BEFORE THE FEDERAL AVIATION ADMINISTRATION

REMOTE IDENTIFICATION OF UNMANNED AIRCRAFT SYSTEMS

14 CFR Parts 1, 47, 48, 89, 91, and 107
Docket No.: FAA-2019-1100; Notice No 20-01
RIN 2120-AL31

EXPERT REPORT OF CHRISTIAN M. DIPPON, Ph.D.
On behalf of DJI Technology Inc.

March 2, 2020

Table of Contents

List of Tables

Expert Report of Christian M. Dippon, Ph.D.

I. QUALIFICATIONS

1. My name is Christian M. Dippon. I am an economist and Managing Director at NERA Economic Consulting (NERA) where I chair NERA's Global Energy, Environment, Communications, and Infrastructure (EECI) Practice. I also serve on NERA's Board of Directors. NERA provides expert economic and financial analysis for firms and government bodies on a wide variety of issues. Founded in 1961, NERA serves clients from approximately 20 offices across North America, Europe, and Asia. My business address is 1255 23rd Street NW, Suite 600, Washington, DC 20037.

2. I hold a Ph.D. in Economics from Curtin University (Perth, Australia), an M.A. in Economics from the University of California, Santa Barbara, and a B.A. with honors in Business Administration from California State University, Hayward. I have specialized in the economics of the Internet ecosystem for 24 years with a focus on the wireless and wireline industries, consumer equipment markets, and media and broadcasting.

3. My experience in the Internet sector includes assessing state and federal regulatory intervention and reform, calculating economic damages in litigation and domestic and international arbitration matters and reviewing claims of anticompetitive conduct. I have testified in depositions, bench and jury trials, and hearings on telecommunications matters before the U.S. Federal Communications Commission (FCC), the International Trade Commission (ITC), U.S. federal and state courts, domestic and international arbitration panels (UNICITRAL and ICC), international competition and regulatory authorities, and numerous U.S. state regulatory commissions. Appendix A of this report contains my curriculum vitae.

II. PURPOSE OF REPORT

4. This report was prepared at the request of DJI Technology Inc. (DJI) in response to the Federal Aviation Administration's (FAA) Notice of Proposed Rulemaking (NPRM) with respect to its proposed *Remote Identification of Unmanned Aircraft Systems* (Remote ID Proposal or Proposal).[1] DJI requested that I conduct an economic evaluation of the FAA's Remote ID Proposal that examines the FAA's estimate of the proposed rule's costs and contrasts these costs with the purported benefits. Specifically, DJI requested that I render an independent assessment of the FAA's statement that "over a 10-year period of analysis this proposed rule would result in net present value costs of about $582 million" and that it "will result in several important benefits and enhancements to support the safe integration of expanded UAS [Unmanned Aircraft Systems] operations in the airspace of the United States."[2]

5. I am informed by DJI that the FAA's NPRM must be in compliance with Executive Order 13563, which, among other things, requires the FAA to:

> (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs …; (2) tailor its regulations to impose the least burden on society …; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits….[3]

DJI requested that I benchmark my findings relative to the standard that reportedly applies to the FAA.

[1] See U.S. Department of Transportation, Federal Aviation Authority, *Remote Identification of Unmanned Aircraft Systems*, Notice of Proposed Rulemaking, Docket No. FAA-2019-1100, Notice No. 20-01, Filed December 26, 2019, FAA Drone Proposal 2019-28100.pdf (hereinafter Remote ID NPRM).

[2] Ibid, pp. 32, 33.

[3] The White House, Office of the Press Secretary, "Executive Order 13563 – Improving Regulation and Regulatory Review", January 18, 2011, https://obamawhitehouse.archives.gov/the-press-office/2011/01/18/executive-order-13563-improving-regulation-and-regulatory-review.

6. The structure of this report is as follows. Section III presents a summary of my findings. Section IV provides the background for this proceeding. Section V discusses the FAA's underestimation of costs, whereas Section VI explains that this Proposal has no quantifiable benefits. Section VII discusses the FAA's proposal relative to Executive Order 13563 and presents a revised proposal. Section VIII concludes.

III. SUMMARY OF FINDINGS

7. **The current version of the Proposal will cost society approximately $5.6 billion over the next decade, which is over nine times more than the FAA's $582 million estimate.** Based on a comprehensive consumer survey, the proposed rule will result in $2.58 billion in additional consumer costs and $1.79 billion in reduced UAS output. Consumers must also spend $50 million in additional registration fees and costs related to early obsolescence. Law enforcement and local communities will also have to spend approximately $1.07 billion in additional UAS related costs. There will also be an additional $80 million in customer support costs. This yields a total societal burden of about $5.6 billion over the next decade or an average $557 million per year.

8. **Offsetting these significant costs is a mere expectation of benefits that are not quantifiable or necessarily the result of the proposed Remote ID requirement**. Although it is reasonable to expect that the proposed rule will generate societal benefits, it is unclear that these would not materialize even absent regulatory intervention. The FAA also incorrectly counts expanded operations as part of the rule's benefits despite acknowledging that its Proposal will not enable UAS operators to fly at night, over people, or beyond the visual line of sight.

9. The FAA's must revise its Remote ID Proposal to maximize the net societal benefit to comply with the guiding executive order. **By allowing drone users to broadcast their Remote ID over local airwaves *or* providing their information to a Remote ID Service Supplier over the Internet, the FAA can significantly reduce the cost burden imposed by the regulation while not materially affecting its societal benefits.** Economists call such change Pareto optimal because it makes all parties better off while making no one worse off.

10. There are two overarching flaws in the FAA's economic evaluation of its Proposal. First, the FAA significantly understates the financial repercussions of its Proposal. Second, it overstates the societal benefits by overstating cost savings and listing benefits that are unrelated to the Proposal. I discuss each of these topics in turn.

The FAA Understates the Costs of Its Proposal

11. The FAA estimates that its Proposal will cost drone manufacturers, drone users, and the FAA $582 million, as expressed in net present value terms over 10 years. The FAA's preliminary estimate of net costs understates several cost categories and incorrectly assumes that increased consumer prices will not affect the demand for drones. The calculation also omits several important cost considerations.

12. The FAA underestimates three important cost categories included in its estimate of net costs. The FAA bases its cost model on a drone sales estimate that is only 30 percent of the drone sales reported by the trade organization Consumer Technology Association (CTA). This affects most of its cost categories and underestimates societal costs by a factor of three. The FAA also significantly underestimates the cost of the Remote ID system that will record, process, store, and safeguard the Remote ID data. The FAA erroneously

assumes that drone user access will cost around $2.50 per month. The FAA based this assumption on the observed prices charged in the Low Altitude Authorization and Notification Capability (LAANC) system. [4] However, the LAANC system is fundamentally different; therefore, it does not accurately represent the costs that will be incurred. Benchmarks that are more accurate include automobile connected services, pet tracking services, and electronic logging devices for trucks and busses. An examination of the prices for these services values monthly Remote ID costs at $9.83. In addition, the FAA's estimation of the Remote ID USS access fee incorrectly assumes that a pricing strategy without a monthly fee yields no societal burden. This is incorrect as a matter of economics and contradicts the FAA's own finding. Finally, the FAA understates the cost of making certain drones obsolete by about $27 million.

13. The FAA's costs assumption also ignores the law of demand. Underlying the FAA's $582 million net cost estimate is the assumption that all parties affected by the proposed rule will accept and absorb these costs. This is an unrealistic assumption because consumers may decide not to purchase drones subject to the Remote ID requirement. To measure the impact of the FAA's Proposal on the demand for drones, I conducted a consumer survey of drone users and purchasers. The survey indicates that consumer cost increases will reduce the demand for drones subject to the Remote ID requirement by 10.6 percent. This leaves the remaining 89.4 percent of drone users to cover all costs associated with the Proposal.

14. In addition, the Proposal is missing cost categories. Among the principal cost categories missing in the FAA's cost calculation are all costs incurred by local law enforcement agencies in responding to drone-related complaints. Also missing from the FAA's

[4] LAANC is a collaboration between the FAA and the industry. It directly supports UAS integration into the airspace.

calculation are increased consumer support costs resulting from a UAS' ability to function, which is now dependent on both the drone and the Remote ID Service Supplier over the Internet, but where the cause (and responsibility) for the performance failure may not be apparent.

The FAA Overstates the Benefits of Its Proposal

15. The FAA asserts societal benefits consisting of improved safety and security of U.S. airspace and expanded operations and UAS integration. Although it is reasonable to anticipate some safety and security benefits from the Remote ID Proposal, it is unclear that these would not come about absent regulatory intervention. Moreover, expanded operations are not benefits the FAA can attribute to the Remote ID Proposal because there is no evidence that makes remote identification a prerequisite to expanded operations. The data also put into question whether the Proposal will reduce the hours that the FAA spends on investigations.

A Revised Rule Would Improve the Cost-Benefit Analysis

16. One simple modification to the FAA's Proposal would yield significant net societal costs and would not reduce drone-related activities and innovation. At the same time, it would make the Remote ID requirement consistent with the guiding executive order. That is, by providing drone users with the option of broadcasting their Remote ID elements *or* of sending them to an FAA-approved service, the FAA would significantly ease the burden on society whereas keeping the Proposal's anticipated benefits. Specifically, drone users would not incur the estimated $9.83 in monthly subscription charges, and they would not have to pay for the drones' Internet connectivity requirement. Further, demand would not be suppressed for those who prefer not to send their flight data to a government-approved

service. This modification would ease the financial burden, and it would be particularly beneficial for operators of model airplanes and remote-control helicopters. The recommended modification would also allow the FAA to streamline its Proposal by removing the "Limited" remote identification UAS category, which would no longer be required because drones with Internet transmission capabilities would be permitted standard drone usage.

IV. BACKGROUND

17. The FAA defines an unmanned aircraft as follows:

> The FAA does not use the terms unmanned aircraft system and unmanned aircraft interchangeably. The FAA uses the term unmanned aircraft as defined in 14 CFR 1.1 to refer specifically to the unmanned aircraft itself. The FAA uses the term unmanned aircraft system to refer to both the unmanned aircraft and any communication links and components that control the unmanned aircraft. As explained in section VII of this proposed rule, the FAA is proposing to add the definition of unmanned aircraft system to part 1 of 14 CFR.[5]

18. Therefore, according to the FAA, a UAS includes the unmanned aircraft and "any communication links and components that control the unmanned aircraft."[6] Although this class of unmanned aircraft includes drones, remote control (RC) helicopters, and model airplanes, this report focuses on drones and uses the terms *drone* and *UAS* to refer to a system consisting of a drone, a control unit, and a communication link between the two components.

[5] Remote ID NPRM, n. 1.
[6] Ibid.

19. Although finding its roots in military use, drone usage for recreational and nonrecreational purposes has significantly increased in the last decade. The FAA reports that since its UAS registration system went into effect on December 21, 2015, "more than 900,000" drones, RC helicopters, and model airplanes have been registered as of year-end 2018.[7] The FAA estimated "the annual [2018] growth rate to be around 13 percent," which was primarily driven by "the introduction of drones as recreation activity facilitated by falling equipment prices and improved technology, such as built-in cameras and relatively easy maneuvering."[8]

20. Because of the increased demand and usage of UAS, the "FAA is integrating unmanned aircraft systems (UAS) operations into the airspace of the United States through a phased, incremental, and risk-based approach."[9] That is, the FAA is creating specific rules for the flying of drones for recreational and commercial reasons. The following sections provide an overview of what standard recreational and nonrecreational drone usage entails and explains the regulatory requirements that the Remote ID Proposal would impose on standard drone usage.

A. Existing Regulations

21. The FAA regulates the operations of all UAS.[10] Among other things, UAS owners must:

- fly at or below 400 feet in uncontrolled airspace;
- keep the drone within line of sight; and

[7] U.S. Department of Transportation, Federal Aviation Administration, "FAA Aerospace Forecast Fiscal Years 2019–2039," TC 19-0012, p. 41, https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2019-39_FAA_Aerospace_Forecast.pdf.

[8] Ibid. p. 42.

[9] Remote ID NPRM, p. 9.

[10] See U.S. Department of Transportation, Federal Aviation Administration, 14 CFR Part 91, Docket No. FAA-2006-25714, *Unmanned Aircraft Operations in National Airspace System*, Notice of Policy; opportunity for feedback, February 6, 2007, https://www.faa.gov/uas/resources/policy_library/media/frnotice_uas.pdf.

- not fly over groups of people, public events, or stadiums full of people.[11]

22. The FAA also regulates the registration of drones weighing more than 0.55 pounds and less than 55 pounds on take-off. Two sets of Federal Aviation Regulations (FAR) detail the registration requirements. Effective as of December 21, 2015, the FAA implemented specific rules with respect to the registration and marking requirements of drones.[12] These rules transitioned the legacy paper-based registration system to an online system, thereby streamlining the registration of drones. Drone owners are also required to "mark their aircraft" with unique identifiers.[13] Recreational users pay $5 to register their entire fleet of drones, whereas those using a drone for nonrecreational purposes pay a registration fee of $5 per aircraft. The FAA does not require the registration of drones weighing less than the 0.55-pound threshold except for those used for nonrecreational purposes.

23. On June 26, 2016, the FAA implemented specific rules for nonrecreational drone users that mandate more stringent registration requirements including a "remote pilot airman certificate" or the presence of a dedicated supervisor in possession of such a certificate.[14] In exchange, the FAA allows nonrecreational drone users to carry an external load and offer drone services for compensation.[15] However, nonrecreational drone users are still required to adhere to all other operational limitations (e.g., flight at no more than 400 feet) and to obtain authorization to fly in controlled airspace, typically through its LAANC capability.

[11] See United States Department of Transportation, Federal Aviation Administration, "Educational Users," https://www.faa.gov/uas/educational_users/ (accessed February 18, 2020).

[12] See U.S. Department of Transportation, Federal Aviation Authority, 14 CFR Parts 1, 45, 47, 48, 91, and 375, Docket No. FAA-2015-7396, *Registration and Marking Requirements for Small Unmanned Aircraft*, Interim final rule, December 16, 2015, FR 80 78594 (hereinafter 2015 Registration Rules)

[13] 2015 Registration Rules, p. 78596

[14] U.S. Department of Transportation, Federal Aviation Authority, *Operation and Certification of Small Unmanned Aircraft Systems*, Rule, August 29, 2016, FR 81 42063, 42067 (hereinafter Part 107 Rules).

[15] See AirMap, "2019 Year in Review," https://www.airmap.com/10-things-to-know-about-part-107/.

B. Remote ID Proposal

1. Proposed Rule

24. The FAA proposes that all registered drones be remotely identifiable. If implemented, the FAA's Proposal would limit standard drone usage to only drones that broadcast so-called remote identification message elements (Remote ID elements) locally over airwaves *and* that transmit the same information to an FAA-approved service that records, stores, and safeguards the data. Access to this service and its data will be available to the FAA, law enforcement agencies, and the public. The Remote ID elements include:

- session ID (i.e., random number assigned to a registered drone on a per-flight basis);
- location of UAS (i.e., longitude and latitude);
- location of control station (i.e., longitude and latitude);
- height of UAS (i.e., barometric pressure altitude); and
- height of control station (i.e., barometric pressure altitude).[16]

25. Under the FAA's Proposal, drones that transmit these Remote ID elements only to the designated FAA-approved service and that do not broadcast this information over the local airwaves are not permitted standard operational drone usage. Instead, these drones must "operate no more than 400 feet from the control station."[17] Further, drones with no Remote ID capabilities are restricted to operating in FAA-recognized identification areas.

26. Thus, the FAA's Proposal would require broadcast *and* Internet connectivity for all drones with standard operational usage, Internet connectivity for all drones with limited operational usage, and pre-designated field use only for amateur-built drones with no Remote ID capabilities. The FAA limits the applicability of its Proposal to drones that

[16] See Remote ID NPRM, p. 26.
[17] Ibid, p. 74.

require FAA registration. Thus, drones weighing less than 0.55 pounds are exempt from the proposed Remote ID rule.

2. Proposed Compliance Responsibilities

27. The FAA's Proposal tasks drone manufacturers with the responsibility of implementing the Remote ID rule. Drone manufacturers must ensure that a drone's functionalities align with the new operational requirements.[18] For instance, manufacturers must equip their drones with technology that measures, collects, and broadcasts the Remote ID elements over the airwaves and simultaneously sends the same data to a designated Remote ID database service. Under the Proposal, drone manufacturers would also have to develop software and hardware solutions that prevent take off if the applicable Remote ID requirements are not functioning. The Proposal also requires that drones send various warning and status messages to a graphical user interface (GUI), which becomes part of the control station. Some drones, particularly those used for professional purposes, currently contain some, but not all, of the needed features to perform these requirements. However, many drones and other UAS (e.g., basic drones and model airplanes) do not have these features and would need significant redesign.

28. Drone manufacturers (or others) would also be responsible for the development of an FAA-approved industry standard for the collection of Remote ID elements as well as offer a database service that not only is accessible via the Internet but also records, stores, and safeguards the Remote ID data. Per the FAA, "Although the FAA anticipates that most Remote ID USS [Remote ID UAS Service Suppliers] would offer their services to the general public, a Remote ID USS, such as an operator of multiple routine unmanned

[18] Ibid, pp. 76, 77.

aircraft flights, may choose to provide remote identification services only for its own fleet. Additionally, the FAA expects that most Remote ID USS would likely come from private industry."[19] Although providing no support for its estimation, the FAA expects 10 entities to request to become Remote ID USS, of which the FAA will qualify nine.[20] The FAA is silent on the types of entities it envisions providing the service.

