Journal of Air Law and Commerce

Volume 88 | Issue 1 Article 4

2023

VFR Into IMC Through the Lens of Behavioral Economics

Stephen O'Mahony
Queensland University of Technology, School of Business and Law

Author(s) ORCID Identifier:

Felicity Deane: https://orcid.org/0000-0003-1980-6576

Kieran Tranter: https://orcid.org/0000-0003-1683-2939

Felicity Deane
Queensland University of Technology, School of Business and Law

Author(s) ORCID Identifier:

Felicity Deane: https://orcid.org/0000-0003-1980-6576

Kieran Tranter: https://orcid.org/0000-0003-1683-2939

Kieran Tranter
Queensland University of Technology, School of Business and Law

Author(s) ORCID Identifier:

Felicity Deane: https://orcid.org/0000-0003-1980-6576

Kieran Tranter: https://orcid.org/0000-0003-1683-2939

VFR INTO IMC THROUGH THE LENS OF BEHAVIORAL ECONOMICS

Stephen O'Mahony*
Felicity Deane**
Kieran Tranter***

ABSTRACT

Decision-making can be the difference between life and death in all types of aviation, but in general aviation (GA), where most of the flying is conducted as single-pilot operations, the decision-making of one individual becomes fundamentally important. It is critical to consider, first, why pilots make bad decisions that can ultimately lead to weather-related aviation accidents or incidents; and second, whether a better understanding of weather-related decision-making can inform regulations that will improve decision-making and consequently reduce the frequency of pilot-error accidents.

Behavioral economics (BE) aims to better understand individual decision-making to model decision-making pathways. As individual decision-making is central to aviation safety, better modeling of decision-making pathways should be a central aim not just for pilots, but also for aviation regulators, such as the Civil Aviation Safety Authority (CASA) in Australia. While there has been little analysis of pilot decision-making using BE, we argue that BE, with its focus on predictive models of individual

DOI:https://doi.org/10.25172/jalc.88.1.4

* Stephen O'Mahony, BA, BLAWS(Hon), GDLP; Sessional Academic QUT Faculty of Business and Law; Legal Practitioner (admitted in Queensland and the United Kingdom); Certified flight instructor Recreational Aviation Australia.

** Associate Professor Felicity Deane, QUT Faculty of Business and Law; Associate Professor Deane has been researching economic analysis of the law for the last ten years. During this time, she has used economic concepts to evaluate regulation of the environment, trade, and technology.

*** Professor Kieran Tranter; Chair of Law, Technology and Future in the School of Law; Professor Tranter researches law, technology, and the future. He has a particular interest in the regulation of mobility.

decision-making, provides a rich framework to understand pilot decision-making and inform more targeted regulation.

This argument is in four parts. The first part identifies that there is an ongoing safety issue with visual flight rules (VFR) pilots flying into instrument meteorological conditions (IMC). The second part introduces some of the core concepts of BE, such as the rejection of perfect rationality and the reliance upon certain behavioral biases in decision-making. We argue that VFR into IMC is an appropriate context in which to apply BE as there is an identifiable measure of a pilot's welfare and concerns around paternalism fall short when dealing with protecting the welfare of those likely to be impacted by a pilot's decision-making, such as passengers and aircraft owners.

The third part reviews the existing research applying behavioral models of decision-making in respect of VFR into IMC and identifies three behavioral biases that—among others—can lead to poor decision-making: (i) environmental literacy, (ii) overconfidence, and (iii) prospect theory. The final part briefly introduces some potential avenues for BE to inform regulatory reform, including better education of pilots and regulators in respect of the psychological factors to which pilots may fall victim, as well as more directed training for pilots to address the environmental literacy concerns identified in this part. We conclude that the regulatory environment should be reformulated to adequately account for predictable behavioral biases.

TABLE OF CONTENTS

I. INTRODUCTION 143
II. PILOT DECISION-MAKING AND VFR INTO IMC 145
  A. THE DANGERS OF VFR INTO IMC 145
  B. THE PREVALENCE OF VFR INTO IMC 149
III. BEHAVIORAL ECONOMICS AND DANGEROUS DECISION-MAKING IN RESPECT OF VFR INTO IMC 153
  A. ENVIRONMENTAL LITERACY AND HEURISTICS 159
  B. RISK ASSESSMENT: OVERCONFIDENCE AND MOTIVATION 164
  C. PROSPECT THEORY 167
IV. WHERE TO FROM HERE? 173
  A. FROM BEHAVIORAL ECONOMICS TO BEHAVIORAL LAW AND ECONOMICS 173
V. CONCLUSION 178

I. INTRODUCTION

ON JUNE 28, 2017, at approximately 10:20 a.m., SOCATA TB-10 Tobago aircraft registered VH-YTM commenced its takeoff roll from Mount Gambier airport.[1] The aircraft was bound for Adelaide, and onboard were the pilot, a seventy-eight-year-old businessman; a sixteen-year-old girl en route to Adelaide for medical treatment; and the sixteen-year-old's mother.[2] As the aircraft became airborne, closed-circuit television (CCTV) footage and weather cameras on the ground at the airfield showed low cloud and reduced visibility.[3] Shortly after take-off, the aircraft flew into cloud, made a turn to the left, and then plunged to the ground below.[4] The aircraft had traveled less than three kilometers, had not climbed above three hundred feet, and had been airborne for just over a minute.[5] All three people onboard were killed.[6] The Australian Transport Safety Bureau (ATSB) concluded that "the pilot took off in low-level cloud without proficiency for flight in instrument meteorological conditions. Shortly after take-off, the pilot likely lost visual cues and probably became spatially disorientated, resulting in loss of control of the aircraft and collision with terrain."[7]

This example demonstrates that decision-making by GA[8] pilots has a clear and direct impact on the safe operation of air-

---

1 *See* Daniel Keane & Courtney Howe, *ATSB Investigation into Plane Crash Which Killed Three Raises Concerns About Angel Flight*, ABC NEWS, https://www.abc.net.au/news/2019-08-13/atsb-releases-findings-into-fatal-angel-flight-crash/11407294 [https://perma.cc/6KAU-BD6M] (Aug. 13, 2019, 3:22 AM).

2 *Id.*

3 *Id.*

4 *Id.*

5 *Id.*

6 *Id.*

7 AUSTL. TRANSP. SAFETY BUREAU [ATSB], COLLISION WITH TERRAIN INVOLVING SOCATA TB-10 TOBAGO, VH-YTM (2019), https://www.atsb.gov.au/publications/investigation_reports/2017/aair/ao-2017-069 [https://perma.cc/H54F-86SG].

8 The International Civil Aviation Organization (ICAO) provides two broad definitions of GA. First, it defines GA as "all civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire." Int'l Civ. Aviation Org. [ICAO], *Review of the Classification and Definitions Used for Civil Aviation Activities*, at B-2, ICAO doc. STA/10-WP/7 (Working Paper 2009), https://www.icao.int/meetings/sta10/documents/sta10_wp007_en.pdf [https://perma.cc/Z24Q-KQ4H]. ICAO classifies GA as covering a range of operations that are not commercial air transport services. *See id.* This includes aerial work (such as agriculture, photography, surveying, search and rescue); instructional flying; and recreational flying. *Id.* However, Australia generally includes all commercial aviation that is not airline or regular public transport

craft.[9] Decision-making can be the difference between life and death in all types of aviation, but in GA, where most of the flying is conducted as single-pilot operations, the decision-making of one individual becomes fundamentally important.[10] It is critical to consider, first, why pilots make bad decisions that can ultimately lead to weather-related aviation accidents or incidents; and second, whether a better understanding of weather-related decision-making can inform regulations that will improve decision-making and consequently reduce the frequency of pilot-error accidents.

Behavioral economics (BE) aims to better understand individual decision-making to model decision-making pathways.[11] As individual decision-making is central to aviation safety, better modeling of decision-making pathways should be a central aim not just for pilots, but also for aviation regulators such as the Civil Aviation Safety Authority (CASA) in Australia. While there has been little analysis of pilot decision-making using BE, we argue that BE, with its focus on predictive models of individual decision-making, provides a rich framework to understand pilot decision-making and inform more targeted regulation.

This is important because better understanding of pilot decision-making informing better regulations will save lives.[12] As shown in the Tobago accident at the start of this Article, one of the primary causes of GA fatalities is "VFR into IMC."[13] Incidents that are classified as "VFR into IMC" refer to a flight conducted under visual flight rules (VFR) flying into instrument meteorological conditions (IMC), often resulting in spatial disorientation and a subsequent crash.[14] This Article argues that the industry would benefit from an approach that incorporates insights from BE in regulation development.

(RPT) type operations. *See generally* GEN. AVIATION ADVISORY NETWORK, AUSTL. DEP'T INFRASTRUCTURE TRANSP. REG'L DEV. & COMM'N, A NEW STRATEGY FOR THE AUSTRALIAN GENERAL AVIATION SECTOR (2020) https://www.infrastructure.gov.au/sites/default/files/documents/GAAN-New-Strategy-for-the-General-Aviation-Sector.pdf [https://perma.cc/8YCD-DSK4].

9 ATSB, *supra* note 7, at 43–44.

10 *Id.* at 44.

11 Lovorka Galetic & Davor Labaš, *Behavioral Economics and Decision Making: Importance, Application and Development Tendencies*, ENTER. ODYSSEY 759, 760 (2012).

12 ATSB, *supra* note 7.

13 *Id.* at 14.

14 ATSB, ACCIDENTS INVOLVING VISUAL FLIGHT RULES PILOTS IN INSTRUMENT METEOROLOGICAL CONDITIONS 1 (2019), https://www.atsb.gov.au/publications/2019/avoidable-accidents-4-vfr-into-imc [https://perma.cc/3NCW-S6LS].

This argument is in four parts. The first part identifies that there is an ongoing safety issue with VFR pilots flying into IMC and that even when an accident does not result, any such incidents are sufficiently serious to be a significant safety occurrence. The second part introduces some of the core concepts of BE, such as the rejection of perfect rationality and the reliance upon certain behavioral biases in decision-making. We introduce these as a tool for regulatory evaluation emphasizing the role BE plays in rethinking human decision-making, and make the case for the application of BE to the study of VFR into IMC. We also address some of the criticism of BE, principally the concerns over identifying the nature of a decision-maker's true welfare and the concerns around paternalism overtaking freedom of choice. We argue that VFR into IMC is an appropriate context in which to apply BE as there is an identifiable measure of a pilot's welfare and concerns around paternalism that fall short when dealing with protecting the welfare of those likely to be impacted by a pilot's decision-making, such as passengers and aircraft owners. The third part reviews the existing research applying behavioral models of decision-making in respect of VFR into IMC. In the third part, we acknowledge that there is unlikely to be a unified theory of decision-making, and instead we identify three behavioral biases that—among others—can lead to poor decision-making: (i) environmental literacy, (ii) overconfidence, and (iii) prospect theory. The final part briefly introduces some potential avenues for BE to inform regulatory reform, including better education of pilots and regulators in respect of the psychological factors to which pilots may fall victim, as well as more directed training for pilots to address the environmental literacy concerns identified in this part. We conclude that CASA's regulatory approach should account for the behavioral context of GA pilot decision-making, and the regulatory environment should be reformulated to adequately take into account the behavioral biases relating to environmental literacy, overconfidence, and prospect theory.

