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Towards a control-centric account of tort liability for automated vehicles

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Towards a Control-Centric Account of Tort Liability for Automated Vehicles

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Existing motor vehicle accident laws are generally described as 'driver-centric', since regulatory, liability, and insurance obligations revolve around drivers. This is sometimes taken to imply that they cannot apply to automated vehicles. This article seeks to re-centre the liability discussion around the tortious doctrine of control. It argues centrally that properly understanding legal control as influence over metaphysical risks, rather than physical objects, clarifies that automated vehicles are both legally controllable in theory, despite having no human drivers, and legally controlled in practice, despite their reliance on machine learning. Examining today's automated driving technology and businesses, this article demonstrates how manufacturers, software developers, fleet operators, and consumers participate in vehicular risk creation. Finally, how control could illuminate courts' analyses of automated vehicle liability is illustrated by a hypothetical application to recent automated vehicle accidents. In this light, this article concludes that existing tort principles are better-equipped to resolve liability issues arising from the use of automated vehicles than initially apparent.

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I Introduction

A 2016 discussion paper by the National Transport Commission ('NTC') noted that present common law frameworks for motor vehicle accident ('MVA') liability are 'sufficiently dynamic and robust to adapt to the challenges that [automated vehicles] will present',[1] particularly if 'government and industry can clarify the meaning of *driver* and *control*'.[2] The NTC subsequently clarified that the legal entity which certifies the vehicle's automated driving system ('ADS', and the entity an 'ADSE') shall be deemed to 'control' an automated vehicle ('AV')[3] when the ADS is engaged.[4] Insofar as liability follows control, liability for ADS-driven vehicles is thus implicitly assigned to ADSEs (who are likely to be ADS manufacturers) without substantially revising the existing liability regime.

This approach stands in apparent contrast to a growing body of academic literature[5] arguing that existing regimes are ill-equipped for AVs and in need of

[1] National Transport Commission ('NTC'), *Regulatory Reforms for Automated Road Vehicles* (Policy Paper, November 2016) 61, quoting a submission by Maurice Blackburn Lawyers.

[2] Ibid 60 (emphasis in original). The paper also examines 'control' and 'driving' in ss 3 and 4 respectively.

[3] AVs are also referred to as autonomous, driverless, or self-driving vehicles. This article prefers 'automated', in keeping with the NTC's terminology, but makes no distinction between these terms.

[4] NTC, *Automated Vehicle Program* (Approach Paper, October 2019) 11 ('NTC Approach Paper').

[5] See, eg, Maurice Schellekens, 'Self-Driving Cars and the Chilling Effect of Liability Law' (2015) 31(4) *Computer Law and Security Review* 506; John W Zipp, 'The Road Will Never Be the Same: A Reexamination of Tort Liability for Autonomous Vehicles' (2016) 43(2) *Transportation Law Journal* 137; KC Webb, 'Products Liability and Autonomous Vehicles: Who's Driving Whom?' (2017) 23(4) *Richmond Journal of Law and Technology* 9; Bryant Walker Smith, 'Automated Driving and Product Liability' [2017] (1) *Michigan State Law Review* 1; Jan De Bruyne and Jarich Werbrouck, 'Merging Self-Driving Cars with the Law' (2018) 34(5) *Computer Law and Security Review* 1150; Maurice Schellekens, 'No-Fault Compensation Schemes for Self-Driving Vehicles' (2018) 10(2) *Law, Innovation and Technology* 314; Kenneth S Abraham and Robert L Rabin, 'Automated Vehicles and Manufacturer Responsibility for Accidents: A New Legal Regime for a New Era' (2019) 105(1) *Virginia Law Review* 127; Steven Shavell, 'On the Redesign of Accident Liability for the World of Autonomous Vehicles' (Discussion Paper No 1014, Harvard Law School, August 2019) ('Redesign Accident Liability').

substantial reform.[6] Proposed alternatives include manufacturer enterprise liability and strict liability to the state.[7] Such divergence is surprising because, like the NTC, most commentators trace the problem with existing law to 'driver-centricity': the assumption that all vehicle have human drivers around which accident liability, as well as insurance obligations, are conventionally centred.[8]

This article seeks to explain and reconcile this tension by analysing the doctrine of control from a tort law (as opposed to the NTC's regulatory) perspective. The central argument is that properly framing existing MVA tort liability laws as control-centric, rather than driver-centric, clarifies that existing doctrine surrounding legal control can apply to AVs. It further examines the current state of AV technology and business models to highlight the (underexplored) extent of legal control traceable to AV manufacturers, developers, operators, and users. Referring to recent AV-related accidents, it then demonstrates how control analysis could illuminate the courts' analysis of AV negligence liability in practical cases.

Part II sets the scene by outlining existing MVA liability frameworks and how they might be seen as 'driver-centric'. It unpacks driver-centricity into two layers at the liability and insurance levels respectively. Next, tracing the historical development of MVA liability, it shows that the doctrine of control, rather than vague notions of 'driverness', has always been the *legal* principle relied on for MVA liability.

Part III examines control as a tortious doctrine. It distinguishes between engineering and lay senses of 'control' on the one hand and control as used and understood by tort law courts on the other. Just as an employer need not actively

[6] Tom Mackie, 'Proving Liability for Highly and Fully Automated Vehicle Accidents in Australia' (2018) 34(6) *Computer Law and Security Review* 1314, 1316.
[7] See generally NTC Approach Paper (n 5).
[8] For academic references to 'driver-centricity' see below n 26. For the NTC's view see NTC Approach Paper (n 4) 4; NTC, *Changing Driving Laws to Support Automated Vehicles* (Policy Paper, May 2018) 1.

dictate all of an employee's physical actions to 'control' the employee for vicarious liability purposes, tortious control does not require active determination of a vehicle's speed and direction. The crux, rather, is that one determines the *metaphysical risks of harm* an AV poses. This clarifies that control remains a workable principle for analysing AV liability even when no human is driving an AV.

Part IV applies the above towards examining who *legally* controls an AV. It first details how AV technologies and business models operate, focusing on the extent of human input in risk creation. It then demonstrates how legal control may be traced to vehicle manufacturers, software developers, AV operators, and consumers. While control of conventional vehicles was indeed driver-centred, control of AVs is *distributed* across the supply chain. The legal implications of this are briefly considered.

Finally, Part V further grounds the analysis by hypothetically considering how control could illuminate the courts' consideration of individual elements in negligence. This analysis is conducted vis-à-vis early examples of AV litigation from the US, four of which are outlined in Part V.

Before proceeding, it should be clarified that this article's control-centric thesis is targeted narrowly at *fault-based* liability regimes. This has three implications for its scope. First, the thesis has admittedly limited relevance to no-fault liability regimes adopted, for instance, in New Zealand and a growing number of Australian states and territories.[9] Nonetheless, given that many jurisdictions within and beyond Australia remain under fault-based regimes, and further that a number of no-fault regimes provide residual rights for tortious claims, clarifying how tort law may allocate AV liability remains important. Indeed, this may help policymakers gauge how the need to provide for AV accidents affects the longstanding debate

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[9] See Part II(A) below for a jurisdictional survey of liability regimes.

between fault and no-fault regimes.[10] Second, while the article's doctrinal discussion refers primarily from Australian tort law, the thesis applies to other fault-based common law jurisdictions to the extent that their tort doctrines are similar. Thus, reference will be made to the position in comparable jurisdictions where appropriate. Third, the article will not comprehensively engage with (important) issues surrounding AV *regulation* such as testing frameworks, quality assurance, insurance regimes, and traffic rules.[11]

II From Driver-Centricity to Control-Centricity

A Existing Liability Regimes

Though common, driving remains particularly hazardous.[12] AV literature routinely emphasises how human drivers cause thousands of fatalities and millions in economic loss yearly.[13] MVA liability standards thus differ internationally, ranging from strict liability, typically imposed on hazardous *and* uncommon activities,[14] to negligence, and no-fault liability. The Australian states and territories varyingly adopt (negligence) fault-based regimes, hybrid regimes (which are primarily no-fault but provide residual rights to common law claims),[15] and

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[10] For historical context on the debate in Australia see Mark R Forwood, 'Whither No-Fault Schemes in Australia: Have We Closed the Care and Compensation Gap?' (2018) 43(3) *Alternative Law Journal* 166.

[11] For regulation-focused view see Henry Prakken, 'On the Problem of Making Autonomous Vehicles Conform to Traffic Law' (2017) 25(3) *Artificial Intelligence and Law* 341.

[12] Gregory H Shill, 'Should Law Subsidize Driving?' (2020) 95(2) *New York University Law Review* 498, 573.