29. Although drone manufacturers appear to be liable for most of the direct compliance responsibilities, the Proposal will affect drone users because they will be limited to flying only drones compliant with the proposed rule. As in most cases such as this, the drone users will eventually bear the burden of these compliance responsibilities because they will have to replace existing drones with Remote ID-compliant drones, thus creating higher drone acquisition costs along with subscription costs to access Remote ID USS. Drone users also must be willing to accept that they will have to forgo a significant privacy element because they now must make their flight routine and flying patterns available to the public. They will have to accept that the Remote ID elements could possibly reveal their identities and the location of their drones or their own locations when flying. Finally, drone users must accept that their location data will be available to the FAA, law enforcement agencies, and the public.

[19] U.S. Department of Transportation, Federal Aviation Authority, Remote Identification of Unmanned Aircraft Systems, Notice of Proposed Rulemaking, *Preliminary Regulatory Impact Analysis*, December 20, 2019, p. 80 (hereinafter Preliminary Analysis).

[20] See Remote ID NPRM, p. 196.

3. Problem the Remote ID Proposal Allegedly Solves

30. The FAA's stated purpose for this Remote ID Proposal is "to ensure public safety and the safety and efficiency of the airspace of the United States."[21] The FAA finds, "The rapid proliferation of UAS has created significant opportunities and challenges for their integration into the airspace of the United States."[22] The FAA lists several instances where improper drone usage created "a unique security challenge."[23] The FAA does indicate that the Proposal alone will not solve the challenges that prevented expanded UAS operations "such as operations over people or beyond visual line of sight."[24] Thus, expanded operations are not a benefit that the FAA anticipates coming from this Proposal. As such, the FAA attempts to solve a societal problem (i.e., drone safety in U.S. airspace) and not a UAS usage problem (i.e., inability of drones to perform the missions they are already quite capable of performing).

V. THE FAA UNDERESTIMATES THE PROPOSED RULE'S COSTS

31. The FAA explains, "Changes to Federal regulations must undergo several economic analyses" to ensure that the benefits from the change outweigh the costs and are in the public interest.[25] Furthermore, I am informed by DJI that the FAA's NPRM must be in compliance with Executive Order 13563 which, among other things, requires the proposed rule to (1) reasonably determine that the benefits justify the costs, (2) impose the least burden on society, and (3) select an approach that maximizes net benefits."[26] Consequently,

[21] Remote ID NPRM, p.10.
[22] Ibid, 40.
[23] Ibid, p. 53.
[24] Ibid, p. 7.
[25] Ibid, p. 187.
[26] The White House, Office of the Press Secretary, "Executive Order 13563 – Improving Regulation and

the FAA analyzes "the costs and cost savings by affected groups within the scope of the proposed rule."[27] The following sections provide an overview of the FAA's cost estimates and explain the flaws in these estimates—flaws that when corrected reveal that the FAA understates the costs of the proposed rule by about 940 percent at a minimum.

A. Overview of the FAA's Cost Model

32. The FAA identifies the following parties as incurring costs because of the proposed rule: UAS owners/operators, UAS producers, community-based organizations (CBOs), and the FAA.[28] In addition, the FAA lists several affected cost categories but refrains from assigning them to a specific party involved in the deployment of drones. These include "Remote ID USS Subscription," "Developers of Remote ID Means of Compliance," and "Remote ID USS Memoranda of Agreement."[29] The FAA developed annual positive and negative cost estimates for each of these affected parties and cost categories for 10 years. Discounting these annual cost streams by 3 percent and 7 percent, as per the FAA, yields net cost estimates of $581.52 million and $473.46 million, respectively.[30]

33. A review of the FAA's cost model reveals several flaws including an underestimation of costs, a fundamental misunderstanding of how these costs will affect consumers and drone-related activities in the United States, and omitted cost categories.

Regulatory Review", January 18, 2011, https://obamawhitehouse.archives.gov/the-press-office/2011/01/18/executive-order-13563-improving-regulation-and-regulatory-review.

[27] Remote ID NPRM, p. 208.

[28] Ibid, p. 228, Table 8a.

[29] Ibid.

[30] Ibid. We use 3 percent in the remainder of this paper because the Office of Management and Budget (OMB) states, "When regulation primarily and directly affects private consumption (e.g., through higher consumer prices for goods and services), a lower discount rate is appropriate." (Office of Management and Budget, "Circular A-4," September 17, 2003, p. 33.)

B. FAA's Cost Model Understates Three Critical Cost Elements

34. The FAA's net cost estimate underestimates (1) the number of UAS affected by its Proposal (e.g., the impact of the proposed change in the registration fee process), (2) the subscription fee to the Remote ID USS, and (3) the costs associated with premature obsolesce. I will discuss each of these flaws in turn.

1. Number of UAS Affected

35. As a general concern, the FAA relies on forecasted drone counts that are significantly lower than those derived by the CTA are. As illustrated in Table 1, the FAA estimated total hobby and professional drone sales of 590,177 units for 2019. This is merely 30 percent of the 1,975,437 units estimated by the CTA for the same year. In fact, as shown in column (4), the FAA's *total* fleet estimate (which includes all drones in the United States) is less than the CTA's estimate for drone sales in 2019 alone.

Table 1: FAA vs. CTA Unit Sales Comparison (2019)

	CTA			FAA	
	Unit Sales	Percent of Owners With Small Sized/ Toy UAS	Estimated Hobbyist & Professional Units Sales	Total UAS Fleet (excludes UAS of Less than 0.55 lbs.)	UAS Sales
	(1)	(2)	(1)x[1-(2)] (3)	(4)	(5)
2019	3,509,000	43.7%	1,975,437	1,714,551	590,177
As a % of CTA Hobbyist & Professional Units					30%

Source: CTA, U.S. Consumer Technology Sales and Forecasts—2015–2020, slide 52; 2018 CTA Drone Survey, slide 16; Preliminary Analysis, Tables 4a and 5a.

36. The CTA is North America's largest technology trade association. Twice each year it asks its members to provide data and information for forecasting purposes. According to the CTA:

> … participants submit their best estimates for the total industry size and growth in a series of categories for a five-year time period. CTA's analysts then blend the responses and adjust them using year-to-date trending data from the CTA shipment data program (CE MarketMetrics) where appropriate, along with other quantitative and qualitative inputs. The results are estimates that reflect the broader industry sentiment. Hardware-related data within this report represent shipment volumes from manufacturers to U.S. dealers and installers. This includes both domestic production and imports of products to consumer-oriented sales channels, regardless of retail type, including distribution and direct-to-consumer sales.[31]

37. On the other hand, the FAA bases its forecasts on UAS registrations, which it equates with UAS ownership.[32] The FAA recognizes, "Each owner registers, and each owner might have multiple UAS. Exceptions may be registered modelers with no owned equipment."[33] The FAA uses "information available for both industry and academia, allowing us to understand aircraft ownership."[34] The FAA also conducts "various research activities to understand the possible magnitude of the sector."[35]

38. Thus, whereas the CTA obtains drone unit and revenue sales data from its members, the FAA seems to rely principally on UAS registrations and independent research. Although no data exist to examine the confidence bound of either estimate, the direct approach used by the CTA carries more promise and is in line with that used in other industries. For instance, the GSMA (the international mobile wireless industry association) routinely

[31] Consumer Technology Association, "U.S. Consumer Technology Sales and Forecasts 2015-2020," January 2020, slide 52; Consumer Technology Association, "Drones: Public Perceptions & Consumer Attitudes," 2018, slides 2-3.

[32] See U.S. Department of Transportation, Federal Aviation Administration, "FAA Aerospace Forecast Fiscal Years 2019–2039," TC 19-0012, p. 42, https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2019-39_FAA_Aerospace_Forecast.pdf.

[33] Ibid.

[34] Ibid.

[35] Ibid.

collects data from its members that are widely used by policy makers, regulators, academics, and analysts in evaluating the mobile wireless industry.[36] Similarly, the CTIA (the U.S. mobile wireless industry association) also relies on its members to obtain industry data and statistics.[37]

39. The FAA's apparent underestimation of UAS unit sales affects its estimates for many of its cost categories with the exceptions being compliance submissions and developing industry standards, which are independent of the drone count. To put this data difference into perspective, if the FAA had relied on the CTA's forecasts, its net cost of the proposed rule would be approximately $2 billion instead of $582 million because most of the FAA's larger cost categories are unit related.[38]

40. The FAA's apparent underestimation of the UAS fleet affects, among other things, its estimate of the registration fee impact. The FAA's proposed rule includes a change in registration fees that will require operators to register all drones individually. Currently, the FAA requires only one application per fleet of drones used for recreational purposes.[39] Consequently, the proposed rule will increase the registration costs for recreational drone users owning more than one drone. The FAA recognizes this cost category and estimates it at $1 million per year. However, correcting the drone count yields a cost estimate of $3.5 million per year. Discounted at 3 percent over 10 years reveals a cost underestimation of $21.33 million. However, although the FAA calculates the additional registration fees, it

[36] See GSMA, "About Us," https://www.gsma.com/aboutus/.
[37] See, CTIA, https://www.ctia.org/.
[38] Estimated as $582/30 percent.
[39] See Remote ID NPRM, pp. 87, 88.

cites OMB Circular A-4 that views these fees as transfer payments not societal costs.[40] Therefore, the FAA excludes these registration fees from its $582 million cost estimate.[41] Nevertheless, even assuming the correct interpretation of OMB Circular A-4, these registration fees will have an impact on demand because they represent an increase in the cost of drone ownership. Consequently, the FAA must include the increased registration fees in the purchase price of drones and measure their impact on demand. Specifically, the FAA reports an average of 1.4 drones per recreational user, implying that the additional registration fee is equal to $2.75 per drone (0.55 x $5).[42] This price increase will reduce demand and therefore must be included in any cost assessment.

2. Cost of Remote ID System

41. The FAA also significantly underestimates the cost of the Remote ID system. The agency assumes, "Based on the LAANC USS business model, the subscription to a Remote ID USS may range in cost from $0 to $5 per month, per operator, for a midpoint of $2.50 per month."[43] This estimate is unrealistic for at least three reasons. First, LAANC is significantly different from the Remote ID USS envisioned by the FAA and thus does not serve as an accurate benchmark. Second, several comparable subscription models indicate monthly costs much higher than the FAA's $5 upper range estimate. Third, the FAA's assumption of a free subscription model is economically incorrect and contradicts the FAA's own finding. I will discuss each of these flaws in turn.

[40] Ibid, p. 210.
[41] Ibid.
[42] See Preliminary Analysis, p. 67.
[43] Remote ID NPRM, p. 215.

The LAANC USS business model is not a proper benchmark

42. The Remote ID approach, as envisioned by the FAA, requires the transmission of the Remote ID elements through the Internet to a service (Remote ID USS) that will collect the identification and location in real time from in-flight UAS.[44] The information sent through the Internet will be the same as the broadcast identification and location information emanating directly from an unmanned aircraft.[45] The FAA envisions that the Remote ID USS will "perform four primary functions: (1) collect and store the remote identification message elements; (2) provide identification services on behalf of the UAS operator and act as the UAS operator's access point to identification services; (3) provide the FAA access to the remote identification information collected and stored upon request through a data connection that may be on-demand or a continuous connection depending on safety and security needs; and (4) inform the FAA when its services are active and inactive."[46]

43. The proposed Remote ID USS is quite complex. The identification information encompasses both the location of the UAS as well as that of the pilot.[47] The mechanism requires the UAS to send information to the control unit that uses the network of a wireless telecommunications provider to transmit the data to a Remote ID USS. Alternatively, the UAS can send the information directly to the Internet via a Subscriber Identification Module (SIM) embedded in the drone.

44. To serve the intended purpose of assisting in locating UAS and their operators and in improving locational awareness, it is also necessary that the mobile wireless network

[44] Ibid, p. 8.
[45] Ibid, p. 215.
[46] Ibid, pp. 167–168.
[47] Ibid, p. 60.

transmitting data to the Remote ID USS operates at a low latency rate. In fact, as part of its list of Remote ID elements, the FAA includes "message latency, and message transmission rate," highlighting the dependency of the proposed rule's benefits on this metric. The definition of latency is "the time it takes for a source to send a packet of data to a receiver."[48] As explained by the trade press, "relatively little attention has been paid to 3G and [4G] LTE latency speeds."[49] In contrast, latency has become a key benefit to the pending deployment of 5G technology.[50]

45. The Remote ID USS, in turn, will be required to record the Remote ID elements when an Internet connection is available, process the data, and store it per the FAA's specifications. The Remote ID USS also requires a direct broadband connection to the FAA.[51] The FAA requires that the data be stored during the period the Remote ID USS is active plus an additional six months.[52] The FAA can request data on demand or continuously as the situation warrants. The Remote ID USS would also connect to local law enforcement agencies through a broadband or a wireless connection, as demanded.[53]

46. The FAA will not offer the Remote ID UAS services itself. Rather, it envisions nine entities (Remote ID USS) would offer it by the end of the first year of the regulations (with one more entity added in each of the following years).[54] The FAA appears to rely on its

[48] Mike Dano, "3G/4G wireless network latency: Comparing Verizon, AT&T, Sprint and T-Mobile in February 2014," *FierceWireless*, March 17, 2014, https://www.fiercewireless.com/special-report/3g-4g-wireless-network-latency-comparing-verizon-at-t-sprint-and-t-mobile-february.

[49] Ibid.

[50] See Stephen Shankland, "How 5G aims to end network latency," *CNET*, December 8, 2018, https://www.cnet.com/news/how-5g-aims-to-end-network-latency-response-time/.

[51] Remote ID NPRM, p. 101.

[52] Ibid, p. 24.

[53] Ibid, p. 170.

[54] Ibid, p. 196.

experience with the LAANC system and assumes that each LAANC supplier will also become a Remote ID USS supplier. There is no evidence of this occurring. The FAA also does not explain how it derived these numbers and does not specify whether each Remote ID USS will carry all the data, or each Remote ID USS will carry only the data of its users. Figure 1 of the FAA's Request for Information in 2018 shows all the Remote ID USS locations connected to each other as well as to the FAA.[55] The FAA estimates that the service would be free or offered for up to $5.00. For modeling purposes, the FAA elects to include a midpoint of $2.50.[56] The FAA supports its modeling assumption by citing to its experience with the LAANC data exchange.[57] However, the LAANC data exchange is a weak comparator to the proposed Remote ID USS because the two systems serve entirely different functions.

47. LAANC is a *permit system* for access to controlled airspace (e.g., flying near an airport). UAS pilots submit their flight plans to LAANC seeking authorization for flight under standard drone usage, and they use a simple text to communication system without a high performance latency requirement. The data flow is from the drone pilot to the Remote ID USS and then back to the drone pilot. This is fundamentally different from the Remote ID *tracking system* because LAANC does not (1) track UAS flight patterns or the location of the control station, (2) make that information available to an unlimited number of third parties, and (3) require a constant connection to the system. Unlike the Remote ID USS, the LAANC system does not require a low latency rate because there are no repercussions if a permit is submitted with a slight delay. LAANC is also not required unless a pilot seeks

[55] See Department of Transportation, Federal Aviation Authority, *FAA UAS Remote Identification Request for Information (RFI)*, Special Notice, December 20, 2018, Figure 1.
[56] Remote ID NPRM, n. 100.
[57] Ibid, n. 150.

to fly in certain portions of controlled airspace, which is only a small fraction of the airspace in the United States. LAANC also does not need to handle the volume of data that a Remote ID USS will have to record and process.

48. To put this data volume difference into perspective, consider that LAANC received 170,000 requests for authorization in 2019. In stark contrast, a Remote ID USS must handle an estimated 265 million flights per year with each lasting approximately 20 minutes.[58] This translates into 5.3 million data minutes per year of streaming data, distributed to an unlimited number of users (such as members of the public) who wish to access it, as well as the other USS providers who need to be able to access it in order to service their own receivers of Remote ID information. Given these fundamental differences, the monthly subscription fees to LAANC are not a proper benchmark to estimate the subscription fees to the Remote ID USS. I also note that each LAANC submission is only visible to the drone pilot who initiated it whereas the Remote ID USS makes all data available to the public (including law enforcement personnel).

Comparable tracking services indicate significantly higher prices

49. The proposed Remote ID USS is a tracking system comparable to the Internet of Things (IoT) tracking and information systems for automobiles and pets. A survey of the retail prices for these services finds them ranging between $5 and $49.99 per month with a median of $9.83. These prices represent a far superior indicator to the monthly price for the proposed Remote ID USS.

[58] Based on the FAA owner estimate for year four of 1,221,636, which is the first year the system is fully operational. (See Preliminary Analysis, Table 8a; NERA Drone Survey, Questions 8.a and 8.b.)