II. PILOT DECISION-MAKING AND VFR INTO IMC

A. The Dangers of VFR into IMC

"On average, Australian air traffic controllers [ATC] are called upon once every 10 days to assist a pilot in deteriorating weather."[15] Of the reported occurrences, 60% involved aircraft flying above cloud with the pilots unable to descend clear of cloud without assistance from ATC; the remainder were either "in deteriorating weather, in cloud, or ha[d] reduced visibility due to smoke or haze."[16] Weather has, for a long time, been seen as a major factor in GA accidents;[17] however, it is when VFR flights fly into IMC that the aircraft and its occupants are most at risk of an accident.[18]

In this Article, VFR into IMC describes incidents when a pilot, who by training/rating limitations or aircraft limitations is legally obligated to fly by visual references only, then chooses to, or inadvertently, flies the aircraft into conditions that require the use of instruments as the primary reference tool because of loss of visual clues (or out of window clues) for orientation.[19] VFR is a set of rules and procedures governing the operation of aircraft operating in visual meteorological conditions (VMC).[20] In practice, operating an aircraft under VFR means that the aircraft is being flown by reference to visual clues from the ground and horizon, and the pilot must, at intervals of not more than thirty minutes, positively fix the aircraft's position by visual reference to features marked on topographical charts.[21] This is opposed to instrument flight rules (IFR) flights where the aircraft is being operated primarily by reference to instrument navigation systems (and ground-based navigational aids).[22]

---

[15] *178 Seconds to Live—VFR into IMC*, FLIGHT SAFETY AUSTL. (Jan. 22, 2016), https://www.flightsafetyaustralia.com/2016/01/178-seconds-to-live-vfr-into-imc [https://perma.cc/79G9-HL7B].

[16] *Id.*

[17] Charles H. Smith, *Availability and Use of Weather Data*, 44 J. AIR L. & COM. 417, 417 (1978).

[18] RICHARD BATT & DAVID O'HARE, ATSB, REP. B2005/0127, GENERAL AVIATION PILOT BEHAVIOURS IN THE FACE OF ADVERSE WEATHER 55 (2005), https://www.atsb.gov.au/publications/2005/pilot_behaviours_adverse_weather [https://perma.cc/Y628-TRX7].

[19] Sabrina Woods et al., *The Impact of Motivation on Continued VFR into IMC: Another Perspective to an On-Going Problem*, 38 COLLEGIATE AVIATION REV. INT'L 51, 53 (2020).

[20] For an analysis of the requirements of VMC and responsibilities of VFR pilots within the American context, see Ernest E. Anderson, William Watson, Douglas M. Marshall & Kathleen M. Johnson, *A Legal Analysis of 14 C.F.R. Part 91 "See and Avoid" Rules to Identify Provisions Focused on Pilot Responsibilities to "See and Avoid" in the National Airspace System*, 80 J. AIR L. & COM. 53, 92, 141–42 (2015).

[21] LEGAL, INT'L & REGUL. AFFS. DIV., ADVISORY & DRAFTING BRANCH, ss 13.02 *Part 91 (General Operating and Flight Rules) Manual of Standards 2020*, CIV. AVIATION SAFETY AUTH. (2022).

[22] *See id.*

In Australia, an aircraft must be operated under either VFR or IFR.[23] If the flight is a VFR flight, it must be operated in accordance with what is referred to as the VMC Criteria.[24] These are a list of specific meteorological conditions expressed in terms of the minimum standards of flight visibility and distance from cloud (horizontal and vertical).[25] These standards differ depending upon the type of airspace and the altitude at which the aircraft is operating.[26] For example, for fixed-wing aircraft, these standards range from just 5,000 meters of visibility clear of cloud to 8,000 meters visibility and 1,500 meters horizontal and 1,000 feet vertical separation from cloud.[27] Operating a VFR flight in breach of the VMC Criteria is an offense of strict liability.[28]

Once a VFR pilot has flown into IMC, whether the final outcome is fatal will often come down to chance, with just minutes separating a safe outcome from an accident.[29] Spatial disorientation is the most frequent reason identified.[30] Spatial disorientation has been described as the inability of the pilot to determine "which way is 'up.'"[31] Antuñano and Mohler of the Civil Aviation Medical Institute explain it as the inability of a person to perceive motion, position, or attitude in relation to the surrounding environment.[32] A more detailed explanation is provided by Dr. A.J. Benson of the RAF Institute of Aviation Medicine, who portrays it as a range of incidents that can occur in flight when pilots (i) fail to correctly sense the position, motion, or altitude of the aircraft or themselves within the fixed coordinate system provided by the surface of the earth and the gravitational vertical; (ii) make errors in perception of their position, motion, or altitude with respect to their aircraft; or (iii) make errors in per-

---

23 *Civil Aviation Safety Regulations 1998* (Cth) reg 91.270(1) (Austl.).

24 *Id.* reg 91.280(1).

25 LEGAL, INT'L & REGUL. AFFS. DIV., ADVISORY & DRAFTING BRANCH, *supra* note 21, ss 2.07.

26 *Id.*

27 *Id.*

28 *Civil Aviation Safety Regulations 1998* (Cth) reg 91.273(3).

29 *178 Seconds to Live*, FED. AVIATION ADMIN. [FAA], https://www.faa.gov/about/office_org/field_offices/fsdo/fai/local_more/alaskan_articles/media/178-Seconds_to_Live.pdf [https://perma.cc/AC7K-M5VJ].

30 *Spatial Disorientation*, GO FLIGHT MED., https://goflightmedicine.com/2013/04/01/spatial-disorientation [https://perma.cc/F4Y5-NWPJ].

31 FAA, ADVISORY CIRCULAR NO. 60-4A, PILOT'S SPATIAL DISORIENTATION (1983).

32 Melchor J. Antuñano & Stanley R. Mohler, *Inflight Spatial Disorientation*, 39 HUM. FACTORS & AVIATION MED. 1, 1 (1992).

ception of their position, motion, or altitude with respect to their aircraft relative to other aircraft.[33]

Spatial disorientation is one of the leading causes of aircraft accidents, both in respect to commercial[34] and military flying.[35] Spatial disorientation can occur in several situations; however, within this Article we focus on spatial disorientation caused by weather-related events. Over 90% of weather-related accidents involve spatial disorientation.[36] Therefore, in the context of VFR into IMC, spatial disorientation is almost always a factor.[37]

The ability to maintain spatial orientation is dependent on the reception, integration, and interpretation of sensory inputs from the eye, inner ear (vestibular), muscular (proprioceptive), and skin (somatic) receptors.[38] The most significant of these inputs is from the visual receptors: pilots fly by reference to what they see, and they perceive what the aircraft is doing by seeing the environment outside the cockpit window.[39] In conditions where visual cues are poor or absent, up to 80% of the normal orientation information is missing.[40] This means pilots have to rely on the other sensory inputs (particularly the vestibular receptors) to determine what the aircraft is doing.[41] The ear is made up of several smaller structures[42]: the outer ear, which extends through the ear canal to the ear drum; the middle ear that transmits and amplifies sounds between the ear drum and the cochlea; and the inner ear, which is made up of the cochlea and

---

[33] A.J. Benson, *Spatial Disorientation – General Aspects*, *in* AVIATION MED. 277–96 (John Ernsting ed., 1988).

[34] Matthew L. Bolton & Ellen J. Bass, *Using Relative Position and Temporal Judgments to Identify Biases in Spatial Awareness for Synthetic Vision Systems*, 18 INT'L J. AVIATION PSYCH. 183, 183 (2006).

[35] Helena J.M. Pennings et al., *Spatial Disorientation Survey Among Military Pilots*, 91 AEROSPACE MED. & HUM. PERFORMANCE 4, 4 (2020).

[36] Joseph T. Coyne, Carryl L. Baldwin & Kara A. Latorella, *Pilot Weather Assessment: Implications for Visual Flight Rules Flight Into Instrument Meteorological Conditions*, 18 INT'L J. AVIATION PSYCH. 153, 153–54 (2008).

[37] Michael G. McQuillen, *The Deception About the Inception Rule: Coverage for VFR Pilots in IFR Conditions*, 60 J. AIR L. & COM. 179, 180–81 (1994).

[38] Antuñano & Mohler, *supra* note 32, at 1.

[39] *Id.* at 2.

[40] ATSB, *supra* note 14, at 6.

[41] Rachel K. Meeks, Jackie Anderson & Paul M. Bell, *Physiology of Spatial Orientation*, NAT'L CTR. FOR BIOTECHNOLOGY INFO., https://www.ncbi.nlm.nih.gov/books/NBK518976 [https://perma.cc/6DPQ-6M8E] (Aug. 8, 2022).

[42] *See id.*

the vestibular system.[43] It is the vestibular system that is key to the sense of balance, motion, and position, but reliance on the vestibular system is troublesome as these receptors have limitations.[44] On land, this is less troublesome, as there is a degree of physiological compensation that can accommodate a loss of vision.[45] However, in flight it is an entirely a different story as a "deceptive force environment becomes the frame of reference."[46]

When outside reference is lost in flight (for example, in cloud), the pilot is required to rely on instrumentation to maintain spatial orientation.[47] The pilot will experience linear acceleration (a change in velocity without a change of direction, i.e., a straight line) and angular acceleration forces (a change in both velocity and direction at the same time), which will generate confusing vestibular and proprioceptive stimulations that results in motion illusions.[48] In simple terms, the pilot will "feel" the aircraft doing one thing when it will in actuality be doing something completely different.[49] That confusion is almost impossible to overcome for an untrained pilot, and even experienced IMC pilots require regular practice in IMC to remain proficient at trusting their instruments over their inner sense of what the aircraft is doing.[50]

B. The Prevalence of VFR into IMC

The example in the Introduction illustrated the dangers of VFR into IMC.[51] Although tragic, the incident referenced was neither a surprise nor a shock to the GA community.[52] Two simi-

---

[43] *See id.*; *The Normal Ear – Understanding Parts of the Ear and How We Hear*, Boys Town Nat'l Rsch. Hosp., https://www.boystownhospital.org/knowledge-center/the-normal-ear [https://perma.cc/P6P4-EABA].

[44] Meeks et al., *supra* note 41.

[45] Antuñano & Mohler, *supra* note 32, at 2.

[46] John Richard Rollin Stott, *Orientation and Disorientation in Aviation*, 2 Extreme Physiology & Med. 1, 1 (2013).

[47] Melchor J. Antuñano, *Medical Facts for Pilots*, FAA, at 1, https://www.faa.gov/pilots/safety/pilotsafetybrochures/media/spatiald.pdf [https://perma.cc/E5X4-47DM].

[48] *Id.* at 2–3.

[49] *See id.* at 4–5.

[50] *Id.* at 8.

[51] ATSB, *supra* note 7, at 14.

[52] *Id.* at 11–12; *see* Lara Pearce, *Teen Girl, Mother Being Airlifted for Medical Treatment When Flight Crashed*, HuffPost News., https://www.huffpost.com/archive/au/entry/teen-girl-mother-being-airlifted-to-adelaide-hospital-when-

lar events had occurred in Australia during 2011.[53] One involved another patient transport operation that crashed shortly after takeoff from Bendigo airport, killing the pilot and the two passengers (one of whom was a fifteen-year-old).[54] The other involved a Bell 206L helicopter on a private flight in New South Wales.[55] The helicopter collided with terrain shortly after entering reduced visibility and low cloud, killing both people onboard.[56]

In October 2013, a Cessna 182Q aircraft registered VH-KKM encountered low cloud (as was forecast on that day), and shortly after, it collided with terrain on the eastern side of Mount Blue Rag at about 5,000 feet above mean sea level, killing the sole occupant onboard.[57] In 2016, a Piper Aircraft Corp PA-28 aircraft, registered VH-PXD, was on a private flight from Moorabbin Airport, Victoria, to King Island, Tasmania.[58] Within minutes of flying into an area of reduced visibility and following several abrupt control movements, the aircraft impacted the water killing all four people onboard.[59] In January 2020, an amateur-built Wittman Tailwind aircraft departed Casino in New South Wales for Boonah in the neighboring state of Queensland.[60] Twenty minutes into the flight, after entering an area of reduced visibility, the aircraft undertook a series of rapid descents and climbs followed by a descending left turn that caused

---

medi_au_5cd35b0ce4b0acea94ff402d [https://perma.cc/44T2-YMJW] (June 28, 2017, 7:21 PM).