[13] Mark Brady, 'Is Australian Law Adaptable to Automated Vehicles?' (2019) 6(3) *Griffith Journal of Law and Human Dignity* 35, 35; Mark A Geistfeld, 'A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation' (2017) 105(6) *California Law Review* 1611, 1614; Abraham and Rabin (n 5).

[14] See Steven Shavell, 'The Mistaken Restriction of Strict Liability to Uncommon Activities' (2018) 10 *Journal of Legal Analysis* 1.

[15] Eg, Victoria's compensation regime is primarily a no-fault insurance scheme administered by the Transport Accident Commission, but claimants with serious injuries may still file common law claims: Transport Accident Commission, 'Claims for Common Law Damages' (Web Page)

pure no-fault regimes (which do not).[16] This is supplemented by the no-fault National Injury Insurance Scheme ('NIIS') which covers 'catastrophic' injuries countrywide.[17]

The rest of the world is similarly diverse. As with Australia, the United States exhaust the spectrum from fault to no-fault systems; some have notably reverted from the latter to former.[18] MVA liability in the UK, Singapore, and Hong Kong remain premised on negligence,[19] though recent UK legislation establishes strict

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<www.tac.vic.gov.au/clients/how-we-can-help/treatments-and-services/policies/other/lump-sum-damages-common-law>.

[16] The NTC's 2018 discussion paper lists Western Australia, South Australia, the Australian Capital Territory and Queensland as fault-based, Victoria, Tasmania and New South Wales as hybrids, and the North Territory as a pure no-fault system. See NTC, *Motor Accident Injury Insurance and Automated Vehicles* (Discussion Paper, October 2018) 15–16. There have been changes since then, however, with the ACT switching in February 2020 to a hybrid system: Katie Burgess, 'New CTP Bill Passes but Savings Eroded', *The Canberra Times* (online, 17 May 2019) <www.canberratimes.com.au/story/6128524/new-ctp-bill-passes-but-savings-eroded/>. Debate also exists in Queensland on a possible shift to no-fault: Mina Martin, 'Suncorp Pushes for No-Fault CTP Scheme', *Insurance Business Australia* (online, 18 March 2020) <www.insurancebusinessmag.com/au/news/breaking-news/suncorp-pushes-for-nofault-ctp-scheme-217103.aspx>; Greg Black, 'The Reasons Why the Proposed Changes to the Queensland Compulsory Third Party Scheme Is a Terrible Idea', *Compensation Law Experts* (Blog Post, 14 April 2020) <https://vbrlaw.com.au/proposed-changes-qld-ctp-scheme-terrible-idea/>.

[17] For a review of Australian compulsory third-party insurance and the NIIS schemes see Mark Brady et al, 'Automated Vehicles and Australian Personal Injury Compensation Schemes' (2017) 24(1) *Torts Law Journal* 32, 33. Catastrophic injuries narrowly include spinal cord injury, traumatic brain injury, multiple amputations, serious burns, and permanent traumatic blindness: Treasury (Cth), 'Agreed Minimum Benchmarks for Motor Vehicle Accidents' (Web Page) <https://treasury.gov.au/programs-initiatives-consumers-community/niis/agreed-minimum-benchmarks-for-motor-vehicle-accidents>.

[18] There are too many US states to list here. A helpful tabulation may be found at Insurance Information Institute, 'Background on: No-Fault Auto Insurance' (Web Page, 6 November 2018) <www.iii.org/article/background-on-no-fault-auto-insurance>. A more detailed (but dated) survey is available at James M Anderson, Paul Heaton and Stephen J Carroll, *The US Experience with No-Fault Automobile Insurance: A Retrospective* (RAND, 2010) 7–17.

[19] See *Road Traffic Act 1988* (UK); *Road Traffic Act* (Singapore, cap 276, 2004 rev ed); *Road Traffic Ordinance* (Hong Kong) cap 374.

liability against *insurers* for AV accidents.[20] Many civil law jurisdictions, meanwhile, impose strict liability for MVAs.[21] Liability is presumed unless the *defendant* driver proves that the accident fulfils certain 'escape clauses', such as *force majeure* or contributory negligence.[22] Finally, pure no-fault systems exist in Israel, New Zealand, Sweden, as well as Quebec (and other Canadian territories).[23]

Although the line between strict and no-fault liability is not always clear, notice that while strict liability does not require negligence fault to be proven, the victim still needs to establish in a *tort* claim that the accident was caused by the defendant. In pure no-fault systems, however, a victim's *insurance* claim may be grounded upon the mere fact of injury; the identity (and presence of) the defendant driver may be entirely irrelevant.[24]

Given this paper's tort law focus, its thesis applies most to strict liability and negligence-based regimes (collectively, 'tort-based' regimes) and least to no-fault regimes. Despite Australia's notable shift toward no-fault, tort-based regimes are

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[20] *Automated and Electric Vehicles Act 2018* (UK) s 2. For commentary on the Act see James Marson, Katy Ferris and Jill Dickinson, 'The Automated and Electric Vehicles Act 2018 Part 1 and Beyond: A Critical Review' (2020) 41(3) *Statute Law Review* 395.

[21] Schellekens, 'No-Fault Compensation Schemes for Self-Driving Vehicles' (n 5) 317.

[22] As of 2006, strict liability countries included France, Germany, Belgium, Italy, Spain, the Netherlands, and Austria. The scope of available escape clauses depends on jurisdiction: Andrea Renda and Lorna Schrefler, 'Compensation of Victims of Cross-Border Road Traffic Accidents in the EU: Assessment of Selected Options' Study for the Directorate-General for Internal Policies of the European Parliament, Brussels (Briefing Note, March 2007) <www.europarl.europa.eu/RegData/etudes/etudes/join/2007/378292/IPOL-JURI_ET(2007)378292_EN.pdf> 3–4. Japan's provides likewise. See Seiichi Ochiai, 'Civil Liability for Automated Driving Systems in Japan' in Toa Reinsurance Co Ltd, *Japan's Insurance Market 2018* (Brochure, 2018) <www.toare.co.jp/english/img/knowledge/pdf/2018_insurance.pdf>; *Automobile Liability Security Act (No 97) 1955* (Japan) art 3.

[23] Schellekens, 'No-Fault Compensation Schemes for Self-Driving Vehicles' (n 5) 320.

[24] The New Zealand Ministry of Transport considers the fact that their MVA legislation does not explicitly require vehicles to have drivers as a 'particular advantage' of their regime with respect to AV testing: Ministry of Transport (NZ), 'Testing Autonomous Vehicles in New Zealand' (Web Page) <www.transport.govt.nz/assets/Uploads/Our-Work/Images/T-Technology/Testing-Autonomous-Vehicles-in-New-Zealand.pdf>.

still widely relied on both within and beyond the jurisdiction. The NIIS, to recall, covers only particularly severe injuries. Given further that tort-based regimes appear at first glance to be worse-equipped for allocating AV liability than its no-fault counterpart, it remains important to examine how tort law principles might be applied to AVs, if at all. Since MVA fault in Australia and neighbouring common law jurisdictions are generally allocated by negligence, the rest of this article will focus on the same.

Compensation in a negligence-based regime 'depends on showing that personal injury was sustained as a result of...a negligent human driver'.[25] Although negligence *standards* differ across jurisdictions, virtually all negligence-based systems place primary liability incidence on *drivers*. Disagreement occurs not on *who* should be liable, but on *when* liability arises and *how* it is enforced. Existing regimes are thus often described as 'driver-centric', suggesting that they cannot apply to driverless cars.[26] This point will be scrutinised below in Part 0(D).

To be sure, even where legal *liability* is allocated by negligence, the tortfeasor's practical *ability* to pay is typically ensured with additional statutory insurance

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[25] Brady et al (n 17) 35.

[26] See, eg, Donald G Gifford, 'Technological Triggers to Tort Revolutions: Steam Locomotives, Autonomous Vehicles, and Accident Compensation' (2018) 11(1) *Journal of Tort Law* 71, 138; Simon Chesterman, 'Artificial Intelligence and the Problem of Autonomy' (2020) 1(2) *Notre Dame Journal on Emerging Technologies* 210, 215. Abraham and Rabin use the term 'driver-focused' to refer to the same. See Abraham and Rabin (n 5) 133. See also Shavell, 'Redesign Accident Liability' (n 5) 2, noting that '

> [t]he major rule of tort liability that we apply today [that] concerns [the] fault of the driver...will be irrelevant when there are no drivers in active command of their vehicles'. Shavell explicitly points out, however, that his proposal, strict liability to the state, 'does not depend on the assumption that vehicles are autonomous ...