50. For instance, Honda offers remote tracking and information service for $110 per year (about $9.15 per month).[59]

> The HondaLink® app has added new and exciting remote control features like Remote Engine Start, Remote Door Lock/Unlock, and Find My Car, available for 2018+ Odyssey Touring, 2018+ Accord Touring, 2019 Insight Touring, 2019 Pilot and Passport Touring/Elite vehicles. Battery charge monitoring and control is now available for Clarity Plug-in Hybrid vehicles.[60]

A similar service from Chevrolet is available for about $480 per year ($39.99 per month).[61] Porsche charges $116.60 per year for an IoT service that, among other things, displays the vehicle's current position and the owner's position on a map.[62] Another tracking service, Uconnect Access, "keeps you connected on the road with services like 9-1-1 Call, Roadside Assistance Call, Remote Vehicle Start, Send 'n Go™ & Vehicle Finder, and Stolen Vehicle Assistance" and charges $149.99 if purchased for a year ($14.99 if purchased monthly).[63] These and similar IoT services offer superior benchmarks in estimating the cost for Remote ID USS. Unlike LAANC but like Remote ID USS, car remote tracking involves multiple pieces of data collected in a dynamic manner that alerts a user when required, or the car tracking system can instantaneously disseminate the data upon request.

51. Outside the car industry, the pet industry offers tracking services for dogs. Some of these services also take the pets' vitals. Much like the Remote ID USS, these services offer a

[59] The Honda Link is an app downloaded to a smartphone. The service offers geofence alerts, security alerts, find the car stolen vehicle locator, and other features. (See Honda Link, https://hondalink.honda.com/#/, accessed February 3, 2020.)

[60] App Store Preview, HondaLink, https://apps.apple.com/us/app/hondalink/id750465030 (accessed February 18, 2020) (footnotes omitted).

[61] Unlimited Access offers connected navigation, vehicle locate, turn by turn navigation, as well as vehicle diagnostics, and other features. (See Chevrolet Connected Service Plans, my.chevrolet.com, accessed February 3, 2020).

[62] See Porsche, https://pcc.vodafonetelematics.com/cwp/public/welcome.do (accessed February 25, 2020).

[63] Uconnect Access, https://www.driveuconnect.com/uconnectaccess.html (accessed February 3, 2020).

variety of services such as notification by text, email, or app when a pet leaves a designated area, monitoring of potential health issues (e.g., licking, scratching, sleeping, and activity levels), and a detailed chronological breakdown of what they did (e.g., running, sleeping, playing, etc.).[64] Unlike LAANC but like Remote ID USS, dog tracking involves multiple pieces of data collected in a dynamic manner that the service provider can instantaneously disseminate upon request. The numbers involved are also significantly larger than the ones handled by LAANC as likely over a million devices have been sold to date.[65]

52. Table 2 lists the prices of four automobile and 13 dog tracking services reviewed, revealing a range in monthly subscription fees between $5 and $49.99 with a median of $9.83. It is important to note that the prices for IoT services include the mobile wireless data link and thus do not require additional data charges.

[64] See Whistle, https://www.whistle.com/?utm_source=google&utm_medium=cpc&utm_campaign=3Q_Google_Search_DSA&utm_term=&utm_content=319147767324&gclid=EAIaIQobChMI27T6goDW5wIVA6SzCh1MpwBcEAAYASAAEgIuUPD_BwE (accessed February 18, 2020).

[65] See Cameron Albert-Deitch, "Pet Wearables Are a Thing Now. Meet the Company That Wants to Collect Your Dog's Data," *Inc.com*, 2020, https://www.inc.com/cameron-albert-deitch/whistle-pet-wearables-best-industries-2020.html.

Table 2: IoT Tracking and Information Services

Tracking Service	Upfront Cost	Monthly Fee
WUF	$ 189.99	$ 0.00
Voyce	199.00	9.50
Whistle	79.00	6.95
Nuzzle	196.66	0.00
Paw Tracker	99.95	9.95
Squeker Buddy	250.00	8.33
Tile	25.00	0.00
Link AKC Smart Dog Collar	199.00	6.95
Pod 12 GPS & WiFi Pet Trqacker	199.00	49.99
Tractive GPS Tracker	67.95	5.00
iGPS Tracker	79.95	9.95
Petpace	199.95	14.95
GIBI Pet Locator	129.99	9.95
Honda Link	0.00	9.17
Chevrolet Connected Service	0.00	39.99
Porsche Connect	0.00	9.72
Uconnect Access	0.00	12.50
Median	189.99	9.83

Sources: James Rhys Clarke, "We've Compared the Costs of 13 GPS Trackers for Dogs," January 14, 2018, https://topdogtips.com/gps-tracker-for-dogs-costs/; Honda Link, https://hondalink.honda.com/#/ (accessed February 3, 2020); Chevrolet Connected Service Plans, my.chevrolet.com (accessed February 3, 2020); Porsche, https://pcc.vodafonetelematics.com/cwp/public/welcome.do (accessed February 25, 2020); Uconnect Access, https://www.driveuconnect.com/uconnectaccess.html (accessed February 3, 2020).

53. Thus, a reasonable estimate for the Remote ID USS is a subscription model at $9.83 per month. As shown in Table 3, using the FAA's estimate of Remote ID subscriptions results in significantly greater costs than estimated by the FAA—$855 million compared to $217 million over the period or an increase of $638 million.[66]

[66] See Preliminary Analysis, p. 84, Table 12.

Table 3: Comparison of Remote ID USS Subscription Cost Estimates FAA and IoT Tracking

	Total	Per Year
	($ million)	
FAA	217.47	21.75
IoT Tracking	855.44	85.54

54. I note that this estimate may be conservative, and that these costs could be significantly higher when considering other government mandated monitoring requirements. Specifically, the US Department of Transportation (DoT), via the Federal Motor Carrier Safety Administration (FMCSA), regulates and monitors the hours of service (HOS) of "property-carrying and passenger-carrying drivers."[67] Specifically:

> HOS regulations address the number of hours that a commercial motor vehicle (CMV) driver may drive, and the number of hours a CMV driver may be on duty before rest is required, as well as the minimum amount of time that must be reserved for rest and the total number of hours to be on duty and the rest period at the end of a 'work week.'[68]

55. Whereas the proposed Remote ID rule is aimed at improving the safety and security of the U.S. airspace, the objective of HOS regulation is to improve the safety and security of the U.S. roadways.[69] Also like the proposed Remote ID rule, HOS regulation mandates CMVs to be equipped with electronic logging devices (ELDs) that must meet "[m]inimum

[67] U.S. Department of Transportation, Summary of Hours of Service Regulation, https://cms8.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations, (accessed February 28, 2020).

[68] U.S. Department of Transportation, Federal Motor Carrier Safety Administration, "2010-2011 Hours of Service Rule Regulatory Impact Analysis, RIN 2126-AB26," December 2011, p. 1-1.

[69] See Ibid, p. 1-4.

performance … standards."[70] These ELDs automatically record, "(1) Date; (2) time; (3) CMV geographic location information, (4) engine hours; (5) vehicle miles; (6) driver or authenticated user identification data; (7) vehicle identification data; and (8) motor carrier identification data."[71] Like UAS, "ELD providers must register through a FMCSA Web site, and certify through the Web site that their products meet the technical specifications in today's rule."[72] Unlike the proposed Remote ID USS, however, "real-time tracking of CMVs is not required in the ELD rule."[73] The FMCSA, however, recognizes that "a motor carrier may use technology to track its CMVs in real-time for business purposes."[74]

56. Because of the ELD rule and the related business purpose, numerous ELDs are available on the market. ELD providers offer FMCSA approved ELD modules, often packaged with ELD electronic logging services. For instance, ELD supplier ELD Solutions offers a basic service that includes electronic HOS logging at $50 per month with a standard contract length of three years.[75] The supplier also offers a "deluxe" plan that includes real-time GPS tracking and geofencing. This service compares to the required service level under the proposed Remote ID rule and is priced at $60 per month.[76] Research conducted by the OOIDA Foundation indicates that ELD services range between $5.90 and $135, depending

[70] U.S. Department of Transportation, Federal Motor Carrier Safety Administration, 49 CFR Parts 385, 386, 390, and 395, Docket No. FMCSA-2010-0167, RIN 2126-AB20, Electronic Logging Devices and Hours of Service Supporting Documents, FR Vol. 80, No. 241, December 16, 2015, p. 78292.

[71] Ibid, p. 78331.

[72] Ibid, p. 78296.

[73] U.S. Department of Transportation, Federal Motor Carrier Safety Administration, ELD Fact Sheet – English Version, https://www.fmcsa.dot.gov/hours-service/elds/eld-fact-sheet-english-version, (accessed February 28, 2020).

[74] Ibid.

[75] See ELD Solutions, https://www.eldsolutions.com/eld-dedicated-device?hsCtaTracking=c4e65ead-298e-477e-957a-4dcdeb9a598c%7Cc0f6543c-e74a-41c8-a4c3-8a68d233472f, (accessed February 28, 2020).

[76] Ibid.

on the offerings and options selected.[77] The large number of service providers also indicates a competitive market.

57. As this proxy example illustrates, the FAA's $2.50 monthly cost estimate for access to a real-time Remote ID USS tracking system is unrealistic. It also demonstrates that the estimate of $9.83 per month estimated based on automobile and pet tracking system is likely conservative. I also note that unlike the ELD services, which operate in a competitive environment and are optional to users ("real-time tracking of [commercial motor vehicles] CMVs is not required in the ELD rule"),[78] the Remote ID USS is a government mandate and thus cannot be avoided by UAS users. In Table 4, I illustrate the impact on subscription costs from using ELD services based on the median price as a proxy instead of the FAA's estimate.

Table 4: Comparison of Remote ID USS Subscription Cost Estimates FAA and ELD Services

	Total	Per Year
	($ million)	
FAA	217.47	21.75
ELD Services (Min)	1,740.48	174.05
ELD Services (Max)	2,610.72	261.07

The Fallacy of Free Remote ID USS

58. The FAA's net cost estimation assumes that the Remote ID USS could potentially have no societal impact because it might be offered free. This is wrong as a matter of economics and contradicts the FAA's own findings. In a competitive market, demand and supply

[77] See OOID Foundation, https://www.ooida.com/OOIDA%20Foundation/index.asp, (accessed February 28, 2020).

[78] See FMCSA, "ELD Fact Sheet - English Version," (https://www.fmcsa.dot.gov/hours-service/elds/eld-fact-sheet-english-version , accessed February 28, 2020).

conditions determine prices. All market participants are price takers in that they cannot charge more than the market price. However, this does not imply that all market participants charge identical prices for their products and services. Instead, market participants attempt to distinguish their products and services from those of their competitors by pursuing various pricing and marketing strategies. For example, consider the taxi industry in which the price for a taxi ride is a combination of an initial base rate, distance, and time. However, as a competitive alternative to the taxi industry, Uber employs a highly advanced dynamic pricing model in which it considers supply conditions (e.g., time of day, distance, and traffic) and a rider-to-driver ratio.[79]

59. New products and services face unique pricing challenges as their brands and/or products are typically unknown to the public. Therefore, startup companies pursue various pricing strategies when introducing their products to the market. Some companies will pursue the *freemium model* in which a basic level of service is provided free of charge; however, the company offers advanced features for a price. Examples of this type of marketing are numerous and include the streaming music provider Spotify and the cloud storage provider Amazon Web Services (AWS). Still, other startups pursue the *razor-and-blade model* that sells an initial product at a low or perhaps even negative margin (loss leader) in order to stimulate demand for a companion product. Finally, some startups choose an *advertising-supported revenue model* in which consumers pay little to nothing in exchange for data that reveals their purchasing patterns and consumption preferences. These companies sell the data to advertisers that, in turn, target their advertising to interested consumers, as

[79] See Sarah Silverstein, "Uber vs. Taxi," *Business Insider*, October 16, 2014, https://www.businessinsider.com/uber-vs-taxi-pricing-by-city-2014-10.

determined by the data collected. Google and Facebook are two prominent examples of this type of pricing model.

60. Whichever pricing or other market strategy a company chooses to pursue, all firms have one common objective. That is, they aim to maximize the value of its funders (i.e., shareholders and venture capitalists). The rationale for this is quite simple: If firms do not provide sufficient return on capital, funders will not invest and the firm, and in turn, cannot maintain, expand, and innovate. On the consumer side, this implies that in the long run no product is ever truly free as its costs are recouped elsewhere. Economists describe such situations using the old adages: *There is no such thing as a free lunch.* Another such expression is: *You don't get something for nothing*.[80]

61. For analytical purposes, this means that the societal burden must be assessed in the broader context of a pricing strategy rather than by a review of one or a few select variables of such strategy. Yet, by focusing exclusively on the monthly subscription price of Remote ID USS access, the FAA makes this exact error. Specifically, the agency examines the monthly price only, opines that the service might be provided free of charge, and then incorrectly concludes that the related societal burden could be zero. This is wrong. The Remote ID USS will require significant capital to develop, build, and maintain the system. The project's funders will not only expect to recoup the capital but also earn a return on it. Thus, the service will not be free, and the societal burden will not be zero, even if the pricing strategy does not include a monthly recurring charge.

62. The FAA acknowledges the potential multidimensional pricing strategy that a Remote ID USS supplier can pursue, "Remote ID USS may have a variety of business models and may

[80] See C. R. McConnell, S. L. Brue, and S. M. Flynn, *Economics: Principals, Problems, and Policies* (New York, NY: McGraw Hill, 2015), p. 5.

choose to require a subscription, payment, or personal information to access that Remote ID USS."[81] The FAA also states:

> A loss leader is a product or service that is offered at a price that is not profitable, but it is sold to attract new customers or to sell additional products and services to those customers. Loss leading is a common practice when a business first enters a market. *Although this may affect the price to the UAS operator it would not reduce the social cost of the rule*. Other models could include advertising overlays or selling appropriate user data.[82]

63. Yet, when calculating the societal burden related to the Remote ID USS, the FAA contradicts its own statements. The FAA assumes that Remote ID USS might not cause a societal burden because it anticipates that "some Remote ID USS may choose to offer their services for free."[83] This is wrong even according to the FAA's own findings. Consumers will pay for the service even if it is not offered under a subscription fee based model.

64. A Remote ID USS can pursue a multitude of pricing strategies that include no monthly cost but "would not reduce the social cost of the rule."[84] I highlight four possible strategies. First, the cost of the Remote ID USS could be included in the purchase price of the UAS or in the price of UAS service. If included in the UAS purchase price, this would be similar to the approaches pursued by several of the IoT tracking services shown in Table 3 that charge an upfront fee only and no monthly fee. However, society still bears the cost of the Remote ID USS because instead of a monthly subscription fee, the burden is included in the initial purchase price. If the Remote ID USS access fee were part of a UAS service, it would be considered a cost of doing business and would be included in the UAS service

[81] Remote ID NPRM, p. 168.
[82] Preliminary Analysis, n. 118 (emphasis added).
[83] Remote ID NPRM, p. 168.
[84] Preliminary Analysis, n. 118.

price. This is like the approach pursued by UPS and FedEx that routinely incur large amounts of parking fines but simply consider this a cost of doing business.[85] Just because the parking fine is part of the service fee does not mean that the fine was annulled. Similarly, just because a UAS service provider elects to include the Remote ID USS access fee in its service fee does not imply that there is no societal burden from said cost.

65. Second, the cost of the Remote ID USS could also be used as part of a *freemium model* in which drone users obtain basic access at no charge (e.g., time or UAS count limited), but they would have to pay an additional fee if it required full Remote ID access. For instance, UAS software developer Kittyhawk explains, "[P]eople clearly value some features and services enough to pay a subscription fee for them, such as better user experiences, great design, work flows, or data."[86] Under this approach, society still pays for the Remote ID USS—the burden may be spread differently and may be carried only by those electing to upgrade—but it still exists.

66. Third, a Remote ID USS supplier might also opt to provide free access to increase demand for its products. Again, Kittyhawk states that it "offers all auto-approval LAANC capabilities for recreational and commercial authorization for free."[87] Presumably, the software developer does so because it lowers entry barriers and thus raises the demand for UAS, including UAS software. Under this approach, society carries the societal burden for

[85] "Delivery firms' big ticket item: Parking fines," *Associated Press*, September 1, 2006, http://www.nbcnews.com/id/14602712/ns/business-us_business/t/delivery-firms-big-ticket-item-parking-fines/#.XlW3mmg3k2x.

[86] Andrew Elefant, "Separating Fact and Fiction About the Remote ID for Drone NPRM," Kittyhawk, January 21, 2020, https://kittyhawk.io/blog/separating-fact-and-fiction-about-the-remote-id-for-drone-nprm/.

[87] Ibid.

the Remote ID USS through higher retail prices as an increase in demand yields an increase in market price, holding everything else constant.