[53] ATSB, VFR Flight into Dark Night Conditions and Loss of Control Involving Piper PA-28-180, VH-POJ, at 1 (2011), https://www.atsb.gov.au/publications/investigation_reports/2011/aair/ao-2011-100 [https://perma.cc/YA93-HHZE] [hereinafter ATSB, VFR Flight into Dark Night]; ATSB, VFR into IMC – Bell 206L Helicopter, VH-CIV, at 1 (2011), https://www.atsb.gov.au/publications/investigation_reports/2011/aair/ao-2011-085 [https://perma.cc/XAW2-9EAV] [hereinafter ATSB, VFR into IMC – Bell 206L Helicopter].

[54] ATSB, VFR Flight into Dark Night, *supra* note 53, at 1.

[55] ATSB, VFR into IMC – Bell 206L Helicopter, *supra* note 53, at 1.

[56] *Id.*

[57] ATSB, Collision with Terrain Involving Cessna 182, VH-KKM 1, 3, 6 (2013), https://www.atsb.gov.au/publications/investigation_reports/2013/aair/ao-2013-186 [https://perma.cc/VX42-TK8N].

[58] ATSB, Loss of Control and Collision with Water Involving Piper Aircraft Corp PA-28-235, VH-PXD 1 (2016), https://www.atsb.gov.au/publications/investigation_reports/2016/aair/ao-2016-006 [https://perma.cc/7V5Q-9NTM].

[59] *Id.* at 2.

[60] ATSB, VFR into IMC and Loss of Control Involving Wittman Tailwind, VH-TWQ 1 (2021), https://www.atsb.gov.au/publications/investigation_reports/2020/aair/ao-2020-004/ [https://perma.cc/R6H7-V6YB].

the aircraft to impact with the terrain, killing both the pilot and his passenger.[61] While a final report is yet to be released with respect to the March 31, 2022 crash of Airbus EC130, which killed the pilot and the four passengers, the interim report strongly points to deteriorating weather and low cloud as contributing factors.[62]

The above are just some examples in Australia of VFR into IMC. Indeed, in the decade between 2009 and 2019, in Australia there were 101 reported instances of inadvertent flight into IMC by VFR pilots, with one in ten resulting in fatal accidents and twenty-one deaths attributed to VFR into IMC during that period.[63] These incidents and deaths are evenly spread with no evidence of specific peaks or troughs throughout the period, suggesting a consistent and regular occurrence of VFR into IMC.[64] VFR into IMC has been described as "the scourge of general aviation."[65] Even when VFR into IMC does not lead to an accident, the fact that the incident has occurred is always a significant safety matter because once a VFR pilot has flown into IMC, the outcome often comes down to luck and safety is no longer assured.[66]

---

61 *Id.* at 2.

62 ATSB, COLLISION WITH TERRAIN INVOLVING AIRBUS HELICOPTERS EC130 T2, VH-XWD 2 (2022), https://www.atsb.gov.au/publications/investigation_reports/2022/aair/ao-2022-016 [https://perma.cc/UH96-7W6C].

63 ATSB, *supra* note 14, at 1. According to the ATSB, typical VFR into IMC scenarios included the following: (i) occurrences where the aircraft entered cloud but subsequently regained VMC; (ii) accidents where the aircraft was trapped by bad weather and rising terrain; (iii) pilot requests for assistance when the aircraft was already in IMC; and (iv) aircraft crashes in circumstances indicative of VFR in IMC. *See* ATSB, VFR INTO IMC AND IN-FLIGHT BREAK-UP INVOLVING VAN'S AIRCRAFT RV-7A, VH-XWI 11–12 (2022), https://www.atsb.gov.au/publications/investigation_reports/2021/aair/ao-2021-017 [https://perma.cc/MF95-QJ9W].

64 For example, "[i]n Australia, during the period 2003-2017, there were a total of 167 occurrences of VFR into IMC, including 15 accidents and 20 serious incidents, resulting in 22 fatalities, representing 5% of the total fatalities over the period . . ." Rory Buchanan, *Factors Affecting VFR into IMC Occurrences in Australia*, RESEARCHGATE 4 (Nov. 5, 2018), https://www.researchgate.net/publication/341592320_Factors_Affecting_VFR_into_IMC_Occurrences_in_Australia [https://perma.cc/5WFW-FTQY].

65 John Zimmerman, *Why Can't We Solve VFR into IMC?*, FLYING MAG. (Aug. 13, 2019), https://www.flyingmag.com/why-cant-we-solve-vfr-into-imc [https://perma.cc/E4VQ-LW3H].

66 ATSB, *supra* note 14; Richard Batt & David O'Hare, *Pilot Behaviors in the Face of Adverse Weather: A New Look at an Old Problem*, 76 AVIATION SPACE & ENV'T MED. 552, 557 (2005).

VFR into IMC remains a leading cause of fatal accidents in GA,[67] and statistically, VFR into IMC accidents are extremely likely to be fatal.[68] They are almost four times deadlier than encounters with thunderstorms and icing combined.[69] In the United States, on average, 76% of VFR into IMC accidents involve fatalities,[70] and although only accounting for about 6% of aircraft accidents, they account for 25% of the fatalities in GA.[71] In 2019, there were 988 accidents in the United States involving noncommercial general aviation, of which 179 were fatal (an 18.1% lethality rate), with 34 weather-related accidents, of which 19 were attributable to VFR into IMC, 18 of which were fatal.[72] Even those pilots that do survive inadvertent VFR into IMC, even for short periods of time, often survive through luck or good fortune and experience one of the most dangerous and unnerving situations pilots can find themselves in.[73] It cannot be overstated that any inadvertent VFR into IMC is a significant and continued safety issue for general aviation.[74]

The recurring nature of these incidents is one of their most notable features, and they continue to occur, notwithstanding advances in weather forecasting[75] and real-time weather monitoring tools available to pilots.[76] Education tools are readily available to pilots about this issue,[77] and the dangers of VFR into

---

67 Woods et al., *supra* note 19, at 51.

68 *See id.* at 52.

69 Zimmerman, *supra* note 65.

70 FLIGHT SAFETY AUSTL., *supra* note 15.

71 Andrew J. Fultz & Walker S. Ashley, *Fatal Weather-Related General Aviation Accidents in the United States*, 37 PHYSICAL GEOGRAPHY 291, 292 (2016).

72 *The 31st Joseph T. Nall Report*, AIRCRAFT OWNERS & PILOTS ASS'N, https://www.aopa.org/training-and-safety/air-safety-institute/accident-analysis/joseph-t-nall-report/nall-report-figure-view?category=all&year=2019&condition=all&report=true [https://perma.cc/2NYC-CZ5C].

73 Batt & O'Hare, *supra* note 66, at 552.

74 McQuillen, *supra* note 37, at 181–82; Juliana Goh & Douglas Wiegmann, *Human Factors Analysis of Accidents Involving Visual Flight Rules Flight into Adverse Weather*, 73 AVIATION, SPACE & ENV'T MED. 817, 817 (2002); Woods et al., *supra* note 19, at 52; Zimmerman, *supra* note 65; Coyne et al., *supra* note 36, at 153–54.

75 For an interesting discussion of some case law in the United States regarding alleged failures in the provision of weather-related information, see Sarah Keast, *Recent Developments in Aviation Law: General*, 75 J. AIR L. & COM. 285, 285 (2010).

76 Rob Mark, *Making the Most of Today's Pilot Weather Resources*, FLYING MAG. (Sept. 12, 2018), https://www.flyingmag.com/pilot-weather-resources-reviewed [https://perma.cc/535W-5BSE].

77 *See, e.g.*, ATSB, *supra* note 14, at 1–2; *VFR into IMC*, RECREATIONAL AVIATION AUSTL. (2020), https://www.raa.asn.au/our-organisation/safety/nationalsafetymonth/week-1/vfr-into-imc [https://perma.cc/ZJ6N-UJBW]; *VFR into IMC*, AIRCRAFT OWNERS & PILOTS ASS'N, https://www.aopa.org/training-and-safety/air-

IMC are well known.[78] Therefore, pilots exposing themselves and passengers to the potential dangers of VFR into IMC reveals a level of decision-making that seems counter to rationality. This suggests questions as to why these accidents still occur and what role a better understanding of the decision-making behind these accidents plays when seeking to regulate aviation safety in Australia and elsewhere. Are these merely anomalies, or are there predictable behavioral traits that result in faulty decision-making? We propose that incorporating the insights available from BE by CASA and other regulators will serve to assist in the adoption of a more realistic and effective response compared with the current approach, which simply provides a prohibition against VFR into IMC with sanctions imposed for breach.[79]

III. BEHAVIORAL ECONOMICS AND DANGEROUS DECISION-MAKING IN RESPECT OF VFR INTO IMC

In the context of flying in deteriorating weather, the consequences of behavioral biases leading to poor or suboptimal decision-making are extreme.[80] Learning from mistakes, while clearly a part of a pilot's ongoing skill development, has limits when the mistakes are such as to have a high likelihood of fatalities. This is not the sort of environment where pilots can be left to learn from their mistakes. Even if the pilot survives a VFR into IMC incident, the fundamental breakdown of safety that has occurred is too serious to be passed off as a "learning incident." Beyond this, VFR into IMC is also an offense; these are incidents that the law dictates must be avoided in the first place.[81] It is no defense at law that this is the first time the pilot has made such a mistake.[82]

Due to the gravity of the outcomes, it is essential that as much can be learned from the past to inform the future. In this respect, we suggest that the study of decision-making is vital.

---

safety-institute/safety-centers/vfr-into-imc [https://perma.cc/P8RL-8NMS]; *Inadvertent VFR Flight into IMC*, SKYBRARY, https://skybrary.aero/articles/inadvertent-vfr-flight-imc [https://perma.cc/FDP4-JPZY]; FLIGHT SAFETY AUSTL., *supra* note 15; David Ison, *Understanding VFR into IMC Accidents*, PLANE & PILOT, https://www.planeandpilotmag.com/article/understanding-vfr-into-imc-accidents [https://perma.cc/AYY3-27X6] (Feb. 6, 2016).

78 Woods et al., *supra* note 19, at 52.

79 *Civil Aviation Safety Regulations 1998* (Cth) regs 91.273, 91.280 (Austl.).

80 *Id.*

81 *Id.*

82 *Id.*

"Much of analytical thinking in policy-making is either implicitly or explicitly influenced by economics."[83] The primary way of introducing decision-making and "behavioural insights into policy-making is to challenge the assumption that consumers and citizens behave rationally," and instead introduce an "acknowledge[ment of] the presence of systematic violations of rationality (anomalies, biases or heuristics) in human thought."[84] BE is built on the study of these extensively documented systematic violations.[85]

BE joins together and adapts the basic principles of neoclassical microeconomics with the realities imposed by an understanding of human nature.[86] BE does not constitute a singular, unified theory of decision-making; instead, it is best seen as a branch of economics constituting several different models to understand actual human behavior based on empirical evidence.[87] The main aim of BE is to explain unexplored issues that have been regarded as anomalies from neoclassical predictions of human behavior, and ask whether these supposed anomalies are in fact predictable and consistent departures from rationality.[88] BE should not be seen as a wholescale rejection of neoclassical microeconomics, but rather an attempt to include psychological realism in developing the economic tool kit.[89]

Central to BE is the rejection of perfect rationality in decision-making.[90] Instead, BE recognizes the concept of "bounded rationality."[91] Herbert Simon first introduced the concept of bounded rationality as the idea that rationality is limited (or bounded) by the fact that humans have limits to their cognitive

---

83 Xavier Troussard & René van Bavel, *How Can Behavioural Insights Be Used to Improve EU Policy?*, 53 INTERECONOMICS 8, 8 (2018).

84 *Id.*

85 *Id.*

86 Paula-Elena Diacon, Gabriel-Andrei Donici & Liviu-George Maha, *Perspectives of Economics – Behavioural Economics*, 20 THEORETICAL & APPLIED ECON. 27, 29 (2013).

87 *Id.*

88 Justyna Brzezicka & Radoslaw Wisniewski, *Homo Oeconomicus and Behavioral Economics*, 8 CONTEMP. ECON. 353, 356–57 (2014).

89 Richard H. Thaler, *From Cashews to Nudges: The Evolution of Behavioral Economics*, 108 AM. ECON. REV. 1265, 1266–67 (2018).