Ibid 29. For non-academic settings see, eg, Michael Roemer, Steffen Gaenzle and Christian Weiss, 'How Automakers Can Survive the Self-Driving Era' (Report, AT Kearney, 2016) <www.kearney.com/documents/20152/434078/How+Automakers+Can+Survive+the+Self-Driving+Era+%282%29.pdf/3025b1a0-4d71-e24d-51e0-2cc1f290447c>; Timothy Blute, 'Preparing for the Inevitable: The Future of Autonomous Vehicles', *NGA Future* (Blog Post, 13 January 2018) <https://medium.com/nga-future/preparing-for-the-inevitable-the-future-of-autonomous-vehicles-e8e7af23b3e6>.

obligations centred on vehicle owners and/or drivers.[27] The claims process may operate so much on established heuristics for determining fault and computing damages that victim compensation can be a relatively straightforward process which does not actually require fault to be proven in court.[28] This does not, however, imply that tort principles are effectively irrelevant. As Part II(D) will explain, where fault lies naturally shapes where the obligation to insure rests. Further, because notions of fault underpin these very heuristics, attributing fault is a necessary precondition for developing proper heuristics for making the AV claims process as efficient as what we have today for conventional vehicles.

B A Brief History of MVA liability

It is worth remembering that the efficacy of today's MVA compensation schemes is the product of painful experience: thousands of traffic fatalities, and lawsuits, over decades. Questions on the future of MVA liability should thus be addressed against its history. A standalone body of MVA law emerged from a similar transitional period where an untested new technology (the automobile) gradually replaced a familiar one (the horse).[29] 'Riding' and 'driving', then mostly used for horses, were held wide enough to apply to automobiles.[30] Drivers were 'automobilists'.[31] Given America's technological leadership then, MVA cases were quick to reach their courts. Almost 'without exception [they] insisted that the rules

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[27] For a list of Australian state statutes on MVA insurance see Brady et al (n 17) 33 nn 13–15. For comparable statutes in other jurisdictions see above n 19.
[28] Eg, the *Civil Liability Act 1936* (SA) ss 45–50 sets out fixed percentage fault reductions for factors such as non-wearing of seatbelt, intoxication, etc. See also CTP Insurance Regulator, 'Information for People Injured in a Vehicle Accident' (Brochure) <www.ctp.sa.gov.au/__data/assets/pdf_file/0003/32565/Brochure-Information-for-people-injured-in-a-vehicle-accident.pdf>. The Singapore State Courts have published a guide detailing fault percentages in various accident scenarios. See Subordinate Courts (Singapore), *Guidelines for the Assessment of General Damages in Personal Injury Cases* (Academy Publishing, 2010). Note that the Singapore Subordinate Courts were recently renamed to the Singapore State Courts.
[29] Xenophon P Huddy, *The Law of Automobiles* (Matthew Bender, 5th ed, 1919).
[30] Ibid 17.
[31] Ibid 15.

of law applicable to automobile cases ... were no different from those which had been developed in the days of the horse and buggy'.[32] Thus MVA liability was determined by extending negligence rules developed for horses.

So too was the UK situation until the *Road Traffic Act 1930* (UK) c 43 provided comprehensive legislation to address the burgeoning number of traffic accidents.[33] The Act's 'major innovation' was a system of compulsory insurance that, though strongly opposed then, raises little controversy now.[34] Negligence alone was unsatisfactory because accident victims commonly overcame costly litigation only to find tortfeasors insolvent and judgment-proof.[35] The compulsory insurance scheme was designed specifically to ensure that costs fell not 'upon funds derived largely from the generosity of the charitable' but 'on those by whom in equity it should be borne' by compelling motorists to pay regular premiums.[36] It was not meant to disturb tort liability principles. Victims were still to prove negligence before being entitled to compensation.[37]

C Unpacking 'Driver-Centricity'

Driver-centricity, in short, emerged from the search for practical, fair, and efficient means of victim compensation in light of a negligence-based regime inherited from the days of the horse and buggy. As explained below in Part 0(D), the natural person to owe the negligence duty was the driver. With liability centred on the driver, insurance obligations followed.

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[32] Richard M Nixon, 'Changing Rules of Liability in Automobile Accident Litigation' (1936) 3(4) *Law and Contemporary Problems* 476, 476.

[33] See Francis Deak, 'Compulsory Liability Insurance under the British Road Traffic Acts of 1930 and 1934' (1936) 3(4) *Law and Contemporary Problems* 565.

[34] Ibid 576. A similar need was underscored in Royal Commission on Transport, *The Control of Traffic on Roads* (Cmd 3365, 1929) 3–8.

[35] See Deak (n 33).

[36] United Kingdom, *Parliamentary Debates*, House of Lords, 18 December 1929, vol 75, col 1493 (Lord Somerleyton), quoting Voluntary Hospitals Commission, *Termination of the Inquiry* (Final Report, June 1928).

[37] Deak (n 33) 569.

'Driver-centricity' can thus be unpacked into two layers. First, drivers are central *in law* as the focal point of tort liability. Second, drivers are central *in practice* because compulsory insurance identify them as the first parties victims consider suing, possibly even if the accident was caused by manufacturing defects.[38] The layers interact. Denning MR in *Nettleship v Weston* suggested that judges had, since the Road Traffic Acts, become more willing to pin negligence liability on drivers, even in the absence of fault, because this better accorded with the policy of compulsory insurance.[39] Likewise, although American law was slow to adopt compulsory insurance,[40] the courts there, 'though speaking always in terms of fault, have at times stretched the traditional formulas to the breaking point in order to insure recovery to an injured plaintiff'.[41]

D Driving, control, and liability

Existing MVA liability regimes represent a shifting balance jurisdictions strike in the allocation of MVA costs that has been gradually yet continually fine-tuned over time.[42] What has not changed, however, is that driver-centric negligence regimes remain the dominant model of MVA liability. Why are drivers natural liability magnets? The intuitive answer is that drivers *control* the vehicle. This is central to a proper understanding of the basis of MVA liability but, given our historical focus on *drivers*, appears under-appreciated. This sub-Part scrutinises the relationship between driving, control, and liability.

1 'Driving' as Control

A standards document issued by the Society of Automotive Engineers known in the literature as 'J3016' decomposes driving into specific 'strategic', 'operational',

[38] There is, beyond this article's scope, a third, *regulation* layer that as noted in Part 0 attaches centrally onto drivers as well.
[39] [1971] 2 QB 691, 699–700.
[40] See generally Deak (n 33).
[41] Nixon (n 32) 490.
[42] Brady et al (n 17) 33.

and ‘tactical’ tasks.[43] Strategic tasks include planning destinations and waypoints; operational tasks include steering, braking, and monitoring road picture; tactical tasks include responding to road events and changing lanes.[44] The operational and tactical aspects of driving together comprise the ‘dynamic driving task’ (‘DDT’).[45] A vehicle’s automation level turns solely on how far the DDT is automated.[46] J3016 identifies six levels of automation, from 0 to 265. Truly ‘automated’ vehicles are those at or above Level 3. At that level (‘conditional automation’), the ADS handles steering, acceleration, and road picture monitoring, subject to an ‘expectation that a fall-back ready [human] is receptive to an ADS-issued request to intervene ... and will respond appropriately’.[47] At Levels 4 and 5, reliance on human safeguards is progressively removed.[48]

The preceding suggests that ‘driving’ is best understood as a continuum. One is *more or less of a driver* depending on the driving tasks performed. While dynamic, operational tasks appear most integral to ‘driving’, not all such tasks are necessary for it. Command of the gear shift and clutch, for example, has long been obviated by automatic transmissions, yet automatic car operators are still clearly ‘drivers’ in both the lay and legal sense. Taking this further, if one merely steered a vehicle while software determines its speed, is one still ‘driving’? Decomposing driving into its component tasks avoids this conundrum: one simply ‘drives’ the vehicle’s direction while the ADS ‘drives’ the vehicle’s speed.

[43] On-Road Automated Driving Committee, ‘Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles’ (Ground Vehicle Standard No J3016_201806, SAE International, 15 June 2018) 34 <www.sae.org/content/j3016_201806> (‘J3016’).
[44] Ibid.
[45] Ibid 6.
[46] Ibid 19.
[47] Ibid.
[48] Ibid.

It follows that the extent one 'drives' depends on the tasks one controls. To be sure, while J3016 is widely relied on by scholars and regulators,[49] it is expressly not intended as a legal definition.[50] It is thus crucial that legal definitions of 'driving' are likewise premised on control. Specifically, Brady et al identify a number of Australian road traffic laws that define driving as being 'in control of' a vehicle.[51] Leading Australian authority interprets this to require 'some control of the propulsive force which, if operating, will cause the car to move'.[52] As Tranter notes, this represents a 'pragmatic approach ... which involves factual considerations relating to responsibility for the primary controls, the steering, the accelerator and the brake'.[53]

Can these statutory definitions be read more broadly than J3016 to deal with AV liability? Specifically, if one merely controlled the ADS which *in turn* controls the vehicle's propulsion, might one still be 'in control of' the vehicle? If so, would one be liable for its accidents?