67. Fourth, as the FAA acknowledges, "It is unclear if a USS would also sell other UAS services or advertising to users and third parties.[88] However, "The FAA anticipates that the Remote ID USS would recoup the costs of providing services either through the sale of subscriptions for remote identification services, online advertising, or 'value added' services that can be purchased from the service provider."[89] Thus, a Remote ID USS supplier could elect to offer the service at zero monthly costs and earn a return on its capital through selling advertising. This, once more, does not imply that there is no societal burden from the Remote ID USS requirement. Rather, the societal burden comes in the form of prolonged advertising exposure, which in turn drives down demand and thus economic activity. For instance, as demonstrated in a recent economic study analyzing consumer reactions to increased advertising exposure on search engines, "on average, consumers are willing to trade 1.5 searches to avoid one second of advertising."[90]

68. Whether a Remote ID USS opts to pursue these or other pricing strategies, the societal burden is the same and thus must be included in the cost calculation. The provisioning of the system is complex and costly, and UAS users will have to pay for it one way or another. Moreover, unlike the LAANC system, the Remote ID USS is a government mandate and those who seek to fly a UAS weighing more than 0.55 pounds cannot legally avoid it. This implies that the zero monthly costs currently stipulated in the FAA's net cost calculation are wrong. Rather, as shown in the market evidence presented above, UAS owners will

[88] Preliminary Analysis, n. 173.
[89] Ibid., p. 150.
[90] Christian Dippon, "Economic Value of Internet Intermediaries and the Role of Liability Protections," June 5, 2017, p. 14.

have to pay the equivalent of $9.83, whether this is in the form of a monthly subscription, an increased UAS price, a freemium model, advertising exposure, or some other pricing strategy.

3. Obsolescence Costs

69. The FAA also underestimates the costs arising from the premature obsolesce of UAS. The proposed rule will make a portion of the UAS fleet unusable because some will not meet the new identification requirement standards rendering those units not usable. The FAA believes a portion of the existing fleet can be retrofitted to comply with these requirements (e.g., by a software update or *push* through the Internet), which could be achieved within the first year after the effective date of the final rule. The FAA estimates at least 93 percent of the current Part 107 fleet and at least 20 percent of the current recreational fleet would be eligible for retrofits.[91]

70. The FAA estimates the cost of UAS obsolescence (measured as aircraft that cannot be retrofitted) to be $4.63 million for recreational flyers and $4.24 million for nonrecreational (Part 107) operators.[92] The FAA uses 2.4 and 1.4, respectively, as the number of aircraft owned by each Part 107 operator and each recreational flyer.[93] In addition, it assumes an "average lifespan for unmanned aircraft operated by these two groups is three years based on FAA research related to the … annual aerospace forecast, UAS registration information, information from recreational and model unmanned aircraft owners, and a review of literature."[94] Costs are measured as the portion the consumer paid for the UAS. The FAA underestimates these costs in several ways.

[91] See Remote ID NPRM, p. 211.
[92] Preliminary Analysis, pp. 186-187, Table G2 and Table G3.
[93] Remote ID NPRM, p. 193.
[94] Ibid, pp. 193, 194.

71. First, the FAA only measures the loss for UAS purchased in year one even though UAS manufacturers are only required to produce Remote ID compliant UAS after year two.

> This proposal envisions that within three years of the effective date of this rule, all UAS operating in the airspace of the United States will be compliant with the remote identification requirements. No UAS could be produced for operation in the United States after two years and no UAS could be operated after three years except in accordance with the requirements of this proposal.[95]

Keeping all other FAA assumptions as is, adding year two would increase the societal costs of obsolescence by $3.31 million to $7.90 million for recreational UAS and by $6.49 million to $11.26 million for nonrecreational (Part 107) UAS.

72. Second, although the FAA states that some 20 percent of the current recreational fleet can be retrofitted, in its calculation, it uses the inverse of this amount and thus incorrectly assumes a retrofit rate of about 80 percent. Correcting for this error increases year one obsolescence from the FAA's $4.63 million to $16.12 million and including year two obsolescence of $11.62 million increases the total societal cost to $27.74 million, significantly above the $8.87 million calculated by the FAA.

73. The actual societal burden related to early UAS obsolescence is likely significantly higher than even the corrected $27.74 million. This calculation assumes a retrofit rate of approximately 20 percent.[96] However, I understand that the FAA received this industry estimate *prior* to informing UAS manufacturers of the proposed manufacturing compliance certification mandate. Requiring manufacturers not only to update the software of the UAS but also to certify that it complies with the Remote ID mandate likely reduces the retrofit percentage to zero because a manufacturer is unlikely to certify the performance of a

[95] Ibid, p. 9.
[96] Preliminary Analysis, p. 75.

product it has already sold and no longer controls. If so, the societal burden with respect to retrofitting costs increases to $298.44 million using the FAA's forecast—over 33 times the FAA's estimate.

C. FAA's Cost Model Incorrectly Treats Consumer Demand as Inelastic

74. The law of demand teaches that if the price of a product increases and all else remains equal the quantity demanded of that product decreases. There are a few exceptions to this economic principle, which are restricted mostly to life essentials (e.g., gas, water, clothing, food, etc.). Consumer reactions differ across products and services as well as across consumers. Economists measure consumer responsiveness to price changes with the price elasticity of demand. This metric is simply the ratio of the percentage change in quantity demanded and the percentage change in price. This ratio is typically negative. A price elasticity of less than unity is referred to as inelastic demand, whereas a product with a price elasticity larger than unity is subject to elastic demand (i.e., if the price goes up then demand goes down).

75. The FAA's net cost calculation appears to assume that UAS manufacturers will pay for all cost increases resulting from the Remote ID rule *and that any cost increases in the final products will not affect the demand for UAS*. That is, the FAA presumes that UAS demand is either price inelastic or that drone manufacturers will absorb all costs associated with the Proposal and leave prices unchanged, ignoring any manufacturing cost increases. These suppositions are not realistic. UAS manufacturers operate in a competitive market.[97] In a competitive market, manufacturers must pass cost increases through to consumers in the

[97] See, for example, "Unmanned Aerial Vehicle (UAV) Market - Size, Share, Competitive Analysis, Statistics, Regional and Global Forecast to 2023," *TMCnet.com*, September 3, 2019, https://www.tmcnet.com/usubmit/-unmanned-aerial-vehicle-uav-market-size-share-competitive-/2019/09/03/9009945.htm.

form of higher prices and/or reduced functionality. Moreover, it is not reasonable to believe that UAS demand is inelastic and that consumers will simply accept higher prices for UAS retail products or increased monthly recurring charges. Rather, consumers will opt to purchase substitute products, or they will stay out of the relevant market altogether (i.e., not buy). UAS are generally considered a discretionary purchase. The nonmonetary costs imposed on consumers from having to accept that their flight data and remote station locations are available not only to the government but also the public will further reduce demand. Thus, when measuring the cost of the Remote ID Proposal, there are two parts.

76. The first part measures the reduction in demand and the associated reduction in UAS activity. The second part applies only to those consumers who remain in the market and are willing to pay increased UAS prices as well as increased monthly subscription fees to a Remote ID USS and that are willing to forgo the privacy of their flight habits and their user locations.

77. The FAA seems aware of this fundamental omission in its net cost calculation because it "acknowledges that there may be a future loss of consumer surplus for individuals who forgo the purchase of a UAS because of these costs."[98] However, rather than measuring the price elasticity of demand for UAS and calculating the corresponding decline in UAS activity, the FAA treats the demand as inelastic. On the other hand, in its Preliminary Analysis, the FAA solicited "comment on the varying demand elasticities of consumers and how that may create allocative inefficiencies in the production and purchase of UAS."[99] Nevertheless, the FAA only noted this in its Preliminary Analysis; it did not mention this in the NPRM, which is a significant omission.

[98] Preliminary Analysis, p. 74.
[99] Ibid.

78. In order to estimate the impact of the Remote ID Proposal on consumer demand, I conducted a discrete choice analysis.[100] This analysis examines individual decision making in order to draw conclusions about market behavior in the world where the FAA plans to implement the Remote ID Proposal. There are two parts to the model selected for the present purpose. First, in a survey I asked consumers to make a series of choices from among sets of realistic hypothetical drones that varied on several attributes.[101] Attributes are price and non-price characteristics that describe a drone and include, among other things, the acquisition price, the monthly ownership (subscription) costs, camera specifications, weight, regulatory requirements, and (importantly) Internet connectivity. Second, I used a statistical model known as a mixed logit model to estimate how changes in the attributes of drones would affect consumer demand. For example, I calculated how an increase in monthly operating costs would affect the probability of purchasing a drone relative to an otherwise identical drone with a lower cost. Based on this analysis, I was able to estimate how the changes proposed by the Remote ID Proposal would reduce consumer demand for drones. Appendix B details the consumer survey and explains my statistical model, results, and evaluation. Appendix C contains a copy of the survey questions.

79. The results of the discrete choice model confirm that demand for UAS is elastic, not inelastic. Rather, for each percentage increase in UAS retail price, demand decreases approximately 0.25 percent, resulting in a retail price elasticity of −0.26. Further, for an increase in monthly subscription fees from $0 to $1, demand decreases 0.44 percent. UAS consumers also indicated their negative reception of the Remote ID Proposal's requirement

[100] See Kenneth E. Train, *Discrete Choice Methods with Simulation*, 2nd ed. (New York: Cambridge University Press, 2009).

[101] Surveys of this type are referred to as *conjoint analysis*.

to send their relevant data to the government and the public, further decreasing demand by nearly 5 percent.

80. To forecast, the cumulative decrease in demand from all three factors, I forecasted the demand difference from a $22.75 increase in the price of hobby and professional drones, a $9.83 monthly subscription charge, and a requirement to furnish the Remote ID elements to a service that is accessible to the government and the public. I based a $20 retail price increase on the increase in equipage costs (consisting of computer chip, software, and tamper proofing) estimated by the FAA and a $2.75 drone registration based on the additional drone sales estimated by the CTA.[102] The derivation of the $9.83 is explained in Section V.B.2.

81. As shown in Appendix D, line 17, the cumulative effect of these additional costs caused by the proposed rule is a decrease in UAS demand of 10.6 percent. I apply this demand reduction to the revenue forecasts for hobby and professional drones (line 9), which I derived from information received from a combination of historical data from the CTA,[103] industry research on current typical drone prices, and the FAA's fleet size forecast.[104] The units are estimated based on the CTA's estimated units for 2020, adjusted to reflect the CTA's estimated ownership split between toy drones and hobby/professional drones. These units are forecast to 2029 based on the FAA's forecast.[105] Revenue per drone is estimated from the CTA's per unit estimate for 2020, adjusted to exclude the average price

[102] Measures incremental drone costs. The estimation treats the first drone as being covered by the $5 registration already paid.

[103] Consumer Technology Association, "U.S. Consumer Technology Sales and Forecasts 2015-2020," January 2020, slide 52; Consumer Technology Association, "Drones: Public Perceptions & Consumer Attitudes," 2018, slide 16.

[104] Preliminary Analysis, p. 61, Table 4a.

[105] The FAA's estimate runs until 2028 and was extended one year.

of a toy drone.[106] The average price for hobby and professional drones is increased at the average historical rate for 2015–2020 as reported by the CTA. The decrease in the demand for both hobby and professional drones produces an uptick in demand for toy drones because some consumers will substitute between these categories of drones. The offsetting amount is shown in Appendix D, line 11. Discounted over 10 years, the impact on demand results in a reduction of drone-related activities in the amount of about $1.8 billion.

D. FAA's Cost Model Omits Several Critical Cost Elements

82. The FAA's cost calculation omits at least two additional critical cost elements: (1) local law enforcement related costs caused by the drone usage data becoming publicly available and (2) consumer support costs related to the FAA's proposed Internet Remote ID USS. Per the FAA's own objective of ensuring that the benefits from the change outweigh the costs and thus are in the public interest, an accurate net cost calculation must include these costs.[107]

1. Local Law Enforcement Related Costs

83. The introduction of the Remote ID rule will significantly increase drone-related complaints to local law enforcement agencies. Local law enforcement agencies and communities will have to bear the related additional costs of responding to the complaints. Thus, unlike the costs discussed thus far, enforcement costs are not directly borne by UAS operators but by law enforcement agencies and local communities. The same degree of accuracy achieved in estimating consumer costs is not possible when estimating enforcement costs.

[106] The average price of toy drones is estimated at $50. (NERA review of Amazon and Best Buy websites.)
[107] Remote ID NPRM, p. 187.

Nevertheless, a proper cost estimation model must account for them. However, these costs are missing from the FAA's net cost estimate.

84. The FAA "acknowledges that there is a potential uncertainty in the volume type of reports it may receive following the implementation of Remote ID that may be driven by the improved ease of identifying and reporting UAS operations as well as potential deterrent effects."[108] The FAA also notes, "State and local Law Enforcement Agencies (LEA) are often in the best position to deter, detect, immediately investigate, and, as appropriate, pursue enforcement actions to stop unauthorized UAS operations."[109] These agencies are also "in the best position to identify potential witnesses and conduct initial interviews" as well as "to contact the suspected operators of the aircraft" and to document the evidence.[110] The FAA also expects that local law enforcement agencies "should become familiar with the steady-state airspace restrictions," promptly report violations to the FAA, and assist in "preserving any public or private security systems that may provide photographic or other visual evidence of UAS operations."[111]

85. The anticipated increase in costs related to drone investigations, community outreach, and law enforcement training could be substantial as drone-related activities increase whereas the ease of reporting such activities (legal and illegal) becomes significantly easier. Estimating these costs is difficult because of the lack of relevant data and benchmarks. However, several potential scenarios help illustrate the potential large magnitude of these costs. For example, after the introduction of an app for reporting noise-related complaints

[108] Preliminary Analysis, p. 120.
[109] U.S. Department of Transportation, Federal Aviation Authority, "Law Enforcement Guidance for Suspected Unauthorized UAS Operations," undated, p. 1 (footnotes omitted).
[110] Ibid, p. 6.
[111] Ibid, pp. 6, 7.

at Baltimore/Washington International Thurgood Marshall Airport (BWI), the noise-related complaint rate tripled from 6 percent to 22 percent. Not all complaints result in an investigation; however, they all impose a burden on local law enforcement and communities. In the State of Maryland, the complaints resulted in legal action against the FAA regarding the flight path, and the FAA and local community leaders formed roundtables to address the noise issue.[112] The noise-related complaint rates at Washington Dulles (IAD) and Reagan National (DCA) bracket those at BWI at 1.8 percent and 26 percent, respectively.[113]

86. The FAA estimates that it spends on average 8.7 hours and a median of approximately 2.5 hours per investigation.[114] No information exists as to how many drone-related complaints the local authorities receive. The FAA reports that in 2018 it conducted 2,002 investigations.[115] At an estimated 265 million flights per year,[116] this implies a complaint rate (to the FAA) of a small fraction of a percent. The FAA referred many of these complaints to local and federal law enforcement agencies. Table 5 illustrates the sensitivity of the societal burden imposed by drone-related regulation in five different scenarios and contrasts them relative to the baseline.

[112] See Lori Aratani, Complaints about noise from Washington-area airports skyrocket, *The Washington Post*, November 23, 2018.

[113] Ibid. Noise-related complaint rates calculated by dividing the total number of complaints at each airport by the total annual flights (arrival and departures) at each airport.

[114] See Preliminary Analysis, Tables 25 and 26.

[115] See Remote ID NPRM, p. 197.

[116] Based on the FAA owner estimate for year four of 1,221,636, which is the first year the system is fully operational. (See Preliminary Analysis, Table 8a; NERA Drone Survey, Questions 8.a and 8.b.)

Table 5: Local Law Enforcement and Community Cost Scenarios

Scenario	Rate	Volume	Hourly Burden	Incremental Social Time Burden		Net Present Value (10-years; 3%)	
				8.7 hours	2.5 hours	8.7 hours	2.5 hours
		(thousand)		(thousand)		(thousand)	
Baseline	0.001 %	265,000	$ 73.00	$ 1,271	$ 365	$ 10,846	$ 3,117
1	0.076	265,000	73.00	125,876	36,171	1,073,744	308,547
2	0.755	265,000	73.00	1,270,199	365,000	10,835,053	3,113,521
3	0.018	265,000	73.00	29,023	8,340	247,570	71,141
4	0.22	265,000	73.00	368,992	106,032	3,147,575	904,476
5	0.026	265,000	73.00	42,487	12,209	362,422	104,144

Sources: Remote ID NPRM, p. 197; Preliminary Analysis, n. 154, Table 8a; NERA Drone Survey, Questions 8.a and 8.b.

87. The baseline scenario represents the FAA's current costs and assumes that they are indicative of the societal burden. This is likely a significant underestimation of actual law enforcement and community costs because it only reflects UAS-related complaints filed with the FAA. Using the FAA's average and median investigation length and its hourly rates as a proxy for the societal burden indicates that the baseline (current) annual societal burden is $1.23 million on average or $10.85 million discounted over 10 years.[117] A reasonable assumption is that the increase in UAS-related activities and the ease of reporting a complaint will increase the complaint rate a hundredfold. As depicted in Scenario 1, the complaint rate would still be less than 1 percent and far below the noise-related complaint rates observed at BWI, IAD, and DCA airports. Under this conservative scenario, law enforcement and community costs could equal $1.07 billion over the next decade. It is important to highlight that counter to the FAA's expectations it is unlikely that investigation times will decrease following the implementation of the Remote ID rule. Remote ID assists in locating and identifying UAS and UAS operators. This, in turn, will

[117] Remote ID NPRM, p. 197; Preliminary Analysis, n. 154, Table 8a; NERA Drone Survey, Questions 8.a and 8.b.

likely *increase* investigation times as absent said information, many investigations would be aborted in its initial phases as the UAS and its operator could not be located.

88. Scenarios 2, 3, and 4 assume that UAS-related complaints will mirror those observed at the three airports. Although, there is no evidence that UAS-related complaints will reach these levels, they serve to illustrate the sensitivity and thus importance of considering and investigating these costs in any net cost calculation.

