INDEPENDENT REVIEW OF THE SAFETY CULTURE OF UBER TECHNOLOGIES, INC.'s ADVANCED TECHNOLOGIES GROUP FINAL REPORT

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I. BACKGROUND

Uber Technologies, Inc. ("Uber" or "the Company") retained LeClairRyan PLLC to conduct an independent safety review of the existing safety policies, processes, procedures, and culture of its Advanced Technologies Group ("ATG"). ATG has responsibility for Uber’s self-driving vehicle program.

The Company initiated this independent safety review shortly after a pedestrian suffered fatal injuries resulting from being hit by an ATG self-driving vehicle in Tempe, Arizona, on March 18, 2018. The National Transportation Safety Board (NTSB) initiated an investigation of this accident. Although the NTSB issued a preliminary factual report on this accident on May 24, 2018, the results of the investigation and probable cause determination, and likely safety recommendations, will not be available for many months.\(^1\) While we commenced this review shortly after the Tempe, Arizona accident and NTSB’s commencement of its safety investigation, the Company’s instructions to the Safety Review Team ("the Team") reflected its clear intent that the scope of the independent review broadly focus on the safety of its self-driving vehicle program and identify areas for improvement and best practices that would also offer enhanced safety systems and processes.

The Team consisted of Mark Dombroff and David Tochen of LeClairRyan, and LeClairRyan consultant Christopher A. Hart, the immediate past Chairman of the NTSB and long-term NTSB Board Member. (See Appendix A for a copy of their resumes.)

In performing its safety review of ATG, the Team received extensive and unfettered access to senior Uber and ATG officials in San Francisco and Pittsburgh, and Central Operations managers and specialists, driving vehicle operators (VOs), fleet operations managers, and test operations managers and specialists in Pittsburgh, Tempe, and Toronto. We particularly appreciate the opportunity to meet and speak with Uber Chief Executive Officer (CEO) Dara Khosrowshahi.

ATG has also made available nearly 300 files regarding VO hiring and training, workplace policies, safety case materials for its self-driving vehicles, usage of the front seat control application and the Operator Control Station, and videos on the Training and Exercises program (TREX), Continuous Trajectory Control, and "Past Present, and Future of Uber". In addition, the Team went to the test track in Pittsburgh, met with several ATG personnel, and both examined and rode in the vehicles.

The Team also reviewed the U.S. Department of Transportation’s recent document, Preparing for the Future of Transportation Automated Vehicles 3.0 ("AV 3.0").\(^2\) In a Notice of request for comments on AV 3.0, the Department of Transportation indicated the document "is structured around three key areas: (1) Advancing multi-modal safety, (2) Reducing policy uncertainty, and (3) Outlining a process for working with DOT."\(^3\) In reviewing AV 3.0, we find that, with the exception of information we note in Section VI, paragraph A, and Section IX, paragraph C, infra, the document, while impressive in scope and presenting a thoughtful and important safety and policy framework for the ongoing development and implementation of automated vehicle technologies,

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does not directly address the strategies, recommendations we provide in this Report to assist Uber and ATG in ensuring the safety of the ATG self-driving vehicle program. We also note that AV 3.0 draws comparisons with safety enhancements in the field of aviation -- something this Report also addresses quite extensively.

In addition, the U.S. Department of Transportation’s predecessor version of AV 3.0 -- A Vision for Safety 2.0 (AV 2.0)\(^4\) -- encouraged entities involved in the development and testing of automation technology to prepare and issue a Voluntary Safety Self-Assessment (VSSA). AV 3.0 re-emphasizes the usefulness of this tool and states that entities should “make their VSSA publically available as a way to promote transparency and strengthen public confidence in [Automated Driving System] technologies.”\(^5\) We are pleased that Uber has prepared and will be releasing a comprehensive ATG Safety Report that addresses each of the 12 safety elements discussed in AV 2.0.

In conducting its review, the Safety Team also conferred with Uber and ATG officials regarding information included in this Report. This was done to ensure the accuracy of information in the Report and enable the Safety Team to receive and consider feedback on our proposed recommendations. Consistent with our charge to conduct an independent review, this Report solely reflects the views, recommendations, and conclusions of the Safety Team. We have also provided a list of acronyms and abbreviations used in this Report (see Appendix B).

The Team appreciates the support and assistance rendered by Uber and ATG in facilitating our review.

II. EXECUTIVE SUMMARY

In performing our review, it was clear that Uber senior leadership is deeply committed to ensuring the safety of its self-driving vehicles. Many ATG managers and employees with whom we spoke also readily identified safety as one of the organization’s paramount responsibilities. In this Report, we offer various recommendations on what Uber and ATG can do to fully institutionalize and operationalize their commitment to self-driving vehicle safety.

In these pages, we draw on the safety and training processes and requirements in other industries, including aviation and nuclear energy. After an alarming number of serious accidents and safety lapses in these industries over time, considerable efforts were undertaken to improve their safety profiles. We recognize, however, that unlike many participants in those industries which have had decades of experience in building strong safety cultures and implementing important safety systems, ATG is a relatively new organization. Also, ATG operates in a nascent industry where technological change is rapid. For this reason, we were mindful of the need to ensure that our recommendations throughout this Report that are derived from these other industries are otherwise adaptable for ATG in performing its self-driving vehicle research, manufacturing, and controlled operational activities.

This Report discusses the attributes of a strong organizational safety culture and the role of Safety Management Systems (SMSs) in implementing and maintaining a strong safety culture (Sections III, What is “Safety Culture,” and IV, Safety Management Systems, respectively). In our discussion on safety culture, we refer to an extensive body of literature that has been developed in the aviation and nuclear energy industries, where the safety risks can be potentially catastrophic.

We also address our assessment of ATG’s safety culture based on our discussion with senior Uber and ATG officials, engineers, managers, and self-driving vehicle operators and our review of documentation made available to us (Section V, The Safety Review Team’s Findings Regarding ATG’s Safety Culture, and Section VII, Training, paragraph D, Training Documents, respectively). Based on our work, we offer in Section VI, ATG Leadership in Promoting a Safe ATG Culture, a number of recommendations to senior management to communicate to all employees the importance of a strong commitment to a robust safety culture.

Also in Section VI, we discuss the importance of having a collaborative approach to operational safety, including establishing an ATG Safety Committee, appointing senior managers to have oversight and responsibility for training and operational safety, and creating an external safety advisory group.

In Section VII, Training, we discuss examples of a systems approach to training implemented in other industries and make recommendations for a more robust ATG training program, including continuing proficiency tests, line checks, and recurrent training for operators of self-driving vehicles and the use of training simulators.

In Section VIII, ATG Safety Policies, Processes, and Procedures, we make recommendations regarding the importance of a voluntary self-reporting program available to ATG employees, self-driving vehicle passengers, and interested members of the public; and the value of a Quick Reference Handbook, or checklist, available to drivers in each self-driving vehicle.

Finally, in Section IX, as a convenience, we provide a stand-alone listing of every Safety Team recommendation that appears in this Report.
A note of explanation regarding our recommendations in this Report: a number of the recommendations are stated with the verb “should,” (e.g., “ATG should [take the specific action stated in the recommendation]”), while other recommendations describe actions that “should be considered,” (e.g., “ATG should consider [taking the specific action stated in the recommendation]”). This “should/should consider” dichotomy is intentional. Our use of the verb “should” conveys our view that the recommended action be closely examined and evaluated for feasibility of effective implementation, while our use of the phrase “should consider” conveys our view that the recommended action would be beneficial, but provides a higher degree of discretion in determining whether it should be implemented.

We also recognize that our recommended actions should not preclude Uber and ATG from taking actions that may differ from what we urge or suggest. As we pointed to earlier, the self-driving vehicle industry is highly dynamic and subject to rapid technology advancements. As a result, we fully realize that Uber and ATG, in using its best judgement, may implement policies, processes, or procedures that do not fully replicate our recommendations. We in no way mean to suggest that any decision by Uber or ATG to implement the concepts of our recommendations in a different fashion runs afoul of our recommendations.
III. WHAT IS “SAFETY CULTURE”?

There are myriad definitions and descriptions of “safety culture.” The term was first used by the International Atomic Energy Agency’s (IAEA) International Nuclear Safety Advisory Group (INSAG) in its report on the 1986 Chernobyl nuclear accident.⁶ Although there is no consensus regarding a definition, a particularly useful one developed by the Nuclear Regulatory Commission (NRC) states:

The core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment.⁷

Another useful definition from the United Kingdom's Health and Safety Commission has been cited by Dr. James Reason, a prominent expert on human error and organizational processes:

The safety culture of an organization is the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and style and proficiency of, an organization's health and safety [programs]. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures.⁸

Although less precise and helpful, but specific to the automotive field, the International Organization for Standardization's (ISO) International Standard ISO 26262-1, Functional Vehicle Safety (2011), defines “safety culture” as:

Policy and strategy used within an organization to support the development, production and operation of safety-related systems.⁹

An organization with a strong safety culture is sometimes described as a high reliability organization (HRO). While we do not discuss in any detail here the characteristics of an HRO, we mention it in order to point out that it is distinguishable from an organization with a strong safety culture. Although an HRO typically has a strong safety culture, not all organizations that have a strong safety culture are HROs. One useful definition describes an HRO as:

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An organization that repeatedly accomplishes its high hazard mission while avoiding catastrophic events, despite significant hazards, dynamic tasks, time constraints, and complex technologies [and a key attribute of which] is to learn from [its] mistakes.\(^{10}\)

### A. THE INTERNATIONAL CIVIL AVIATION ORGANIZATION

For aviation, the International Civil Aviation Organization (ICAO) has developed extensive information and guidance on safety management and the role of an organization's safety culture in ensuring a safe aviation system. Its Safety Management Manual (SMM) describes a healthy safety culture as one that

... actively seeks improvements, vigilantly remains aware of hazards and utilizes systems and tools for continuous monitoring, analysis and investigation. Other characteristics of a healthy safety culture include a shared commitment by personnel and management to personal safety responsibilities, confidence in the safety system, and a documented set of rules and policies. The ultimate responsibility for the establishment and adherence to sound safety practices rests with the management of the organization. A safety culture cannot be effective unless it is embedded within an organization's own culture.\(^{11}\)

As the ICAO SMM further points out:

An effective way to promote safe operations is to ensure that an organization has developed an environment where all staff feel responsible for safety. This becomes evident when staff consider the impact on safety in everything they do, report all hazards, errors and threats and support the identification and management of all their associated risks. In addition, management must create an environment in which personnel are aware of safety risks, are given sufficient systems to protect themselves and are assured protection when they divulge safety information through the safety reporting system.\(^{12}\)

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\(^{12}\) Id.
B. THE INTERNATIONAL ATOMIC ENERGY AGENCY

The IAEA has developed a framework for a “strong” safety culture consisting of five characteristics:

- Safety is a clearly recognized value
- Leadership for safety is clear
- Accountability for safety is clear
- Safety is integrated into all activities
- Safety is learning driven

In its Safety Guide No. GS-G-3.5, The Management System for Nuclear Installations (2009), the IAEA identifies a series of attributes for each of these five characteristics. We believe the attributes IAEA identifies are important and can serve as a useful benchmark for ATG.