2 Control as the Source of Liability

The crux of the question lies in what 'control' means. This will be dealt with separately in the following Part. The point here is that although we are accustomed to centralising MVA liability around *drivers*, we are in truth interested in liability for *controllers* — and justifiably so. Control is associable with moral fault through the well-established Control Principle:[54] the more a

[49] Department of Transportation (US), *Preparing for the Future of Transportation: Automated Vehicle 3.0* (October 2018). Most of the literature cited throughout this article import this definition.
[50] On-Road Automated Driving Committee (n 43) 18.
[51] Brady et al (n 17) 36–7.
[52] *Tink v Francis* [1983] 2 VR 17. See also Kieran Tranter, 'The Challenges of Autonomous Motor Vehicles for Queensland Road and Criminal Laws' (2016) 16(2) *Queensland University of Technology Law Review* 59, 65.
[53] Tranter (n 52) 66.
[54] Mehmet Y Gurdal, Joshua B Miller and Aldo Rustichini, 'Why Blame?' (2013) 121(6) *Journal of Political Economy* 1205.

rational agent controls his or her actions, the more those actions reflect not only the agent's intentions and beliefs but also the agent's view of 'all the reasons that apply to the occasion, and ways of pursuing [those reasons]'.[55] It is then natural to hold that individual responsible for those actions.[56] While moral responsibility should be distinguished from legal liability,[57] the link between MVA liability and control is equally well-established. As Huddy wrote in 1919:

> *Sec 655. Liability based on control of machine.*
>
> Liability for the operation of a motor vehicle is imposed on the person having 'control' of its movements. Primarily, this is the chauffeur, and he is, of course, charged with his personal negligence. But liability may go farther than a personal judgment against the driver, for the doctrine of *respondeat superior* may charge his employer or the owner of the machine with liability. The negligence of the driver, moreover, may be imputed to one having control, though such person is not the owner of the machine or the employer.[58]

Indeed, instrumental and non-instrumental rationales of tort law converge on driver liability, given that they are in positions of both least-cost avoidance and moral responsibility where MVA risks are concerned.[59] It is nonetheless crucial to understand 'driver-centricity' as an *artefact* of (moral and legal) control principles.

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[55] Joseph Raz, 'Being in the World' (2010) 23(4) *Ratio* 433, 436. Although Raz rejects the universal-sufficiency of the control principle as the basis of responsibility for all actions, he accepts that the control principle together with the intention principle form the 'paradigmatic cases' of rational agent moral responsibility for actions: at 451.

[56] Eg, through Gardner's 'basic responsibility'. See John Gardner, 'The Negligence Standard: Political Not Metaphysical' (2017) 80(1) *Modern Law Review* 1.

[57] See generally Peter Cane, 'Morality, Law and Conflicting Reasons for Action' (2012) 71(1) *Cambridge Law Journal* 59. On motor accidents specifically, Goudkamp observes that courts have 'frequently [found] drivers liable in circumstances in which there is little or no evidence of moral blameworthiness'. See James Goudkamp, 'The Spurious Relationship between Moral Blameworthiness and Liability for Negligence' (2004) 28(2) *Melbourne University Law Review* 342, 353.

[58] Huddy (n 29) 849 (emphasis in original) (citations omitted).

[59] By 'instrumental' I refer to utilitarian and/or functional accounts of tort law and by non-instrumental I refer to all others. See Richard A Posner, 'Instrumental and Noninstrumental Theories of Tort Law' (2013) 88(2) *Indiana Law Review* 469, 469.

Liability attaches not because of one's 'driverness', but because of one's *control* of the vehicle.[60] The legal question should then not be who *drives* an AV, which misleadingly implies that any software that drives should be liable for resulting accidents, but who *controls* the AV, which conversely *clarifies* that the absence of a driver is *not* fatal to legal doctrine *provided* control may be established. This necessitates a careful definition of legal 'control'.

III Clarifying Legal Control

Smith has argued that the 'inconsistent use' of terms like control by lawyers and engineers has engendered unnecessary confusion.[61] J3016 likewise notes that

> [b]ecause the term 'control' has numerous technical, legal, and popular meanings, using it without careful qualification can confuse rather than clarify. In law, for example, 'control,' 'actual physical control,' and 'ability to control' can have distinct meanings that bear little relation to engineering control loops. Similarly, the statement that the (human) driver 'does not have control' may unintentionally and erroneously suggest the loss of all human authority.[62]

An underappreciated distinction must be drawn between control as an *engineering* concept and as a legal doctrine. In engineering control theory, a 'controller' is said to control an object (the 'control plant') only when the controller can make specific input choices that translate into the object exhibiting desired output behaviours.[63] Such control is not premised on legal capacity, but on a precise definition of the relevant 'control system', which broadly comprise the set of inputs, outputs, and

[60] This is not merely a matter of semantics. As Parts 0 and 0 below demonstrate, it is possible to *legally* control a vehicle without physically driving it.

[61] Bryant Walker Smith, 'Lawyers and Engineers Should Speak the Same Robot Language' in Ryan Calo, A Michael Froomkin and Ian Kerr (eds), *Robot Law* (Edward Elgar, 2016) 78.

[62] On-Road Automated Driving Committee (n 43) 29.

[63] Smith (n 61) 83 n 18. On control theory generally see James Ron Leigh, *Control Theory: A Guided Tour* (Institution of Engineering and Technology, 3rd ed, 2012).

translational processes one is interested in studying.[64] Controlling a vehicle's direction, for instance, involves setting the steering wheel to a specific angle corresponding to the desired output direction. If a defect in the vehicle's differentials causes the front axle to turn in entirely random directions for any given wheel input, control does not exist. Engineering control, therefore, focuses on a vehicle's *physical* variables such as speed and heading. This is what an engineer or layperson means when they, not inaccurately, assert that 'no one controls an AV when the ADS is driving'.

Courts need not and indeed do not use 'control' the same way. A survey of how control is analysed in the precedents below show that tort law is instead concerned with the determination of the *metaphysical* risks of harm posed to society.

Foremost, control is a salient feature for ascertaining negligence duties. In *Perre v Apand Pty Ltd*,[65] the defendant company Apand invited the Sparnons to participant in a potato growing experiment and negligently introduced bacterial wilt onto the Sparnons' farm by providing them with infected potato seed. Western Australian regulations then prohibited the importation into Western Australia of potatoes grown on neighbouring farms as well, inflicting pure economic losses on the Perres' farms.[66] Holding that Apand owed the Perres a duty of care, the HCA emphasised how Apand had been in a position of 'control over the experiment and where it would occur'.[67] Thus, the 'relevant risk to the commercial interests of [the Perres] was in the exclusive control of Apand'.[68] It did not matter that Apand did not control the *physical* mechanism through which the economic loss was occasioned: the Sparnons planted the infected seeds and the import restrictions were government-imposed.

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[64] Smith (n 61) 85. Smith further argues that because 'most automatic control systems can be defined broadly enough that they involve a human and narrowly enough that they do not ... system definition could drive the legal conclusion': at 84.
[65] (1999) 198 CLR 180.
[66] Ibid 191–2 [2]–[4].
[67] Ibid 236 [149] (McHugh J).
[68] Ibid 259–60 [216] (McHugh J).