2. Customer Support Costs

89. Implementing the Remote ID rule will also likely increase the customer support costs for UAS manufacturers. Absent the proposed rule, the entire UAS experience rested with the UAS manufacturer who directly controlled the technical capabilities of the UAS. However, post implementation the UAS experience is also a function of the Remote ID USS, which directly affects the flight experience. For instance, per the FAA's proposal, "Limited" category drones with no broadcasting function and no Internet connectivity will not take off. Similarly, under the proposal, for a Standard Remote ID UAS, a technical failure on the part of a USS will manifest as an inability of the UAS to take off, even if it is broadcasting ID and even though the internet is available. The UAS operator in either of these scenarios might mistake these *designed* operational limitations as a product failure and file a complaint with the UAS manufacturer or return the equipment altogether. To minimize these occurrences, UAS manufacturers must not only train their support staff and educate the UAS consumer but also increase their customer service staff. This, in turn, increases production costs and, once more, yields an increase in UAS prices and a reduction in demand. The FAA's net cost estimation also omits this cost consideration.

90. No data exist on the additional societal burden created by this missing cost item. However, the number can be approximated using complaint rates from the telecommunication sector as a proxy. Specifically, the Australian Communications and Media Authority (ACMA) tracks the number of complaints received by large and medium-sized Australian mobile wireless providers. During the July 2018 to June 2019 period, the ACCC reported 58 mobile wireless complaints per 10,000 services.[118] A service could be a voice call, a data session, or sending and receiving an SMS. These data imply a complaint rate of 0.0058, or just over half a percent. According to the Harvard Business Review, the average cost of a live service contact is $10.[119] Using the Australian mobile wireless complaint rate and applying to it the $10 service cost estimate, the size of the US fleet, and the number of forecasted flights per UAS, indicates an additional societal burden from additional customer services costs in the amount of $80 million over the next decade.

E. The Proposal's Costs Yields Societal Costs in the Amount of $5.6 Billion

91. As summarized in Table 6, the total costs of the Remote ID Proposal are approximately $5.6 billion, which is more than nine times the FAA's estimate.

[118] ACMA, "Telecommunications complaints handling 2018 to 2019," October 2019, Table 1.
[119] M. Dixon, L. Ponomareff, S. Turner, and R. DeLisi, "Kick-Ass Customer Service," *Harvard Business Review*, January–February 2017.

Table 6: Remote ID Proposal Net Societal Cost Estimates

Cost Category	NPV (10 years; 3%) ($ billion)
Reduction in drone-related activity	1.79
Incremental consumer costs	2.58
Local law enforcement and community costs	1.07
Customer support costs	0.08
Other (registration and obsolesce)	0.05
Total Costs to Society	5.57

Source: NERA Research.

92. Specifically, as explained in Section V.C, the Proposal results in a reduction in drone-related activity in the amount of $1.8 billion. With a demand reduction of 10.6 percent, the remaining 89.4 percent of UAS purchasers will pay an additional $22.75 per drone. With a useful life expectancy of three years, consumers will incur an additional $156 million over 10 years. Consumers will also pay $9.83 per month to send their Remote ID elements to the FAA-designated service, which will cost consumers an additional $2.4 billion over 10 years. The combined effects are close to $2.6 billion over 10 years. No additional mobile wireless charges are required as this subscription model includes the costs of the mobile wireless data link. In addition, society will have to pay for local law enforcement agencies and related costs as communities respond to the increased drone complaints in addition to educating themselves and their constituents. As explained previously, a precise estimate is difficult to calculate but a conservative assumption indicates costs in excess of $1 billion. Finally, the additional customer support, registration fees and premature obsolesce of UAS will further increase the societal burden. In total, it is reasonable to expect that the FAA's Remote ID Proposal will generate a societal burden of $5.6 billion over 10 years or $557 million per year.

VI. FAA PROPOSAL HAS NO QUANTIFIABLE BENEFITS

93. The FAA asserts societal benefits consisting of the improved safety and security of U.S. airspace and expanded operations and UAS integration. Although it is reasonable to anticipate some safety and security benefits from the Remote ID Proposal, these benefits are not quantifiable; therefore, the FAA cannot directly attribute them to the Proposal. Further, the FAA provides no evidence that expanded operations are contingent on the Remote ID Proposal.

94. The FAA anticipates that this Proposal will:

- provide situational awareness;
- provide information to distinguish legal and illegal UAS;
- enable law enforcement to obtain real-time UAS traffic data; and
- promote accountability through the registration of each UAS.[120]

95. The alleged benefits are vague. More important, it is unlikely that the Remote ID Proposal can achieve all of this. As described in the industry literature, "Drones with obstacle detection and collision avoidance sensors are becoming more prevalent in both the consumer and professional sectors. This year, we have quite a few drones with collision avoidance technology."[121] Drones with collision avoidance technology do not require Remote ID data. Further, this technology has significant advantages over the Remote ID Proposal.

96. Situational awareness through the Remote ID Proposal only offers benefits if all "other aircraft in the vicinity of those operations" have real-time access to the Remote ID elements

[120] See Remote ID NPRM, p. 33.

[121] Fintan Corrigan, "12 Top Collision Avoidance Drones and Obstacle Detection Explained," *DroneZon*, January 5, 2020, https://www.dronezon.com/learn-about-drones-quadcopters/top-drones-with-obstacle-detection-collision-avoidance-sensors-explained/.

of all drones.[122] This is unlikely especially if an aircraft is not subject to the Remote ID rule (e.g., UAS weighing less than 0.55 pounds, manned aircraft, etc.). Therefore, the Remote ID Proposal will not be of much use for obstacle avoidance.

97. The FAA also asserts that the proposed rule will (1) assist in expanding UAS usage by allowing flights over people and during nighttime hours, (2) offer the necessary data for additional operational capabilities including collision avoidance systems, and (3) provide data for a comprehensive data traffic-management system.[123] Similar to the FAA's other asserted societal benefits these benefits are vague. The FAA is dealing with flights over people and at night in another NPRM.[124] The operational capabilities for collision avoidance are also being addressed separately. Consider, for example, Project Wing developed by Google's parent company Alphabet. Driven by market forces and thus unrelated to the proposed rule, Project Wing is an autonomous delivery service designed to fly beyond the visual line-of-sight (BVLOS) using video imaging for navigation.[125] Project Wing also is "developing an unmanned traffic management platform that will allow unmanned aircraft to navigate around other drones, manned aircraft, and other obstacles like trees, buildings and power lines."[126] As part of its collision avoidance system, "Wing's software informs its aircraft where and how to fly, and can allow other commercial and recreational drone users to safely access the sky."[127]

---

[122] Remote ID NPRM, p. 33, Table 3.

[123] Ibid, pp. 33, 34.

[124] "On February 13, 2019, the FAA published a notice of proposed rulemaking titled "Operation of Small Unmanned Aircraft Systems over People," (84 FR 3856) in which the FAA proposed to allow operations of small unmanned aircraft over people in certain conditions and operations of small UAS at night without obtaining a waiver." (Ibid, n. 8.)

[125] Alan Levin, "Google Spinoff's Drone Delivery Business First to Get FAA Approval," *Bloomberg.com*, April 23, 2019, https://www.bloomberg.com/news/articles/2019-04-23/alphabet-s-drone-delivery-business.

[126] Wing, "Transforming the way goods are transported," https://x.company/projects/wing/ (accessed February 20, 2020).

[127] Wing Aviation LLC. https://wing.com (accessed February 20, 2020).

98. Finally, the FAA estimates that it will save $57 million over the next decade in reduced investigation costs. This is another unlikely benefit. As discussed in Section V.D.1, although it is reasonable to assume that the Remote ID elements most likely will reduce the time for each investigation, the ease of reporting a UAS will yield a significant increase in the number of investigations similar to what happened with the mobile app for noise-related complaints at airports. The FAA offers no insight as to the anticipated future volume in complaints and accordingly cannot support a net cost savings with respect to future investigations.

VII. A REVISED PROPOSAL PRESENTS AN ECONOMICALLY SUPERIOR SOLUTION

99. Considering the evidence, including direct survey responses from past and future UAS purchasers, the proposed Remote ID rule will result in a significant societal burden. This burden is at least $4.4 billion and likely as high as $5.6 billion, which is far in excess of the FAA's $582 million estimate. The Proposal's benefits are less clear. Although one cannot rule out some societal benefits, at least a portion of these benefits will materialize because of induced innovation by market forces irrespective of the FAA's Proposal.

100. With strong negative societal repercussions and speculative offsetting benefits, the FAA needs to revise the Proposal because it contradicts the agency's aim of developing an NPRM "that will be most cost effective for small UAS."[128] It is also inconsistent with Executive Order 13563, which, among other things, requires that the proposed rule (1) be

[128] Daniel K. Elwell (Acting Administrator FAA) letter to Senator Roger Wicker, re: progress in meeting the requirements of Section 2202 of the 2016 FAA Extension, Safety, and Security Act., February 13, 2019.

based on a reasoned determination that the benefits justify the costs, (2) imposes the least burden on society, and (3) selects an approach that maximizes net benefits.[129]

101. A simple solution exists that preserves some or all of the benefits the Proposal might bring whereas minimizing its negative side effects. Economists call such a revision Pareto optimal because it makes all involved parties better off and no party worse off. Per the Remote ID Proposal, "a 'standard identification UAS' is a UAS with remote identification capable of both: (1) connecting to the internet when transmitting through that internet connection to a Remote ID USS; and (2) broadcasting directly from the unmanned aircraft."[130] The improvement entails a simple modification. Instead of requiring both capabilities, the FAA needs to require only one so that the UAS can connect to the Internet *or* broadcast directly. The improvement would also eliminate the need for a "Limited Remote Identification UAS" because it would be no longer required.[131]

102. This simple change to the proposed rule stands to decrease significantly the Proposal's costs.

- It eliminates the monthly access charge to the Remote ID USS. This change reduces the demand impact from 10.6 percent to 6.2 percent. It also lowers the additional out-of-pocket expenses for UAS purchasers who would remain in the market from $9.83 to zero, thereby reducing this portion of the societal costs from $2.6 billion to as low as $156 million. Taken together, this could reduce the Proposal's costs by up to $3.3 billion.

- It reduces the $20 anticipated retail cost increase for hobby and professional drones by not requiring all drones with dual Internet and broadcast capabilities. Assuming an even split in costs between the two, a single remote transmission medium would add $10 to the purchase price of a UAS. This change reduces the demand impact from 10.6 percent to 10.1 percent. It also lowers the additional out-of-pocket expenses for

[129] The White House, Office of the Press Secretary, "Executive Order 13563 – Improving Regulation and Regulatory Review", January 18, 2011, https://obamawhitehouse.archives.gov/the-press-office/2011/01/18/executive-order-13563-improving-regulation-and-regulatory-review.

[130] Remote ID NPRM, pp. 13, 14.

[131] Ibid, pp. 15, 16 for the definition of a Limited Remote Identification UAS.

UAS purchasers who would remain in the market by $10 per drone, thereby reducing this portion of the societal costs from $2.6 billion to $2.5 billion. Taken together, this could reduce the Proposal's costs by over $100 million.

103. At the same time, the modification would preserve most, if not all, of the anticipated benefits. The revised proposal still adds to safety and security. Situational awareness would be untampered by the revision because other aircraft in the vicinity of the UAS would still receive the relevant locational information from the UAS. The FAA and law enforcement agencies could still distinguish compliant drones from illegal drones. The registration requirement remains unchanged.

VIII. CONCLUSION

104. Based on the analyses and considerations discussed herein, it is my expert opinion that the FAA significantly understated the societal burdens of its proposed Remote ID rule and failed to demonstrate adequately the material societal benefits. My calculations show that the costs of the Remote ID Proposal are at least $4.4 billion and could be as high as $5.6 billion, which is over nine times the $582 million estimated by the FAA. I find that most of the FAA's stated benefits would materialize even without a Remote ID mandate because many have already materialized.

105. I recommend that the FAA revise its Remote ID Proposal by making standard drone usage subject to *either* an Internet *or* broadcast requirement. With this revision, UAS users have a choice of sending their Remote ID elements via the Internet to a Remote ID USS *or* broadcasting the same information over the local airwaves. I conclude that this revision is Pareto optimal because it minimizes societal costs and does not materially affect the Remote ID Proposal's measurable benefits.

Washington, DC, March 2, 2020

By: 

Christian Dippon

APPENDIX A: CURRICULUM VITAE OF CHRISTIAN M. DIPPON, PH.D.

Christian M. Dippon, PhD

CHAIR, NERA'S GLOBAL ENERGY, ENVIRONMENT, COMMUNICATIONS & INFRASTRUCTURE PRACTICE

Dr. Dippon is a Managing Director at NERA and a leading authority in complex litigation disputes and competition matters in the communications, Internet, and high-tech sectors. He is also the Chair of NERA's Global Energy, Environment, Communications & Infrastructure (EECI) Practice, where he leads over 100 experts in the areas of energy, communications, media, Internet, environment, auctions, transport, and water. Global Arbitration Review (2019, 2020) ranks Dr. Dippon among the world's leading commercial arbitration experts (see https://whoswholegal.com/christian-dippon).

Dr. Dippon advises his clients in economic damages assessments, class certifications and damages, false advertising, antitrust matters, and regulatory and competition issues. He has extensive testimonial and litigation experience, including depositions, jury and bench trials in state and federal courts, domestic (AAA) and international arbitrations (UNCITRAL, ICC, ICSID), and submissions before international courts. He assists clients with a broad range of litigation disputes related to wireline, wireless, cable, media, Internet, Internet of Things (IoT), consumer electronics, and the high-tech sector. Dr. Dippon also routinely testifies before US and international regulatory authorities, including the Federal Communications Commission, the Federal Aviation Administration, the International Trade Commission, the Canadian Radio-television and Telecommunications Commission, and the Competition Bureau Canada.

Dr. Dippon has authored and edited several books as well as book chapters in anthologies and has written numerous articles on telecommunications competition and strategies. He also frequently lectures in these areas at industry conferences, continuing education programs for lawyers, and at universities. National and international newspapers and magazines, including the *Financial Times*, *Business Week*, *Forbes*, the *Chicago Tribune*, and the *Financial Post*, have cited his work.

Dr. Dippon serves on NERA's Board of Directors, the Board of Directors of the International Telecommunications Society (ITS), and on the Editorial Board of *Telecommunications Policy*. He is a member of the Economic Club of Washington, DC, the American Economic Association (AEA), the American Bar Association (ABA), and the Federal Communications Bar Association (FCBA).

EDUCATION

Curtin University, Perth, Australia
PhD in Economics, 2011

University of California, Santa Barbara, CA, USA
MA in Economics, 1995

California State University, Hayward, CA, USA
BS *cum laude* in Business Administration, 1993

THESIS

"Consumer Preferences for Mobile Phone Service in the U.S.: An Application of Efficient Design on Conjoint Analysis," Curtin University, 2011.

Committee: Dr. Gary Madden, Curtin University; Dr. Kenneth Train, University of California at Berkeley; Dr. Ruhul Salim; Curtin University.

Blind reviews by Dr. Jerry Hausman, Massachusetts Institute of Technology and Dr. Glenn Woroch, University of California at Berkeley.

PROFESSIONAL EXPERIENCE

NERA Economic Consulting

2017–present	Chair, NERA's Global Energy, Environment, Communications & Infrastructure (EECI) Practice
2017–present	Member, Board of Directors, NERA Economic Consulting
2014–present	Senior Vice President / Managing Director
2014–2017	Co-Chair, Communications, Media & Internet Practice
2015–2017	Head, NERA Washington, DC
2014–2015	Co-Head, NERA Washington, DC
2012–2014	Chair, Communications, Media & Internet Practice
2004–2014	Vice President
2000–2004	Senior Consultant
1998–2000	Consultant
1997–1998	Senior Analyst
1996–1997	Analyst

BMW Thailand

1993–1994	Business Analyst

HONORS AND PROFESSIONAL ACTIVITIES

Member, International Bar Association (IBA)

Member, The Economic Club, Washington, DC

Editorial Board, Telecommunications Policy

Board of Directors, International Telecommunications Society (ITS)

Assistant Treasurer, International Telecommunications Society (ITS)

Member, American Economic Association (AEA)

Member, Federal Communications Bar Association (FCBA)

Associate, American Bar Association (ABA)

Who's Who Legal Arbitration 2019, Expert Witness

TESTIMONY IN REGULATORY AND JUDICIAL PROCEEDINGS (2010–PRESENT)

ON BEHALF OF [CONFIDENTIAL SATELLITE INDUSTRY]

In the Matter of an Arbitration und the Rules of Arbitration of the International Centre for Settlement of Investment Disputes, ICSID Case No. [Confidential], [Confidential], Claimant against [Confidential], Respondent against [Confidential], (Expert Report on Behalf of Claimant], January 9, 2019 (Economic Damages).

ON BEHALF OF [CONFIDENTIAL CONSUMER ELECTRONICS]

In the Matter of an Arbitration under the Rules of Arbitration of the International Chamber of Commerce, ICC Case No. [Confidential], [Confidential], Claimant against [Confidential], Respondent against [Confidential], Counterclaim-Respondent, July 6, 2018 (Expert Report on Behalf of Respondent], November 16, 2018 [Second Expert Report on Behalf of Respondent], December 20 – 21, 2018 [Oral Testimony on Behalf of Respondent] (Economic Damages).