90 Herbert A. Simon, *A Behavioral Model of Rational Choice*, 69 Q.J. ECON. 99, 99–100 (1955).

91 Matthias Klaes & Esther-Mirjam Sent, *A Conceptual History of the Emergence of Bounded Rationality*, 37 HIST. POL. ECON. 27, 27–28 (2005).

abilities, among other things.[92] As a result, individuals must rely on various heuristics ("a fancy word for rules-of-thumb")[93] to make judgments and decisions.[94] Simon argues that rationality is limited (or bounded) by given factors, including information limitations, time limitations, and cognitive limitations.[95] He argued that as a result, humans engage in satisfying behavior, and through understanding this better, predictions for behavior can be developed.[96] Bounded rationality can be described as the concept that human actions are affected (and presumably limited) by, among other things, "their initial endowments," "their inability to appreciate future costs, their lack of self-control, and the general use of flawed heuristics."[97] To put it another way, individuals systematically fail to act in their best interest because of defects in their decision-making.[98]

Many economists have come to accept that people sometimes exhibit bounded rationality but are able to pass these traits off as examples of random errors, relying on the proposition that people still generally make optimal choices based on rational expectation.[99] However, if errors are predictable, then departures from supposedly rational behavior could also be predictable. The crucial insight from Tversky and Kahneman's original work, *Judgment Under Uncertainty: Heuristics and Biases*, is the implication that it might be possible to improve the explanatory power of economics by adding psychological realism.[100] The importance of Tversky and Kahneman's work is that it identified the predictability of the use of shortcuts and rules of thumb that

---

92 Simon, *supra* note 90, at 112–13.

93 Thaler, *supra* note 89, at 1266.

94 Roberta Muramatsu & Patrícia Fonseca, *Freedom of Choice and Bounded Rationality: A Brief Appraisal of Behavioral Economists' Plea for Light Paternalism*, 32 BRAZILIAN J. POL. ECON. 445, 448 (2012).

95 Herbert A. Simon, *Theories of Bounded Rationality*, *in* DECISION AND ORGANIZATION 161, 161–63 (C.B. McGuire & Roy Radner eds., 1972).

96 Herbert A. Simon, *Rational Decision Making in Business Organizations*, 69 AM. ECON. REV. 493, 496 (1979); Simon, *supra* note 90, at 101; RICHARD M. CYERT & JAMES G. MARCH, A BEHAVIORAL THEORY OF THE FIRM 10 (2d ed. 1992).

97 Jana Bellová, *Behavioural Economics and Its Implications on Regulatory Law*, 15 INT'L & COMPAR. L. REV. 89, 91 (2015).

98 Joshua D. Wright & Douglas H. Ginsburg, *Behavioral Law and Economics: Its Origins, Fatal Flaws, and Implications for Liberty*, 106 NW. U. L. REV. 1, 2 (2012).

99 Thaler, *supra* note 89, at 1266.

100 Amos Tversky & Daniel Kahneman, *Judgment Under Uncertainty: Heuristics and Biases*, 185 SCIENCE 1124, 1127 (1974).

influenced and led to erroneous judgments.[101] These were not anomalies.[102]

BE is not without its critics.[103] Critics question whether predictable behavioral biases actually exist, arguing that what is "good" for the decision maker should be left up to the decision maker, and freedom of choice is an inherent good.[104] These critics argue that BE models often suggest increased government intervention to encourage subjects to make better decisions leading to a paternalistic reduction in liberty for an individual.[105] Drawing from the tradition of Mill and Kant, Wright and Ginsburg argue that to address the liberty cost arguments, one must start from the assumption against interventions against liberty, rebuttable "only by demonstrating that the regulation is likely to generate significant gains in economic welfare."[106] We argue that VFR into IMC meets this threshold. Within the context of VFR into IMC, welfare can be identified as pilot and passenger staying alive. If improved regulation can help reduce the number of VFR into IMC events, then there is a significant gain in the welfare of those that are subject to the regulation.

We do not seek to challenge the basic principle that individual autonomy has value in its own right. We do not accept the characterization as placing no value on the "process aspect of freedom" or "decisional autonomy."[107] Individual autonomy in the cockpit is an inherent part of single-pilot operations. However, many of the philosophical arguments against paternalism simply fall short when applied to aviation. Overall, we are confident that the theoretical foundations for BE are sound and have application to the study of (and regulation of) VFR into IMC.

Although this is essential research, until the beginning of the new century, there was a limited understanding of the behavioral factors or traits that lead pilots into allowing their aircraft

---

101 Cass R. Sunstein, Christine Jolls & Richard H. Thaler, *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1477 (1998).

102 *See id.* at 1511.

103 *See* Gregory Mitchell, *Taking Behavioralism Too Seriously? The Unwarranted Pessimism of the New Behavioral Analysis of Law*, 43 WM. & MARY L. REV. 1907, 1907 (2002).

104 *See id.* at 1927–29.

105 *See id.* at 1929 n.35.

106 Wright & Ginsburg, *supra* note 98, at 36.

107 Amartya Sen, *Markets and Freedoms: Achievements and Limitations of the Market Mechanism in Promoting Individual Freedoms*, 45 OXFORD ECON. PAPERS 519, 523–24 (1993). That is "the operative role that a person has in the process of choice." *Id.* at 524.

to fly into IMC.[108] There were many reasons for this. First, there was a tendency to view such events as simple rule breaches.[109] In such a scenario, the behavior is simply put down to recalcitrance; a pilot chose to breach the rules.[110] Such a construct does not lend itself to much in-depth analysis. Second, the high fatality rate of these accidents meant that the insight into the pilot's decision-making needed to be inferred from surrounding information (usually provided in the accident report).[111] There is also a reluctance among pilots who have flown into IMC and survived to be candid after the fact for fear of prosecution for a breach of the rules[112] or a lack of coverage from the insurer.[113]

More broadly, decision-making was not necessarily seen as a separate factor to consider in the context of pilot actions; instead, regulators relied on vague concepts of airmanship and the notion that you either could or you couldn't. Or to put it another way, a select few had the "right stuff" and the rest did not.[114] However, "the contemporary view sees aeronautical decision[-]making as a cognitive function that is open to analysis on the basis of standard psychological theory and practice,"[115] and the concept of decision-making is now recognized as a crucial element in relation to aviation safety, particularly as technological advances have reduced the impact of mechanical failures.[116] A central part of a pilot's role is decision-making, and often those decisions are "complex, especially when made under conditions of uncertainty, when ambiguous information is involved or when there is limited time available."[117] Few wonder there-

---

108 Goh & Wiegmann, *supra* note 74, at 817–18.

109 *See id.*

110 Coyne et al., *supra* note 36, at 154; Barbara K. Burian, Judith Orasanu & Jim Hitt, *Weather-Related Decision Errors: Differences Across Flight Types*, 44 PROC. HUM. FACTORS & ERGONOMICS SOC'Y ANN. MEETING 22, 25 (2000).

111 Goh & Wiegmann, *supra* note 74, at 817.

112 Michael A. Gallo et al., *Inadvertent VFR-into-IMC Flights: A Qualitative Approach to Describing GA Pilots' First-Hand Experiences*, 33 COLLEGIATE AVIATION REV. INT'L 27, 46 (2015).

113 For an interesting analysis of a number of U.S. cases concerning insurance coverage in the instance of VFR into IMC, see McQuillen, *supra* note 37, at 191–204.

114 BATT & O'HARE, *supra* note 18, at 2.

115 *Id.*

116 *Id.*

117 Stephen Walmsley & Andrew Gilbey, *Cognitive Biases in Visual Pilots' Weather-Related Decision Making*, 30 APPLIED COGNITIVE PSYCH. 532, 532 (2016).

fore that faulty information analysis in decision-making is the main factor behind VFR into IMC.[118]

Over the last thirty years, there has been a number of studies into the behavioral traits of pilots in such accidents, some of which have included simulation-based studies.[119] This research suggests that VFR into IMC can be linked to a number of different characteristics or behaviors, but they are neither independent nor conflicting. Instead, each behavior is related but relevant to different stages of the decision-making process.[120] Therefore, it is difficult to arrive at a single, unified model of pilot behavior. Instead, there are different hypotheses and behavioral models that have been applied to pilot decision-making.[121]

Two themes from this research have emerged. First, multiple theories can be used as a basis for predicting decision-making by pilots, and there are many variables involved, limiting the predictability of the theories.[122] Second, situational awareness is linked to decision-making particularly when, in the chain of events, a decision is made to avoid deteriorating conditions.[123] Further, Batt and O'Hare note, when examining the behavior of pilots within the context of deteriorating weather, that there is a

---

[118] Stephen Walmsley & Andrew Gilbey, *Applying Prospect Theory to Pilot Weather-Related Decision-Making: The Impact of Monetary and Time Considerations on Risk Taking Behaviour*, 34 APPLIED COGNITIVE PSYCH. 685, 694 (2020); David R. Hunter, Monica Martinussen & Mark Wiggins, *Understanding How Pilots Make Weather-Related Decisions*, 13 INT'L J. AVIATION PSYCH. 73, 75 (2003); Poornima Madhavan & Frank C. Lacson, *Psychological Factors Affecting Pilots' Decisions to Navigate in Deteriorating Weather*, 8 N. AM. J. PSYCH. 47, 49 (2006).

[119] *See, e.g.*, Juliana Goh & Douglas A. Wiegmann, *Visual Flight Rules Flight into Instrument Meteorological Conditions: An Empirical Investigation of the Possible Causes*, 11 INT'L J. AVIATION PSYCH. 359, 365 (2001); David O'Hare, Douglas Owen & Douglas Wiegmann, *The 'Where' and the 'Why' of Cross-Country VFR Crashes: Database and Simulation Analyses*, 45 PROC. HUM. FACTORS & ERGONOMICS SOC'Y ANN. MEETING 78, 79 (2001); Goh & Wiegmann, *supra* note 74, at 818; Coyne, *supra* note 36, at 154; David O'Hare & Tracy Smitheram, *"Pressing On" into Deteriorating Conditions: An Application of Behavioral Decision Theory to Pilot Decision Making*, 5 INT'L J. AVIATION PSYCH. 351, 356 (1995); Wesley L. Major et al., *VFR-into-IMC Accident Trends: Perceptions of Deficiencies in Training*, 7 J. AVIATION TECH. & ENG'G 50, 50–51 (2017); Buchanan, *supra* note 64, at 3; Woods et al., *supra* note 19, at 54; Ayiei Ayiei, John Murray & Graham Wild, *Visual Flight into Instrument Meteorological Condition: A Post Accident Analysis*, 6 SAFETY 1, 19 (2020).

[120] Goh and Wiegmann use Jensen's judgment model, which focuses on stages of a judgment rather than a unified behavioral model. *See* Goh & Wiegmann, *supra* note 74, at 821.

[121] *Id.*

[122] Major et al., *supra* note 119, at 51.

[123] *Id.*

range of behaviors that can impact the decisions and thus leads to a spectrum of outcomes, starting with (i) returning/diverting at the first indication of deteriorating weather to (ii) pressing on until the aircraft enters IMC.[124] Between these two extremes, there are various stages at which the pilot decides to return to home base or divert to an alternative airport.[125] We would add one prior outcome on this spectrum: the decision that means the pilot will choose not to commence the flight in the first place in anticipation of deteriorating weather en route.

This Article therefore addresses three of the primary theories used to explain pilot behavior in the context of deteriorating conditions. These theories are (i) environmental literacy and heuristics, (ii) overconfidence, and (iii) prospect theory. These must be understood within the context that one theory may be more attributable than another to a specific occurrence depending upon when the decision on whether to fly into deteriorating conditions is being made.[126]

A. Environmental Literacy and Heuristics

A pilot's inaccurate assessment of the hazard posed is often identified as the first factor in detrimental decision-making.[127] In such cases, the pilot misdiagnoses the situation and does not predict that the conditions will deteriorate and become dangerous until it is too late.[128] This is often linked to inexperience in the interpretation of the weather data at all stages of the flight, with a particular inability to recognize the gradual transition from VFR into IMC.[129] In a study where pilots who had survived VFR into IMC had been interviewed, it was noted that most pilots had received an appropriate weather briefing prior to the flight, but none had anticipated IMC conditions developing en route.[130] This plays straight into the path of bounded rationality. Too often, pilots simply lack the weather-related cognitive skills to judge something as complex and dynamic as changing weather conditions, especially in the high-workload context of operating an aircraft, often as the sole pilot.