A similar focus on risk control can be observed in contexts involving physical harm arising in connection with property (which more readily analogises to MVAs). In *Burnie Port Authority v General Jones Pty Ltd*,[69] where fire from the defendant's land damaged the plaintiff's goods, the five-judge majority held that circumstances which prima facie attract liability under the rule in *Rylands v Fletcher*[70] are characterized by 'a central element of control', in that the defendant has taken advantage of their control of premises to undertake or allow a dangerous activity thereon, thereby exposing the plaintiff, who had no such control, to a 'foreseeable risk of danger'.[71]

Similarly, the duty of care that occupiers owe entrants 'arise[s] from the ... right of control over the premises and those who enter them'.[72] The Singapore Court of Appeal has held that occupiers with control of premises owe a 'prima facie duty of care to lawful entrants' because it is 'eminently foreseeable that entrants will suffer damage if occupiers do not take reasonable care to eliminate danger'.[73]

Control of risks is also pivotal in multi-party scenarios. The High Court in *Burnie* held that, as with *Rylands*, relationships giving rise to non-delegable duties were commonly characterised by a "central element of control".[74] In *New South Wales v Lepore*, McHugh J, argued that a school authority owed its pupils a non-delegable duty of care because the 'school authority has control of the pupil whose immaturity is likely to lead to harm to the pupil unless the authority exercises reasonable care in supervising him or her'.[75] McHugh J's analysis of non-delegable

[69] (1994) 179 CLR 520 ('*Burnie*').
[70] (1868) LR 3 HL 330.
[71] Ibid [37] (emphasis added) (citations omitted). This case also abolished the application of *Rylands* in Australia by subsuming it into negligence.
[72] *Cole v South Tweed Heads Rugby Club Ltd* (2004) 217 CLR 469, 480–1 [30] (McHugh J).
[73] *See Toh Siew Kee v Ho Ah Lam Ferrocement Pte Ltd* [2013] 3 SLR 284, 316–7 [77]–[80] (Court of Appeal) ('*See Toh*'). The case also clarifies that in Singapore, like in Australia but unlike in England, occupier's liability is subsumed under the common law of negligence: at 316 [76].
[74] *Burnie* (n 69) 330 [36].
[75] (2003) 212 CLR 511, 563–4 [139] (McHugh J). See also *Woodland v Essex County Council* [2014] AC 537, 582–3 [23]–[24].

duties was notably not shared by the majority who preferred to base the decision on vicarious liability instead.[76] Yet in vicarious liability as well, the control test has long been 'of vital importance' in establishing a sufficient relationship between employer and primary tortfeasor.[77] In the classic case of *Mersey Docks and Harbour Board v Coggins & Griffith (Liverpool) Ltd*,[78] the harbour board remained vicariously liable for the tort of a crane-driver the board had hired out because control of how the crane-driver drove had not been transferred to the hirer. In English law, control remains one of five key policy factors that make it 'fair, just, and reasonable' to hold the employer liable for the employee's tort.[79]

Notably, although control 'does not have the significance which once it did' in vicarious liability because today's 'employer is likely to be able to tell an employee what to do but not (at least always) how to do it,'[80] the English courts' response was precisely to clarify that legal 'control' is broader than physically determining what is done. *Armes v Nottinghamshire County Council*[81] held that a County Council could be vicariously liable for sexual abuse by foster parents to whom the Council entrusted the claimant. Lord Reed, who delivered the leading judgment, pinned the Council's control on how:

> [a]lthough the foster parents controlled the organisation and management of their household ... and dealt with most aspects of the daily care of the children without immediate supervision ... The local authority exercised powers of approval, inspection, supervision and removal without any parallel in ordinary family life. By virtue of those powers, the local authority exercised a *significant degree of control* over both what the foster parents did and how they did it ...[82]

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[76] Ibid [34]–[38] (Gleeson CJ), [270] (Gummow and Hayne JJ).
[77] *Various Claimants v Catholic Child Welfare Society* [2013] 2 AC 1, 16 [37] ('*CCWS*').
[78] [1947] AC 1.
[79] *CCWS* (n 77) 15 [35(e)], applied by both majority and minority in *Barclays Bank plc v Various Claimants* [2020] 2 WLR 960 ('*Barclays*').
[80] *Barclays* (n 79) 967–8 [20].
[81] [2018] AC 355.
[82] Ibid 379 [62] (emphasis added). See also *Barclays* (n 79) 967–8 [20].

Across these legal contexts, active physical control of the subject is neither necessary nor sufficient to constitute legal control; what matters is that the controller is *in a position* to determine the risks of harm the subject poses to society. The vicariously liable employer need not have physically steered the employee like a puppet; nor does the employee's unquestionable human autonomy preclude the former from 'controlling' them.[83] Rather, powers of approval or supervision may suffice, as long as the defendant had set a risk in motion.

To be sure, physical control is *indicative* of legal control because physical states and behaviours shape metaphysical risks. Indeed, conventional drivers legally control vehicles by physically controlling them. The touchstone being *risk* control, however, means the crux lies in identifying specific states and/or behaviours responsible for risk creation, and determining if the putative controller was in a position to determine these inputs. This accords with the old principle that an occupier who controls the general state of affairs on land is less likely liable than one who controls the dynamic activities giving rise to the harm.[84] Nonetheless, physical and legal control are conceptually separable: one could physically control system attributes unrelated to risk creation, or conversely be in a *legal* position to determine a system's risks without *physically* controlling the system itself.[85]

IV Legal Control of Automated Vehicles

Any entity in a position to determine a vehicle's risks, therefore, might be said to be in *legal* control of that vehicle — even one *physically* controlled by an ADS.

[83] Consider also that we have no problems assigning liability to horse carriage drivers even though horses can be said to have 'autonomous' minds and can also be unpredictable. See David King, 'Putting the Reins on Autonomous Vehicle Liability: Why Horse Accidents Are the Best Common Law Analogy' (2018) 19(4) *North Carolina Journal of Law and Technology* 128, 147–8. On the definition of autonomy in the AV context see Mark Chinen, *Law and Autonomous Machines: The Co-Evolution of Legal Responsibility and Technology* (Edward Elgar, 2019) 3–5.

[84] *Australian Safeway Stores Pty Ltd v Zaluzna* (1987) 162 CLR 479, 486. For a review of the history and current Commonwealth treatment of the static-dynamic classification see *See Toh* (n 73) 305–16 [41]–[75].

[85] For instance, by controlling an employee who in turn performs the physical work.

Yet even if ADS-driven vehicles *can*, in law, be controlled by a separate legal entity, it remains to be seen whether they *are* so controlled. A control-centric view clarifies that, far from there being no one 'driver' to pin liability upon, a range of potential defendants arise by virtue of their participation in AV risk creation. These include vehicle manufacturers, software developers, fleet operators, vehicle operators such as safety drivers, and possibly consumers. To provide necessary context, this Part first outlines how AV technology and businesses operate before analysing how each entity legally controls an AV.

A How AV Technology Operates

An ADS comprises 'the hardware and software that are collectively capable of performing the entire DDT on a *sustained* basis'.[86] This importantly dispels misconceptions that artificially-intelligent *software* is all that is required. There is no such 'magic' to automated driving.[87] Instead, an ADS is itself a complex system of interconnected software elements that graft onto hardware systems like the steering and braking assemblies.[88] Relevant hardware include cameras, LiDARs, radars, GPS systems, and other devices first used to *sense* the AV's surroundings. Environmental data from these sensors are necessary but are insufficient for automated driving until interpreted by the ADS software. Typical ADS software process data in three stages, in order: perception, decision and planning, and control.[89] Sensor data is first analysed by perception modules that detect a range

[86] On-Road Automated Driving Committee (n 43) 3 (emphasis in original). This was adopted in NTC, *Changing Driving Laws to Support Automated Vehicles* (n 8). See also National Highway Traffic Safety Administration, *Automated Driving Systems 2.0: A Vision for Safety* (September 2017) <www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf>.

[87] Hannah YeeFen Lim, *Autonomous Vehicles and the Law: Technology, Algorithms and Ethics* (Edward Elgar, 2018) 2.

[88] On the technology see generally ibid.

[89] Wenhao Zong et al, 'Architecture Design and Implementation of an Autonomous Vehicle' (2018) 6 *IEEE (Institute of Electrical and Electronics Engineers) Access* 21956, 21959. There, the authors provide an instructive diagram that enumerates specific modules within each category, such as the lane marks recognition module and the vehicle and pedestrian detection module.

of objects of interest like traffic lights, lane markings, and pedestrians. Algorithms are deployed to interpret the sensor data.[90] For example, an image classification algorithm, commonly based on a neural network, could be used to identify pedestrians and other road obstacles from out of the camera feed.[91] Notably, while some modules may involve machine learning ('ML') techniques, and thus implicate the range of legal complications that ML raises, other computational techniques are also involved. For instance, certain lane detection algorithms use only linear algebra and matrix operations that need not be trained.[92]

The enriched data is then sent to the decision and planning modules which decide on a course of action given the general road picture as well as the target destination. Again, these could involve both deterministic and non-deterministic algorithms.[93] Further, certain aspects of the vehicle's behaviour may be hard-coded (that is, predetermined) by developers.[94] To illustrate, developers may specify in the decision module that if a pedestrian is detected in the middle of the detected lane, then the vehicle's desired speed should be set to zero. Finally, the chosen action(s) are piped into the control module which, in turn, causes the vehicle's hardware to accordingly produce the speed, bearings, and other physical variables desired.[95]

It should be noted that ADS architectures, including the sensors and algorithms, differ across developer. Indeed, developers guard their ADS recipes cautiously.[96]

[90] On machine learning ('ML') in AVs see Brian S Haney, 'The Optimal Agent: The Future of Autonomous Vehicles & Liability Theory' (2020) 30(1) *Albany Law Journal of Science and Technology* 1.
[91] YeeFen Lim (n 87) 15.
[92] Yang Xing et al, 'Advances in Vision-Based Lane Detection: Algorithms, Integration, Assessment, and Perspectives on ACP-Based Parallel Vision' (2018) 5(3) *IEEE/CAA (Chinese Association of Automation) Journal of Automatica Sinica* 645.
[93] YeeFen Lim (n 87) 16.
[94] Ibid.
[95] Zong et al (n 89) 21959.
[96] YeeFen Lim (n 87) 84.