ON BEHALF OF ALCATEL-LUCENT USA INC.

In the Superior Court of California, County of Santa Clara, *In re: Alcatel-Lucent USA Inc. v. Brilliant Telecommunications, Inc., Juniper Networks, Inc., et al.*, December 7, 2012, December 13, 2012, February 21 and 25, 2013. (Economic damages)

ON BEHALF OF AT&T ALABAMA

Before the Federal Communications Commission, Washington, DC 20554, BellSouth Telecommunications, LLC d/b/a AT&T Alabama, Complainant v. Alabama Power Company, Defendant, Proceeding No. 19 - 119, Bureau ID No. EB-19-MD-002, Affidavit of Christian M. Dippon, Ph.D., In Support of Pole Attachment Complaint, April 16, 2019, Reply Declaration of Christian M. Dippon, Ph.D., In Support of Pole Attachment Complaint, July 19, 2019 (Regulatory Rate Dispute / Industry Expertise)

ON BEHALF OF AT&T FLORIDA

Before the Federal Communications Commission, Washington, DC 20554, BellSouth Telecommunications, LLC d/b/a AT&T Florida, Complainant v. Florida Power and Light Company, Defendant, Proceeding No. 19 - __, Bureau ID No. EB-19-MD-___, Affidavit of Christian M. Dippon, Ph.D., In Support of Pole Attachment Complaint, June 28, 2019. (Regulatory Rate Dispute / Industry Expertise)

ON BEHALF OF BELL MOBILITY

Before the Superior Court, Province of Quebec, District of Montreal, In the Matter of *Gagnon vs. Bell Mobility*, No: 500-06-000496-105, October 25, 2013, March 14, 2014 (updated version from October 25, 2013, and April 2–3, 2014. (Economic damages)

ON BEHALF OF CALINNOVATES

Before the Federal Communications Commission, Washington, DC, In the Matter of Expanding Consumers' Video Navigation Choices, MB Docket No. 16-42, Commercial Availability of Navigation Devices, CS Docket No. 97-80, April 22, 2016 (Public policy), October 11, 2016. (Economic damages)

Before the Federal Communications Commission, Washington, DC, In the Matter of Protecting and Promoting the Open Internet, GN Docket 14-28, "Economic Repercussions of Applying Title II to Internet Services," White Paper, by Christian Dippon, PhD and Jonathan Falk, filed as attachment to the Reply Comments of CALinnovates, September 11, 2014. (Public policy)

ON BEHALF OF CELLCOM ISRAEL, LTD.

Before the Israel Ministry of Communications, Expert Report of NERA Economic Consulting, "Reply to Frontier's Responses, Estimating the Cost of Wholesale Access Service on Bezeq's Network," Christian Dippon with Marta Petrucci, Leen Dickx, and Howard Cobb (Finite State Systems), September 29, 2014. (Regulatory policy and cost modeling)

Before the Israel Ministry of Communications, Expert Report of NERA Economic Consulting, "Estimating the Cost of Wholesale Access Services on Bezeq's Network, A Cost Modeling Review," Christian Dippon with Nigel Attenborough, Marta Petrucci, Sally Tam, Anthony Schmitz, and Howard Cobb, March 10, 2014. (Regulatory policy and cost modeling)

ON BEHALF OF COMCAST CORPORATION

Before the Federal Communications Commission, Washington, DC, In the Matter of Restoring Internet Freedom, WC Docket No. 17-108, Notice of Proposed Rulemaking, White Paper, "Public Interest Benefits of Repealing Utility-Style Title II Regulation and Reapplying Light-Touch Regulation to Broadband Internet Services, July 17 and August 28, 2017. (Competition analysis)

ON BEHALF OF THE COMMERCE COMMISSION NEW ZEALAND

"Review of Covec's 'Economic Analysis of 700MHz Allocation,'" Christian Dippon with James Mellsop, Richard Marsden, and Kevin Counsell, February 14, 2014. (Regulatory policy and competition analysis)

ON BEHALF OF THE COMPETITION BUREAU CANADA

The Commissioner of Competition, Applicant and Chatr Wireless Inc, and Rogers Communications Inc., Respondents, Ontario Superior Court of Justice, June 13, 2012, July 25, 2012, August 15–16, 2012. (Economic damages)

ON BEHALF OF FPL GROUP INC.

In reference to *Adelphia Communications Corp., et al., Adelphia Recovery Trust, v. FPL Group Inc.*, United States Bankruptcy Court Southern District of New York, July 8, 2011, July 26, 2011, April 17, 2012, and May 2–3, 2012. (Competition analysis)

ON BEHALF OF MICROSOFT MOBILE OY AND NOKIA INC.

Before the United States International Trade Commission, In the Matter of Certain 3G Mobile Handsets and Components, Investigation No. 337-TA-613, September 12, 2014, October 3, 2014, October 15, 2014, November 21, 2014, December 12, 2014, and January 28, 2015. (Competition analysis)

Before the United States International Trade Commission, In the Matter of Certain Wireless Devices including Mobile Phones and Tablets II, Investigation No. 337-TA-905, June 26, 2014. (Competition analysis)

ON BEHALF OF MONSTER, INC.

Circuit Court of Cook County, Illinois County Department, Chancery Division, *Amy Joseph, individually and on behalf of all others similarly situated, Plaintiff, Benjamin Perez, individually and on behalf of all others similarly situated, Intervening Plaintiff vs. Monster, Inc., a Delaware Corporation and Best Buy Co, Inc., a Minnesota Corporation, Defendants*, Case No. 2015 CH 13991, September 9, 2016 and February 8, 2018. (Economic damages)

ON BEHALF OF NETLINK TRUST

Before the Info-communications Development Authority of Singapore (IDA), "The Appropriate Cost Methodology for Price Regulation of Interconnection Wholesale Fiber Services," Christian Dippon with Dr. Bruno Soria, December 15, 2015. (Regulatory policy)

ON BEHALF OF NOKIA CORPORATION AND NOKIA INC.

Before the United States International Trade Commission, In the Matter of Certain Wireless Devices with 3G and/or 4G Capabilities and Components Thereof, Investigation No. 337-TA-868, August 23, 2013, September 5, 2013, September 20, 2013, October 8, 2013, November 19, 2013, December 6, 2013, January 6, 2014, and February 18, 2014. (Competition analysis)

Before the United States International Trade Commission, In the Matter of Certain Integrated Circuit Devices and Products Containing the Same, Investigation No. 337-TA-873, August 30, 2013, September 16, 2013, and March 6, 2014. (Competition analysis)

ON BEHALF OF NOKIA SOLUTIONS AND NETWORKS US LLC

In the Matter of the Arbitration between *MTPCS, LLC d/b/a Cellular One vs. Nokia Solutions and Networks US LLC d/b/a Nokia Networks*, Before the American Arbitration Association, RE: 01-15-0003-5349, December 5–6, 2016 (Economic damages and competition analysis) and May 4, 2016. (Economic damages)

Before the American Arbitration Association, *Nokia Siemens Networks US LLC n/k/a Nokia Solutions Networks US, Plaintiff vs. Viaero Wireless a/k/a NE Colorado Cellular, Inc., Defendant*, Case No. 50 494 T 00510 13, May 27, 2014 and June 2, 2014. (Economic damages)

ON BEHALF OF QATAR TELECOM (QTEL)

In Connection with *Vodafone Qatar Q.S.C v. Qatar Telecom (Qtel) Q.S.C,* Pursuant to Dispute Resolution Agreement Dated 11 November 2010, January 20, 2011 and February 21, 2011. (Economic damages)

ON BEHALF OF SINGAPORE TELECOMMUNICATIONS LIMITED AND SINGAPORE TELECOM MOBILE PTE. LTD.

Before the District Court of Tangerang, "Economic Assessment and Examination of Alleged Anticompetitive Behavior in the Indonesian Mobile Market," Expert Report by Christian Dippon, Nigel Attenborough, and William Taylor, April 21, 2010. (Economic damages)

Before the Central Jakarta District Court, "Economic Assessment and Examination of Alleged Anticompetitive Behavior in the Indonesian Mobile Market," Expert Report by Christian Dippon, Nigel Attenborough, and William Taylor, Prepared for Singapore Telecommunications Limited and Singapore Telecom Mobile Pte. Ltd., January 15, 2010. (Economic damages and competition analysis)

ON BEHALF OF SONY COMPUTER ENTERTAINMENT AMERICA LLC

Before the United States District Court Northern District of California San Francisco Division, In Re Sony PS3 "Other OS" Litigation, Case No. CV-10-1811 SC, April 4, 2017 and June 7, 2017. (Economic damages)

ON BEHALF OF SPRINT COMMUNICATION COMPANY L.P., SPRINT SPECTRUM L.P., AND NEXTEL OPERATIONS, INC.

Before the United States District Court for the Eastern District of Pennsylvania, *Comcast Cable Communications, LLC; TVWorks, LLC, and Comcast Mo Group Inc. v. of Sprint Communication Company L.P., Sprint Spectrum L.P., and Nextel Operations, Inc.*, Civil Action No. 2:12-cv-00859-JD, July 15, 2015. (Economic damages), March 18, 2016 (Economic damages), February 14, 2017 (Economic damages and incremental cost modeling)

ON BEHALF OF SPRINT SPECTRUM LP AND WIRELESS CO. LP, NEXTEL COMMUNICATIONS INC., AND NEXTEL CALIFORNIA INC.

Superior Court of the State of California, County of Alameda, JCCP No. 4332, Case No. RG03114147, *Ayyad, et al. v. Sprint Spectrum Limited Partnership, et. al.*, Cellphone Termination Fee Cases, September 13, 2011, April 26, 2013, May 29, 2013, July 16, 2013, July 30, 2013, April 1, 2016, and January 29, 2016. (Economic damages)

ON BEHALF OF TELE FÁCIL MEXICO, S.A. DE C.V.

In the Matter of an Arbitration Under the North American Free Trade Agreement and The Arbitration Rules of the United Nations Commission on International Trade Law (1976) between *Joshua Dean Nelson, in His Own Right and On Behalf of Tele Fácil Mexico, S.A., De C.V., and Jorge Luis Blanco (the Claimants) and The United Mexican States (the Respondent),* ICSID Case No. UNCT/17/1, November 7, 2017, June 5, 2018, and November 21, 2018. (Economic damages). April 25, 2019 [Oral Testimony on Behalf of Claimants]

ON BEHALF OF TELUS COMMUNICATIONS INC.

Before the Competition Bureau Canada, Market Study Notice: Competition in Broadband Services, "Expert Report of Christian M. Dippon, Ph.D. On Behalf of TELUS Communications Inc., August 31, 2018 and November 26, 2018 (Competition Policy).

Before Innovation, Science and Economic Development Canada, SLPB-004-18, June 2018, Spectrum Management and Telecommunications, "Expert Report of Christian M. Dippon, PhD On Behalf of TELUS Communications Inc.," Consultation on Revisions to the 3500 MHz Band to Accommodate Flexible Use and Preliminary Consultation on Changes to the 3800 MHz Band, August 10, 2018 (Competition Policy).

Before Innovation, Science and Economic Development Canada, SLPB-005-17, August 2017, Spectrum Management and Telecommunications, "Expert Report of Christian M. Dippon, PhD On Behalf of TELUS Communications Inc.," Consultation on a Technical, Policy and Licensing Framework for Spectrum in the 600 MHz Band, October 2, 2017 and November 3, 2017 (Competition Policy).

Before the Canadian Radio-television and Telecommunications Commission, CRTC 2017-259, Reconsideration of Telecom Decision 2017-56 regarding final terms and conditions for wholesale mobile wireless roaming services, September 8, 2017 and December 1, 2017. (Competition Policy)

Zedi Canada Inc. vs. TELUS Communications Company, Expert Report, May 27, 2016; Oral Testimony, June 23, 2016. (Economic damages)

Before the Canadian Radio-television and Telecommunications Commission, Regulatory framework for wholesale mobile wireless services, CRTC 2015-177, November 23, 2015 (Regulatory policy), May 31, 2016 (Competition analysis and cost modeling), April 4, 2017. (Regulatory cost modeling)

Before the Canadian Radio-Television and Telecommunications Commission, CRTC 2014-76, Review of Wholesale Mobile Services, August 20, 2014 (Competition analysis and regulatory policy) and September 30, 2014. (Regulatory policy)

In the Supreme Court of British Columbia between Michelle Seidel, Plaintiff, and TELUS Communications Inc., Defendant, Proceeding under the Class Proceeding Act, R.S.B.C. 1996, c.50, No. L050143, Vancouver Registry, March 3, 2014 and July 4, 2014. (Economic damages)

Before the Canadian Radio-television and Telecommunications Commission, In the Matter of Wholesale Mobile Wireless Roaming in Canada, CRTC 2013-685, January 29, 2014. (Regulatory policy)

ON BEHALF OF U MOBILE SDN BHD

"The Refarming of the 900 MHz Spectrum in Malaysia, Expert Report," September 25, 2010. (Economic damages)

ON BEHALF OF 425331 CANADA INC. AND NEXTWAVE HOLDCO LLC

Inukshuk Wireless Partnership, Plaintiff vs. 425331 Canada Inc. and Nextwave HoldCo, LLC, Ontario Superior Court of Justice, Court File CV-13-10031-00CL, April 5, 2013. (Economic damages)

WHITE PAPERS AND CONSULTING REPORTS (2010–PRESENT)

ON BEHALF OF TELUS COMMUNICATIONS INC.

Competitive Mobile Wireless Pricing Under Varying Demand and Supply Conditions, Reply to the Canadian Competition Bureau's Claim of Coordinated Behavior Based on Provincial Price Differences, September 13, 2019.

ON BEHALF OF [MERGING PARTY]

Economic Supplement, A Critical Review of Rewheel's Digital Fuel Monitor Reports, March 26, 2019.

ON BEHALF OF TELUS COMMUNICATIONS INC.

An Accurate Price Comparison of Communications Services in Canada and Select Foreign Jurisdictions, October 19, 2018.

ON BEHALF OF [MERGING PARTY]

An Examination of the European Experience with Mergers in the Wireless Sector, Economic Lessons for the Evaluation of [Confidential], Christian M. Dippon, September 17, 2018.

ON BEHALF OF THE AUSTRALIAN CONSUMER AND COMPETITION COMMISSION

"NBN Co's Proposed Price Structure: An Economic Evaluation," with Katherine Lowe, Howard Cobb, and Sally Tam, August 31, 2012.

ON BEHALF OF BROADBAND AUSTRALIA LIMITED

"An Economic Analysis of the Value of Australian Spectrum," August 5, 2010.

ON BEHALF OF CALINNOVATES

"This Old Act: Economic Repercussions of Relying on the Telecommunications Act of 1996, January 30, 2017.

ON BEHALF OF THE INTERNET ASSOCIATION

"Economic Value of Internet Intermediaries and the Role of Liability Protections," June 5, 2017

ON BEHALF OF THE ISRAEL MINISTRY OF COMMUNICATIONS AND MINISTRY OF FINANCE
"An Examination of Charges for Mobile Network Elements in Israel," with Nigel Attenborough, Thomas Reynolds, and Sumit Sharma, May 3, 2010; "Mobile Network Cost Elements Model, A Technical Report," with Nigel Attenborough, Thomas Reynolds, and Sumit Sharma, May 4, 2010.

ON BEHALF OF NETVISION LTD

"Creating Effective Wholesale Access Markets in Israel, Economic Assessment and Policy Recommendation," April 6, 2011.

ON BEHALF OF THE PALESTINE TELECOMMUNICATIONS COMPANY

"Pricing Consultancy and Regulatory Support, Final Recommendations," August 4, 2012.

ON BEHALF OF TURK TELECOM

"Wholesale Access to Fiber Ducts and Dark Fiber – A Benchmark Study," June 28, 2013.

ON BEHALF OF U MOBILE SDN BHD

"U Mobile Sdn BhD, Application for Spectrum Assignment (2600 MHz Spectrum)," November 19, 2010.

ON BEHALF OF WHITWORTH ANALYTICS

"FirstNet: An Economic Analysis of Opting-In vs. Opting-Out," March 2017.

ON BEHALF OF WIRELESS BROADBAND AUSTRALIA LIMITED

"An Economic Analysis of the Value of Australian Spectrum, August 5, 2010.

BOOK PUBLICATIONS

"Measuring Economic Damages with Maximum Certainty," with Julie Carey and Will Taylor, Chapter forthcoming in *The Guide to Damages in International Arbitrations, Fourth Edition,* Global Arbitration Review, 2019.

"Stated Consumer Behavior with D-Efficient Choice Set Designs: The Case of Mobile Service Bundles," with Gary Madden, Chapter in forthcoming book *Essays in Honor of Gary Madden,* publication pending 2019.

K&L Gates – NERA 2008 Global Telecom Review, A Legal and Economic Examination of Current Industry Issues, Christian Dippon and Martin Stern (Eds.), April 23, 2008.

"Regulation under Fixed Mobile Convergence, Examining Recent Developments in Hong Kong," by Keith Lee, Wendy Lo, Christine Yam, and Christian Dippon, Chapter 4 in *K&L Gates – NERA 2008 Global Telecom Review, A Legal and Economic Examination of Current Industry Issues*, April 23, 2008, pages 21–26.