These attributes are as follows:

1. SAFETY IS A CLEARLY RECOGNIZED VALUE
   - The high priority given to safety is shown in documentation, communications and decision making
   - Safety is a primary consideration in the allocation of resources
   - The strategic business importance of safety is reflected in the business plan
   - Individuals are convinced that safety and production go hand in hand
   - Safety conscious behavior is socially accepted and supported (both formally and informally)

2. LEADERSHIP FOR SAFETY IS CLEAR
   - Senior management is clearly committed to safety
   - Commitment to safety is evident at all levels of management
   - There is visible leadership showing the involvement of management in safety related activities
   - Leadership skills are systematically developed
   - Management ensures that there are sufficient competent individuals
   - Management seeks the active involvement of individuals in improving safety
   - Management shows a continual effort to strive for openness and good communication throughout the organization
   - Relationships between managers and individuals are built on trust

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3. ACCOUNTABILITY FOR SAFETY IS CLEAR

- An appropriate relationship with the regulatory body exists that ensures that the accountability for safety remains with the licensee
- Roles and responsibilities are clearly defined and understood
- There is a high level of compliance with regulations and procedures
- Management delegates responsibility with appropriate authority to enable clear accountabilities to be established
- “Ownership” for safety is evident at all organizational levels and for all personnel

4. SAFETY IS INTEGRATED INTO ALL ACTIVITIES

- Trust permeates the organization
- Consideration of all types of safety, including industrial safety and environmental safety, and of security is evident
- The quality of documentation and procedures is good
- The quality of processes, from planning to implementation and review, is good
- Individuals have the necessary knowledge and understanding of the work processes
- Factors affecting work motivation and job satisfaction are considered
- Good working conditions exist with regard to time pressures, workload and stress
- There is cross-functional and interdisciplinary cooperation and teamwork
- Housekeeping and material conditions reflect commitment to excellence

5. SAFETY IS LEARNING DRIVEN

- A questioning attitude prevails at all organizational levels
- Open reporting of deviations and errors is encouraged
- Internal and external assessments, including self-assessments, are used
- Organizational experience and operating experience (both internal and external to the installation) are used
- Learning is facilitated through the ability to recognize and diagnose deviations, to formulate and implement solutions and to monitor the effects of corrective actions
- Safety performance indicators are tracked, trended and evaluated, and acted upon
- There is systematic development of individual competences

C. NTSB EXAMINATIONS OF SAFETY CULTURE

The NTSB has hosted two public programs on safety culture. In April 1997, the agency hosted a symposium on Corporate Culture and Transportation Safety, which attracted over 550 participants.14 In September 2013, the NTSB hosted a two-day forum entitled Safety Culture: Enhancing Transportation Safety.15 The NTSB has also addressed safety culture in a number of its accident reports.

In its report on a June 2009, collision of two Washington Metrorail trains near the Fort Totten Station in Washington, D.C., the NTSB determined that the Washington Metropolitan Area Transit

15 Presentations submitted by over 20 speakers at this program and a transcript of the proceedings are available at http://dms.ntsb.gov/pubdms/search/nitlist.cfm?docketID=55256&CFID=259897&CFTOKEN=59053233.
Authority's (WMATA) lack of a safety culture contributed to the accident.\textsuperscript{16} The report discussed how shortcomings in WMATA's internal communications, its recognition of hazards, its assessment of risk from those hazards, and its implementation of corrective actions were all evidence of an ineffective safety culture.

In a section of the accident report that specifically addressed safety culture, the agency stated:

Organizations with effective safety cultures are generally described as having a commitment to safety that permeates the entire organization; that is, senior management demonstrates a commitment to safety and a concern for hazards that are shared by employees at all levels within the organization. In order ... to maintain an effective safety culture, senior managers must continuously review their organization's performance and practices through monitoring, analysis, and feedback systems. When safety deficiencies are identified, the problems and the mitigation procedures must be communicated to all affected personnel in the organization.\textsuperscript{17}

It should be clear from the above discussion that a strong safety culture cannot spring forth quickly or easily. As a study of safety culture in the offshore oil and gas industry explained:

Safety culture is not built or sustained solely through such formal means as punishment of individuals for incidents of noncompliance and rewards for compliance, public declarations by the chief executive officer (CEO) and human resources department, or perfunctory discussions of safety in formal notices or safety minutes. Safety culture is something leadership must fully embrace and the entire organization must commit to, engage in, and execute every day.\textsuperscript{18}


\textsuperscript{17} Id., at p. 99.

IV. SAFETY MANAGEMENT SYSTEMS

Simply put, a safety management system (SMS) is a formal organization-wide approach to managing safety and controlling or reducing safety risks to an acceptable level by means of systematic procedures, practices, and policies.\textsuperscript{19} SMSs are typically found in industries with high safety risks, including nuclear power, construction, chemical manufacturing, and health care.

It is in aviation, however, that SMS programs have gained maturity and have resulted in significant and well-studied safety benefits. For this reason, we will focus primarily on the structure of aviation SMS structures while also providing more concise information on SMS programs in the maritime and pipeline industries.

We are also aware that several automotive manufacturers have developed safety programs that appear to have elements of an SMS program but they lack many of the characteristics of a robust SMS. For example, one automotive manufacturer has put in place an “Integrated Safety Management Concept,” which according to the manufacturer “pursues a higher level of safety by linking each individual safety technology system equipped on vehicles [with a] goal to create a vehicle that causes no accidents by supporting the driver in each stage of driving (Parking, Active Safety, Pre-Collision Safety, Passive Safety and Rescue) and integrating each system.”\textsuperscript{20} The manufacturer’s program appears to be a Quality Management System (QMS) rather than an SMS. While “SMSs are based on QMS principles,”\textsuperscript{21} the QMS is a system with defined people, processes and tools to ensure that the product will meet or exceed customer expectations. SMSs, by contrast, place more emphasis on risk and hazard identification and treatment.

A. SMS PROGRAMS IN AVIATION

After six major aviation accidents in August and September 2005 claimed more lives than in all of 2004, ICAO and its member countries developed an integrated approach to aviation safety initiatives. The ICAO SMM\textsuperscript{22} was first published in 2006 and it provides guidance to major air carriers and regulatory agencies of ICAO member countries in implementing SMS programs. From 2006, ICAO and its member countries revised several Annexes to the Chicago Convention to address a number of initiatives, including the implementation and maintenance of SMSs, and required aviation operators to implement an SMS programs by January 1, 2009. ICAO subsequently consolidated these protocols in a new Annex – Annex 19, Safety Management, which took effect in November 2013.\textsuperscript{23}

Contemporaneously with the ICAO efforts to implement SMS programs for its member countries and aviation service providers, the Federal Aviation Administration (FAA) issued an Advisory Circular to

\textsuperscript{19} See ICAO SMM, supra, note 9, and FAA Final Rule on Safety Management Systems, 14 CFR Part 5, § 5.5.
\textsuperscript{20} See http://www.toyotaglobal.com/innovation/safety_technology/concept/.
\textsuperscript{22} ICAO SMM, supra, note 9.
introduce the concept of SMS, and provide voluntary guidance, to airlines, air taxi operators, corporate flight departments, pilot schools, and other service providers.24

After investigating a 2004 aircraft crash, the NTSB's final accident report focused on a number of safety issues, including flight crew training and professionalism, and recommended that the FAA require that all Part 121 operators (major air carriers certified under 14 CFR Part 121 of the Federal Aviation Regulations (FARs)) establish SMS programs.25 In responding to the NTSB recommendation, the FAA indicated that it initiated a rulemaking to meet the ICAO January 1, 2009 deadline for operators to implement an SMS program.

The FAA subsequently issued a notice of proposed rulemaking for Part 121 operators to develop and implement an SMS, and while the rulemaking was pending, the U.S. Congress, in 2010, directed the FAA to conduct a rulemaking proceeding to require all Part 121 air carriers to implement an SMS.26 The FAA’s SMS final rule (14 CFR Part 5) was published on January 8, 2015 and required Part 121 certificate holders to submit their SMS implementation plan to FAA for review by September 9, 2015. The final rule further required FAA to approve Part 121 certificate holders’ implementation plans by March 9, 2016 and the certificate holders to put their SMS programs in place by March 9, 2018.27

In the preamble to the SMS final rule, the FAA acknowledges that while the commercial air carrier accident rate in the United States has decreased substantially in recent years, the agency has identified a trend involving hazards that were revealed during accident investigations. The FAA identified 123 accidents involving Part 121 air carriers from fiscal year (FY) 2001 through FY 2010 for which identified causal factors could have been mitigated if air carriers had implemented an SMS to identify hazards in their operations and developed methods to control the risk. The FAA concluded that:

[t]his type of approach allows air carriers to anticipate and mitigate the likely causes of potential accidents. This is a significant improvement over current “reactive” safety action emphasis, which focuses on discovering and mitigating the cause of an accident only after that accident has occurred.28

The FAA SMS final rule, the related FAA Advisory Circular (No. 120-92B),29 ICAO Annex 19, and the ICAO SMM, all share a common four-part SMS framework and specify that an SMS program contain at least the following components:

- a safety policy
- safety risk management


27 14 CFR §§ 5.1 and 119.8(a).


29 Note 24, supra.
- safety assurance
- safety promotion

The FAA SMS final rule further delineates the elements of each of the four components as follows:

**The Safety Policy** must:
- state the entity's safety objectives
- state the entity's commitment to fulfill its safety objectives
- include a clear statement about the provision of the necessary resources for implementing the SMS
- include a safety reporting policy that defines requirements for employee reporting of safety hazards or issues
- include a policy that defines unacceptable behavior and conditions for disciplinary action
- include an emergency response plan that provides for the safe transition from normal to emergency operation.
- be signed by the accountable executive
- be documented and communicated throughout the certificate holder's organization
- be regularly reviewed by the accountable executive to ensure it remains relevant and appropriate.\(^{30}\)

**Safety Risk Management** must:
- be applied to implementation of new systems, revision of existing systems, development of operational procedures, and identification of hazards or ineffective risk controls through the safety assurance process
- be applied to conduct system analysis which considers the function and purpose of each system, the system's operating environment and process and procedures, and the personnel, equipment, and facilities necessary to operate each system
- establish a process for conducting risk assessment that allows for the determination of acceptable safety risk
- include the development and maintenance of processes to develop safety risk controls
- include steps to evaluate whether the risk will be acceptable with the proposed safety risk control applied, before the safety risk control is implemented.\(^{31}\)

**Safety Assurance** processes and systems must include:

a) Safety Performance Monitoring and Measurement
- monitoring of operational processes
- monitoring of the operational environment to detect changes
- auditing of operational processes and systems
- evaluations of the SMS and operational processes and systems
- investigations of incidents and accidents
- investigations of reports regarding potential non-compliance with regulatory standards or other safety risk controls established by the entity through it safety risk management process

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- a confidential employee reporting system in which employees can report hazards, issues, concerns, occurrences, incidents, as well as propose solutions and safety improvements
- requirements to analyze data acquired through the Safety Assurance processes and systems and any other relevant data with respect to its operations, products, and services.

b) Safety Performance Assessments including reviews by the accountable executive to:
- ensure compliance with the safety risk controls established by the entity
- evaluate the performance of the SMS
- evaluate the effectiveness of the safety risk controls and identify any ineffective controls
- identify changes in the operational environment that may introduce new hazards
- identify new hazards.

