICA (Jan. 14, 2020), https://www.britannica.com/technology/farm-machinery [https://perma.cc/8886-BTLE].

117. FRED WHITFORD ET. AL., PURDUE EXTENSION, TRANSPORTING FARM EQUIPMENT: WHAT GROWERS NEED TO KNOW 11 (2009), https://ppp.purdue.edu/wp-content/uploads/2016/08/PPP-83-reduced.pdf [https://perma.cc/L497-M3UB].

118. *See* Terri Queck-Matzie, *The Combine: King of the Harvest*, SUCCESSFUL FARMING (Feb. 7, 2019), https://www.agriculture.com/machinery/harvesting/the-combine-king-of-the-harvest [https://perma.cc/NG9L-KYG5].

119. *See* KERRY HARRISON, FACTORS TO CONSIDER IN SELECTING A FARM IRRIGATION SYSTEM 1 (Wesley M. Porter & Calvin Perry eds., 2015), https://secure.caes.uga.edu/extension/publications/files/pdf/B%20882_4.PDF [https://perma.cc/5SAR-HT9W].

120. *See id.* at 5-6.

little as thirty feet per hour.[121] A New Holland CR9090 combine harvester, for example, is a massive machine with a weight of thirty tons.[122] In addition, this combine is exceptionally wide with some attachments reaching thirty feet in width.[123] Regardless of its size, this combine is capable of speeds up to twenty miles per hour.[124] A vehicle as large and powerful as a combine exponentially increases the risk of becoming a destructive tool in the event of a malfunction or loss of control. A six-foot-wide rogue sprinkler vehicle, in comparison, would pose significantly less danger to its surrounding environment. Even these simple comparisons of size and purpose demonstrate the importance of establishing different categories of autonomous farm vehicles so appropriate regulations can be created without overregulating one vehicle and underregulating another.

Operator/owner licensing requirements are additional considerations that often revolve around the complexity of a particular vehicle. Under federal law, the operation of a commercial motor vehicle requires an operator to obtain a commercial drivers' license (CDL).[125] The term "commercial motor vehicles" normally covers farm vehicles of greater than 10,001 pounds.[126] However, the Federal Motor Vehicle Safety Administration (FMVSA) created a federal exemption to the CDL requirement for an individual operating a "covered farm vehicle" if they meet specific requirements.[127] A covered farm vehicle means

> (1) A straight truck or articulated vehicle—
>
> (i) Registered in a State with a license plate or other designation issued by the State of registration that allows law enforcement officials to identify it as a farm vehicle;
>
> (ii) Operated by the owner or operator of a farm or ranch, or an employee or family member of an owner or operator of a farm or ranch;
>
> (iii) Used to transport agricultural commodities, livestock, machinery or supplies to or from a farm or ranch; and

121. *Id.* at 7.

122. Stuart Birch, *Combine Harvester review*, TELEGRAPH (Aug. 31, 2010, 10:38 AM), https://www.telegraph.co.uk/motoring/first-drives/7968276/Combine-Harvester-review.html [https://perma.cc/WT75-9A88].

123. *Id.*

124. *Id.*

125. 49 C.F.R § 383.23(a)(1) (2020).

126. 49 C.F.R § 390.5 (2020).

127. 49 C.F.R. § 390.39(a) (2020).

> (iv) Not used in for-hire motor carrier operations; however, for-hire motor carrier operations do not include the operation of a vehicle meeting the requirements of paragraphs (1)(i) through (iii) of this definition by a tenant pursuant to a crop share farm lease agreement to transport the landlord's portion of the crops under that agreement.
>
> (2) Meeting the requirements of paragraphs (1)(i) through (iv) of this definition:
>
> (i) With a gross vehicle weight or gross vehicle weight rating, whichever is greater, of 26,001 pounds or less may utilize the exemptions in §390.39 anywhere in the United States; or
>
> (ii) With a gross vehicle weight or gross vehicle weight rating, whichever is greater, of more than 26,001 pounds may utilize the exemptions in §390.39 anywhere in the State of registration or across State lines within 150 air miles of the farm or ranch with respect to which the vehicle is being operated.[128]

Within the restraints of this definition, the exemptions regarding covered farm vehicles will only apply to the owner of the farm and vehicle, not to any hired operators.[129] States also have their own considerations to take into account as the federal regulations are "not intended to preclude States or subdivisions thereof from establishing or enforcing State or local laws relating to safety, the compliance with which would not prevent full compliance with these regulations by the person subject thereto."[130] Every state has individual licensing laws, but a few states have begun to consider new licensing for the use or ownership of autonomous farming vehicles, while other states have yet to address or consider the issue.[131]

In addition to licensing, categorical consideration should be made for whether a human operator should be required to be in the vehicle or within a certain radius during operation.[132] For autonomous farming vehicles, these considerations should also pertain to task performance and dimensional characteristics of the vehicles.[133] Several states have already begun addressing operator accessibility requirements for public road vehicles, with outcomes varying from state to state.[134]

128. 49 C.F.R. § 390.5 (2020).

129. *Id.*

130. 49 C.F.R. § 390.9 (2020).

131. *Autonomous vehicle laws*, INS. INST. FOR HIGHWAY SAFETY (Sept. 2020), https://www.iihs.org/topics/advanced-driver-assistance/autonomous-vehicle-laws [https://perma.cc/3QEL-V8X5].