B AV Business Models

There are two primary models through which AVs are made available to consumers. First, AVs may first be sold directly to consumers like conventional vehicles. A number of partially automated Teslas are now in private use on American roads. While these are not fully-automated vehicles in the J3016 sense, the Tesla model indicates a possible future. Tesla's Autopilot system lets users determine 'speed limit offsets' that represent how far the vehicle may deviate from road limits.[97] Users may also tweak how abruptly the vehicle changes lanes. Tesla calls the most extreme setting 'Mad Max' mode.[98] The company has also announced that riders may be allowed to choose between 'gradually more aggressive' driving modes.[99] Fully-automated consumer AVs, however, remain a distant prospect given technological constraints.[100]

The second model involves intermediary platforms offering on-demand AV rides to consumers. Google subsidiary Waymo, for instance, launched an automated taxi service in late 2019 that transported 6,299 passengers in its first month.[101] Like today's ride-hailing platforms, these 'fleet operators' need not manufacture or own their own AVs. In practice, however, fleet operators tend to be technology companies which offer rides precisely because they had developed, and wish to test,

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[97] For an illustration of the settings panel see 'Autopilot Settings', *Teslarati* (Web Page) <www.teslarati.com/first-experience-tesla-autopilot-features/autopilot-settings/>. See also Tesla, 'Support: Discover Software Version 9.0' (Web Page) <www.tesla.com/support/software-v9?redirect=no#controls> for the suite of configurable settings.

[98] Sean O'Kane, 'Elon Musk Says Tesla Will Allow Aggressive Autopilot Mode with "Slight Chance of a Fender Bender"', *The Verge* (online, 22 April 2019) <www.theverge.com/2019/4/22/18511527/elon-musk-tesla-aggressive-autopilot-mode-fender-bender>.

[99] Ibid.

[100] Alex Davies, 'The WIRED Guide to Self-Driving Cars', *Wired* (online, 13 December 2018) <www.wired.com/story/guide-self-driving-cars/>.

[101] Kirsten Korosec, 'Waymo's Robotaxi Pilot Surpassed 6,200 Riders in Its First Month in California', *Techcrunch* (online, 17 September 2019) <https://techcrunch.com/2019/09/16/waymos-robotaxi-pilot-surpassed-6200-riders-in-its-first-month-in-california/>.

an AV. Importantly, fleets may be monitored and/or physically controlled by operators through overarching 'fleet control systems'.[102]

C Tracing Control to Manufacturers, Developers, Fleet Operators, and Consumers

It should by now be clear that even though the ADS commands most of the *physical* control in a highly automated vehicle, *legal* control of AV risks nonetheless resides, in varying degrees and forms, in manufacturers, developers, fleet operators, and consumers.

Manufacturers control AV *hardware* risks. If defective brakes cause an AV accident, there should be little doubt that the manufacturer is liable. Victims may, of course, have some difficulty *proving* that an accident was due to hardware defects where AVs are concerned, but the problem here is a *factual* rather than legal one. Complications may arise if defective hardware *in turn* causes an ADS error. Suppose a defective LiDAR fails to sense a pedestrian and the ADS, driving with erroneous sensor data, crashes into them. But even here, there is no question as to the manufacturer's control (and indeed fault). The issue is whether the developer *also* contributed to the actualized risk, so as to be a co-defendant.

Developers make deliberate design choices in building an ADS. This applies *especially* to any hard-coded or deterministic ADS components, but extends

[102] General Motors subsidiary Cruise announced in early 2019 an SAE Level 4 AV which was to be monitored live from the company's fleet control room: Chris Teague, 'The Cruise Origin Is GM's Driverless Shared Shuttle Pod: And It's Headed for Mass Production', *The Drive* (online, 21 January 2020) <www.thedrive.com/news/31913/the-cruise-origin-is-gms-driverless-shared-shuttle-pod-and-its-headed-for-mass-production>. The startup Drive.ai, since acquired by Apple, had 'fleet control operators' on standby to take over the wheel remotely if necessary: Andrew J Hawkins, 'Fully Driverless Cars Are on Public Roads in Texas', *The Verge* (online, 17 May 2018) <www.theverge.com/2018/5/17/17365188/drive-ai-driverless-self-driving-car-texas>; Andrew J Hawkins and Sean Hollister, 'Apple Buys Self-Driving Startup Drive.ai Just Days before It Would have Died', *The Verge* (online, 25 June 2019) <www.theverge.com/2019/6/25/18758820/drive-ai-self-driving-startup-shutting-down-apple>.

equally to ML components. The argument that the 'black box' nature of ML algorithms obfuscates legal analyses of intent and causality[103] does not apply to control: the engineering concept of a 'black box' describes precisely systems for which we may 'relate stimuli to responses without regard to the parts or organs of the system'.[104] 'Black boxes' are by original *definition* systems that *can* be controlled even where the controller does not fully understand the system's internal workings. The narrow ML algorithms typically used in today's ADSes are broadly output-predictable: a neural network trained for road sign detection would not, when provided a road image, perform lane detection instead. It is also possible to generate explanations of (black box) algorithms by probing its behaviour against different inputs.[105]

Further, even if developers do not physically control how the ADS ultimately behaves, they are nonetheless in a position to determine the societal risks an ADS constitutes. Developers control how extensively a ML algorithm is trained, how stringently the ADS is tested before it is released to consumers, and *whether* the ADS is released at all.

Apart from possible additional roles as manufacturer or developer, fleet operators also participate in AV risks. Operators can monitor active AVs via fleet control systems enabled by the rich data network that AV systems create. This puts them in a unique informational and resource position for regulating AV safety. Operators can further choose between different ADS and vehicle offerings: if one opts for deploying untested software in its vehicles without further testing, or installs software incompatible with its hardware systems, liability logically follows.

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[103] Yavar Bathaee, 'The Artificial Intelligence Black Box and the Failure of Intent and Causation' (2018) 31(2) *Harvard Journal of Law and Technology* 889.

[104] Mario Bunge, 'A General Black Box Theory' (1963) 30(4) *Philosophy of Science* 346. Recall from Part 0 that the essence of engineering control is the ability to choose inputs to achieve desired output behaviours. For how neural networks operate in AVs see Haney (n 90) 9–21.

[105] Sandra Wachter, Brent Mittelstadt and Chris Russell, 'Counterfactual Explanations Without Opening the Black Box: Automated Decisions and the GDPR' (2018) 31(2) *Harvard Journal of Law and Technology* 841.

Further, as the primary consumer-facing entity, operators decide precaution levels in consumer offerings. A crucial decision is whether to provide safety drivers. Notably, a cautious operator who does so may be *vicariously* liable for accidents the driver should reasonably have prevented (regardless of whether an ADS failure was involved). It would be absurd if, for the same ADS and vehicle set-up, a less cautious operator who forgoes safety drivers is placed in a better position.

Lastly, consumers may also participate in AV risk creation through user settings (notably exposed to them by either manufacturers, developers, and/or operators). To recall Tesla's customisable settings, should one choose large speed limit offset and a 'Mad Max' driving policy, one should arguably bear some if not all of any resulting accident costs.