---

[124] Batt & O'Hare, *supra* note 66, at 552.
[125] *Id.*
[126] Major et al., *supra* note 119, at 52, 56.
[127] Ayiei et al., *supra* note 119, at 2.
[128] *Id.* at 1–2.
[129] Gallo et al., *supra* note 112, at 43.
[130] *Id.* at 44.

In a study of 319 accidents that could be attributed to VFR into IMC occurring between the period of 2003–2012, 67.4% involved pilots who did not have an instrument rating,[131] suggesting that these pilots had fewer skills in assessing and operating an aircraft in poor and deteriorating weather (skills that would have been developed had the pilot obtained an instrument rating). Within the sample accidents, there was also a trend for accidents to occur at the lower end of the experience pool of pilots, that is:

- 23.4% had fewer than 250 hours of flight time;
- 17.7% had 250–500 flight hours;
- 20.3% had 500–1,000 flight hours;
- 13.6% had 1,000–2,000 flight hours;
- 11.7% had 2,000–5,000 flight hours; and
- 13.3% had over 5,000 flight hours.[132]

This suggests that as experience increased, the chance of an accident decreased, supporting the hypothesis that, at least to some extent, inexperience (and therefore the cognitive limitations) play a role in such accidents.

The literature supports the hypothesis that situational assessment deficiencies—that is, misdiagnoses of deteriorating weather due to inexperience or poor training—is one factor to consider in civilian and military flying.[133] Simulator assessment studies undertaken by researchers Goh and Wiegmann[134] and Coyne et al.[135] both found that, in general, pilots were poor at judging simulated weather conditions and tended to underestimate the severity of the weather conditions. Similar results were

---

131 Why is this not 100%? Of the remaining, the pilots with an instrument rating could have not intended to fly into IMC, and therefore, it still counts as "inadvertent," albeit their training as instrument pilots would assist them once in IMC. Alternatively, they could have an instrument rating that has lapsed, or is current but has not been exercised sufficiently frequently so that the skills of the pilot are simply deficient. Instrument flying is a skill that is very prone to atrophy, so it is still correct to refer to these accidents as inadvertent VFR into IMC even if the pilot had previously held an instrument rating. Major et al., *supra* note 119, at 53.

132 *Id.*

133 Douglas A. Wiegmann & Scott A. Shappell, *Human Factors Analysis of Postaccident Data: Applying Theoretical Taxonomies of Human Error*, 7 INT'L J. AVIATION PSYCH. 67, 67 (1997).

134 Goh & Wiegmann, *supra* note 74, at 817; Douglas A. Wiegmann, Juliana Goh & David O'Hare, *The Role of Situation Assessment and Flight Experience in Pilots' Decisions to Continue Visual Flight Rules Flight into Adverse Weather*, 44 HUM. FACTORS 189, 192–95 (2002); Goh & Wiegmann, *supra* note 119, at 359–60; Hunter et al., *supra* note 118, at 73.

135 Coyne et al., *supra* note 36, at 155–56.

reported by researchers Knecht and Lenz, who identified that data from a survey of one hundred pilots indicated inadvertent VFR into IMC to the U.S. regulator, the National Transportation Safety Board (NTSB).[136] In this instance, 95% of the pilots had received an adequate weather briefing prior to the incident occurring but did not anticipate that IMC would exist along their route.[137] Similar findings were reported by researchers Shappell et al.[138] and Gallo et al.[139] confirming that situational awareness was a factor in VFR into IMC. These authors noted that the most "at-risk target groups"—that is, the ones who flew furthest into deteriorating weather conditions before attempting a resolution—were non-instrument-rated pilots and recently certified instrument-rated pilots, suggesting that the level of expertise and experience was a factor in these incidents.[140]

Similarly researchers Shappell et al. concluded that, "[c]ontrary to what the accident record seems to suggest, flight into adverse weather may also be influenced by the lack of appreciation/understanding of the hazards associated with adverse weather."[141] This is not to suggest that all studies confirm that the experience of the pilot will be a factor in VFR into IMC incidents as the link has been questioned by at least one study.[142] Overall, however, there is strong evidence that simple, cognitive limitations play a significant role in these cases, whether those limitations are inherent or simply due to a lack of training.[143]

In 1974, Tversky and Kahneman published the first of their seminal works on heuristics and biases in decision-making.[144] Focusing on how people make predictions based on uncertain information, they explored the basis of peoples' beliefs as to the

---

136 WILLIAM R. KNECHT & MICHAEL LENZ, FAA, OFF. AEROSPACE MED., DOT/FAA/AM-10/13, CAUSES OF GENERAL AVIATION WEATHER-RELATED, NON-FATAL INCIDENTS: ANALYSIS USING NASA AVIATION SAFETY REPORTING SYSTEM DATA 3 (2010).

137 *Id.* at 20.

138 Scott Shappell et al., *Human Error and Commercial Aviation Accidents: An Analysis Using the Human Factors Analysis and Classification System*, 49 HUM. FACTORS 227, 231 (2007).

139 Gallo et al., *supra* note 112, at 44.

140 KNECHT & LENZ, *supra* note 136, at i.

141 SCOTT SHAPPELL ET AL., FAA, OFF. OF AEROSPACE MED., DOT/FAA/AM-10/16, DEVELOPING PROACTIVE METHODS FOR GENERAL AVIATION DATA COLLECTION 12 (2010).

142 *See* Ayiei et al., *supra* note 119, at 20.

143 Shappell et al., *supra* note 138, at 237.

144 Tversky & Kahneman, *supra* note 100, at 1124.

outcome of uncertain events and concluded that "people rely on a limited number of heuristic principles which reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations. In general, these heuristics are quite useful, but sometimes they lead to severe and systematic errors."[145] The work has been described as dominating the judgment and decision-making literature ever since.[146] It must be noted that the use of heuristics, and therefore the erroneous cognitive functioning, is not always a negative concept; shortcuts can be useful in saving our brain's time or energy and increasing efficiency.[147] However, they do, by their very nature, involve trade-offs, and these can often be ascribed simply to "human error" without understanding the complexity of the psychological factors involved.[148]

Heuristics are used to navigate complexity.[149] Decisions that require analysis and predictions of the weather are extremely complex.[150] The information used by a pilot to make a judgment on weather conditions comes from a range of sources, including preflight weather briefings, in-flight weather reports, and decoding visual clues from the cockpit.[151] As noted by Hunter et al.:

> [P]ilots are expected to integrate this information and formulate an expectation of the nature of the conditions that are likely to be present at a given location and time. The dynamic nature of the aviation environment is such that the meteorological conditions may change rapidly and generally require a continuous reappraisal and reinterpretation of the information available.[152]

Heuristics appear to play a role in pilots' poor environmental literacy.[153] Driskill et al. conducted a study in which pilots were given twenty-seven weather scenarios and had to rank each one

---

145 *Id.*

146 James Shanteau, *Cognitive Heuristics and Biases in Behavioral Auditing: Review, Comments and Observations*, 14 ACCT. ORGS. & SOC'Y 165, 165 (1989).

147 Cynthia Null, *Human Error*, *in* SPACE SAFETY AND HUMAN PERFORMANCE 34, 42 (Barbara Kanki, Jean-François Clervoy & Gro Mjeldheim eds., 2018); Rüdiger F. Pohl, *Introduction: Cognitive Illusions*, *in* COGNITIVE ILLUSIONS: A HANDBOOK ON FALLACIES AND BIASES IN THINKING, JUDGEMENT AND MEMORY 1, 12–13 (Rüdiger F. Pohl ed., 2004).

148 Shanteau, *supra* note 146, at 168.

149 *Id.* at 165.

150 Hunter et al., *supra* note 118, at 74.

151 *Id.*

152 *Id.*

153 Shanteau, *supra* note 146, at 170.

and state their level of comfort for each scenario; they found that pilots tended to adopt what is known as "compensatory" strategies to their assessment of the various options.[154] A broader study conducted by Hunter et al. of over four hundred pilots from the United States, Australia, and Norway came to similar conclusions with pilots from all three countries evidencing a preference for compensatory decision models of analysis over noncompensatory.[155] Compensatory models are good examples of heuristics in action.[156]

To explain, a compensatory model is one where pilots "mathematically combine the different aspects of the weather to create an overall assessment."[157] In other words, the model involves a consideration of the positive and negative attributes of each option and the selection of the option with the greatest number of positive attributes.[158] A noncompensatory model is where pilots consider each individual attribute against set criteria, and if one attribute fails to meet the criteria, then the pilot will conclude that the global conditions are unsuitable (therefore, not allowing one "good" criteria to compensate for a "bad" one).[159] Hence, applying a noncompensatory model would mean that if one element of the conditions (e.g., visibility) was below a preset minimum, then irrespective of the cloud ceiling, the pilot would conclude the global conditions were unsuitable.[160]

While compensatory models may have a level of efficiency in the context of the dynamic and time-limited environment in which pilots operate, the outcomes of applying these models are often flawed.[161] As Hunter et al. note, the tendency to use one positive attribute (e.g., high cloud ceiling) to compensate for another negative one (e.g., poor visibility) in the global evaluation of the situation is problematic as one attribute does not actually compensate for the other.[162] Similar analysis is provided by researchers Coyne et al., who note that a compensatory

---

154 Walter E. Driskill et al., FAA, Off. of Aviation Med., DOT/FAA/AM-97/3, The Use of Weather Information in Aeronautical Decision-Making 7, 13 (1997).

155 Hunter et al., *supra* note 118, at 78–79, 84.

156 *Id.* at 85.

157 Coyne et al., *supra* note 36, at 155.

158 Joanne Vining & Lesley Fishwick, *An Exploratory Study of Outdoor Recreation Site Choices*, 23 J. Leisure Rsch. 114, 114 (1991).

159 Hunter et al., *supra* note 118, at 76.

160 *Id.*

161 *Id.* at 85.

162 *Id.*

model could explain their subject pilots' deficiencies in integrating visibility and ceiling factors; they additionally noted that while compensatory models might make for efficient use of the available information, those models are a suboptimal decision-making strategy.[163] Therefore, heuristics, as a common theme among BE thinkers, appear to also be a common tool used by pilots within the context of VFR into IMC.[164]

B. Risk Assessment: Overconfidence and Motivation

Assessing and managing risk is another area in which cognitive limitations and biases can be found.[165] This is an essential skill for any pilot, but in many ways, it is more important for GA pilots.[166] In GA, more emphasis is placed on the individual pilot for judgment and decision-making with less oversight and fewer processes and systems to guide or inform the pilot's decision-making.[167] The connection between context and risk aversion has led to the hypothesis that risk-taking is linked in part to motivation: a person will only take risks when they have a motivation to do so.[168] Motivational factors continue to be identified as important factors in pilot decision-making.[169]

It has been argued that sound aeronautical decision-making is part motivational and part cognitive,[170] suggesting that poor decision-making is due, in part, to inappropriate motivation. Re-

---

163 Coyne et al., *supra* note 36, at 155.

164 Driskill et al., *supra* note 154, at 3.

165 Shanteau, *supra* note 146, at 168.

166 Hunter et al., *supra* note 118, at 75.

167 *Id.* at 74.

168 Lola L. Lopes, *Between Hope and Fear: The Psychology of Risk*, 20 Advances Experimental Soc. Psych. 255, 260 (1987); Yaniv Hanoch, Joseph G. Johnson & Andreas Wilke, *Domain Specificity in Experimental Measures and Participant Recruitment: An Application to Risk-Taking Behavior*,17 Psych. Sci. 300, 303 (2006); Elke U. Weber, Ann-Renée Blais & Nancy E. Betz, *A Domain-Specific Risk-Attitude Scale: Measuring Risk Perceptions and Risk Behaviors*, 15 J. Behav. Decision Making 263, 265 (2002).