"Size Matters, Relevant Market Definition and Competition Review in a World with Intermodal Competition," by Christian Dippon, Chapter 3 in *K&L Gates – NERA 2008 Global Telecom Review, A Legal and Economic Examination of Current Industry Issues*, April 23, 2008, pages 15–20.

"Mobile Virtual Network Operators: Blessing or Curse? An Economic Evaluation of the MVNO Value Proposition," by Christian Dippon and Aniruddha Banerjee, National Economic Research Associates, Inc., ISBN 0-9748788-2-0, 2006.

"The Implications of Convergence in Telecommunications," by Christian Dippon and Timothy Tardiff, published in *The Preston Gates Guide to Telecommunications in Asia*, 2006 Edition, Asia Law & Practice, 2006, ISBN 962-936-155-8, pages 31–40.

"When East Meets West –Converging Trends in the Economics of Intellectual Property Damages Calculation," by Christian Dippon and Noriko Kakihara, Chapter 19 in *Economic Approaches to Intellectual Property Policy, Litigation, and Management*, edited by Dr. Gregory Leonard and Dr. Lauren J. Stiroh, National Economic Research Associates, Inc., 2005, ISBN 0-9748788-1-2, pages 277–291.

"Marketing Research," Chapter 4 in *Internet Marketing: Building Advantage in a Networked Economy*, an MBA coursework textbook by Rafi Mohammed, Robert J. Fisher, Bernard Jaworski, Aileen M. Cahill, published by McGraw-Hill Higher Education, ISBN 0-07-251022-6, pages 127–167.

PAPER AND ARTICLE PUBLICATIONS (2010–PRESENT)

"International Price Comparisons: An Area of Further Research, *Telecommunications Policy*, September 8, 2019, accepted for publication, publication pending.

"Do Economic, Institutional, or Political Variables Explain Regulated Wholesale Unbundled Local Loop Rate Setting," with Dr. Gary Madden and Dr. Hiroaki Suenaga, *Applied Economics,* Volume 48, 2016 – Issue 39.

"FCC Open Internet Order Creates Uncertainty and Risk," with Marty Stern and Sam Castic (K&L Gates), published in *Corporate Counsel*, July 27, 2015.

"Is It Worth the Effort? Measuring the Benefits of D-Efficient Survey Design to Qualitative Choice Analysis," November 1, 2014.

"Consumer Demand for Mobile Phone Service in the US: An Examination beyond the Mobile Phone," November 1, 2014.

"Is Faster Necessarily Better? Third Generation (3G) Take-up Rates and the Implications for Next Generation Services," published in *International Journal of Communications, Network and System Sciences,* Vol.5 No.8, 2012, September 2012.

"Replacement of the Legacy High-Cost Universal Support Fund with a Connect America Fund, Key Economic and Legal Considerations," with Christopher Huther and Megan Troy, *Communications & Strategies* 80, 4Q2010, pages 67–81.

"Is Faster Necessarily Better? Third Generation (3G) Take-up Rates and the Implications for Next Generation Services," June 28, 2010, presented at the International Telecommunications Society (ITS) 18th Biennial and Silver Anniversary Conference, Tokyo, Japan, June 30, 2010.

"Wholesale unbundling and intermodal competition," with Dr. Harold Ware, published in *Telecommunications Policy*, Volume 34, Numbers 1-2, February-March 2010.

SELECTED NEWS CITATIONS (2010–PRESENT)

Giuseppe Marci, "Economists Predict Net Neutrality Cost 700K Jobs and $35 Billion Annually," *Inside Sources,* July 20, 2017.

Giuseppe Marci, "Former FCC Economist Says Unlocking the Set-Top Box Will Hurt the TV Market," *Inside Sources,* April 23, 2016.

CALInnovates, PRNewswire, "FCC Set-Top Box Proposal Based Upon Faulty Economic Foundation, Will Harm Consumers, Innovators And Golden Age of Television, Warns CALInnovates," April 22, 2016.

Sophia Harris, "Telus speed claim not based on real-world experience," *CBC News*, October 15, 2014.

Gus Sentementes, "Data-thirsty smartphones lead wireless companies to prep 4G networks," *The Baltimore Sun,* October 18, 2010.

SELECTED SPEECHES AND PRESENTATIONS

"Properly Comparing International Prices of Telecommunication Services, Statistical Method and Policy Implications for the Canadian Case Study," Presented at the 22nd Biennial Conference of the International Telecommunications Society, June 25, 2018.

"Can Femtocells Resolve the Spectrum Crunch?" Presented at the International Telecommunications Society 6th Africa-Asia-Australasia Regional Conference, Curtin Business School, Curtin University, Bentley, Western Australia, August 7, 2013.

"Modern Approaches to Spectrum Valuation," Presented at the International Telecommunications Society 6th Africa-Asia-Australasia Regional Conference, Curtin Business School, Curtin University, Bentley, Western Australia, August 5, 2013.

"Consumer Demand for Mobile Phone Service in the US: An Examination Beyond the Mobile Phone," Presented at the International Telecommunications Society (ITS) 19th Biennial Conference, Bangkok, Thailand, November 20, 2012.

"The Link Between Spectrum Availability and Mobile Market Consolidation," Session Chair, Second Annual Spectrum Management Conference, Washington DC, October 23, 2012.

"Broadband, Productivity, and Product Innovation - A Look behind the Scenes in the United States," invited Keynote Address, 5th Africa-Asia-Australasia Regional Conference, International Telecommunications Society Perth, Western Australia, November 15, 2011.

"Build It and They Will Come, Consumer Willingness to Pay for Mobile Broadband Services," 5th Africa-Asia-Australasia Regional Conference, International Telecommunications Society Perth, Western Australia, November 14, 2011.

"Consumer Preferences for Mobile Phone Service in the US – An Application of Efficient Design to Conjoint Analysis," Guest Lecture, University of California, Santa Barbara, March 1, 2011.

APPENDIX B: DISCRETE CHOICE ANALYSIS OF THE DEMAND FOR DRONES

The survey of consumer demand for drones was administered to an online panel of 466 individuals.[1] The survey was limited to individuals who stated that they had purchased, used or were considering purchasing a drone.

After qualifying for the survey, respondents were presented with descriptions of eight attributes of drones they might consider when choosing a drone. These attributes were (1) purchase price, (2) monthly cost of ownership (subscription), (3) battery life, (4) camera resolution, (5) weights, (6) GPS capability, (7) range, and (8) operating requirements. With the exception of operating requirements, these attributes and the levels of each attribute were selected to reflect the characteristics of real-world drones. The operating requirements attribute was designed to reflect the different regulatory regimes proposed by the FAA and others.

A detailed description of the attributes and the levels of these attributes are as follows.

Attribute Descriptions

Purchase Price: Purchase price of the drone in dollars excluding taxes and any other fees.
Monthly Cost of Ownership: Ongoing costs of drone ownership not including the purchase price of the drone.
Battery Life: Continuous flight time measured in minutes from a single full charge.
Camera Resolution**:** Image resolution of the drone's camera.
Weight**:** Net weight of the drone including the battery. Drone weight can affect durability and portability.
GPS**:** Whether the drone has GPS capability.
Range**:** Maximum distance between the drone and the controller at which the drone will operate.
Operating Requirements**:** Whether the drone is subject to additional operating requirements. The levels of this attribute are:

- **Standard:** This type of drone is not subject to additional operating requirements.
- **Broadcast and Internet:** These drones are only permitted to fly if they broadcast the drone's location, height, and ID number and the location of the drone's control station

[1] The survey was administered to 526 individuals, but 60 were removed for quality control purposes (primarily nonsensical answers to the open-ended responses in which they were asked to explain one of their choices).

(remote control) *locally* over the airwaves. They must also provide the same information to the *public* over an Internet connection.

- **Broadcast Only:** These drones are permitted to fly if they broadcast the drone's location, height, and ID number and the location of the drone's control station (remote control) *locally* over the airwaves. They do not have to make this information available *publicly* over the Internet.

Attribute Levels

Purchase Price	Monthly Cost of Ownership	Battery Life	Camera Resolution	Weight	GPS	Range	Operating Requirements
$40	$0	12 minutes	No camera	About ½ pound or less	Yes	Less than 400 feet	Standard
$50	Under $5	18 minutes	Standard definition (480p)	Between ½ pound and 2 pounds	No	401–1,000 feet	Broadcast and internet
$75	$5 – $10	24 minutes	High definition (1080p)	About 2 pounds or more		1,000 feet to 1 mile	Broadcast only
$100	$10 - $15	30 minutes	Ultra HD/4K (2160p)			1 to 2 miles	
$200	$20	36 minutes				Over 2 miles	
$500		42 minutes					
$1000							
$1500							
$2000							

The survey respondents were asked to make a series of choices from among sets of hypothetical drones. Surveys of this type are often known as conjoint analysis. Each choice scenario shown to the respondents presented three hypothetical drones with a distinct combination of the eight attributes described above. Respondents were asked to select the drone they would be most likely to purchase or to state if they would not purchase any of the three drones presented. An example of one choice scenario presented to respondents in the survey is shown in Figure B1.

Figure B1. Example of a Choice Scenario in the Drone Conjoint Analysis

Thinking about the options you see here, which drone would you be most likely to select for purchase?

For more information about the drone features shown, click on any of the [?] icons next to the features.

	Product 1	Product 2	Product 3	None
Price ($) [?]	$40	$50	$1500	I would not choose any of these
Monthly Cost of Ownership ($) [?]	$0	Under $5	$5 - $10	
Battery Life (min) [?]	36	18	30	
Camera Resolution [?]	No Camera	Standard Definition (480p)	HD (1080p)	
Weight [?]	Between 1/2 pound and 2 pounds	About 1/2 pound or less	About 2 pounds or more	
GPS [?]	No	No	Yes	
Range (feet) [?]	401 - 1000 feet	1000 feet to 1 mile	Over 2 miles	
Operating Requirements [?]	Broadcast Only	Standard	Broadcast Only	
	○	○	○	○

Each respondent was presented with 11 different choice scenarios in total, which gave us a total of 5,786 choices from among these hypothetical drones. The full survey instrument is presented in Appendix C.

The influence of the various drone attributes on consumer choice behavior was estimated with a mixed logit model. The mixed logit model determines how the levels of each attribute influences the probability that an individual will purchase a particular drone while controlling for individual-level heterogeneity in preferences on some attributes.[2] In this mixed logit the coefficient on price was specified as the negative of a lognormal distribution while the coefficients on the operating requirements variables were specified as normal distributions. All other coefficients were specified as fixed (not varying across individuals).

The results were sensible; that is, a desire for more battery life, better cameras, more range, and GPS capabilities lead to higher probabilities of purchasing the drone, whereas higher prices and monthly cost of ownership reduce the probability of purchasing the drone. Weight did not have a statistically significant effect on choice. The means of the random coefficients on both operating

[2] For more details, see Train, K. (2009), *Discrete Choice Methods with Simulation*, 2nd. ed. (New York: Cambridge University Press, 2009).

requirement variables were negative (although statistically insignificant for broadcast and internet), indicating that a majority of respondents were less likely to purchase drones subject to these additional requirements. The results of estimating this mixed logit model are presented in Table B1.

Table B1. Mixed Logit Analysis of Drone Choices

Attribute	*Coefficient*	*Standard Error*	*Z-Score*
Price	-6.4104	0.0599	-107.01
SD(Price)	1.9459	0.0491	39.66
Broadcast and Internet	-0.0995	0.1302	-0.76
SD(Broadcast and Internet)	0.9998	0.0704	14.21
Broadcast only	-0.2899	0.1318	-2.20
SD(Broadcast only)	0.8767	0.0732	11.98
Monthly cost of ownership	-0.0216	0.0032	-6.69
Battery life	0.0156	0.0022	6.98
Camera: standard definition (480p)	0.8106	0.0716	11.32
Camera: high definition (1080p)	1.6233	0.0688	23.59
Camera: ultra HD/ 4K (2160p)	1.7990	0.0694	25.94
Weight: ½ – 2 pounds	0.0247	0.1336	0.19
Weight: over 2 pounds	-0.1276	0.1322	-0.97
GPS	0.2609	0.0430	6.07
Range: under 1000 feet	0.0634	0.0708	0.89
Range: 1000 feet - 1 mile	0.5079	0.0702	7.23
Range: 1 – 2 miles	0.4127	0.0724	5.70
Range: over 2 miles	0.4750	0.0721	6.59
Would not purchase these drones	0.5424	0.1031	5.26

Note: The coefficient on *price* is lognormally distributed. The coefficients presented here describe the normal distribution underlying the lognormal price coefficient. The actual price coefficient is obtained by taking the exponential of this normal distribution and multiplying by -1. The coefficients on *broadcast and internet* and *broadcast only* are normally distributed.

The estimated mixed logit coefficients were then used to forecast the drop in consumer demand for drones under the proposed regulatory regime. The relative demand for three classes of drones (toy, hobby, and pro) was calculated for representative models for these classes both for the "baseline" case of no new regulation, and for the case where the new regulations take effect. The differences in the attributes of the representative drones between the baseline case and the regulation case are presented in Table B2.

Table B2. Attributes of the Representative Drones

Baseline			
Attribute	***Toy***	***Hobby***	***Pro***
Price	$50	$400	$1,500
Broadcast and internet	No	No	No
Monthly cost of ownership	$0	$0	$0
Battery life	7 minutes	20 minutes	30 minutes
Camera	No	480p	1080p
Weight	Under ½ pound	½ – 2 pounds	Over 2 pounds
GPS	No	Yes	Yes
Range	Under 400 feet	Under 1 mile	Over 2 miles
FAA Regulation			
Attribute	***Toy***	***Hobby***	***Pro***
Price	$50	**$422.75**	**$1,522.75**
Broadcast and internet	No	**Yes**	**Yes**
Monthly cost of ownership	$0	**$9.83**	**$9.83**
Battery life	7 minutes	20 minutes	30 minutes
Camera	No	480p	1080p
Weight	Under ½ pound	½ – 2 pounds	Over 2 pounds
GPS	No	Yes	Yes
Range	Under 400 feet	Under 1 mile	Over 2 miles

Demand for hobby and pro drones (the drones subject to the new regulations) drops by 10.6 percent in the FAA regulation case as compared to the baseline case.

This estimated drop in demand is used to estimate the lost margin for drone manufacturers for the years 2020–2029. This is one component of the total impact of the Remote ID Proposal. Lost revenue in each year is calculated as the projected revenue for non-toy drones, multiplied by the percentage decrease in demand for hobby and toy drones (10.6 percent). This lost revenue is partially offset by the increase in revenue from the sale of toy drones because some consumers will substitute toy drones for hobby and pro drones as the latter categories become less desirable. The lost margin for drone manufacturers is calculated assuming that the cost of goods sold is 60 percent of revenue.

The total impact of the Remote ID Proposal also includes the additional costs to those consumers who continue to buy hobby or pro drones. These additional costs are calculated in each year as the projected units of hobby and pro drones sold after subtracting the percentage decrease in demand,

multiplied by the additional annual cost of drone ownership. The additional annual cost of purchasing a drone is estimated to be $22.75 (a $20 increase in drone prices plus a $2.75 one-time registration fee), which is divided by three under the assumption that the average hobby or pro drone user purchases one new drone every three years. The additional cost also includes monthly operating costs of $9.83 per month ($117.96 annually). The total additional annual cost is estimated to be $125.54.

The total impact of the Remote ID Proposal over 10 years is estimated as the net present value of the sum of the lost margin for drone manufacturers and the additional costs to consumers, assuming a 3 percent discount rate. The total impact over 10 years is thus estimated to be approximately $4.4 billion. Further details on this calculation are presented in Appendix D.

APPENDIX C: NERA CONSUMER SURVEY QUESTIONS

[DO NOT ALLOW ROUTED SURVEY TRAFFIC]
[PROGRAMMER: DISABLE RESUME LATER BUTTON FOR ENTIRE SURVEY]
[PROGRAMMER: DISABLE BACK BUTTON FOR ENTIRE SURVEY]
[SURVEY WILL ONLY BE SHOWN ON LAPTOP, TABLET OR DESKTOP COMPUTERS (NOT CELL PHONES)]

Introduction: Thank you for your willingness to participate in our study. This is a brief study that should take no more than 10 minutes of your time. The responses you give to our questions are very important to us. If you don't know an answer to a question or if you don't have an opinion, please indicate this in your response. Do not guess. Your answers will only be used in the aggregate and your personal information will be kept confidential. The results of this study will not be used to try to sell you anything. When you are ready to get started, please click the ">" button.
[NEXT SCREEN]

S1. Before continuing with this survey, please carefully read these instructions:
- Please take the survey in one session.
- While taking this survey, please do not, at any time, open any other windows or tabs on this computer or device or any other computer or device.
- Please do not view any other written material while taking this survey.
- Please do not consult or talk with any person while taking this survey.
- You will not be able to go back to previous screens to change your answers.