c) Continuous Improvement including:
- establishing and implementing processes to correct safety performance deficiencies.\textsuperscript{32}

**Safety Promotion** which includes:
- training to each management individual responsible for SMS within their area of responsibility to ensure each individual attains and maintains the competencies necessary to perform their duties relevant to the operation and performance of the SMS
- communicating safety information that at a minimum
- ensures that employees are aware of the SMS policies, processes, and tools that are relevant to their responsibilities
- conveys hazard information relevant to the employee's responsibilities
- explains why safety actions have been taken
- explains why safety procedures are introduced or changed.\textsuperscript{33}
- The FAA SMS regulation and related Advisory Circular also address the need for the responsible entity to develop and maintain SMS documentation that describes the entity's safety policy and SMS processes and procedures.\textsuperscript{34}

**B. MARITIME SMS PROGRAMS**

Section 3203 of title 46, United States Code (U.S.C.), directed the U.S. Coast Guard to issue regulations which establish an SMS for U.S. vessels and foreign vessels bound for places under the jurisdiction of the U.S. The statute specifies that the regulations address:

- a safety and environmental protection policy
- instructions and procedures to ensure safe operation of those vessels and protection of the environment in compliance with international and United States law
- defined levels of authority and lines of communications between, and among, personnel on shore and on the vessel
- procedures for reporting accidents

\textsuperscript{32} 14 CFR Part 5, Subpart D; Advisory Circular 120-92B, at ¶ 3-5, pp. 28-41; Annex 19, at Appendix 2 and Attachment A; ICAO SMM, at Appendix 2 and Attachment A-1, at pp. A-2 to A-3.

\textsuperscript{33} 14 CFR Part 5, Subpart E; Advisory Circular 120-92B, at ¶ 3-6, pages 42-44; Annex 19, at Appendix 2 and Attachment A; ICAO SMM, at Appendix 2 and Attachment A-1, at p. A-3.

\textsuperscript{34} 14 CFR § 5.95; Advisory Circular 120-92B, at ¶ 3-7, pages 44-45; Annex 19, at Appendix 2.
• procedures for preparing for and responding to emergency situations, and
• procedures for internal audits and management reviews of the system.

The statute also directed the Coast Guard to ensure that the promulgated regulations were consistent with the International Safety Management (ISM) Code.\textsuperscript{35} Under the Code, the owner or any other organization that has assumed responsibility for operating a vessel is required to establish an SMS for the vessel. According to section 1.2.2 of the Code, the SMS should “assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards.” Section 7 of the Code requires the company to “establish procedures, plans and instructions, including checklists as appropriate, for key shipboard operations concerning the safety of the personnel, ship, and protection of the environment.” Furthermore, the Code requires that the company “identify potential emergency shipboard situations, and establish procedures to respond to them.”\textsuperscript{36}

The Coast Guard regulations implement Chapter IX of the SOLAS, as required by 46 U.S.C. § 3203.\textsuperscript{37} The regulations specify that the owner or other person responsible for operation of a vessel must implement an SMS that:

• provides for safe practices in vessel operation and a safe work environment
• establishes safeguards against all identified risks
• specifies actions to continuously improve safety management skills of operating personnel, including preparation for emergencies
• ensures compliance with international and national regulations, codes, and maritime industry guidelines, and
• includes documented procedures for internal audits of the company and for management review of these audit reports.\textsuperscript{38}

Late last year, the NTMB completed its investigation into the sinking of the 790-foot U.S. cargo vessel, \textit{El Faro}, after it transited near the eye of Hurricane Joaquin, resulting in the death of all 33 crewmembers. The Board determined that the company's inadequate SMS contributed to the vessel's sinking. As a result, the NTMB recommended that the vessel owner conduct an external audit of its entire SMS to ensure compliance with the ISM Code and correct numerous deficiencies.\textsuperscript{39}

\textbf{C. PIPELINE SMS PROGRAMS}

In July 2010, the rupture of a pipeline segment in a Michigan wetland occurred but was not discovered or addressed for over 17 hours. The oil saturated the surrounding wetland and flowed into a nearby creek and river. Local residents self-evacuated from their houses and environmental cleanup and remediation efforts continued for several years, with costs exceeding $767 million. About 320 people reported symptoms consistent with crude oil exposure.

\textsuperscript{35} Chapter IX of the Annex to the Safe Operation of Ships at Sea (SOLAS) incorporates the ISM Code, and went into force in July 1998.
\textsuperscript{37} 33 \textit{CFR} Part 96.
\textsuperscript{38} Id., at Subpart B.
\textsuperscript{39} Note 36, supra, at p. 213.
In its investigation of the pipeline rupture, the NTSB learned that prior to the rupture, the responsible pipeline operator implemented a health and safety management system, which primarily pertained to on-site safety. Several years before the rupture, the operator conducted a safety culture assessment and also created the position of director of safety culture after three pipeline employees had been killed in two on-site accidents in a 5-month period. The focus of the program was in the areas of workplace. As the NTSB further pointed out:

Although the operator had implemented what it referred to as a health and safety management system, the system only partially met the standards of an SMS. For example, it addressed only on-site safety, not pipeline operations. Control center errors were identified as employee-caused and were not considered system deficiencies, contrary to SMS guidelines. Had the company implemented and maintained a comprehensive SMS, it would have focused not only on field operations safety, but also would have incorporated control center operations, pipeline integrity management, and postaccident response plans and a comprehensive continuous examination of the safety of pipeline operations.40

While recognizing that the federal pipeline safety regulator – the Pipeline and Hazardous Materials Safety Administration (PHMSA) – did not have a requirement for pipeline operating companies to implement an SMS, the NTSB recommended that the American Petroleum Institute (API) develop a consensus SMS specific to the pipeline industry. Working with PHMSA, the pipeline industry, state pipeline regulators, and other interested stakeholders developed an API Recommended Practice for Pipeline Safety Management Systems, RPI 1173 (2015), to bring the benefits of SMS to pipeline operators.41

RPI 1173 was designed to strengthen pipeline operators’ safety culture and enable continuous safety performance improvement. The Recommended Practice relies closely on the Plan-Do-Check-Act (PDCA) cycle used in other management systems. A pictorial representation of the PDCA cycle is provided in Appendix C.

D. ATG SAFETY MANAGEMENT SYSTEM

In developing and implementing an SMS program, a “one size fits all” approach is unrealistic and unworkable. Even in industries with many years of experience, available SMS guidance clearly reflects that different SMS approaches are necessary. For example, FAA guidance points out that its SMS Framework:

... stresses what the organization must do rather than how it will be accomplished (and is) applicable to a wide variety of types and sizes of operators. Therefore, the FAA [guidance] is designed to be scalable to allow operators to integrate safety management practices into their unique business models.42 (Emphasis in original.)

We clearly recognize that ATG is engaged in self-driving vehicle research, manufacturing, and controlled operational activities in several cities, and that an ATG SMS program will probably be

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42 Advisory Circular No. 120-92B, supra, note 24, ¶3, at p. 1.
significantly different from an SMS program developed and implemented by an automotive manufacturer or an entity solely engaged in operational activities. For these reasons, our recommendations below for developing and implementing an SMS program at ATG call for a phased and manageable approach that will evolve over a considerable period of time.

RECOMMENDATIONS

As we discussed above regarding the FAA SMS final rule (14 CFR Part 5), FAA Advisory Circular 120-92B, and ICAO Annex 19, all share a common four-part framework which contains the following components: a safety policy, safety risk management, safety assurance, and safety promotion. We also identified the various elements that comprise each of these components. We recommend that ATG develop an SMS program and, as a preliminary matter, consider the four-part framework and components established for aviation SMS programs and, to the extent feasible, adopt various specified elements for each component tailored to the ATG organization. Further, many of the more detailed recommendations we make later in this Report are designed to provide greater specificity on how to craft a detailed ATG SMS program.

In developing and implementing its SMS program, ATG should, where desirable, seek the services of individuals and organizations with SMS expertise.
V. THE SAFETY REVIEW TEAM’S FINDINGS REGARDING ATG’S SAFETY CULTURE

A. CURRENT STATE

We applaud the commitment of Uber leadership to reenforcing safety as a fundamental guidepost for the entire Company, and we support these efforts to consistently articulate this value on a broad and frequent basis throughout the Company and in public statements. It is clear from our review that current Company leadership has taken steps to emphasize the importance of safety culture and the Company's responsibility to enhance public safety on our streets and highways. We are also encouraged that ATG is working to institutionalize safety in its processes and operations.

A robust safety culture is important as a general matter because members of the public are at risk from being in, or in the vicinity of, operating motor vehicles, irrespective of whether the vehicles have drivers. Safety is even more paramount in this developmental context because a large percentage of the public is skeptical about driverless motor vehicles, and any perceived safety issues about present or future driverless vehicles may delay the implementation of life-saving automation technologies. With nearly 40,000 people reportedly being killed every year in the U.S. alone from motor vehicle crashes, any delay will mean more lives needlessly lost.

The development of Uber's Cultural Norms and the role played by its employees in shaping that important document, as described by CEO Khosrowshahi in his November 7, 2017, on line article,\(^{43}\) establish a critical foundation for a strong Uber safety culture. In addition, the 2018 Stand for Safety priorities he articulated in an Uber Global All-Hands Meeting on October 30, 2017, further reenforce the important role of safety in the Company's operations. By his actions and commitment, CEO Khosrowshahi demonstrates his belief that the core value of safety is immutable.

The Team notes a number of important manifestations of Uber's commitment to safety. Immediately after the March 2018, Tempe ATG test vehicle crash, ATG voluntarily stopped all of ATG's test vehicle operations throughout the country. ATG also began an internal review of the safety of its operations, which is currently underway, and Uber commissioned this external review. We note also, that after a less serious incident involving an ATG test vehicle that also occurred in Tempe in March 2017, and one in Pittsburgh in September 2017, ATG suspended test vehicle operations for a limited period of time. These actions are consistent with the recognition that safety is a priority.

The commitment to safety at the top within Uber is clearly good news, as is Uber senior leadership's recognition that institutionalizing a safety culture is a long-term process and it will take time for this to occur. This Report also makes recommendations directed at steps which can be implemented in the short term that can help further institutionalize the safety culture within ATG.

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B. ATG ORGANIZATIONAL STRUCTURE

In General

ATG is structured as a functional organization; that is, it is organized based on the tasks and roles performed by its employees and contractors. The Organization Chart we were provided shows the following seven ATG components: Research and Development; Systems Safety; Product; Hardware and Vehicle Programs; Software; Strategy and Operations; and Global Product Operations and Facilities.

Importantly, the Team noted opportunities to enhance communications techniques and processes within the organization. In its review, the Team determined that the different ATG functions, particularly Operations and Safety, would benefit from more frequent interactions with each other and steps could be taken to minimize the effects of geographic distance and to improve the ability to receive useful informal feedback, and implement effective policy and direction.

RECOMMENDATIONS

To ensure that ATG Test and Fleet Operations personnel continue to have frequent and robust interactions with Systems Safety, as well as other ATG units, we recommend that the Head of ATG, or his designee, establish additional communications and feedback mechanisms within ATG. Implementing these mechanisms will provide opportunities to enhance collaboration within ATG and facilitate “ownership” for safety at all organizational levels.