D Special Features of AV Control

Contrasting AV control with that of conventional vehicles illuminates how AVs challenge tort law. Conventionally, physical and legal control of MVA were both centred on drivers. AVs do not only dissociate physical from legal control; they *distribute* legal control amongst parties across the AV supply and consumption chain.[106] The content of such control also differs: while human drivers determine accident risks by contemporaneously determining a vehicle's physical speed and direction, ADS risks are largely determined *pre-emptively* in the manufacturing/development process.[107] As Shavell has noted, sequential torts

[106] This is a legal instance of Elish's insight that, for complex systems, moral responsibility is often centred solely on particular human actors even though systematic control is distributed over a range of actors. Elish calls these 'moral crumple zones' that society constructs to protect the overall integrity of that system: Madeleine Clare Elish, 'Moral Crumple Zones: Cautionary Tales in Human-Robot Interaction' (2019) 5 *Engaging Science, Technology, and Society* 40. Chinen likewise notes that, for autonomous systems generally, one solution may be to disaggregate responsibility and cast a wider net over who may be held responsible: Chinen (n 83) 232–5.
[107] Though as noted above operators and consumers determine some risks contemporaneously. See above Part 0(C).

involve different behavioural incentives from simultaneous ones.[108] Because manufacturers and developers act *ex ante*, they may, in fact, be in a *better* position than human drivers to invest in precaution.[109]

The control paradigm for AVs is thus fundamentally different. The problem is not that there is no longer a driver, nor that manufacturers or developers are the new drivers. Rather, in some sense, *everyone* is a driver, though in a different way from the past and from each other. This may however be recast as an *opportunity* for legal systems to *choose* who should bear liability for AV accidents. Since control may be traced to each of them, manufacturers, developers, operators, and/or riders may be held primarily (or jointly and/or severally) liable. Conventional motor vehicles did not present this choice; any liability system not centralised first on drivers would have been strange and unstable. How jurisdictions make this choice may ultimately be a function of policy priorities. This could explain the emerging divergence amongst major jurisdictions on AV liability.[110]

V Application to Negligence

This Part examines how courts could analyse AV negligence cases from a tortious control perspective, taking reference from early AV accidents. Note that as most cases remain in preliminary stages, the following (alleged) facts should be read only as *illustrations* of possible AV accidents. The present discussion will also limit

[108] See Steven Shavell, 'Torts in Which Victim and Injurer Act Sequentially' (1983) 26(3) *Journal of Law and Economics* 589.
[109] Abraham and Rabin (n 5) 29.
[110] For the Australian position and the range of US academic proposals see above Part 0. The EU has signalled a need to examine whether AVs may 'justify a shift in liability to the manufacturer which, as a risk factor that is independent of negligence, can be linked simply to the risk posed by bringing an autonomous vehicle onto the market': *European Parliament Resolution of 15 January 2019 on Autonomous Driving in European Transport*, P8_TA(2019)0005 (15 January 2019) [21]. Recent UK legislation established strict *insurer* liability for automated vehicles. See generally the *Automated and Electric Vehicles Act* (n 20); Marson, Ferris and Dickinson (n 20).

itself to narrating the broad picture, leaving a closer (control) analysis for when further and better case details become available.

A Early AV Accidents

In *Nilsson v General Motors LLC* ('*Nilsson*'),[111] the plaintiff motorcyclist was travelling behind a vehicle manufactured by the defendant sometime in the morning. The vehicle's driver Salazar had put the vehicle in self-driving mode[112] and, according to the complaint, kept his hands off the steering wheel.[113] Salazar commanded the vehicle to filter left, and it did. It then 'suddenly veered back into [the plaintiff's] lane', striking and injuring him.[114] The complaint alleged negligence against General Motors alone without naming Salazar as defendant. The case settled.[115]

In *Umeda v Tesla Inc* ('*Umeda*'),[116] some motorcyclists were parked behind a small van on the far-right lane of an expressway in Japan, following an accident between the van and a group member. At around 2:49pm, a Tesla Model X crashed headfirst into the group, killing the victim. According to the complaint, the Tesla driver had engaged the Autopilot about 30 minutes earlier and instructed it to track the vehicle in front. When that front vehicle encountered the motorcyclist group, it signalled and filtered left to avoid them. The Tesla, however, 'began

[111] Complaint, *Nilsson v General Motors LLC* (ND Cal, No 3:18-cv-00471-KAW, 22 January 2018) ('*Nilsson*').
[112] General Motors calls its ADS the 'Cruise' system. Around the material time in 2017, Cruise had been involved in a number of accidents: David Shepardson, 'GM's Self-Driving Cars Involved in Six Accidents in September', *Reuters* (online, 5 October 2017) <www.reuters.com/article/autos-selfdriving-crashes/gms-self-driving-cars-involved-in-six-accidents-in-september-idUSL2N1MF1RO>.
[113] *Nilsson* (n 111) [7].
[114] Ibid [11].
[115] David Shepardson, 'GM Settles Lawsuit with Motorcyclist Hit by Self-Driving Car', *Reuters* (online, 2 June 2018) <www.reuters.com/article/us-gm-selfdriving/gm-settles-lawsuit-with-motorcyclist-hit-by-self-driving-car-idUSKCN1IX604>.
[116] Complaint, *Umeda v Tesla Inc* (ND Cal, No 5:20-cv-02926, 28 April 2020) ('*Umeda*').

rapidly accelerating from about 15 km/h to approximately 38 km/h'.[117] The complaint alleged that the vehicle did not detect the group, and that the driver had 'begun to doze off' before the incident, which thus occurred 'without any actual input or action' from the driver.[118]

In *Hudson v Tesla Inc* ('*Hudson*'),[119] the plaintiff put his Tesla Model S on Autopilot while on a highway. He was then 'relaxing during his [morning] commute, fully confident that the vehicle would "do everything else" just as Tesla promised'.[120] Gonzalez-Bustamante, the second defendant, had left his stalled vehicle on the same highway lane. The plaintiff's vehicle crashed headfirst into it, leaving him severely injured.

In *Sz Hua Huang v Tesla Inc* ('*Huang*'),[121] the victim was travelling in his Autopiloted Tesla down a US interstate highway at around 9:27am. As the vehicle approached a paved area dividing the highway from an exit, the Autopilot 'turned the vehicle left, out of the designated travel lane, and drove it straight into a concrete highway median'.[122] According to a separate complaint filed in *Muwafi v Tesla Inc* ('*Muwafi*'),[123] which arose from the same incident, the Tesla then 'ricocheted back into [the highway]' and collided with a (conventional) vehicle driven by the plaintiff in the second suit.[124] Both suits claimed, *inter alia*, negligence against Tesla as well as its individual employees.[125]

These cases by no means exhaust all AV accidents that have occurred internationally. A further caveat is that they all involved Level 2, privately-owned

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[117] Ibid [27].
[118] Ibid [27]–[29].
[119] Complaint, *Hudson v Tesla Inc* (Fla Cir Ct, No 2018-CA-011812-O, 30 October 2018) ('*Hudson*').
[120] Ibid [42].
[121] Complaint, *Sz Hua Huang v Tesla Inc* (Cal Super Ct, No 19CV346663, 26 April 2019) ('*Huang*').
[122] Ibid [25].
[123] Complaint, *Muwafi v Tesla Inc* (Cal Super Ct, No 20CV365747, 26 April 2019) ('*Muwafi*').
[124] Ibid [9].
[125] *Huang* (n 121) [9]; *Muwafi* (n 123) [12].

AVs. Nonetheless, they provide the best available indication of the accident archetypes to be expected with AVs. In particular, given the nature of algorithmic failures, AV accidents may tend to be especially severe. An ADS may work well most of the time, but *if* an ADS fails, it tends to fail *catastrophically*, with initial input errors magnified in downstream modules reliant on the integrity of upstream inputs. Large obstacles could be completely missed in daylight. There are further two types of AV lawsuits: *Nilsson* and *Umeda* involved third-party road users harmed by AVs, while *Hudson* and *Huang* involved harm to the AV riders themselves. While all plaintiffs sued the AV developers; the third-party victims Nilsson and Umeda notably did not sue the (partially) AV drivers.[126]

B Control Analysis

Assuming for exposition that the alleged facts are true, how might control illuminate the courts' analysis of the above cases? Problems with applying existing negligence principles to AVs have been identified in the literature, including the cost of verifying software standards,[127] difficulties with proving causation,[128] questions on when human users may 'reasonably rely' on the ADS,[129] and issues surrounding specific state liability statutes.[130] Control analysis alleviates some of these concerns while reinforcing others.[131]

First, it clarifies that identifying *who* might be liable, which retraces to establishing who owes victims a duty of care, may not be as difficult as sometimes thought. While true that the behaviour of AI systems is not completely foreseeable a

[126] To be sure, it is not known if the drivers had privately agreed to compensate.
[127] YeeFen Lim (n 87) 82–94.
[128] Mackie (n 6).
[129] Brady et al (n 17) 42.
[130] Ibid 41.
[131] Note that although the cases considered all involved partially automated vehicles, the analysis below applies to fully automated vehicles.

priori,[132] legal control, as earlier established, requires not the foreseeability of specific *physical* behaviours, but of general *metaphysical* risks. Tesla need not have actually or even reasonably foreseen that Huang's vehicle would inexplicably veer left into a highway median for a duty to arise. What *is* required is simply that they could reasonably foresee that someone in Huang's position would be harmed if they failed to take reasonable care in manufacturing/developing the AV/ADS.[133] Indeed, precisely because AI systems are *known* to act in not-completely-predictable ways, it is eminently foreseeable that carelessness with their creation or sale could cause harm — particularly the physical harm that most accident victims will suffer.[134] Similar arguments could be made for establishing negligence duties against operators.