1. I have read the above instructions, I understand them, and I will adhere to them.
2. I do not understand the above instructions, or I don't wish to agree to them. **[SCREEN OUT]**

S2. What type of device are you using to complete this survey? **[RANDOMIZE 1-4]**
1. Desktop computer
2. Laptop computer
3. Tablet computer
4. Mobile phone or cell phone **[SCREEN OUT]**
5. Other **[SCREEN OUT]**

S3. Please verify that you are human.
[INSERT CAPTCHA BELOW]

S4. Are you…?
1. Male
2. Female

[TERMINATE IF GENDER DOES NOT MATCH PANEL DATA]

S5. Please select your age. **[PROVIDE DROP DOWN BOX WITH AGE]**
Prefer not to answer **[INCLUDE IN DROP DOWN; SCREEN OUT]**
[TERMINATE IF RESPONDENT IS UNDER 18]
[TERMINATE IF AGE DOES NOT MATCH PANEL DATA]

S6. In which state do you currently reside?
[INSERT DROP DOWN BOX WITH STATES]
[INCLUDE "Outside the U.S."; SCREEN OUT IF SELECTED]

S7. Please enter your ZIP code.
[TERMINATE IF ZIP CODE DOES NOT MATCH STATE]

S8. Do you or does any member of your household work for any of the following? **(*Select all that apply*)**
[RANDOMIZE LIST 1-5]
1. A drone manufacturer **[TERMINATE]**
2. A mobile phone manufacturer
3. A radio-controlled (RC) electric racing car manufacturer
4. A laptop computer manufacturer
5. A market research or advertising agency **[SCREEN OUT]**
6. None of the above **[ANCHOR; EXCLUSIVE]**
7. Don't know / unsure **[ANCHOR; SCREEN OUT]**

S9. In the past six months, have you taken a survey about any of the following types of products?
(Select all that apply) **[RANDOMIZE 1-4]**
1. Drones **[TERMINATE]**
2. Mobile handsets
3. Radio-controlled (RC) electric racing cars
4. Laptop computers
5. None of these **[ANCHOR; EXCLUSIVE]**
6. Don't know / unsure **[ANCHOR; EXCLUSIVE; SCREEN OUT]**

S10. Which of the following items, if any, have you ever purchased?
(*Select all that apply*) [RANDOMIZE 1-6]
1. Drone
2. Camera
3. Smartphone
4. Desktop computer
5. Laptop computer
6. Radio-controlled (RC) electric racing car
7. None of these **[ANCHOR; EXCLUSIVE]**
8. Don't know / unsure **[ANCHOR; EXCLUSIVE; SCREEN OUT]**

[NEXT SCREEN]

S11. Which of the following items, if any, are you likely to purchase in the next twelve months?
(*Select all that apply*) [RANDOMIZE 1-6 IN SAME ORDER AS S10]
1. Drone
2. Camera
3. Smartphone
4. Desktop computer
5. Laptop computer
6. Radio-controlled (RC) electric racing car
7. None of these **[ANCHOR; EXCLUSIVE]**
8. Don't know / unsure **[ANCHOR; EXCLUSIVE; SCREEN OUT]**

[ASK Q1 THROUGH Q8 IF PASTPURCHASER=1; IF FUTUREPURCHASE ONLY, SKIP TO Q9]

Q1. How many drones, if any, do you currently own?
[PROVIDE DROP DOWN BOX WITH QUANTITY, RANGE IS 0 TO 20, "MORE THAN 20", & "DON'T KNOW / UNSURE"]

[IF Q1=0 OR "DON'T KNOW", SKIP TO Q9]

Q2a. **[ASK IF Q1=1]** What brand is your drone? ***(Select one)*** **[RANDOMIZE 1-6]**
1. DJI
2. Yuneec

3. 3D Robotics (3DR)
4. Parrot
5. Intel
6. GoPro
7. Other ***(Please specify***) **[ANCHOR]**
8. Don't know / unsure **[ANCHOR]**

Q2b. **[ASK IF Q1 IS 2+]** What brands are your drones? ***(Select all that apply)*** **[RANDOMIZE 1-6]**

1. DJI
2. Yuneec
3. 3D Robotics (3DR)
4. Parrot
5. Intel
6. GoPro
7. Other ***(Please specify***) **[ANCHOR]**
8. Don't know / unsure **[ANCHOR; EXCLUSIVE]**

[ASK Q3 IF MULTIPLE DRONES IN Q1 & MULTIPLE COMPANIES IN Q2b. OTHERWISE RECORD SINGLE COMPANY LISTED IN Q2a/Q2b, SKIP TO Q4]

Q3. What brand is the drone you use most often? **[INSERT DRONE COMPANIES FROM Q2b; SINGLE SELECT**]

[PIPING INSTRUCTIONS Q4-Q8C: IF Q1=1, PIPE "your drone". IF Q1=2+, PIPE "the drone you use most often"]

Q4. Approximately how much did [your drone / the drone you use most often] cost?
[ROTATE ENDS OF SCALE 1-6, 6-1]

1. $50 or Less
2. $51 – $100
3. $101 – $500
4. $501 - $1000
5. $1001 – $2000
6. $2001 or More
7. Don't know / unsure **[ANCHOR]**

Q5. Approximately how much does [your drone / the drone you use most often] weigh?
[ROTATE ENDS OF SCALE 1-3, 3-1]

1. About ½ pound or less
2. Between ½ pound and 2 pounds
3. About 2 pounds or more
4. Don't know / unsure **[ANCHOR]**

Q6. What is the primary use of [your drone / the drone you use most often]? ***(Select all that apply)*** **[ROTATE 1 AND 2]**
1. Commercial purposes
2. Recreational purposes
3. Other ***(Please specify)*** **[ANCHOR]**
4. Don't know / unsure **[ANCHOR; EXCLUSIVE]**

Q7. At what distance from the control station do you primarily operate [your drone / the drone you use most often]? **[RANDOMIZE 1 AND 2]**
1. Less than 400 feet
2. 400 feet or more
3. Don't know / unsure **[ANCHOR]**

Q8. How do you control [your drone / the drone you use most often]? **(*Select all that apply*) [ROTATE 1-3]**
1. Smartphone
2. Tablet
3. Remote Controller
4. Other ***(Please specify)*** **[ANCHOR]**
5. Don't know / unsure **[ANCHOR; EXCLUSIVE]**

Q8a. In a typical month, how many days do you use [your drone / the drone you use most often]? **[PROVIDE DROP DOWN BOX WITH RANGE OF OPTIONS 1-31 & "DON'T KNOW / UNSURE"]**

Q8b. When you use [your drone / the drone you use most often], how many flights do you typically use it for?

[ROTATE ENDS OF SCALE 1-6, 6-1]
1. 1 flight
2. 2 flights
3. 3 flights
4. 4 flights
5. 5 flights
6. More than 5 flights
7. Don't know / unsure **[ANCHOR]**

Q8c. How far do you typically travel to the place where you fly [your drone / the drone you use most often]? **[ROTATE ENDS OF SCALE 1-6, 6-1]**

1. Less than 5 minutes
2. 5 to 9 minutes
3. 10 to 14 minutes
4. 15 to 19 minutes
5. 20 to 39 minutes
6. 30 minutes or more
7. I do not travel to fly the drone **[ANCHOR]**
8. Don't know / unsure **[ANCHOR]**

[NEXT SCREEN]

Q9. What drone features or attributes are important to you when considering which drone to purchase? ***(Please type in your response)***

Q10. You may have already mentioned this, but which of the following features or attributes are important to you when considering which drone to purchase? [**RANDOMIZE 1 – 11] *(Select all that apply)***

1. Purchase price
2. Monthly cost of ownership
3. Brand
4. Camera quality
5. Control type (App, Computer, Remote)
6. Object detection
7. Subject tracking
8. Portability
9. Product design
10. Flight time
11. Ease of use
12. Other features (***Please specify***) **[ANCHOR]**
13. Don't know / unsure **[ANCHOR; EXCLUSIVE]**

[NEXT SCREEN]

This survey is interested in understanding how consumers think about the various features of a drone. Consumers often think about and review different sources of information to help them decide what drone to purchase.

The next exercise will ask you to compare several different features and attributes you might consider when selecting a drone to purchase. Before the next exercise, we would like you to review some information about drones.

Please review the following buying guide to learn about some things you may want to consider when purchasing a drone.

[NEXT SCREEN]
[ON EACH SCREEN, 5 SECOND DELAY BEFORE ">" APPEARS]

Getting started
Drones are also known as unmanned aerial vehicles (UAVs), which are a type of unmanned aircraft systems (UAS). A drone is an aircraft that does not have a pilot on board. Instead, it is remotely

controlled, or may fly autonomously using software-controlled flight plans. Most drones have four rotors.

[NEXT SCREEN]

Drones may vary on the following features, among others:
[RANDOMIZE ORDER OF FEATURES ACROSS RESPONDENTS; WITHIN A RESPONDENT, KEEP ORDER CONSISTENT BETWEEN LIST BELOW AND FEATURE DESCRIPTION PAGES]

- Purchase Price
- Monthly Cost of Ownership
- Battery Life (minutes)
- Camera Resolution
- GPS
- Range (feet)
- Weight (pounds)
- Operating Requirements

On the next several screens, each of these features will be described.
[PROGRAMMER: EACH DESCRIPTION SHOULD APPEAR ON A NEW SCREEN. ORDER OF ATTRIBUTES SHOULD RANDOMIZE CONSISTENT WITH LIST IN INTRODUCTION TO FEATURE DESCRIPTIONS. FOR EACH ATTRIBUTE SCREEN. NEXT BUTTON SHOULD ONLY APPEAR AFTER 5 SECONDS HAVE PASSED.]

[NEXT SCREEN]
Purchase Price
You will be shown different prices for the drones displayed. This is simply the purchase price for the drone, excluding taxes and any other fees.

[NEXT SCREEN]
Monthly Cost of Ownership
This refers to the ongoing cost of ownership of the drone. These costs are separate from the purchase price.

[NEXT SCREEN]
Battery Life
Battery life measures the amount of continuous flight time, in minutes, from a single full charge. Many drones can be charged through a USB cable, while some require a special charger to be used.

[NEXT SCREEN]
Camera Resolution
Many drones have a camera attached and are used to transmit images and/or videos. Drone cameras vary in their image resolution. Some are standard definition (480p). Others are HD

(1080p), which is a higher quality than standard definition. The highest-resolution cameras are UHD/4K (2160p).

[NEXT SCREEN]
Weight
Drones can vary significantly in weight. This refers to the net weight of the drone, including battery. Drone weight can affect durability and portability.

[NEXT SCREEN]
GPS
You can choose a drone with or without GPS capability. Drones with GPS capability can show their location on a digital map in real time.

[NEXT SCREEN]
Range
Range describes the maximum distance between the drone and the controller at which the drone will operate.

[NEXT SCREEN]
Operating Requirements
Drone usage is subject to Federal Aviation Administration (FAA) regulation. For instance, drones may be used in certain classes of airspace up to 400 feet above ground level. Further, different types of drones may or may not be subject to additional operating requirements:

Standard: This type of drone is not subject to additional operating requirements.

Broadcast and Internet: These drones are only permitted to fly if they broadcast the drone's location, height, and ID number and the location of the drone's control station (remote control) locally over the airwaves. They must also provide the same information to the public over an internet connection.

Broadcast Only: These drones are permitted to fly if they broadcast the drone's location, height, and ID number and the location of the drone's control station (remote control) locally over the airwaves. They do not have to make this information available publicly over the internet.

[NEXT SCREEN]
You will now see three different drone purchase options, which vary on their features. Assuming these are the only three drones available to you, you will be asked to choose which of these three drones you would be most likely to purchase.

Please assume that the **drone purchase options you will see do not vary in any other way beyond the features described** and that all feature descriptions are accurate.

You can also select "none of these," which means that you would not purchase any of the three drones displayed.

[NEXT SCREEN]
[DISPLAY CONJOINT EXERCISE, KEEP ON SCREEN]

C1. Thinking about the options you see here, which drone would you be most likely to select for purchase?

For more information about the drone features shown, click on any of the ? icons next to the features.

[SHOW ATTRIBUTES IN SAME ORDER AS DESCRIPTION SCREENS.]
[INCLUDE "NONE OF THESE" OPTION.]
[PLEASE INCLUDE HOVER LINK WHICH ALLOWS RESPONDENT TO SEE FEATURE DESCRIPTION FOR EACH ATTRIBUTE]

C1a. Why did you select this option? **(*Please type in your response*) [ASK C1a FOR FIRST CHOICE SET ONLY. DISPLAY ON SAME SCREEN AS CHOICE SET].**

[COMPLETE A TOTAL OF 11 CHOICE SETS. C1 –C11. INCLUDE ONE HOLDOUT TASK]

[NEXT SCREEN]

[END] Thank you for your participation in today's study.

APPENDIX D: REMOTE ID SOCIETAL COST ESTIMATES

	Item	Calculation	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
(1)	Total Units Sold (thousands) [1]		2,215	2,432	2,535	2,596	2,646	2,691	2,737	2,782	2,825	2,869
(2)	Average Unit Price [2]		$ 723	$ 744	$ 766	$ 789	$ 812	$ 836	$ 861	$ 886	$ 912	939
(3)	Total Revenue ($ mil.)	=(1)x(2)/1000	$ 1,602	$ 1,811	$ 1,943	$ 2,048	$ 2,149	$ 2,250	$ 2,355	$ 2,465	$ 2,577	$ 2,694
(4)	Unit Growth Rate		12.1%	9.8%	4.2%	2.4%	1.9%	1.7%	1.7%	1.7%	1.6%	1.6%
(5)	Revenue Growth Rate		38.3%	13.0%	7.3%	5.4%	4.9%	4.7%	4.7%	4.6%	4.5%	4.5%
(6)	Avg. Unit Price Growth Rate		23.3%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%
(7)	**Percentage Demand Reduction (standard)**		5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%
(8)	**Percentage Demand Reduction (broadcast & internet)**		10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%
(9)	**Total UAS Sale Losses (units, thousands)**	=(1)x(8)	234.76	257.78	268.69	275.16	280.45	285.24	290.09	294.88	299.47	304.14
(10)	**Total Non-toy Revenue Losses (mil.)**	=(3)x(8)	$ 169.78	$ 191.91	$ 205.92	$ 217.08	$ 227.77	$ 238.47	$ 249.66	$ 261.25	$ 273.12	$ 285.54
(11)	**Revenue Gains from Increased Toy Drone Sales (mil.)**		$ 23.64	$ 25.29	$ 26.04	$ 26.30	$ 26.38	$ 26.36	$ 26.27	$ 26.11	$ 25.86	$ 25.54
(12)	**Total Revenue Losses (millions)**	=(10)-(11)	$ 146.15	$ 166.62	$ 179.89	$ 190.79	$ 201.39	$ 212.12	$ 223.39	$ 235.13	$ 247.26	$ 260.00
(13)	**NPV Total Revenue Losses (3% discount)**	=(12) discounted	$ 146.15	$ 161.77	$ 169.56	$ 174.60	$ 178.93	$ 182.97	$ 187.08	$ 191.18	$ 195.19	$ 199.27
(14)	**Total Purchase Cost to Consumers (mil.)**	=[(1)-(9)]x[22.75/3 years]/1000	$ 15.01	$ 16.49	$ 17.18	$ 17.60	$ 17.94	$ 18.24	$ 18.55	$ 18.86	$ 19.15	$ 19.45
(15)	**NPV Total Purchase Cost Losses (3% discount)**	=(14) discounted	$ 15.01	$ 16.01	$ 16.20	$ 16.10	$ 15.94	$ 15.74	$ 15.54	$ 15.33	$ 15.12	$ 14.91
(16)	**Total Subscription Cost to Consumers (mil.)**	=[(1)-(9)]x[9.83x12 months]/1000	$ 233.55	$ 256.45	$ 267.31	$ 273.74	$ 279.01	$ 283.78	$ 288.60	$ 293.36	$ 297.94	$ 302.58
(17)	**NPV Total Revenue Losses (3% discount)**	=(16) discounted	$ 233.55	$ 248.98	$ 251.97	$ 250.51	$ 247.90	$ 244.79	$ 241.70	$ 238.53	$ 235.19	$ 231.90
(18)	**NPV Total Cost to Consumers (3% Discount)**	=(15)+(17)	$ 248.57	$ 264.99	$ 268.17	$ 266.62	$ 263.84	$ 260.52	$ 257.24	$ 253.87	$ 250.31	$ 246.81
(19)	**Total Impact (millions)**	=(10)+(11)+(14)	$ 394.71	$ 439.56	$ 464.38	$ 482.13	$ 498.34	$ 514.14	$ 530.54	$ 547.35	$ 564.35	$ 582.04
(20)	**NPV Total Impact (3% discount)**	=(16) discounted	$ 394.71	$ 426.76	$ 437.73	$ 441.22	$ 442.77	$ 443.50	$ 444.32	$ 445.05	$ 445.50	$ 446.08

(21)	**Total Revenue Losses Over 10 Years (mil.)**	**$**	**2,062.73**
(22)	**Total Revenue Losses Over 10 Years (mil., NPV)**	**$**	**1,786.70**
(23)	**Total Cost to Consumers Over 10 Years (mil.)**	**$**	**2,954.82**
(24)	**Total Cost to Consumers Over 10 Years (mil., NPV)**	**$**	**2,580.93**
(25)	**Total Impact Over 10 Years (mil.)**	**$**	**5,017.55**
(26)	**Total Impact Over 10 Years (mil., NPV)**	**$**	**4,367.64**

Notes: [1] Excludes toy drone using split from CTA 2018 survey. [2] Average unit price uses the average growth rate from 2015-2020.