In addition, although we recognize the need for Uber corporate leadership to exercise oversight and direction of ATG from Company headquarters, we also recommend that the Company consider placing a senior manager in the ATG Strategy and Operations unit in ATG Headquarters in Pittsburgh. The senior manager should report directly to the Head of Strategy and Operations. Having a senior manager in Pittsburgh will ensure more visible Strategy and Operations leadership at ATG Headquarters and demonstrate its day-to-day involvement in strategic and operational issues.

Job Analyses

Current and accurate information concerning the tasks and competencies for positions at ATG is important to make clear the roles and responsibilities of each position. Based on our review of documentation, ATG can take steps to further address these areas. Such steps can help ensure that the individual holding a position is held accountable for each job function. One approach to address this issue is to ensure that tasks and competencies are provided in position descriptions. Also, as the scope and duties of a particular position are modified, the corresponding tasks and competencies should be promptly revised to reflect the changes.

RECOMMENDATION

ATG managers, in cooperation with Human Resources, should take steps to verify that a complete and up-to-date job description is in place for every ATG position and that each employee receives a copy of the job description during the onboarding process, as well as revisions promptly after they are made.
VI. ROLE OF UBER/ATG LEADERSHIP IN PROMOTING A SAFE ATG CULTURE

Uber and ATG senior leaders are the key advocates for safety and should consistently demonstrate their unwavering commitment to safety by their own activities, emphasizing its importance on a frequent basis, encouraging employees at all levels to improve safety, and holding managers accountable for safety.

It is not uncommon for a tragic event, such as the March 18, 2018, fatality in Tempe, to cause an organization to examine closely its safety policies, processes, and procedures. Clearly, and to its credit, the Tempe accident motivated Uber and ATG to take important steps to ensure that the self-driving vehicle program is as safe as possible. We offer several additional suggestions to assist leaders in further promoting safety at ATG.

A. ROLE OF SENIOR MANAGEMENT

As the ICAO SMM points out, “[s]enior management provides the leadership to promote the safety culture throughout an organization.” In addition, senior management must communicate its expectation of high safety performance by everyone in the organization.

RECOMMENDATIONS

We recommend that ATG senior leadership take further steps to communicate to all employees the importance of a robust safety culture as a core value and a way of doing business every day, as opposed to a mere “box to check.” To further demonstrate that leadership is “walking the talk,” they could note as examples the voluntary cessation of testing and their decision to conduct both an internal and external review of ATG’s safety culture.

To complement CEO Khosrowshahi’s Stand for Safety priorities, ATG leadership may want to consider holding a one-day Stand-down for Safety program for all its employees, contractors, and third-party vendors. At this program, Uber and ATG leadership can reinforce their commitment to safety and encourage frank discussions on ways to improve safety management, policies, and processes. Presentations from safety culture subject matter experts can also offer beneficial approaches to building a more robust ATG safety culture.

Provide More Self-Driving Vehicle Safety-Related Information on the ATG Website

The ATG website does provide information concerning safety. For example, the website states the following:

Uber’s self-driving engineering team [is] dedicated to self-driving technologies, mapping, and vehicle safety. Our teams are passionate about developing long-term technologies that advance Uber’s mission of bringing safe, reliable transportation to everyone, everywhere

As another approach to providing better public awareness and appreciation for the safety of its vehicles and drivers, the website should include information about ATG’s safety culture and the training and proficiency of VOs and other self-driving vehicle operators.

44 Note 11, supra, § 5.3.83, at p. 5-25.
B. A SYSTEMS APPROACH TO COLLABORATION

The safety of commercial aviation over the past decade has been exemplary. While this success is due to a combination of factors, one of the key factors has been the voluntary collaborative efforts of the U.S. aviation industry and the Federal Government to identify potential safety issues and to ensure that appropriate safety enhancements are implemented. This collaboration, which is called the Commercial Aviation Safety Team, or CAST, brings all of the parts of the industry to the table together – airlines, manufacturers, pilots, air traffic controllers, airports, and the regulator – to work in a collaborative manner to identify and address potential safety concerns. Analogous to a systems approach to training referenced in Section VII, paragraph B, infra., bringing all the parties together to improve safety collaboratively represents commercial aviation's version of a systems approach to operations.

The CAST collaborative approach has been very successful. When the previously declining fatal accident rate had begun to “plateau” in the early 1990s, at a rate that many safety experts thought could not be improved much, CAST resulted in a further reduction of more than 80% in the rate in less than 10 years. After focusing initially on examining past accident data, CAST has evolved to a more proactive, data-driven approach that focuses on detecting risk and implementing mitigation strategies before accidents or serious incidents occur. CAST also demonstrated that, contrary to conventional wisdom that safety improvements usually hurt productivity, safety improvements that result from a collaborative approach can simultaneously improve productivity.45

CAST has been so successful because it is a systems approach to operations that embodies the simple principle that everyone who is involved in a problem should be involved in developing the solution to the problem. Much of the CAST success story is transferable to help improve Uber’s real-world self-driving vehicle testing. Including all who are involved in the process into the collaboration means not only the VOs and their trainers and supervisors, but also the developers of the hardware and software.

C. ESTABLISHMENT OF AN ATG SAFETY COMMITTEE

RECOMMENDATIONS

Using CAST as a model, we recommend that ATG establish a permanent internal ATG Safety Committee that uses a collaborative process to identify and address ATG safety issues.

The ATG Safety Committee should be responsible for evaluating policies, procedures, and processes related to the safety of the self-driving vehicle program, as well as safety risks and mitigation measures, and training effectiveness. The Committee should also review safety incidents and infractions to evaluate management’s responses and ensure consistency in decision making and accountability for managers and employees. Upon implementation of feedback processes mentioned above, the Committee can evaluate the information gathered under these processes and make appropriate recommendations, including which ATG component should exercise oversight for a particular matter.

We suggest that the Committee include representatives from ATG Strategy & Operations (including Test, Fleet, and Central Operations); Systems Safety; Hardware & Vehicle Programs; Software; and Human Resources.

The Safety Committee should address a wide range of training issues, including:

- identifying safety issues that warrant closer review and analysis (e.g., distraction, fatigue)
- ensuring that all training materials are current and presented in a logical and systematic manner that maximizes their efficacy\(^\text{46}\)
- ensuring that any changes in relevant guidance, process, and procedures, especially those that reflect lessons learned from operational experience, are reflected in training materials and are communicated and implemented expeditiously and effectively\(^\text{47}\)
- determining the most effective content and form (online, hard copies, or both) of training materials\(^\text{48}\)
- ensuring that appropriate metrics and data are developed to measure training effectiveness and results, and
- evaluating alternative approaches to training.\(^\text{49}\)

The establishment and role of the Safety Committee should be formalized in a charter that provides for broad-based participation in this collaborative effort, regular meetings, procedures for establishing working groups, and decision making on a consensual basis.

D. ADDITIONAL ACTIONS TO INSTITUTIONALIZE A SYSTEMS APPROACH TO TRAINING

RECOMMENDATIONS

Appoint Senior Managers with Oversight and Responsibility for Training and Operational Safety
Senior Manager for Training

To ensure further effective oversight and management of the self-driving training program, we recommend that the Head of ATG appoint a senior manager to be responsible for ATG training.

The senior manager’s key responsibilities for training in ATG should include:

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\(^{46}\) For example, date tagging of training documents can minimize the possibility of conflicting or inconsistent policy, guidance, and information. This is particularly important in the dynamic environment that is prevalent regarding self-driving testing, where change is a constant.

\(^{47}\) Although the need to communicate human resources-related information swiftly to the affected audience is obvious, we recommend that email communications regarding training issues be memorialized in more systematic training documents.

\(^{48}\) We understand that the ATG VO hiring and training policies, guidance, and related documents are available online to VOs. The Company may want to consider whether there are valid reasons for maintaining hard copies of these documents at each ATG location.

\(^{49}\) See, in particular, our recommendation concerning the development and use of training simulators (paragraph C. under Section VII, *Training, infra*).
developing key performance indicators for the training program and ensuring that appropriate performance standards are in place for training specialists and managers

- performing periodic evaluation of training program content to identify potential improvements and similarly working closely with the ATG Safety Committee to identify deficiencies in the self-driving training program and to develop and implement desired changes

- considering obtaining the services of an independent evaluator to periodically assess the training program and offer recommendations. (Although we understand that ATG has, on two occasions, used an independent evaluator to assess its training program, we recommend that an independent review be performed at least every six months.)

In Section VII, Training, infra, we discuss our suggestions to enhance the ATG training program for VOs, flight managers, and other employees who operate self-driving vehicles and revisions to available training materials. In our view, it would be appropriate for the Senior Manager to have the lead responsibility for overseeing implementation of these various recommendations. In the event this position is not established or is otherwise unoccupied, one or more other ATG managers could assume responsibility for implementing these recommendations.

Senior Manager for Operational Safety

To ensure further effective oversight and management of operational safety issues at ATG, we recommend that the Head of ATG appoint a senior manager for operational safety.

The senior manager's key responsibilities for ATG operational safety should include:

- chairing the ATG Safety Committee
- overseeing all operational safety processes and procedures within ATG, including vehicle and operator safety and occupational health and safety
- acting as the ATG safety champion, reviewing current safety policies, guidance, procedures, and processes and, in consultation with other ATG officials, and revising them as appropriate
- working with other ATG officials to address safety issues as part of the VO and flight monitor training process
- evaluating feedback obtained from VOs, test engineers, mission specialists, managers, passengers, and others regarding potential safety issues and initiating corrective measures when warranted
- playing a key role in evaluating accidents and incidents involving a self-driving vehicle, and serving as a point of contact to any public agency authorized to investigate an accident or incident
- communicating safety-related expectations to third party contractors and monitoring contractors' compliance with these expectations; and reporting to the ATG Safety Committee on relevant safety issues.

We also note that the senior manager's operational safety responsibilities appear, in our view, to be clearly distinguishable from those performed by the Head of Systems Safety. Rather than responsibility for the safety of ATG operations, the Head of Systems Safety appears to have lead responsibility for overseeing ATG's engineering safety programs and safety architecture development for self-driving vehicles.

The Head of ATG should designate the Head of Systems Safety and the senior managers for training and operational safety to lead the SMS effort.
Until there is a functional ATG Safety Committee, the Head of Systems Safety and the senior managers for training and operational safety should initiate development of the ATG SMS program. In consultation with the ATG Safety Committee, the Head of Systems Safety and the senior managers for training and operational safety should be empowered to make necessary changes to ATG policies, procedures, processes, and operations.

**Establish an External Safety Advisory Panel**

In addition to considering the creation of an ATG Safety Committee, a panel of outside safety experts could, in an ongoing fashion, offer valuable independent advice on ATG safety policies, processes, and procedures. An expert panel could also offer valuable insights by identifying and evaluating safety risks and hazards in the ATG self-driving program and recommending appropriate mitigations. Although the purview of the expert panel would be broader than the ATG training program for VOs, flight managers, and other self-driving vehicle operators, it could work closely with the ATG Safety Committee and the senior managers for training and operational safety in reviewing and evaluating the training program.