Questions of remoteness which differ only in requiring the foreseeability of the *type* of harm occasioned, can also be thus addressed.[135] Carelessness in the design, manufacture, and indeed operation of an AV foreseeably risks *physically* injuring both AV users and other road users.

Turning next to breach, res ipsa loquitur may be more readily applicable to AVs than initially apparent, alleviating (though not fully solving) the evidential difficulties[136] that AV accident victims could face. Res ipsa requires (a) an absence of explanation of the occurrence that caused the harm, (b) that the accident does not ordinarily occur without the tortfeasor's negligence, and (c) that the cause of injury was in the defendant's exclusive control.[137] It has been applied in

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[132] Mackie argues that 'the fundamental problem posed by machine learning techniques for the allocation of liability is that manufacturers are not, in principle, capable of fully predicting the future behaviour of the algorithms': Mackie (n 6) 1318.

[133] To recall, Lord Atkin's neighbour principle simply holds that 'you must take reasonable care to avoid acts or omissions which you can reasonably foresee would be likely to injure your neighbour': *Donoghue v Stevenson* [1932] AC 562, 580.

[134] Mackie (n 6) 1320; YeeFen Lim (n 87) 21–3.

[135] *Overseas Tankship (UK) Ltd v Morts Dock & Engineering Co Ltd* [1961] AC 388.

[136] Mackie (n 6) 1324.

[137] *Schellenberg v Tunnel Holdings Pty Ltd* (2000) 200 CLR 121, 134 [24]–[25]. For the similar English and Singapore positions see *O'Connor v The Pennine Acute Hospitals NHS Trust* [2015]

conventional MVA contexts to assist victims who had no information on the situation in the defendant's vehicle.[138] Clarifying that AVs remain legally controlled by multiple parties means limb (c) does not a priori bar the doctrine's application to AVs.

This can be illustrated against the cases above. If, like in *Umeda*, there is direct evidence of an ADS failure, victims need not rely on the doctrine to establish breach. If there is no such evidence, there would be an 'absence of explanation'. Next, it would be difficult for ADS manufacturer/developers to argue that an AV would 'ordinarily' drive straight into a highway median (*Huang*), a stalled vehicle (*Nilsson*), or plough into a group of motorcyclists (*Umeda*) without negligence — that may well be admitting that AVs are hazardous *even* when carefully designed and manufactured. Finally, assuming the ADS was not modified or poorly-maintained post-sale, the risks which materialised to cause the accident — ADS malfunction — are arguably in the exclusive *legal* control of the manufacturer/developer. To be sure, the strength of this argument depends on specific case facts. Nonetheless, given the typical severity of AV accidents, standards-setting courts, which essentially balance the probability and severity of AV harm against precaution costs and activity utility,[139] may be sympathetic to victim claims.

On causation, algorithmic opacity precludes easy answers to whether, had General Motors or Tesla been more careful building the AVs, the above accidents would still have occurred. But tort law is not powerless in the face of scientific

EWCA Civ 1244, [58]–[59]; *Grace Electrical Engineering Pte Ltd v Te Deum Engineering Pte Ltd* [2018] 1 SLR 76, 90–1 [39] respectively.

[138] See, eg, *Halliwell v Venables* [1930] All ER Rep 284; *Richley v Faull* [1965] 3 All ER 109; *Ooi Han Sun v Bee Hua Meng* [1991] 1 SLR(R) 922.

[139] *Wyong Shire Council v Shirt* (1980) 146 CLR 40, 47–8; *Graham Barclay Oysters Pty Ltd v Ryan* (2002) 211 CLR 540, 611–12 [190]–[192]. This approach has been codified in civil liability statutes across many Australian states (see Mackie (n 6) 1321).

uncertainty,[140] and in such situations courts have famously accepted alternative approaches to causation.[141] Given the distributed nature of AV legal control, liability could be established, and perhaps apportioned, across multiple (careless) controllers based on material contribution to harm and/or risk.[142] This, in turn, implicates *legal* causation, which involves policy considerations over whether legal responsibility should attach to the defendant's conduct.[143] Since each AV stakeholder possesses a non-trivial amount of legal control, the question would probably not be *whether* that stakeholder can be held liable at all, but on *how* liability should be apportioned.[144]

To illustrate, consider the similarities between *Hudson* and *Muwafi* and the textbook case of *Wright v Lodge*,[145] where Lodge's recklessly driven lorry collided with a broken-down car Shepherd negligently left on the highway. Lodge's lorry spun out of control and crashed into opposing traffic, injuring one plaintiff and killing another. The court held that the injuries were wholly attributable to Lodge

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[140] This notably includes uncertainty over subsequent human conduct, as in *Chester v Afshar* [2005] 1 AC 134. It follows that uncertainty over subsequent *software* conduct can equally be dealt with, though a detailed discussion falls beyond this article's scope.

[141] For a review of the key cases and situations see generally Jane Stapleton, 'Unnecessary Causes' (2012) 129(1) *Law Quarterly Review* 39. Stapleton has argued for an extended causation test that accounts for 'contribution[s] to an element of the positive requirements for the existence of the [harm]': Jane Stapleton, 'An "Extended But-For" Test for the Causal Relation in the Law of Obligations' (2015) 35(4) *Oxford Journal of Legal Studies* 697, 713.

[142] As famously enunciated in *Bonnington Castings Ltd v Wardlaw* [1956] AC 613; *McGhee v National Coal Board* [1973] 1 WLR 1; *Fairchild v Glenhaven Funeral Services Ltd* [2003] 1 AC 32. In *Barker v Corus UK Ltd* [2006] 2 WLR 1027, liability was indeed so apportioned, and subsequent statutory departure of these rules in the *Compensation Act 2006* (UK) targeted mesothelioma *only*. See *Sienkiewicz v Greif (UK) Ltd* [2011] 2 AC 229, 256–7 [56]–[58]. On the applicability of the material contribution approach in Australia see *Strong v Woolworths Ltd* (2012) 246 CLR 182, 190–5 [17]–[30].

[143] *Roads and Traffic Authority v Royal* (2008) 245 ALR 653, 687 [135]; *Strong v Woolworths Ltd* (n 140) 190–1 [18]–[19]. See also *Kuwait Airways Corporation v Iraqi Airways Co [Nos 4 and 5]* [2002] AC 883, 1091.

[144] This is in line with the private law trend towards apportionment, though a detailed examination falls beyond scope. See Kit Barker and Ross Grantham (eds), *Apportionment in Private Law* (Hart Publishing, 2019).

[145] [1993] 4 All ER 299.

and not Shepherd, as Lodge's reckless driving and speed were the primary reasons why the lorry violently swerved onto the opposing lane. Lodge, in other words, was primarily responsible for creating the actuated risks, and thus contributed most to the resulting harm. While the cases are not identical (*Hudson* was himself in the 'lorry', and Tesla's ADS is now 'Lodge'), determining who — amongst the manufacturer, developer, the 'sleepy' AV driver, and the victims themselves — had most control over the actuated risks would be equally pivotal.

This article does not claim that control-centric analysis overcomes every obstacle with establishing negligence for AVs. Difficult legal questions remain, including what the standard of a reasonable AV manufacturer, developer, operator, or user should be. The point is merely that framing the AV liability question as one of *distributed control over risks* avoids the mistaken conclusion that tort law is ill-equipped to deal with AVs.

VI Conclusion

This article demonstrates how the doctrine of control can illuminate analyses of AV negligence liability. Part II demonstrated how the 'driver-centricity' of existing liability regimes can, and should, be understood as the result of legal and moral control principles. Part III distinguishes between engineering and legal usages of 'control', emphasising that control in tort law relates primarily to the determination of metaphysical *risks* rather than physical behaviours. This is consistent with how courts have analysed control as a salient feature for establishing negligence duties, establishing *Rylands* as well as occupiers' liability, and attributing third party liability.

Against this backdrop, Part IV clarified that while AVs may be physically *steered* by software, legal persons across the AV supply and consumption chain, including manufacturers, developers, operators and consumers, nonetheless participate in the AV risk creation process and can thus be said to be in *legal* control of the same. Further, the elements of ML often present in ADS software do not undermine *legal* control. Taking reference from actual AV accidents, Part V illustrated how the tortious doctrine of control, properly understood, can assist courts with analysing negligence liability for such cases. Given the extent of legal control that manufacturers and developers have over AVs, including fully automated ones, establishing duty, breach, and causation for AV accidents may not be as problematic as initially apparent. The common law of torts, with its characteristic flexibility, may be better equipped to deal with AV accidents than initially apparent.