132. *See id.*

133. *Id.*

134. *Id.*

Alabama, for example, does not require an operator to be in the vehicle during operation.[135] Illinois does require an operator to be in the vehicle, and many states, including Iowa and North Dakota, consider the vehicles level of autonomous performance capability when deciding.[136] Similar considerations should be applied to autonomous farm vehicles, including the complexities of the autonomous tasks to be performed and the physical characteristics of the vehicles themselves because farm vehicles have the potential to vary on a much larger scale than road vehicles.

Another categorical consideration pertains to "when" the autonomous vehicles will perform their operations. Seasonal considerations strongly influence agricultural operations in general and, thus, should be a categorical option for describing new autonomous farming technology. Corn in Iowa is planted from April through early June and harvested between October and November.[137] Carrots, on the other hand, are capable of year-round growth. Vehicles that only participate in seasonal operations may be categorized according to their active seasons. Lawmakers may find such categorizations helpful in implementing later liability insurance requirements or similar legislation.[138]

Last, a critical categorical consideration lawmakers should apply to future autonomous farming vehicles pertains to the "how," in reference to both power and methods of operation. Now, and even more so in the future, the selection of power options continues to increase.[139] Today, even vehicle power sources include gasoline, diesel, electric, hydrogen, solar, etc.[140] Each fuel can have different impacts on the economy and environment from creation to emissions. Crude oil prices are always shifting subject to supply, demand, and other political influences directly affecting petroleum products including cars, planes, and other machinery.[141] Tesla has recently established its economic influence, becoming the

135. *Id.*

136. *Id.*

137. *See* Chuck Kowalski, *Corn Crop Planting and Harvest Seasons*, TREEHUGGER (May 12, 2020), https://www.thebalance.com/corn-planting-and-harvest-seasons-809309 [https://perma.cc/ER5Z-963Q].

138. *See Autonomous vehicle laws*, *supra* note 131.

139. *See* STEPHANIE PAIN, OUTLOOK, ENERGY TRANSITIONS: POWER THROUGH THE AGES, ENERGY TRANSITIONS 4 (Nov. 30, 2017), https://media.nature.com/original/magazine-assets/d41586-017-07506-z/d41586-017-07506-z.pdf [https://perma.cc/4PRM-GZTT].

140. *Alternative Fuels and Advanced Vehicles*, U.S. DEP'T ENERGY (Aug. 24, 2020, 1:18 PM), https://afdc.energy.gov/fuels/ [https://perma.cc/R9AW-5AWM].

141. *What are the possible causes and consequences of higher oil prices on the overall economy*?, FED. RES. BANK S.F. (Nov. 2007), https://www.frbsf.org/education/publications/doctor-econ/2007/november/oil-prices-impact-economy/ [https://perma.cc/979P-QFP9].

most valuable car company in the United States with a market value of over $81 billion.[142] When looking at emissions, burning one gallon of traditional gasoline will produce 8,887 grams of carbon dioxide and one gallon of burned diesel fuel produces over 10,000 grams of carbon dioxide.[143] The carbon emissions produced in manufacturing a single electric car battery can range from 56,000 to 494,000 grams of carbon dioxide.[144] Environmental and economic factors such as these should be central to what lawmakers consider when deciding how to define and categorize new autonomous farming vehicles.

Further, when considering how autonomous farm vehicles could potentially function, an analysis of the available range of autonomous features should impact the categorical threshold of such vehicles.[145] Autonomous vehicles may be equipped with varying levels of autonomous capability and differing levels of capable human influence. Vehicles may even be capable of switching between full automation, partial automation, and manual control during operation and lawmakers should be aware of this in determining legislation and regulations.[146] Additional considerations should be directed towards the potential for remote-controlled manual operations, whether through computer or a phone, and how such control should be defined among the descriptive levels and definitions of autonomy.[147]

IV. CONCLUSION

To conclude, this world of fast paced innovation will soon present autonomous farming among its next great innovative implementations. As with drones, phones, and other technological advances, innovation arrives faster than some institutions can adapt. Legal institutions have often played catch up with its responsive nature to the nation's issues, but it does not necessarily have to. The law is only limited by those who make and interpret it. However, their foresight is

142. Karen Langley, *Tesla is Now the Most Valuable U.S. Car Maker of All Time*, WALL ST. J. (Jan. 7, 2020, 4:17 PM), https://www.wsj.com/articles/tesla-is-now-the-most-valuable-u-s-car-maker-of-all-time-11578427858 [https://perma.cc/6BXA-CSRM].

143. *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, EPA (Aug. 24, 2020, 1:28 PM), https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle [https://perma.cc/D4LL-M52D].

144. DALE HALL & NIC LUTSEY, INT'L COUNCIL ON CLEAN TRANSP., EFFECTS OF BATTERY MANUFACTURING ON ELECTRIC VEHICLE LIFE-CYCLE GREENHOUSE GAS EMISSIONS 2 (Feb. 2018), https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf [https://perma.cc/9ACG-SLJ7].

145. *Autonomous Concept Vehicle*, *supra* note 58.

146. *See* Allen, *supra* note 48.

147. *See* Burke, *supra* note 59.

greatly hindered by a lack of awareness and information in novel areas of autonomous technologies. This Note should provide lawmakers with an awareness for the impending autonomous advancements in the realm of agriculture.

Although this Note is only the beginning of a complex analysis of autonomous vehicles, autonomous farm vehicles, and autonomous farming in general, regulative anticipations for the future will have profound effects on the success of farmers and others, including technology developers, vehicle manufacturers, and an entire nation dependent on an efficient and successful agricultural industry.