**RECOMMENDATION**

We recommend that ATG consider establishing an independent panel of safety experts to provide periodic objective reviews of, and input to, ATG’s self-driving program policies, procedures, and processes, identify potential risks and hazards, and recommend corrective actions. The panel can be drawn from recognized experts in the aviation, automotive, and IT fields, and could include one or more representatives from highway safety advocacy organizations.
VII. TRAINING

A. HUMAN-AUTOMATION INTERACTION

Organizations' training efforts in highly-automated fields typically reflect the complex intersection of two concepts which, if not properly navigated, do not necessarily work well together. The first concept is that the challenges of bringing automation to public streets and highways can be so daunting, variable, and unpredictable that real-world testing on the streets is essential to continued improvement. Robust and well-considered initial development in the laboratory and on the test track is necessary, but far from sufficient; further testing and development on our streets and highways are necessary in order to ensure that the vehicles that ATG is developing respond adequately and safely to the reality of operating on public streets and highways.

The second concept is that humans are not good at monitoring very reliable systems. For example, as aviation automation has become increasingly reliable, experience has demonstrated that (a) increasing automation has resulted in the diminution of operator skills and proficiency because the operators conduct fewer operations manually, and (b) increasing reliability has caused operators to become more complacent about the need to monitor, so they are less likely to be "in the loop" enough to identify a problem and, if necessary, take over quickly. The combination of the need for real-world testing and the challenge of humans adequately monitoring very reliable systems is a scenario with very little precedent.

B. TRAINING IN OTHER INDUSTRIES

The Team notes the importance of a systems approach to training as developed and implemented by HROs and, in some instances, mandated by regulators. For example, the Nuclear Regulatory Commission (NRC) has regulatory requirements for training provided to key safety personnel at licensed facilities which include the following elements:

- Systematic analysis of the jobs to be performed.
- Learning objectives derived from the analysis which describes desired performance after training.
- Training design and implementation based on the learning objectives.
- Evaluation of trainee mastery of the objectives during training.
- Evaluation and revision of the training based on the performance of trained personnel in the job setting.

10 Code of Federal Regulations (CFR), § 55.4.

A systems approach to training, including elements identified by the NRC, is an important benchmarking tool. This systems approach to training is also fully consistent with the Quality Management Principles (QPMs) set forth in ISO 9000, ISO 9001, and related ISO Quality Management Standards.50

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50 These seven principles are: QMP 1 – Customer focus; QMP 2 – Leadership; QMP 3 – Engagement of people; QMP 4 – Process approach; QMP 5 – Improvement; QMP 6 – Evidence-based decision making; and QMP 7 – Relationship management.
This systematic process of Analysis, Design, Development, Implementation, and Evaluation (known as ADDIE) is referred to as Instructional Systems Design (ISD). Using an ISD process would permit the Company and ATG to determine, based on data and operational experience, the appropriate contours of its training program for VOs and other employees who operate self-driving vehicles.

The FAA has also established a voluntary Advanced Qualification Program (AQP) as an alternate method of qualifying and certifying pilots and other flight crew members. Despite the clear differences in training requirements for aviation pilots and other aircrew members and ATG VOs, flight monitors, and other ATG employees who operate self-driving vehicles, we believe numerous aspects of AQP programs offer useful guidance for ATG in setting standards for developmental training.

The objectives of AQP are: to achieve the highest possible standard of individual and crew performance by training to proficiency, as opposed to simply ensuring that all training activities have been completed; and to provide effective training that will enhance professional qualifications to a level above the present standards that are provided in 14 CFR Parts 121 and 135 of the FARs. The AQP process allows major air carriers (airlines certified under Part 121 of the FARs) and commuter and on-demand air carriers (airlines certified under Part 135 of the FARs) that are subject to FAA training and evaluation requirements, to develop innovative training and qualification programs that incorporate advances in training methods and techniques.

The AQP development process allows applicants to use ISD, as described above, in developing a training curriculum. According to the FAA guidance document:

AQPs are systematically developed, continuously maintained, and empirically validated, proficiency-based training systems. They allow for the systematic analysis, design, development, implementation, progressive evaluation, and maintenance of self-correcting training programs that include integrated CRM [Crew Resource Management], improved instructor/evaluator standardization, scenario-based evaluation, and a comprehensive data-driven quality assurance system.

C. ATG TRAINING PROGRAM CONTENT

A number of the specific training recommendations we recommend below can, if acted upon, be developed and implemented in the course of several months. Also, we are confident that our overall training recommendations lay a solid foundation for ATG to develop a first-class systems approach to training.

Since early 2016, the training program for VOs, flight managers, and others who operate self-driving vehicles has matured and become more robust. In general, the Team considers the program, as currently constituted, to be an effective means to ensure that VOs and other employees are fully capable to perform self-driving vehicle tasks on public roads and flight managers can proficiently perform their oversight responsibilities and tasks. Also, the onboarding

52 Id., at ¶ 1.4. As the FAA guidance document indicates, there is a wide range of support organizations, documents, and services available to Part 121 and Part 135 operators in developing voluntary AQPs. Uber/ATG should consider consulting these resources to ensure the ATG self-driving vehicle program is as safe as possible.
processes and TREX, Home City, stress mission, and UberX training and certification processes are comprehensive in scope and reflect worthwhile adjustments over time based on experience.

**Continuing Proficiency (including Line Checks) and Recurrent Training for VOs and Other Employees Who Operate Self-Driving Vehicles**

It is clear that self-driving vehicles' hardware and software changes require ATG drivers to understand clearly how these changes affect their performance and operation of the vehicle. Given this, ensuring VOs' and other employees' continuing proficiency is crucial. While ATG managers closely observe the VOs' and other employees' performance and skills in operating the self-driving vehicles and, on occasion, managers initiated, without prior notice, rides with self-driving vehicles on public roads, given the Company's significant investment in hiring and training VOs and other self-driving vehicle operators, a more systematic approach to ensure their continuing performance skills is warranted.

One way to help ensure that this systematic approach will reflect a *systems approach to training* is to have periodic meetings that include everyone who is involved in the training process, including makers of the hardware, creators of the software, representative VOs, and representatives of those who are involved in training and supervising the VOs. The purpose of these periodic meetings would be to find out from the VOs and their trainers and supervisors what are the most significant challenges encountered by each participant, e.g., the challenge of ensuring that the VOs are adequately monitoring highly reliable systems, and then to collaboratively develop solutions for these challenges. These meetings should be periodic both because the software, and to a lesser extent, the hardware, are continually changing, and because the collaborative process should continually be informed by lessons learned from actual training and monitoring since the previous meeting.

There are longstanding flight crew training and proficiency requirements in the aviation industry. The first requirements for air carrier training programs became effective under the Civil Air Regulations in 1954. On numerous occasions since requirements for air carrier training programs became effective under the Civil Air Regulations in 1954, the FAA has modified and supplemented these requirements. Its regulations on pilot proficiency and rating testing have been amended nine times since 1970. Currently, FAA regulations require a pilot in command (PIC) of a Part 121 operation to have completed a proficiency check or approved simulator course of training within the preceding 6 calendar months and a proficiency check in the aircraft type in which the pilot is to serve within the preceding 12 calendar months.

Proficiency requirements are also in place for pilots other than PICs, whereby checks or simulator training must occur within the preceding 12 calendar months and again in the preceding 24 calendar months. 14 CFR § 121.441. A detailed description of required proficiency check maneuvers and procedures is located in 14 CFR Part 121, Appendix F. The regulations also require Part 121 operators to provide recurrent training for crewmembers in order to ensure that they are adequately trained and currently proficient with respect to the type airplane. 14 CFR § 121.427. FAA regulations for Part 135 operators also establish initial training and recurrent training requirements for crewmembers.\(^5\)

In addition to required proficiency checks, a pilot is not permitted to be a PIC in Part 121 and 135 operations unless, within the preceding 12 calendar months, that person has passed a continuing

\(^5\) 14 CFR § 135.293.
qualification line check in which he or she satisfactorily performs the duties and responsibilities of a pilot in command in one of the types of airplanes he/she is to fly. The line check must be given by a pilot check airman who is currently qualified on both the route and the airplane and must consist of at least one flight over a typical part of the certificate holder’s route. Line checks can either be scheduled in advance or performed on a no-notice random basis.

The Federal Railroad Administration has compliance test and monitoring requirements for locomotive engineers. For example, the railroad must give each locomotive engineer at least one operational monitoring observation by a qualified supervisor in each calendar year and at least one unannounced compliance test each calendar year. The unannounced test must assess the engineer’s compliance with specified operating rules of the railroad. 49 CFR § 240.303.

RECOMMENDATION

As a part of a systems approach to training, we recommend that ATG design and implement a recurrent training program and proficiency testing and line check standards and procedures for VOs and other employees who operate self-driving vehicles, including appropriate remedial training where necessary. In addition, VOs and other employees who operate self-driving vehicles should be subject to periodic, unannounced monitoring/compliance checks while the vehicle is operating on public roads to ensure they maintain the necessary skills for safe operations of self-driving vehicles. The standards and procedures we recommend should ideally be developed and implemented with the assistance of the ATG Safety Committee and under the direction and leadership of the Heads of Training and Operational Safety.

To facilitate a highly effective recurrent training process, ATG may also want to consider holding periodic collaborative meetings of all involved participants in the training process, including VOs and trainers. These meetings could be chaired by the senior manager for training and could serve to continuously improve the training process based on changes implemented, challenges encountered, and lessons learned in actual self-driving vehicle operations over time.

Use of Training Simulators

Many industries have incorporated simulators in their training programs for employees who perform safety-sensitive functions. Not surprisingly, simulator capabilities vary widely and high-quality ones can reproduce real world conditions with a high degree of fidelity. Simulators enable the training and testing of operators in scenarios that could compromise safety if trained or tested in the real environment.

The use of simulators for training is particularly advanced in aviation. Since the 1970s, the FAA has gradually expanded the permitted use of flight simulation for training—first permitting simulation to be used in air carrier training programs and eventually permitting pilots to credit time in devices toward the aeronautical experience requirements for airman certification and recency.

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54 14 CFR §§ 121.440 and 135.299.
FAA regulations, 14 CFR Part 60, govern the qualification of flight simulation training devices (FSTDs), which include full flight simulators (FFSs) and flight training devices (FTDs). FAA regulations on the use of flight simulators and other training devices used to fulfill Part 121 operators’ training requirements are codified at 14 CFR § 121.400.

Simulators are also used in other transportation modes for operator training purposes, including pipelines and the rail and maritime sectors (see 49 CFR §§ 240.7 and 240.127 and 46 CFR § 10.41, respectively). The NRC also has regulatory standards for nuclear facilities that use simulators for operating tests and on-the-job training. 10 CFR § 55.46. The FAA also has in place a National Simulator Program, the goal of which is to improve aviation safety through the application of regulations and standards governing the qualifications of FSTDs, and to seek continuous improvement of flight simulation. See also 14 CFR Part 60, Appendix E, Quality Performance Standards for Quality Management Systems for Flight Simulation Training Devices.