169 David O'Hare & Douglas Owen, Continued VFR into IMC: An Empirical Investigation of the Possible Causes: Final Report on Preliminary Study (1999) (unpublished manuscript) (on file with the University of Otago); Juliana Goh & Douglas Wiegmann, *Visual Flight Rules (VFR) Flight into Instrument Meteorological Conditions (IMC): A Review of the Accident Data*, 11 Proc. Int'l Symp. Aviation Psych. 1, 5 (2001); Dale R. Wilson & Teresa A. Sloan, *VFR Flight into IMC: Reducing the Hazard*, 13 J. Aviation/Aerospace Educ. & Rsch. 29, 35 (2003).

170 Jang R. Lee, Richard O. Fanjoy & Brian G. Dillman, *The Effects of Safety Information on Aeronautical Decision Making*, 10 J. Air Transp. 3, 5–6 (2005); R.S. Jensen et al., *Pilot Judgment Skills Test Battery*, Final Report F33615-86-4519, U.S.A.F. (1987).

searchers Murray[171] and Hunter et al.[172] suggest that the link between misplaced motivation and poor decision-making is an "assumption" but note that there is significant anecdotal evidence to support it nonetheless.[173] The role of social pressure, along with the contribution of other decision biases, has often been labeled as "get-there-itis" and has started to be recognized in the literature.[174] For instance, at times, the motivation has been ascribed to the carrying of passengers, where a pilot is reluctant to disappoint or let down a passenger and therefore presses on into deteriorating conditions in order to "get there."[175] This has also been cited by both CASA and the ATSB in recent years in response to two medical transport accidents, with both organizations theorizing that the desire to get a sick patient home or to a medical appointment has the potential to cloud a pilot's judgment as to whether it is safe to proceed with the flight.[176]

We argue that motivation plays a significant role in pilot decision-making[177] and can be considered either intrinsic, extrinsic, or a combination of the two.[178] Extrinsic motivation, otherwise known as external pressure, refers to motivation derived from external factors (such as reward, accolades, or desire to avoid punishment), whereas intrinsic motivation is where the motivation to act is driven by something intrinsic to the decision maker.[179] However, a study conducted by Woods et al. indicated that motivation was not itself a clear factor in determining sub-

---

171 Stephen R. Murray, *FACE: Fear of Loss of Face and the Five Hazardous Attitudes Concept*, 9 INT'L J. AVIATION PSYCH. 403, 408 (1999).

172 Hunter et al., *supra* note 118, at 74.

173 *Id.*; Murray, *supra* note 171, at 408.

174 Wilson & Sloan, *supra* note 169, at 35.

175 Shappell et al., *supra* note 138, at 239; Goh & Wiegmann, *supra* note 74, at 818; J.B. Holbrook et al., *Weather-Related Decision Making by Aviators in Alaska*, 12 PROC. INT'L SYMP. AVIATION PSYCH. 576 (2003).

176 *Community Service Flights*, CIV. AVIATION SAFETY AUTH., https://www.casa.gov.au/operations-safety-and-travel/safety-advice/community-service-flights [https://perma.cc/DNH3-E4D2] (July 25, 2022); *CASA Brings in Community Service Flight Standards*, FLIGHT SAFETY AUSTL. (Feb. 13, 2019), https://www.flightsafetyaustralia.com/2019/02/casa-bring-in-community-service-flight-standards [https://perma.cc/CG5K-Z56N]; *ATSB Investigation Highlights Risks of Community Service Flights*, ATSB (Aug. 13, 2019), https://www.atsb.gov.au/media/news-items/2019/community-service-flights [https://perma.cc/LEY8-A2ZQ].

177 Woods et al., *supra* note 19, at 61.

178 Edward L. Deci, Richard M. Ryan & Richard Koestner, *A Meta-Analytic Review of Experiments Examining the Effects of Extrinsic Rewards on Intrinsic Motivation*, 125 PSYCH. BULL. 627, 627–28 (1999).

179 *Id.*

jects' willingness to fly in the face of deteriorating weather conditions, although there were some significant outliers.[180] Researchers O'Hare and Smitheram have previously concluded that where motivational factors have been relevant, extrinsic factors have played a bigger part than intrinsic ones.[181] They pointed to the large volume of accident data that clearly evidenced attempts to impress bystanders or passengers to argue that social pressures (i.e., extrinsic motivations) must play some part in the decision-making of pilots.[182] Motivation, therefore, can be seen as one of the bounds to a pilot's rational decision-making.[183] Simply put, it is irrational to place these motivations above the considerations of the risk and dangers of potential VFR into IMC. A truly "rational pilot" would make the difficult decision not to proceed into deteriorating conditions; however, in some cases, the evidence points to pilots becoming bound by improper motivation.[184]

Faulty risk assessment is also related to the concept of overconfidence.[185] Overconfidence, and the lack of clear, objective self-analysis of ability has been identified as a factor in VFR into IMC incidents.[186] For example, O'Hare found that most GA pilots are unrealistically optimistic regarding their chances of experiencing an aircraft accident.[187] Further, many pilots believe they possess greater flying skill, are less likely to experience an aircraft accident, and are less inclined to take risks in flight than their peers.[188] These biases extend to VFR into IMC conditions.[189] A simulation conducted by Goh and Wiegmann found that pilots who rated their own abilities as higher than average were more likely to proceed into the simulated IMC conditions.[190] When those pilots were questioned, they appeared to accept the general dangers of continuing into IMC but down-

---

180 Woods et al., *supra* note 19, at 63.

181 O'Hare & Smitheram, *supra* note 119, at 366.

182 *Id.* at 362.

183 *Id.* at 367.

184 *Id.* at 366–67.

185 *Id.* at 352.

186 *Id.*

187 David O'Hare, *Pilots' Perception of Risks and Hazards in General Aviation*, 61 AVIATION SPACE & ENV'T MED. 599, 599 (1990).

188 Goh & Wiegmann, *supra* note 119, at 376.

189 Dale R. Wilson & Marte Fallshore, *Optimistic and Ability Biases in Pilots' Decisions and Perceptions of Risk Regarding VFR Flight into IMC*, 11 PROC. INT'L SYMP. AVIATION PSYCH. 1, 2 (2001); O'Hare, *supra* note 187, at 559.

190 Goh & Wiegmann, *supra* note 74, at 376.

played their own specific chances of an accident caused by IMC, and as noted by the authors, "the differences in self-judgment on skill and ability appear to reflect differences in self-awareness or metacognitive estimates of one's own abilities."[191]

In a study reviewing 1,100 GA accidents, of which 319 were determined to be inadvertent VFR into IMC, Major et al. concluded that pilots' decisions to continue into IMC were likely due in part to overconfidence, either from having made the flight before or from their own sense of invulnerability.[192] This conclusion was drawn in part because the pilots involved in the accidents almost always received weather briefings prior to accidents occurring.[193]

C. Prospect Theory

Tversky and Kahneman released their research on "Prospect Theory" in 1979.[194] They attempted to describe how humans choose between different options (or prospects).[195] A decision is made as a result of a judgment.[196] There are four elements to prospect theory: (i) loss aversion, (ii) reference dependence, (iii) diminishing sensitivity, and (iv) probability weighting.[197] In this Article, we focus on loss aversion and reference dependence as most relevant to weather-related decision-making.

Loss aversion posits that when choosing between prospects that appear to be gains, people tend to make *risk-averse* choices, and when choosing between options that appear to be losses, there is a tendency towards *risk-seeking* choices.[198] Reference dependence is the notion that people will measure the utility of losses and gains from a certain reference point—ultimately subjective to them—rather than from an absolute reference

---

191 *Id.*

192 Major et al., *supra* note 119, at 51–52, 56.

193 *Id.* at 51.

194 Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263, 263 (1979).

195 *Id.*

196 *Id.* at 289.

197 Nicholas C. Barberis, *Thirty Years of Prospect Theory in Economics: A Review and Assessment*, 27 J. ECON. PERSPS. 173, 175 (2013).

198 Kahneman & Tversky, *supra* note 194, at 268–69; David V. Budescu & Wendy Weiss, *Reflection of Transitive and Intransitive Preferences: A Test of Prospect Theory*, 39 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 184, 184 (1987).

point.[199] In other words, when judging whether something is a loss or a gain, people use a reference point (either their current state or some future anticipated change) rather than an end state.[200] As prospect theory is about the perception of gains and losses; the way information is framed has been demonstrated to have an effect on decision-making across a range of contexts where the cost of poor decision-making is significant.[201]

As noted by Goh and Wiegmann, a decision to fly into deteriorating weather can be likened to a risky gamble with uncertain outcomes.[202] In contrast, the decision to divert and land (or not fly in the first place) is effectively a sure thing.[203] This opens the door to elements of prospect theory and decision framing as factors to consider as prospect theory predicts that how one frames a decision (as a loss or gain) will influence a person's decision-making.[204] Tversky and Kahneman suggested that by changing the reference point from which outcomes are evaluated, one can change preferences for certain options.[205] Interestingly, where studies have claimed to have found framing and its effect occurring, it has occurred across the spectrum of experience

---

[199] Ted O'Donoghue & Charles Sprenger, *Reference-Dependent Preferences*, *in* 1 HANDBOOK OF BEHAVIORAL ECONOMICS 1, 2 (B. Doulgas Bernheim, Stefano Dellavigna & David Laibson, eds., 2018).

[200] Barberis, *supra* note 197, at 178.

[201] *See, e.g.*, Catherine S. Elliott & Robert B. Archibald, *Subjective Framing and Attitudes Towards Risk*, 10 J. ECON. PSYCH. 321, 321–22 (1989); N.S. Fagley & Paul M. Miller, *The Effect of Framing on Choice: Interactions with Risk-Taking Propensity, Cognitive Style, and Sex*, 16 PERSONALITY & SOC. PSYCH. BULL. 496, 496 (1990); Theresa M. Marteau, *Framing of Information: Its Influence upon Decisions of Doctors and Patients*, 28 BRIT. J. SOC. PSYCH. 89, 89 (1989); Irwin P. Levin, Sandra L. Schneider & Gary J. Gaeth, *All Frames Are Not Created Equal: A Typology and Critical Analysis of Framing Effects*, 76 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 149, 150 (1998); Irwin P. Levin & Daniel P. Chapman, *Risk Taking, Frame of Reference, and Characterization of Victim Groups in AIDS Treatment Decisions*, 26 J. EXPERIMENTAL SOC. PSYCH. 421, 421 (1990); Beth E. Meyerowitz & Shelly Chaiken, *The Effect of Message Framing on Breast Self-Examination Attitudes, Intentions, and Behavior*, 52 J. PERSONALITY & SOC. PSYCH. 500, 501 (1987); John Schaubroeck & Elaine Davis, *Prospect Theory Predictions When Escalation Is Not the Only Chance to Recover Sunk Costs*, 57 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 59, 59 (1994).

[202] Goh & Wiegmann, *supra* note 119, at 359–60.

[203] *Id.* at 362; O'Hare & Smitheram, *supra* note 119, at 367.

[204] Murray, *supra* note 171, at 406; Major et al., *supra* note 119, at 51; Wiegmann & O'Hare, *supra* note 134, at 190.