RECOMMENDATION

We suggest that ATG further consider the feasibility and utility of designing and developing a self-driving vehicle simulator to enhance the training of developmental VOs and other employees who operate self-driving vehicles and to provide recurring training for experienced VOs and other self-driving vehicle operators. Even though self-driving vehicles are readily available due to the Company’s decision to ground the fleet, once the vehicles are again operating on public roads, their availability for training may be more limited. However, there may be real-world driving experiences that may be difficult to replicate during TREX or Stress training or public road self-driving, but would be more conducive to simulator training.

D. TRAINING DOCUMENTS

In General

A key aspect of a systems approach to training is the need to fully document training objectives (including safe operation of vehicles), processes, procedures, and evaluation methods. The VO

55 The FAA regulations define Full Flight Simulator (FFS) as “a replica of a specific type, make, model, or series aircraft. It includes the equipment and computer programs necessary to represent aircraft operations in ground and flight conditions, a visual system providing an out-of-the-flight deck view, a system that provides cues at least equivalent to those of a three-degree-of-freedom motion system, and has the full range of capabilities of the systems installed in the device as described in part 60 of this chapter and the qualification performance standard for a specific FFS qualification level.” 14 CFR Part 60, Appendix F.

56 The FAA regulations define Flight Training Device (FTD) as “a replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft flight deck replica. It includes the equipment and computer programs necessary to represent aircraft (or set of aircraft) operations in ground and flight conditions having the full range of capabilities of the systems installed in the device as described in part 60 of this chapter and the qualification performance standard for a specific FTD qualification level.” Id.

57 Hazardous Liquid Pipeline Regulations issued by the Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, require operators of pipeline facilities to include in their control room controller training program either “[u]se of a computerized simulator or non-computerized (tabletop) method for training controllers to recognize abnormal operating conditions.” 49 CFR § 195.446(h)(2).

58 The FAA has also issued Simulation Quality Management System Guidelines (SQMS) for a Basic System to comport with Appendix E of 14 CFR Part 60. The Guidelines are available at https://www.faa.gov/about/initiatives/np/sqms/media/SQMS_Guidelines.doc.
and flight manager training documents we were provided include information the operators need to know in order to operate the vehicle, and evaluation forms that measure the operators' knowledge and understanding of the training components. We recommend these documents also set forth training objectives with descriptions of desired performance after training, or training design and implementation based on documented training objectives. There clearly were changes and adjustments over time to training content and the length of training in Pittsburgh and in the operator's home city. We recommend that documentation supporting the basis for any future changes be available.

Of the nearly 300 total files the Team was provided and examined, all but 45 files contained documents pertaining to VO hiring; materials for onboard training; Central training (Pittsburgh) and, INDOL training (currently referred to as City training); flight manager training; and employment and incident response policies. Overall, the documents include important information in easy-to-understand language. In addition, the numerous quiz, exam, and evaluation instruments developed and used by ATG appear to be appropriate means to measure self-driving vehicle trainees' knowledge and understanding of vehicle software and other software tools, procedures for reporting and managing incidents, proper public relations, opt-in triage, and other important aspects of the self-driving vehicle program.

Going forward, development of ATG training documents can benefit from adopting a more methodical and systematic approach. For example, many documents repeat information included elsewhere. We recommend that Uber/ATG systematically review all of its training documents, remove information that is out-of-date, combine duplicative information, and identify gaps where additional information needs to be supplied. We also have several more specific areas which we recommend be addressed.

References to Safety in Training Documents

Given the extent to which the importance of safety was emphasized in the Team’s conversations with Uber and ATG executives, managers, and VOIs, we recommend that the emphasis on safety as a core value be stated more prominently by ATG.

RECOMMENDATION

ATG leadership should avail itself of every opportunity to consistently stress the importance of safety. Further, ATG should review its current hiring and training documents, and consider incorporating and emphasizing additional references to safety and its importance.

Current Information in Training Documents

Recognizing that training documents reflect issues that are subject to change, having current and consistent training documents is important. For example, one document lists several Uber Cultural Values that were recently superseded by the Uber Cultural Norms statement issued in November 2017. Based on our review, there are steps ATG can take in this regard.

RECOMMENDATION

ATG should review its current training documents to verify that they reflect the current Uber Cultural Norms.
Use of Training Videos

In general, videos are a very effective means to convey key information. The Team reviewed several videos and found them to be engaging and informative.

RECOMMENDATION

ATG should, where possible, make more frequent use of video presentations as part of their overall self-driving vehicle training programs. The videos should be revised, as appropriate, to incorporate training lessons learned. Moreover, videos present an excellent opportunity to stress the importance of safety as a core value.

Development VO Pre-Interview Test

Although the Team did not review the contents of the pre-interview test used by ATG to evaluate VO applicants, it did review a pre-interview test that was previously administered. Candidates completed that test online and they were able to seek correct answers online or elsewhere before responding to the various questions, i.e., an open book test. We encourage ATG to ensure that it uses robust tools for screening VO candidates and assessing their knowledge and capabilities, including whether an open book format is the most effective screening and assessment approach.

RECOMMENDATION

In screening and evaluating VO candidates in the future, ATG should consider seeking assistance from psychometric experts in designing test instruments which are most suitable to a VO's position and its requirements.
VIII. ATG SAFETY POLICIES, PROCESSES, AND PROCEDURES

A. VOLUNTARY SELF-REPORTING

Given the complexity and variability of the real-world environment, feedback about actual experience can be very helpful for improving hardware design, software design, and training. Accordingly, this Report recommends the development and/or improvement of non-punitive processes for feeding back information from ATG VOs, specialists, and managers, passengers, public bystanders, and anyone else with pertinent information about potential safety issues that are revealed during real-world operations.

Many sources may have valuable feedback to offer, ranging from ATG employees (for which the process must clearly be non-punitive unless it involves criminal or intentional wrongdoing), Uber passengers, and the general public, and ATG could benefit greatly from the information provided in its quest to improve the safety of test operations.

Based on our review of documents and our discussions with ATG employees, we believe ATG should consider additional steps to establish and/or improve voluntary non-punitive self-reporting systems and disseminate information about this resource to the ATG workforce.

As part of a robust safety culture, Reason has posited the need for an organization to have an informed culture in which:

Those who manage and operate the system have current knowledge about the human, technical, organizational, and environmental factors that determine the safety of the system as a whole. In most important respects an informed culture is a safety culture.\(^{59}\) (Emphasis in original.)

As Reason and others have made clear, information collection systems that include voluntary reporting must ensure that workforce members are willing to report safety concerns. Even where an organization’s leaders make clear their commitment to safety, they may be uninformed about safety risks encountered by operational employees, whose primary interest is in keeping their job and avoiding punishment for violations of safety protocols.\(^ {60}\)

Voluntary reporting systems have been established in numerous industries including aviation, nuclear power, chemical processing, and health care, and have been highly successful. For example, following an airline crash in 1974, the FAA established the Aviation Safety Reporting Program (ASRP).

The ASRP is “designed to encourage the identification and reporting of deficiencies and discrepancies in the [National Airspace System (NAS)].”\(^ {61}\) Under the program, pilots, air traffic controllers, flight attendants, dispatchers, maintenance personnel, ramp agents, and other professionals involved in aviation, can submit reports to the Aviation Safety Reporting System.

\(^{59}\) Note 8, supra, at p. 195.


(ASRS) when they are involved in or observe an incident involving a potential breakdown in safety. ASRS’s particular concern is the quality of human performance in the NAS. The information provided in reports is used to remedy actual or potential safety issues in the NAS and provide data for improving the current system.

Under a Memorandum of Agreement with the FAA, the National Aeronautics and Space Administration (NASA) receives, processes, and analyzes each report. After a report is submitted, NASA de-identifies the report by removing all personal information before entering the de-identified information in the ASRS database. The FARs prohibit the use of any submitted reports, or any information derived from them, in any enforcement action, except where a violation involves a criminal offense or an accident.

Another aviation industry voluntary disclosure program is the Aviation Safety Action Program (ASAP). Originally implemented by several major commercial air carriers in the 1990s, the FAA issued an advisory circular in 1997 to further explain and promote the program. Under an ASAP, the FAA enters into a Memorandum of Understanding (MOU) with an air carrier or a repair station and, if applicable, a labor union. The program is designed to encourage employees of the air carrier or repair station to report possible violations or safety issues to an ASAP Event Review Committee (ERC) comprised of one representative from each party who signed the MOU. In evaluating each report, the ERC must reach consensus on whether the report should be accepted in the program and, if so, whether corrective actions should be implemented. In order to be accepted in the program, the reported event must not appear to involve criminal activity, substance abuse, controlled substances, alcohol, or intentional falsification, and the violation must be inadvertent and not deliberate.

The Federal Railroad Administration, also in partnership with NASA, has similarly established a Confidential Close Call Reporting System (C³RS) in conjunction with participating railroad carriers and labor organizations. It is designed to improve railroad safety by collecting and analyzing reports which describe unsafe conditions or events in the railroad industry. Employees can report safety issues or “close calls” voluntarily and confidentially. By analyzing these events, potential lifesaving information can be obtained to help prevent more serious incidents in the future.

As has been pointed out with regard to the FAA’s ASAP,

A successful [voluntary self-reporting program] cannot flourish just under any circumstances. Instead, companies must also have a robust safety culture that promotes behaviors and attitudes related to safety for the program to thrive. There must be a strong sense of trust between employees and managers, as there is sometimes fear that management will use the information from the [reports] to punish employees.

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63 For additional information on ASRS, see https://asrs.arc.nasa.gov/overview/summary.html.
64 14 CFR § 91.25.
66 Further information about C³RS is available at https://c3rs.arc.nasa.gov/information/summary.html.
67 Cusick, Cortes, and Rodrigues, supra, note 62, at p. 250.
RECOMMENDATIONS

We recommend that ATG consider establishing and implementing one or more voluntary non-punitive self-reporting programs that allow ATG employees, passengers in ATG self-driving vehicles, and any interested member of the public to report potential safety risks and hazards for analysis, review, and appropriate corrective actions. We recognize, however, that an ATG self-reporting program should not guarantee that appropriate disciplinary action will not take place. Rather, the program should establish appropriate criteria to identify those circumstances where punitive actions could result from self-reporting.

The Team also has reviewed documentation concerning the recently established Uber Integrity Helpline program. As a result of this review, we also recommend that Uber examine whether its Integrity Helpline is an appropriate mechanism for reporting self-driving vehicle program safety concerns or whether a separate reporting mechanism should be established. If Uber determines that a separate reporting mechanism is appropriate, it should also assess whether the mechanism should be administered internally or by a third-party contractor.

B. QUICK REFERENCE HANDBOOK

A checklist document generally referred to as a Quick Reference Handbook (QRH) is used by aviation pilots and health care specialists to deal with emergencies or abnormal conditions. The aviation QRH usually contains information on procedures, subdivided by each aircraft systems and an abnormal/caution section, also broken down by each system. It also typically contains various checklists including those for operating an aircraft in normal and non-normal conditions. The checklists provide information to enable the pilot flying and the pilot monitoring to quickly identify problem(s) and cope with non-normal situations. (An example of a QRH is included in Delta Airlines’ Boeing 777 Operations Manual.)