[205] Daniel Kahneman & Amos Tversky, *The Psychology of Preferences*, 246 SCI. AM. 160, 160–62 (1982).

levels of subjects—meaning, both novices and experts have exhibited framing and made decisions influenced by it.[206]

The obvious application to this study is determining whether pilots are more likely to continue into deteriorating weather when they view diverting (or not flying in the first place) as a loss rather than a gain.[207] The implications of this were explored by O'Hare and Smitheram, who showed that decisions to continue a flight into uncertain conditions were less likely when the prospects were framed in terms of possible gains rather than as possible losses.[208] However, it must be noted that this was a simulated environment, so the "losses" and "gains" were not real, and thus caution must be had before placing too much emphasis on this study.[209]

However, in 2020, Walmsley and Gilbey reported their findings from a study of 132 pilots where each pilot was given five scenarios, each of which was a simple gamble.[210] In each scenario, there were two versions, one positive prospect (gain) and one negative prospect (loss).[211] In each case, the pilot had to choose between Route A (shorter route to destination but with some risk of bad weather) or Route B (longer route to destination but guarantee of good weather).[212] For example, in the first problem, pilots had to decide whether to take the shorter Route A, with an 85% chance of the weather being fine and earning $1,000, or the longer Route B, where the weather was fine but earning only $800.[213] If they took Route A and had to turn back (i.e., the 15% chance of poor weather occurred), then they would earn $0.[214] Prospect theory would suggest that where there was a sure thing (Route B), then people would tend to be risk-averse, even though Route A had a higher expected value.[215] The second variation of the first scenario was similar but this time was presented as a loss.[216] In this case, the pilot had

---

206 Barbara J. McNeil, Stephen G. Pauker, Herald C. Sox & Amos Tversky, *On the Elicitation of Preferences for Alternative Therapies*, 306 New Eng. J. Med. 1259, 1262 (1982).

207 O'Hare & Smitheram, *supra* note 119, at 351.

208 *Id.*

209 *Id.*

210 Walmsley & Gilbey, *supra* note 118, at 688.

211 *Id.*

212 *Id.* at 689.

213 *Id.*

214 *Id.*

215 *Id.*

216 *Id.*

rented the aircraft, and if they successfully took the shorter Route A, there would be no late fee, but if they took Route A and had to turn back (now with an 85% chance of poor weather), they would be very late, and $1,000 would be owed.[217] Otherwise, they could take Route B, which was longer than Route A, resulting in an $800 late fee but a 100% chance of good weather.[218] Prospect theory would suggest that because the prospect is now a loss (i.e., late fees), participants should be more likely to choose the gamble of Route A despite the higher expected utility of Route B.[219] The other scenarios were variations on these.[220] For example, one scenario replaced monetary gains and losses with time, and other scenarios used a starting reference point (e.g., the pilots started with a certain amount of money).[221] Overall, Walmsley and Gilbey found that pilot decision-making around uncertain prospects was generally consistent with prospect theory (albeit more markedly in respect of financial losses and gains compared to time losses and gains where participants tended to be risk-averse in respect of time losses).[222] Consistent with previous research where pilots were asked to self-assess their risk tolerance, the vast majority self-identified as risk-averse.[223] That is, they would view the decision to divert or not fly as a gain, not a loss.[224] But in the scenarios where decisions were made, risk tolerance tended to vary based on the scenarios presented and broadly followed prospect theory predictions.[225]

A final comment should also be made about reference dependence. We argue that reference dependence is a significant factor in judgments about weather, as weather is constantly changing. Walmsley and Gilbey noted that, from a sensory perspective, we are more attuned to changes in attributes than to absolute magnitudes, and on that basis, we tend to judge outcomes by reference to a certain, subjective reference point.[226] A simple example might be where two different pilots, Pilot A and Pilot B, must decide whether to proceed into poor flying condi-

---

217 *Id.*
218 *Id.*
219 *Id.*
220 *See id.*
221 *Id.* at 689–90.
222 *Id.* at 694.
223 *Id.*
224 *Id.*
225 *Id.*
226 *Id.* at 695.

tions. The conditions on the day might constitute an improvement to the conditions that Pilot A last flew in, whereas those same conditions might constitute worse conditions than those that Pilot B last flew in. Each pilot's separate decision-making will therefore be impacted by whether they see the conditions as an improvement or a deterioration from their own reference points. The weather conditions for Pilot A and Pilot B are the same; what differs is how they depart from each individual pilot's reference point. This is consistent with the notion of anchoring and adjustment from Tversky and Kahneman's previous work.[227]

The sunk cost bias is an element of prospect theory.[228] It holds that those who have more invested in a venture will be more likely to continue with it, even when it appears foolish to do so.[229] Batt and O'Hare identified 491 occurrences of weather-related flight occurrences from the ATSB databases.[230] Of these, 280 were actual VFR into IMC, 60 were precautionary landing[231] cases due to deteriorating weather, and 151 were weather avoidance cases.[232] Overall, the majority of occurrences took place beyond the halfway point of the flight, and the researchers could not identify any clear, operational reason for this.[233] Further, it did not seem to matter whether the flight was a short flight or a long flight; rather, they hypothesized that the halfway point exists as a psychological construct.[234] On that basis, they concluded that decision-making can be influenced by "psychological factors that do not directly equate to any particular operational aspect of the flight."[235] Where these incidents did result in VFR into IMC, these events tended to occur later in the flight compared to the weather avoidance incidents where the "avoidance"

---

227 Tversky & Kahneman, *supra* note 100, at 1128–30.

228 Hal R. Arkes & Catherine Blumer, *The Psychology of Sunk Cost,* 35 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 124, 130 (1985).

229 *Id.* at 132.

230 Batt & O'Hare, *supra* note 66, at 553.

231 That is, a premeditated emergency landing. Continued flight is possible but inadvisable (compare with a normal emergency landing, such as an engine failure, where the emergency landing is completely forced on the pilot). Precautionary landings are off-field landings (that is, not at a recognized airfield). As noted by Batt and O'Hare, precautionary landings are not normal operations, and some involve damage to the aircraft while others do not. *Id.*

232 *Id.* at 553.

233 *Id.* at 556.

234 *Id.* at 558.

235 *Id.*

occurred earlier in the flight.[236] This is consistent with the findings of O'Hare and Owen, who found that, on average, in a study of seventy-seven accidents in New Zealand, VFR into IMC-related incidents occurred during the second half of the flight.[237] A study by the ATSB in 2005 found that 61% of accidents occurred after the halfway point in the flight and concluded that:

> This finding suggests that psychological aspects, rather than specific operational considerations, are the primary influence on pilots' *decision-making* in these situations. This is because the halfway point may relate, for example, to an absolute distance of *5 miles, 50 miles, or 500 miles*. Therefore the halfway point has standing only as a psychological construct.[238]

In a separate study, O'Hare, Owen, and Wiegmann found that when comparing accidents on cross-country flights, weather-related accidents tended to occur later in the flight and closer to the destination than accidents caused by issues such as mechanical failures (where the decision-making of the pilot was not a factor in the accident occurrence), supporting the hypothesis that the proximity of the goal (in this case, the destination airport) and time already invested in the flight are factors that influence decision-making in the face of deteriorating weather.[239]

There is some questioning of the sunk cost theory in relation to pilot decision-making.[240] Wiegmann and Goh's study based on a simulated flight had participants split into two groups, one that experienced adverse weather early in the flight, and one that experienced adverse weather later in the flight.[241] Their study revealed that out of thirty-six participants, those who experienced deteriorating conditions earlier in the flight were more likely to press on and continue the flight, compared to those who experienced the deteriorating conditions later in the flight, suggesting that a lack of support for the sunk cost theory.[242] However, this still suffers from the simulation problem,

---

[236] *Id.*

[237] David O'Hare & Douglas Owen, *Cross-Country VFR Crashes: Pilot and Contextual Factors*, 73 AVIATION SPACE & ENV'T MED. 363, 363, 368 (2002).

[238] BATT & O'HARE, *supra* note 18, at 42, 50 (emphasis added).

[239] O'Hare & Wiegmann, *supra* note 119, at 80.

[240] For an interesting discussion, see Jaclyn Brianne Baron, *Pilot Weather Decision Making and the Influence of Passenger Pressure*, 693 ALL DISSERTATIONS 1, 60–61 (2011).

[241] Wiegmann & Goh, *supra* note 134, at 192–93.

[242] *Id.* at 195.

and as the authors themselves note, it might have been explainable by the fact that for the longer group, they had a better baseline to determine the severity of the change in the weather, having been exposed to a longer period of stable weather conditions.[243]

Overall, there is "a substantial body of research that indicates normal human decision[-]making is often not very rational and is subject to bias."[244] In this part, we have identified certain behavioral traits and biases that tend to indicate that decision-making within the cockpit is at times similarly subject to such deficiencies. This results in exposing the pilot, passengers, and aircraft to one of the most dangerous risks in aviation through faulty decision-making, as a result of (among other things) either poor environmental literacy, overconfidence, or prospect theory (or a combination of these). Without further analysis, this would serve as little more than an interesting observation explaining why such seemingly irrational decisions are made leading to serious accidents. However, by introducing behavioral law and economics (BLE) as an analytical paradigm, we have the potential to examine how the law might use these behavioral insights to better regulate this area of aviation for greater safety outcomes.

IV. WHERE TO FROM HERE?

A. From Behavioral Economics to Behavioral Law and Economics

A common theme in BE is the belief that government intervention can improve an individual's decision-making by reducing the errors attributable to the various biases identified in the BE literature, thereby making each individual better off as measured by that person's own preferences.[245] The application of BE to the law and to regulation, therefore, allows for more realistic predictions of behavior than traditional law and economic analysis by seeking to more accurately model human decision-making through adopting more psychological realism into its

---

243 *Id.*

244 Wilson & Sloan, *supra* note 169, at 35.

245 Wright & Ginsburg, *supra* note 98, at 1063; Christine Jolls, Cass R. Sunstein & Richard Thaler, *Theories and Tropes: A Reply to Posner and Kelman*, 50 STAN. L. REV. 1593, 1595–96 (1998).

analysis.[246] Importantly, the idea is for a light touch—that is, intervention should target the poor decision makers but leave the rational decision makers unaffected.[247]

Behavioral law and economics ("BLE") marries the behavioral insights of BE to regulatory policy-making.[248] The BLE movement has gained considerable international traction, influencing policy in the United States;[249] the United Kingdom (particularly in health, personal finance, and the environment);[250] and Europe.[251] In 2014, the Organisation for Economic Co-operation and Development (OECD) provided a review of over sixty instances where BE had been used in developing policy (particularly economic and finance policy) around the world.[252] Further evidence of this can be seen in respect to research into changing policy aimed at changing habits in relation to use of public transport and climate change,[253] consumer

---

246 Bellová, *supra* note 97, at 92; Diacon et al., *supra* note 86, at 29; Thomas S. Ulen, *European and American Perspectives on Behavioural Law and Economics*, *in* EUROPEAN PERSPECTIVES ON BEHAVIOURAL LAW AND ECONOMICS 3, 5 (Klaus Mathis ed., 2015).

247 Ted O'Donoghue & Matthew Rabin, *Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes*, 93 BEHAV. ECON., PUB. POL'Y, & PATERNALISM 186, 186 (2003); Colin Camerer et al., *Regulation for Conservatives: Behavioral Economics and the Case for "Asymmetric Paternalism"*, 151 U. PA. L. REV. 1211, 1212–13 (2003).

248 Ryan Bubb & Richard H. Pildes, *How Behavioral Economics Trims Its Sails and Why*, 127 HARV. L. REV. 1593, 1595 (2014).

249 Cass R. Sunstein, *Deciding by Default*, 162 U. PA. L. REV. 1, 37–38 (2013); Courtney Subramanian, *'Nudge' Back in Fashion at White House*, TIME (Aug. 9, 2013), https://swampland.time.com/2013/08/09/nudge-back-in-fashion-at-white-house [https://perma.cc/Z23Y-VLAP].

250 RHYS JONES, JESSICA PYKETT & MARK WHITEHEAD, CHANGING BEHAVIOURS: ON THE RISE OF THE PSYCHOLOGICAL STATE 5 (2013); FINANCIAL CONDUCT AUTHORITY, APPLYING BEHAVIOURAL ECONOMICS AT THE FINANCIAL CONDUCT AUTHORITY, 2013-1, at 51 (UK).

251 *See* EUR. COMM'N JOINT RSCH. CENTRE, APPLYING BEHAVIOURAL SCIENCE TO EU POLICY-MAKING 3 (2013); ORG. FOR ECON. CO-OPERATION & DEV., CONSUMER POLICY TOOLKIT 42 (2010), https://www.oecd.org/sti/consumer/consumer-policy-toolkit-9789264079663-en.htm [https://perma.cc/VM6P-9QL8].

252 PETE LUNN, REGULATORY POLICY AND BEHAVIOURAL ECONOMICS 9 (2014), https://www.oecd-ilibrary.org/governance/regulatory-policy-and-behavioural-economics_9789264207851-en [https://perma.cc/3YCN-9X3M].

253 Tim Schwanen, David Banister & Jillian Anable, *Rethinking Habits and Their Role in Behaviour Change: The Case of Low-Carbon Mobility*, 24 J. TRANSP. GEOGRAPHY 522, 522 (2012); Erel Avineri, *On the Use and Potential of Behavioural Economics from the Perspective of Transport and Climate Change*, 24 J. TRANSP. GEOGRAPHY 512, 512 (2012); Rita Markovits-Somogyi & Balázs Aczél, *Implications of Behavioural Economics for the Transport Sector*, 41 PERIODICA POLYTECHNICA: TRANSP. ENG'G 65, 65–66 (2013).

credit,[254] retirement savings, and investor protection,[255] as well as the response to the COVID-19 pandemic.[256]

A familiar concept from BLE is "nudge theory," which has been popularized by Thaler and Sunstein since the early 2000s.[257] Although directing decision-making in a particular way, libertarian paternalism maintains the discretion of the actor themselves, allowing the moral choices to be made but, at the same time, leaving the discretion to do so with the actor.[258] Libertarian paternalism assists in overcoming concerns with infantilizing regulated entities.[259] At the same time, talk of infantilizing the public by interfering with their free judgment as to what is best for them[260] is less relevant when one is considering ways to protect the public from other people's actions. As noted, this is not just a debate around the safety of pilots; it is about the safety of passengers and also the economic welfare of aircraft owners burdened by increased insurance costs or the loss of their aircraft at the hands of another pilot. It may be that in many areas of life, effective decision-making is acquired through trial and error, getting feedback, or observing the success or lack thereof of one's decision-making.[261] But in some areas of practice, applying such a philosophy would be disastrous. Aviation is one of those areas. Trial and error is not a basis upon

---

254 Oren Bar-Gill & Elizabeth Warren, *Making Credit Safer*, 157 U. PA. L. REV. 1, 6 (2008).

255 Camerer et al., *supra* note 247, at 1227.

256 *COVID-19 Is Changing Our Understanding of Behavioral Economics*, JOHN HOPKINS U. (Feb. 19, 2021), https://hbhi.jhu.edu/news/covid-19-changing-our-understanding-behavioral-economics [https://perma.cc/Q5JF-XTB5].

257 RICHARD H. THALER & CASS R. SUNSTEIN, NUDGE: IMPROVING DECISIONS ABOUT HEALTH, WEALTH, AND HAPPINESS 6 (2008); Sally Brooks, *Configuring the Digital Farmer: A Nudge World in the Making?*, 50 ECON. & SOC'Y 374, 377 (2021); Nicole Kobie, *Nudge Theory: When Your Smart Gadgets Nag You*, GUARDIAN (Aug. 7, 2015, 2:00 PM), https://www.theguardian.com/technology/2015/aug/07/nudge-theory-smart-gadgets-silicon-valley [https://perma.cc/2NG7-H853].

258 Rhys Jones, Jessica Pykett & Mark Whitehead, *Governing Temptation: Changing Behaviour in an Age of Libertarian Paternalism*, 35 PROGRESS HUM. GEOGRAPHY 483, 483 (2010); Nick Gill & Matthew Gill, *The Limits to Libertarian Paternalism: Two New Critiques and Seven Best Practice Imperatives*, 30 ENV'T & PLAN. C: GOV'T & POL'Y 924, 930 (2012); RICHARD H. THALER & CASS R. SUNSTEIN, NUDGE: THE FINAL EDITION 6 (2021).

259 THALER & SUNSTEIN, *supra* note 258, at 7.

260 *See* Wright & Ginsburg, *supra* note 98, at 38–39.

261 James P. Byrnes, David C. Miller & Marianne Reynolds, *Learning to Make Good Decisions: A Self-Regulation Perspective*, 70 CHILD DEV. 1121, 1121–22 (1999); Ziva Kunda, *The Case for Motivated Reasoning*, 108 PSYCH. BULL. 480, 481, 489 (1990).

which to build a true safety structure around aviation operations. The reality is that most VFR pilots rarely get the luxury of obtaining feedback from external sources once their training has finished. A significant portion of VFR operations are single-pilot operations.[262] External review may be available at mandated flight-review intervals, but in between these, pilots are left to their own devices to develop their skill, and decision-making can take into account their personalities, competence, and exposure to different environments as best as they can.[263]

In this respect, where behavioral change is necessary, we argue that regulatory interventions must be accompanied by instruments that inform and incentivize actors to modify behaviors without overtly forcing them to do so. Put differently, "[b]ehaviourally informed interventions often aim to assist rather than to prohibit certain decisions, in keeping with the idea of regulatory policy as an enabler and facilitator to achieve positive outcomes."[264] Although regulation is essential in any effective policy mix of instruments, behavioral responses such as incentives, education, and self-regulatory approaches must be a part of that mix.[265]

Although this is an area that is opportune for governmental intervention to assist pilots to make better choices, here we do not aim for a thorough analysis of the existing law nor do we propose holistic solutions. Rather, we present three interventions as a starting point to help facilitate better decision-making. The first of these is a threshold issue, and the regulator must accept that the behavioral biases are real and can result in predictable departures from rationality across the spectrum of pilot skill levels and personalities. This is a cultural change, and we do not underestimate the challenges of this. However, as we have seen, many organizations, government agencies, and academics have come to adopt many of the precepts of BE to address their own areas of regulation and responsibility, using a BLE approach to review and renew regulation.[266] This will require the

---

[262] For a review of the GA sector in Australia, see AUSTL. DEP'T OF INFRASTRUCTURE & REG'L DEV., GENERAL AVIATION STUDY (2017), https://www.bitre.gov.au/sites/default/files/2019-11/cr_001_0.pdf [https://perma.cc/NDD2-8MJD].

[263] For the requirements, see *Flight Reviews*, CIV. AVIATION SAFETY AUTH., https://www.casa.gov.au/licences-and-certificates/pilots/ratings-reviews-and-endorsements/flight-reviews-and-proficiency-checks/flight-reviews (Dec. 5, 2021).

[264] Lunn, *supra* note 252, at 12.

[265] Neil Gunningham & Darren Sinclair, *Integrative Regulation: A Principle-Based Approach to Environmental Policy*, 24 LAW & SOC. INQUIRY 853, 854, 863 (1999).

[266] *See supra* notes 249–56 and accompanying text.

regulator to move away from a prohibit-and-punish regime to better reflect the real-life context of pilot decision-making. If the known dangers of VFR into IMC are insufficient incentives to VFR pilots to avoid situations where the risk of IMC exists, then it would seem the threat of a sanction from regulators is unlikely to do so either. As this Article has shown, the theoretical underpinnings of BE and BLE can provide useful insight into the why of VFR into IMC.

The second recommendation is associated with mandatory training. However, merely educating pilots about the dangers of VFR into IMC and prohibiting such behavior is an overly simplistic and ultimately unrealistic approach. As we have shown, the dangers of VFR into IMC are well-known, documented, and frequently identified.[267] Further, we have established that it is common knowledge among the aviation community that these events continue to occur notwithstanding the almost-universal acceptance of the high level of danger and risk associated with flying into IMC.[268] Simplistic explanations such as pilot stupidity or "anti-rule" behavior must be dispensed with. These accidents are not just occurring among the incompetent and the recalcitrant. The behavioral aspects of VFR into IMC are complex, and the issue is sufficiently serious to warrant a careful and serious analysis of how these accidents continue to occur. Indeed, the educational regime does have a critical role to play in this, but it needs to be deeper and more adept at explaining to pilots the psychological factors to which they may fall victim; it is time for pilots to be better educated about their own psychology.

Finally, pilots will need better practical (and mandatory) weather training. Currently, the training available to pilots is based around understanding basic weather theory, being able to predict weather using weather-forecasting tools, and understanding the legal requirements of VMC and IMC.[269] As we have shown, environmental literacy often becomes an issue in flight, with pilots struggling to perceive subtle changes in the weather until the weather has deteriorated to dangerous conditions.[270] This practical en route flying training is apt for simulation-based training, a tool which is becoming more common in GA, with

[267] *See supra* Section II.A.
[268] *See supra* notes 77–78 and accompanying text.
[269] Woods et al., *supra* note 19, at 62.
[270] *See supra* Section III.A.

the advent of cheaper and more sophisticated software.[271] BLE is not just informing the regulator's approach; it is informing what the training syllabus might look like in the future. Importantly, although we make suggestions for mandatory training and change, none of these limit the autonomy of the pilot during or in preparation of flight. That is not to suggest that there is not space or a need to do so—quite the opposite, as this will be the subject of our future research.

V. CONCLUSION

VFR into IMC remains one of the primary killers in GA.[272] Even when VFR into IMC does not result in an accident, a critical failure of safety has occurred and the pilot, passengers, and aircraft have been placed in serious (and largely unnecessary) risk.[273] In the modern era of advanced flight planning tools, real-time weather updates, and even rain radars, all available to a pilot at the click of a button on a phone or tablet, that pilots are still so frequently making decisions that result in VFR into IMC events is concerning and begs the question as to why such suboptimal decision-making occurs. In an endeavor in which decision-making plays such a fundamental part, the study of how and why individuals make decisions has to be at the forefront of how we approach the regulation of safety in GA.

In respect of VFR into IMC, it is critical to consider two questions: first, why it is that pilots make suboptimal decisions; and second, whether a better understanding of weather-related decision-making can inform regulations that will improve decision-making and consequently reduce the frequency of VFR into IMC incidents. As we have shown, much of the existing research applying behavioral models of decision-making in respect of VFR into IMC is consistent with some of the theories underpinning BE.[274] We did not identify a unified theory of decision-making that can explain VFR into IMC events but rather identified three behavioral biases of (i) environmental literacy, (ii) overconfidence, and (iii) prospect theory that (among others) have

---

[271] *See* Geoffrey R. Whitehurst et al., *The Effect of Experiential Education on Pilots' VFR into IMC Decision-Making*, 28 J. AVIATION/AEROSPACE EDUC. & RSCH. 27, 29–30 (2019).

[272] Woods et al., *supra* note 19, at 52.

[273] *See* McQuillen, *supra* note 37, at 181–82.

[274] *See supra* Part III.

the potential to influence poor weather-related decision-making in the cockpit.[275]

The potential of a BE-informed approach to regulation is that government intervention can improve an individual's decision-making by reducing the errors attributable to the various biases identified in the BE literature. The application of BE to the law (BLE) allows for more realistic predictions of behavior than traditional economic analysis and has the potential to inform more realistic and effective regulatory responses to this ongoing issue.[276] Therefore, we argue that it is essential for the GA industry and the regulator to adopt the insights available from BE analysis to better regulate and educate pilots in respect of the true nature of decision-making.

We presented three interventions as a starting point to help facilitate better decision-making. The first of these is an acceptance by the regulator that the behavioral biases are real and can result in predictable departures from rationality across the spectrum of pilot skill levels and personalities. This is a threshold issue: without CASA accepting and engaging in the theory behind BE as a valid tool in analyzing decision-making, there can be no change in the regulatory approach. Secondly, the educational regime mandated by CASA has a critical role to play. In playing its role, the regime needs to be deeper and more adept at explaining to pilots the psychological factors to which they may fall victim, and we advocate for regulatory intervention to better educate pilots about their own psychology. Finally, a BE-informed training syllabus would take advantage of the advent of cheaper and more sophisticated simulation software available to GA, tools which were once the sole province of the airline industry. This would help to train and educate pilots and focus on the cognitive limitations that have been identified in the literature.

---

275 *See supra* Part III.

276 *See supra* Section IV.A.