RECOMMENDATION

The Team received and reviewed a large number of ATG handbooks, guidelines, instructional documents, and checklists for VOs and flight managers. The information in these materials is comprehensive in scope and voluminous. Although we recognize that VOs are able to obtain online and offline assistance from their flight managers, Flight Desk, and other teams, we recommend that ATG consider whether key information to enable VOs and other ATG employees who operate self-driving vehicles on public roads to identify and troubleshoot vehicle hardware, software, and other important handling and performance and/or operational issues should be compiled in a QRH that is available in each vehicle. If ATG decides to develop a QRH, the document should clearly state that it is not to be read while the vehicle is moving. Detailed indices/tabs can assist VOs in locating quickly needed information to address the problem.

C. ENCOURAGE AND PARTICIPATE IN CONTINUING INDUSTRY EFFORTS TO VOLUNTARILY SHARE NONPROPRIETARY INFORMATION

During one of our visits to ATG Headquarters and during our visit to Uber Headquarters, we informally suggested that ATG should participate in informal voluntary autonomous vehicle industry-based exchanges of nonproprietary information sharing. Information subject to sharing could include safety, technology, operations, and policy issues and other subjects of interest to the participants. Subsequently, we were advised by ATG leadership that certain information sharing efforts are ongoing. We are pleased that these efforts are continuing and also suggest that information sharing could also include Federal and state agencies with oversight responsibilities for autonomous vehicles and standards-setting organizations.

We note that AV 3.0 similarly encourages voluntary data exchanges to “help improve the safety and operations of [Automated Driving Systems] and lead to the development of industry best practices, voluntary standards, and other useful tools.”69

RECOMMENDATION

To further enhance ATG’s role in the autonomous vehicle industry, we recommend that ATG continue its participation in informal industry-based voluntary sharing of nonproprietary information that addresses common issues related to autonomous vehicle safety, technology, operations, and policy. These voluntary exchanges of information could also include Federal and state agencies with oversight responsibilities for autonomous vehicles and standards-setting organizations.

69 At p. 30.
IX. SUMMARY OF RECOMMENDATIONS

A. ATG SAFETY MANAGEMENT SYSTEM

<table>
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<tr>
<td>ATG should develop an SMS program and, as a preliminary step, consider the four-part framework and components established for aviation SMS programs and, to the extent feasible, adopt specified elements for each component tailored to the ATG organization.</td>
<td>16</td>
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<td>In developing and implementing its SMS program, ATG should, where desirable, seek the services of individuals and organizations with SMS expertise.</td>
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B. ATG SAFETY CULTURE

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<tr>
<td>The Head of ATG, or his designee, should establish additional communications and feedback mechanisms within ATG.</td>
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<td>Uber should consider placing a senior manager in the ATG Strategy and Operations unit in ATG Headquarters in Pittsburgh. The senior manager should report directly to the Head of Strategy and Operations.</td>
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<td>ATG managers, in cooperation with Human Resources, should take steps to verify that a complete and up-to-date job description is in place for every ATG position and that each employee receives a copy of the job description during the onboarding process, as well as revisions promptly after they are made.</td>
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<tr>
<td>ATG senior leadership should take further steps to communicate to all employees the importance of a robust safety culture as a core value and a way of doing business every day, as opposed to a mere “box to check.”</td>
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<td>ATG leadership may want to consider holding a one-day Stand-down for Safety program for all its employees, contractors, and third-party vendors. At this program, Uber and ATG leadership can reinforce their commitment to safety and</td>
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encourage frank discussions on ways to improve safety management, policies, and processes. Presentations from safety culture subject matter experts can also offer beneficial approaches to building a more robust ATG safety culture.

The ATG website should include additional information about ATG’s safety culture and the training and proficiency of VOIs and other self-driving vehicle operators.

Using the Commercial Aviation Safety Team (CAST) as a model, establish a permanent internal ATG Safety Committee that uses a collaborative process to identify and address ATG safety issues.

The Head of ATG should appoint a senior manager for training who will facilitate an independent review of ATG training at least every six months.

The Head of ATG should appoint a senior manager for operational safety.

The Head of ATG should designate the Head of Systems Safety and the senior managers for training and operational safety to lead the SMS effort.

Until there is a functional SMS Committee, the Head of Systems Safety and the senior managers for training and operational safety should initiate development of the ATG SMS program.

In consultation with the SMS Committee, the Head of Systems Safety and the senior managers for training and operational safety should be empowered to make necessary changes to ATG policies, procedures, processes, and operations.

Establish an independent panel of safety experts to provide periodic objective reviews of, and input to, ATG’s self-driving program policies, procedures, and processes, identify potential risks and hazards, and recommend corrective actions.
### C. TRAINING

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<td>Design and implement a recurrent training program and proficiency testing and</td>
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<td>line check standards and procedures for VOs and other employees who operate</td>
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<td>self-driving vehicles, including appropriate remedial training where necessary.</td>
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<td>Provide periodic, unannounced monitoring/compliance checks for VOs and other</td>
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<td>self-driving vehicle operators while the vehicle is operating on public roads.</td>
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<td>ATG should consider holding periodic collaborative meetings of all involved</td>
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<td>participants in the training process. These meetings could be chaired by the</td>
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<td>senior manager for training and could serve to continuously improve the training</td>
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<td>process based on changes implemented, challenges encountered, and lessons</td>
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<td>learned in actual self-driving vehicle operations over time.</td>
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<td>Further consider the feasibility and utility of designing and developing a</td>
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<td>self-driving vehicle simulator to enhance the training of developmental VOs and</td>
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<td>other employees who operate self-driving vehicles and to provide recurring</td>
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<td>training for experienced VOs and other self-driving vehicle operators.</td>
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<td>ATG leadership should avail itself of every opportunity to consistently stress</td>
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<td>the importance of safety. Further, ATG should review its current hiring and</td>
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<td>training documents, incorporating and emphasizing additional references to safety</td>
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### D. ATG SAFETY POLICIES, PROCESSES, AND PROCEDURES

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<td>ATG should consider whether key information to enable VOs and other ATG employees who operate self-driving vehicles on public roads to identify and troubleshoot vehicle hardware, software, and other important handling and performance and/or operational issues should be compiled in a Quick Reference Handbook (QRH) that is available in each vehicle. If Uber/ATG decides to develop a QRH, the document should clearly state that it is not to be read while the vehicle is moving.</td>
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X. CONCLUSION

Make safety a value, not "a top priority." Priorities change. Values don't, not without a lot of wrangling.

National Transportation Safety Board Chairman Robert L. Sumwalt. 70

In the course of the Safety Review Team's independent review of the ATG's safety culture and training, and our frequent opportunities to interact with Uber and ATG senior executives, as well as their engineers, managers, technicians, and self-driving operators, we have been impressed with everyone's resolute commitment to safety. The Uber Cultural Norm, We Do the Right Thing. Period., is also an entirely apt value statement that will continue to clearly resonate with Uber and ATG employees.

As we have pointed out, the upcoming challenge is for ATG to institutionalize a robust and systematic safety culture. As Dr. James Reason has pointed out

A safety culture is not something that springs up ready-made from the organizational equivalent of a near-death experience, rather it emerges gradually from the persistent and successful application of practical and down-to-earth measures. There is nothing mystical about it. Acquiring a safety culture is a process of collective learning, like any other. 71

In this Report, we have provided a great deal of information concerning the key features of the strong safety culture and the application of SMSs in the aviation industry. Although aviation has been a bellwether for effective safety systems, the development of its strong safety culture has, as Dr. Reason points out, been an evolutionary process. Also, despite the obvious differences in aviation technologies and the still-developing self-driving vehicle technologies, public concern with the safety of both technologies is evident. Although we do not mean to suggest that ATG can or should develop and implement safety systems and processes that approximate those in place in a mature industry such as aviation, we have endeavored to set forth recommended approaches that, in our view, make sense and will receive strong support from the public and regulatory agencies.

We appreciate the opportunity to perform this important review for Uber and ATG and look forward to offering continuing support and assistance.

71 Reason, supra, note 8, at 192.
APPENDICES
APPENDIX A

RESUMES OF LECLAIRRYAN TEAM
Mark A. Dombroff
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Alexandria, Virginia 22314
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Biography
Mark Dombroff concentrates his practice on the aviation and transportation industries, including litigation, regulatory administrative and enforcement matters, National Transportation Safety Board (NTSB) investigations, airport and aircraft security, and employment issues.

Mark has handled numerous safety, enforcement and regulatory matters before the Federal Aviation Administration (FAA), the NTSB and other administrative agencies, whether arising from an accident or incident or other material compliance matter, including issues involving the Departments of State, Justice, the Treasury and Homeland Security, and the Transportation Security Administration.

Over the course of a career spanning more than four decades, Mark has tried dozens of jury and non-jury cases, ranging in length from one day to several months, and argued before state and federal appellate courts at all levels. He represented Sikorsky Aircraft Corp. in the landmark Supreme Court case Boyle v. United Technologies, which established the government contractor defense, and in Mounsey v. Allied-Signal, a "friendly fire" litigation, winning the manufacturer's dismissal from the case after the government invoked the state secrets doctrine to avoid responding to third-party subpoenas.

Mark counsels and represents airlines, including Arrow Air, US Airways, Alaska Airlines, Colgan Air, National Airlines, Southwest Airlines, Mesa Airlines, SkyWest Airlines, Trans State Airlines, Virgin America, Spirit Airlines, and Empire Airlines and aviation service providers, including airports, fuelers, ground handlers, fixed base operators, maintenance and overhaul companies, catering companies, security companies, and airframe and other aerospace manufacturers.

In 2006, recognizing that there was virtually no experience base within individual aviation companies concerning emergency response, Mark founded the annual Airline Symposium to address best practices in the wake of an accident or incident. The program, which draws hundreds of attendees from all segments of

Education
J.D., American University, Washington College of Law
B.A., American University

Bar Admissions
District of Columbia, 1970
Maryland, 1970
Pennsylvania, 1994

Court Admissions
Supreme Court of the United States
US District Court for the District of Arizona
U.S. Court of Appeals for the District of Columbia Circuit
U.S. Court of Appeals for the Federal Circuit
U.S. Court of Appeals for the Fifth Circuit
U.S. Court of Appeals for the Fourth Circuit
U.S. Court of Appeals for the Ninth Circuit
U.S. Court of Appeals for the Second Circuit
U.S. Court of Appeals for the Seventh Circuit
U.S. Court of Appeals for the Sixth Circuit
U.S. Court of Appeals for the Tenth Circuit
U.S. Court of Appeals for the Third Circuit
U.S. Court of Military Appeals
U.S. District Court for the District of Columbia
U.S. District Court for the
the aviation industry, covers NTSB, FAA and criminal investigations; family/survivor matters; civil litigation; employee and union issues; financial and shareholder concerns; and emergency preparedness issues. More than 400 aviation professionals attended the 11th annual symposium, which included a showcase panel of emergency responders and family assistance personnel of Malaysia Airlines, a virtual reality simulation of an airplane crash, and presentations by the chairman of the NTSB and current and former senior staff members and investigators from the NTSB and FAA.

In 2014, Mark founded the annual UAS Symposium to address the growing body of drone laws and regulations. Panels composed of FAA, insurance and industry representatives discussed such topics as FAA appropriation issues, legal and regulatory obstacles in deployment of anti-drone technologies, the Part 107 waiver process, state and local drone laws, buying and selling UAS services, and other contractual, commercial and insurance issues.

Mark is outside general counsel to the Aviation Emergency Response Organization (AERO), which focuses on informing, educating, sharing and providing a forum for emergency response professionals from all aspects of the aviation industry worldwide, as well as the UAS Insurance Association, comprised of the leading aviation insurers providing insurance coverage to the rapidly growing drone industry.

**Representative Experience**

- 9-11 Civil Litigation
- Representation of the FAA Administrator in 9-11 Commission Hearings
- Arrow Air Disaster at Gander, Newfoundland
- Air Florida Disaster at Washington, D.C.
- Alaska Airlines Flight 261, Los Angeles, California
- Operation "Babylift" - Crash of Lockheed C-5A at Saigon, Vietnam
- Harduvel v. General Dynamics - Defense of General Dynamics in F-16 Crash
- Derailment of Ringling Bros. Barnum and Bailey Circus Train
- Korean Airlines 007 Shoot Down by Soviet Union
- Southwest Airlines Flight 1248 - Midway Airport Overrun, Chicago, Illinois
- Payne Stewart Learjet Crash
- Swissair Flight 111 Crash
- TWA Flight 514 Crash at Mt. Weather, Virginia
- Crash of The Galloping Ghost at the 2011 National Championship Air Races at Reno, Nevada
- TWA Flight 800 Crash
- United 232 at Sioux City, Iowa
- US Airways Flight 405 at La Guardia Airport, New York, New York
- US Airways Flight 427 at Pittsburgh, Pennsylvania
- US Airways Flight 1016 at Charlotte, North Carolina
- US Airways Flight 1549: The Miracle on the Hudson River
- Scaled Composites/Virgin Galactic Spaceship, Mojave, California
- Representation of Sikorsky Aircraft/UTC in Boyle v. United Technologies (Government Contractor Defense), US Supreme Court and Friendly Fire Litigation, Ninth Circuit Court of Appeals
- Liability Counsel for Cessna Aircraft, Piper Aircraft and Commander Aircraft in Numerous Cases throughout the United States
- Liability Counsel for over 400 airports including Meigs Field, Palwaukee, Charlotte, Dulles, Livermore
- National Counsel for 3SI Security Systems, Inc. handling all products liability, commercial and employment matters
National Liability Counsel for Piper Aircraft Irrevocable Product Trust
Empire Airlines Accident in Lubbock, Texas
Trans States Airlines Accidents in Ottawa, Canada
Counsel for Avantair, Clearwater, Florida in FAA Regulatory and Enforcement Matters
Crash of Presidential Airways, CASA 212 aircraft in Afghanistan
Colgan Air Crashes near Hyannis, MA and Buffalo, New York
National Airlines crash at Bagram Air Base, Afghanistan

Speaking Engagements

- Presenter, International Association of Claims Professionals, New York, New York, 2017
- Moderator, Aviation Law & Insurance Symposium, Orlando, Florida, 2017
- Panelist, Crisis Aviation and Accident Management, American Bar Association Air and Space Law Forum, 2016
- Speaker and instructor on aviation, trial advocacy, products liability, evidence and trial strategy at more than 250 bar association, CLE and other educational forums throughout the world

Legal Experience

- LeClairRyan, Alexandria, Virginia, 2017 - Present
- Dentons US, LLP / McKenna Long & Aldridge, LLP, McLean, Virginia, 2013 - 2017
- Dombroff & Gilmore, PC, McLean, Virginia, 1994 - 2013
- Department of Justice - Director, Aviation and Admiralty Section, Washington, D.C., 1971 - 1985

Memberships and Affiliations

- DRI Aviation Law Committee, Chair of UAS Subcommittee
- Flight Safety Foundation, Director and Legal Counsel
- UAS Insurance Association
- ABA Tort/Insurance Practice Section
- ABA Litigation Section
- ABA Forum on Air & Space Law
- American Bar Association
- Association of Trial Lawyers of America
- Aviation Insurance Association
- Conrad Foundation, Board Member
- District of Columbia Bar Association
- Defense Research Institute
- International Association of Defense Counsel
- NTSB Bar Association
- Virginia Trial Lawyers Association
- The Virginia Bar Association
Distinctions

- Chambers USA, Recognized Practitioner
- World's Leading Aviation Lawyers (Euromoney Publications)
- The Legal 500: Top Aviation Lawyers
- Attorney General's Award for Meritorious Service
- Civil Air Patrol Award for Special Achievement
- Assistant Editor, The American University Law Review
- Editorial Advisory Board Member, Law360 Transportation, 2018

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Washington, District of Columbia 20006
Phone: 202.659.6704
Fax: 202.659.4130
david.tochen@leclairryan.com

Biography
Mr. Tochen focuses on aviation matters related to accident investigations, accident prevention, and regulatory and compliance issues, as well as non-aviation interstate transportation matters.

Prior to entering private practice, Mr. Tochen served as general counsel at the National Transportation Safety Board (NTSB); deputy chief counsel at the Federal Motor Carrier Safety Administration, U.S. Department of Transportation (DOT); and deputy assistant general counsel for environmental, civil rights, and general law at the DOT. As NTSB general counsel, he led the effort to revise agency regulations, including investigative procedures, and prepared an agreement regarding the sharing of aviation safety data among air carriers.

During his tenure at the DOT, he served as the lead attorney in the establishment of the Transportation Security Administration following 9/11. He also was the lead attorney in establishing drug and alcohol testing programs for over 19,000 USDOT/FAA employees performing safety-sensitive duties.

Legal Experience
- LeClairRyan, Washington, D.C., 2017 - Present
- National Transportation Safety Board, General Counsel, 2011 - 2017
- Federal Motor Carrier Safety Administration, Deputy Chief Counsel, 2008 - 2011
- Department of Transportation, Deputy Assistant General Counsel for Environmental, Civil, Rights, and General Law, 1991 - 2008

Memberships and Affiliations
- American Bar Association: Administrative Law Section; Forum on Air and Space Law; Infrastructure and Regulated Industries Section; Tort Trial and Insurance Practice Section; Litigation Section; Labor and Employment Law Section
- Federal Bar Association: Transportation and Transportation Security Law Section

Education
J.D., George Washington University, 1977
B.A., economics, State University of New York at Binghamton, 1974

Bar Admissions
District of Columbia, 1977
- DRI: Aviation Law Committee; Trucking Law Committee; Governmental Liability Committee
- American Association for Justice: Aviation Law Section; Railroad Law Section Transportation
- International Air and Transportation Safety Bar Association
- Lawyer-Pilots Bar Association

Distinctions

- Transportation Lawyer of the Year, Federal Bar Association, 2002
- Award for Meritorious Achievement, Secretary of Transportation, 1987
BIOGRAPHY

of

CHRISTOPHER A. HART

Christopher A. Hart is the founder of Hart Solutions LLC, a consulting firm that focuses on improving safety while also improving the bottom line.

Until January 2018 he was a Member of the National Transportation Safety Board. In March, 2015, he was nominated by President Obama and confirmed by the Senate to be Chairman, which he was until March, 2017. Prior to that he was Vice Chairman and Acting Chairman of the NTSB, after being nominated by President Obama and confirmed by the Senate in 2009 and 2013. The NTSB investigates major transportation accidents in all modes of transportation, determines probable cause, and makes recommendations to prevent recurrences. He was previously a Member of the NTSB from 1990 to 1993, having been nominated by (the first) President Bush.

Mr. Hart’s previous positions have included:
- Deputy Director, Air Traffic Safety Oversight Service, Federal Aviation Administration, 2005-2009;
- Assistant Administrator for System Safety, Federal Aviation Administration, 1995-2005;
- Deputy and Acting Administrator for the National Highway Traffic Safety Administration (NHTSA), 1994-1995;
- Associate at Dickstein, Shapiro, and Morin, a Washington, D.C., law firm, 1979-1981;
- Deputy Assistant General Counsel at the Department of Transportation, 1977-1979;
- Attorney with the Air Transport Association, 1976-1977; and

In addition, Mr. Hart serves as the Chairman of the Washington Metrorail Safety Commission, that oversees the safety of the Washington area rail mass transit system (2018 to present); and he serves as a Trustee at Lowell School, the lower and middle school in Washington, D.C., that his daughter attended (2005-2010; 2018 to present).

Mr. Hart has a law degree from Harvard Law School and Master’s and Bachelor’s Degrees in Aerospace Engineering from Princeton University. He is a member of the District of Columbia Bar and the Lawyer-Pilots Bar Association, and he is a pilot with commercial, multi-engine, and instrument ratings.
APPENDIX B

ACRONYMS AND ABBREVIATIONS
### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
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<tr>
<td>ASAP</td>
<td>Aviation Safety Action Program</td>
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<tr>
<td>ASRP</td>
<td>Aviation Safety Reporting Program</td>
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<tr>
<td>ASRS</td>
<td>Aviation Safety Reporting System</td>
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<tr>
<td>ATG</td>
<td>Advanced Technologies Group</td>
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<tr>
<td>AVSTART Act</td>
<td>American Vision for a Safer Transportation for Advancement of Revolutionary Technologies (S. 1885)</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>C³RS</td>
<td>Confidential Close Call Reporting System</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
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<tr>
<td>FARs</td>
<td>Federal Aviation Regulations</td>
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<tr>
<td>HRO</td>
<td>High Reliability Organizations</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
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<tr>
<td>INSAG</td>
<td>International Nuclear Safety Advisory Group</td>
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<tr>
<td>ISD</td>
<td>Instructional Systems Design</td>
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<tr>
<td>ISM Code</td>
<td>International Safety Management Code</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>KSA</td>
<td>Knowledge, Skills, and Abilities</td>
</tr>
<tr>
<td>NHTSA</td>
<td>National Highway Traffic Safety Administration</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>NRC</td>
<td>Nuclear Regulatory Commission</td>
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<tr>
<td>NTSB</td>
<td>National Transportation Safety Board</td>
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<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>PDCA</td>
<td>Plan-Do-Check-Act</td>
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<tr>
<td>QMS</td>
<td>Quality Management System</td>
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<tr>
<td>QRH</td>
<td>Quick Reference Handbook</td>
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<tr>
<td>RTCA, Inc.</td>
<td>Formerly known as the Radio Technical Commission for Aeronautics</td>
</tr>
<tr>
<td>SELF DRIVE Act</td>
<td>Safely Insuring Lives Future Deployment and Research In Vehicle Evolution Act (H.R. 3388)</td>
</tr>
<tr>
<td>SMM</td>
<td>Safety Management Manual (ICAO)</td>
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<tr>
<td>SMS</td>
<td>Safety Management System</td>
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<tr>
<td>SoTIF</td>
<td>Safety of the Intended Function</td>
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<tr>
<td>STPA</td>
<td>Systems Theoretic Process Analysis</td>
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<tr>
<td>TREX</td>
<td>Training and Exercises</td>
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<td>VO</td>
<td>Vehicle Operators</td>
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<tr>
<td>WMATA</td>
<td>Washington Metropolitan Area Transit Authority</td>
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</tbody>
</table>
APPENDIX C

PLAN-DO-CHECK-ACT (PDCA) CYCLE